IS IT TRUE?

T[illegible] Watertown *Times* of Friday asserts that a lady in the northern part of Herkimer County was so frightened at the appearance of a snake in her path that her hair, previously a glossy back, turned white.

Early Rising.

There is another class of superstitions borne down to us from the crabbed times of our Puritan ancestry which I fancy we shall also somewhat shamefacedly own. They were the daily maxims which formed a part of the teaching in every genuine New England home, and their permanence as a part of our mental constitution is an encouraging circumstance to educators who sometimes are inclined to think that even line upon line and precept upon precept fail to make their impression upon the wayward mind of youth. To remove this fear, we stand as living monuments, boldly avowing, first, that we find it constantly difficult to convince ourselves—though our reason tells us that we are absurd—that it is not a moral duty to rise before, or at least, with the sun. Day by day, as we descend to our eight-o'clock or nine-o'clock breakfast, we are conscious of a certain sense of moral torpitude which we know to be unreasonable. It is in the effort to shake off this sense, which is only the remnant of an old superstition, that I write. [illegible] general axioms on the subject of [illegible] wh[illegible] helped to make the New E[illegible]nd Primer and the Farmer's Almanac a never-failing source of supposed improvement, and which were afterward re-enunciated by Franklin, do not not apply to the present day nor to city life. What is gained even for useful work by rising at six, and then being obliged to take a nap in the middle of the day? Why not do up all our sleeping at once, and have a clear sweep for work? If, again, one could carefully rake up and cover the embers of his fire at nine P. M., and sleep the sleep of the righteous till six, he might possibly rise at six, or even five, though why, even in that case, any sane person should insist on doing two hours' work, before eating, and call such action virtue, I could never understand. Circumstances alter rules as well as cass, which is what we of Puritan stock find it hard to understand. I myself know two young women of New England birth and training who, though they go into much evening society, and are frequently awake at midnight or after, each week during the New York winter, yet persist in being punctual every morning at the half-past-seven breakfast of the family. True, they have no appetites; true, they take long naps in the afternoon; true, they break down every year by March; yet they gallantly return to the assault every autumn, and would feel ashamed and guilty if they did otherwise. So strong i[illegible] the force of superstition!

In the future more perfect days it will be considered a sin to awake any one from sleep except in cases of life and death, and our grandchildren may perhaps be free from the inherited weakness of believing, because the flowers and the chickens and the birds wake when the sun does, that therefore a human being should do so. By what logic do we select the one action of waking as suitable for our imitation?—*Anna C. Brack[illegible]t in Harper's Magazine.*

Geo. J. Harley
Pke

HEIGHT AND WEIGHT.

The Philosophy of Human Length, Breadth and Thickness.

"How much should a person of given height weigh? Is there a standard between height and weight?" A healthy child, male or female, grows in length by more than one-half its size during the first two years; it increases from 19.675 inches to about 31.10 inches. It trebles or quadruples its weight; that is to say, it weighs 7½ to 10 pounds at birth; 25 pounds in the first year, 30 pounds in the second. On the average a child from six months to eight years grows in length about 2.4622 inches each year; the weight of of the body goes on increasing to the eighth year, rising in boys to 50 pounds and in girls 47½ pounds. From this age until puberty boys increase in height 2.165 feet each year, reaching at the age of 12 years a height of over 4.52 feet, and girls 4.421 feet on the average. Boys gain about 5 pounds in weight per year, girls a little more, so that in the twelfth year children of both sexes weigh on the average about 75 pounds. From 13 to 20 years youth grow some 11.8 inches; girls 7.8 inches. The increase of weight is even more rapid than before, reaching 145 pounds in boys 18 years old, and in girls of the same age 127½ pounds. In the 25th year the man is over 5½ feet in height and weighs 157½ pounds, while the woman is 5.15 in height and weighs 127½. Man in the fortieth year attains his maximum weight, 159 pounds, and then begins to lose flesh. Women continue to grow heavier, reaching about 140 pounds, until the fiftieth year. Between 45 and 60 men become more corpulent, and women rapidly grow older; in both the size of the body diminishes.

It is desirable for all persons, whether suffering in health or otherwise, to know as near as possible what the normal weight should be. We are indebted to the late Dr. Hutchinson for weighing about 2,600 men at various ages. There is, indeed, an obvious relation between height and weight so pertinaciously weighed and measured; starting with the lowest men in the tables, it will be found that the increased weight was as near as possible five pounds for every inch in height beyond sixty-one inches.

The following figures show the relative height and weight of individuals measuring five feet and upward:

STATURE.

Feet.	Inches.		Weight, lbs.
5	1	should be......................	120
5	2	should be......................	126
5	3	should be....	133
5	4	should be......................	136
5	5	should be......	142
5	6	should be......................	145
5	7	should be......................	149
5	8	should be......................	155
5	9	should be......................	162
5	10	should be......................	169
5	11	should be......................	174
6	0	should be......................	178

The Children's Paradise.

If you should start from Boston and go West more than half way round the world, you would come to Japan. Travellers call it a "paradise for children." There is a saying that Japanese children never cry. Perhaps you can guess why they are so happy if I tell you some things I noticed very soon after ... th...

The climate is beautiful, the scenery ... liant and varied. The houses are low ... furniture in the ... surface safe, and they have no ... be harmed or broken, no hard ... or sharp corners to inflict bumps and bruises.

The doors and windows are made of paper. Soft mats of rice straw serve for carpets; soft cotton mattresses for beds, which can be rolled up and put away. At meals straw tablecloths are laid on mats, and all the family sit on the floor around them. How like a picnic!

The dress of the children is like that of their elders—a plain, loose garment, girded about the waist with a sash. There are no hooks to pull out, no buttons to drop off, and no pins to scratch: a strong silk cord does all the fastening.

Then the garments, instead of being sewed together like ours, are basted together with a strong silk thread, so that they can easily be taken to pieces for washing. Stockings are made with a place for the big toe, like the thumbs in our mittens. A kind of clog is worn in the streets. Pockets are put in the large sleeves. Handkerchiefs and napkins are made of thin, white paper, soft as silk.

The sliding doors and partitions in the houses are almost always pushed back, so that you can see and hear all that is going on. Many a house has an aquarium, with gold and silver fish, or bamboo cages in which beds of flowers make a home for numerous butterflies and grasshoppers.

Mothers play with their children much of the time. Fat little dogs and pretty cats are their companions too. Babies are carried upon the back, and are never afraid of falling. Everywhere their shaven heads and black eyes peep out of folds of garments, or sleepily bob up and down, as their nurses rushes to and fro in the excitement of kite-flying or other play. Japan is the land of toys and dolls and kites and fans and parasols. A little girl will sometimes have over one hundred dolls.

The children have much rice to eat, but hardly any milk, for the queer little cows do not give much. Fruit is eaten green, for it is thought unfit to eat when soft and mellow.

The flowers of Japan have no odor, and the birds do not sing. The stork is one of the favorite birds.

The golden globe (instead of stars and stripes) is the flag that floats over Japan, and the chrysanthemum is the national emblem. It is wrought in tiles for roofs, on opium-pipes, on earthen ware and on many other things.—*Nursery*.

FIRST LINES

OF

PHYSIOLOGY.

BY

ALBERT VON HALLER.

TRANSLATED FROM THE
THIRD LATIN EDITION.

TO WHICH IS ADDED,
A TRANSLATION OF THE
INDEX,
COMPOSED FOR THE EDINBURGH EDITION,
PRINTED UNDER THE INSPECTION
OF DR. WILLIAM CULLEN.

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....

1803.

reasoning is always practical, but never abstract. Brutes do wonderful things suggested by the objective fact before them, but I think never go beyond it. Thus, a dog left in a room rang the bell to fetch a servant. Had not the dog been taught to ring the bell, (which on inquiry proved to have been the case,) this would have been abstract reasoning, but it was only practical. The Arctic fox, too wary to be shot like the first who took a bait tied to a string which was attached to the trigger of a gun—would dive under the snow, and so pull the bait down below the line of fire. This is purely practical reasoning: but had the fox pulled the string first out of the line of fire in order to discharge the gun and then get the bait, that would have been abstract reasoning. * * * Brutes and boys are just alike, in that nothing occurs to them beyond what the immediate fact before them may suggest. The one kind I call purely practical reasoning, which both have; the other abstract, which brutes never acquire, but which the boy will as his intelligence develops."

ADVERTISEMENT

TO THE EDINBURGH EDITION.

THE correction of this volume for the preſs was undertaken at the deſire of the Publiſhers. Having already undergone three editions, the preſent Editor believed, that a careful peruſal of the proof-ſheets, and attention to the typographical accuracy of the work, would chiefly conſtitute his ſhare in the publication. On collating, however, the laſt edition with the original of HALLER, it appeared, that few ſentences, and ſcarcely one paragraph, conveyed the true meaning of the Author. In many places, the ſenſe was totally miſtaken, ſometimes perverted, and the omiſſions and interpolations were both ſo numerous, and ſo prejudicial to the work, that thoſe who have formed their opinion of the value of HALLER's Firſt Lines, from any tranſlation in the Engliſh language, muſt have formed an opinion of them, highly detrimental to the well deſerved reputation of the Author. In the preſent edition, with much labour, the Editor has endeavoured to correct theſe miſtakes, to ſupply what was omitted, and to expunge the interpolations; in ſhort, to give HALLER's Firſt Lines in Engliſh.

THE very great deviations made by the original Tranſlator from the meaning of the Author, have betrayed the preſent Editor into an oppoſite fault, that of making his edition more literal than perhaps is conſiſtent with the true idiom of the Engliſh language. For this imperfection he has no other apology to offer: but for the omiſſion of Dr. WRISBERG's Notes, one is neceſſary. Of theſe notes, many are excellent; but as moſt of them are literary, ſome controverſial, and others but add a new conjecture upon points not yet underſtood, and, finally, as they do not now fulfil their original intention of ſupplying every diſcovery made in Phyſiology ſince HALLER's time, it was thought proper not to increaſe the ſize and price of the volume by their inſertion.

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CONTENTS.

FIRST LINES

OF

PHYSIOLOGY.

CHAP. I.

FIBRE.—CELLULAR SUBSTANCE.

I. THE moſt ſimple parts of the human body, are either fluid or ſolid. As the fluids are of different kinds, we ſhall conſider each of them in its proper place; and premiſe the hiſtory of the ſolids, which are moſt ſimple, and the true baſis of the body, to the conſideration of the other parts.

II. The ſolid parts of animals and vegetables have this fabric in common; that their elements, as ſeen by the moſt powerful microſcopes, are either fibres, or laminæ, or unorganized gluten.

III. Fibres for the moſt part, reſemble lines of very minute breadth, or rather ſlender cylinders. Their moſt permanent particles are demonſtrated to

be earthy, by combuſtion, or long continued putrefaction.

IV. Theſe earthy particles derive connection and the power of coheſion, not from themſelves, but from interpoſed gluten. We know this from the preceding obſervations, (III.) and the eaſy experiment, in which a burnt hair, whoſe parts hang ſtill together, recovers a certain degree of firmneſs by being dipped in water or oil. Ivory and bones alſo become friable, by the extraction of their gelly. Long expoſure to weather effects a ſimilar change, rendering bones a true earth, abſorbent and bibulous. But even bone, become friable from having its gelly extracted, reacquires its oſſeous hardneſs, when that gelly is reſtored. The more ſimple animals conſiſt entirely of this gluten.

V. Laſtly, the chemical analyſis of bone, and hair, the gelly of bone, ivory, and horn, the nature of our aliments, &c. prove, that this gluten is compoſed of water, incorporated with oil by animal life. Nor does any other kind of gluten unite the parts of animals more ſtrongly, as we ſee in ſize and common glue.

VI. The primary ſimple fibre, ſuch as we rather comprehend from reaſon than ſenſe, is compoſed of earthy particles, adhering longitudinally, and connected by intervening and coheſive gluten.

VII. But the fibres which appear primary to the ſight, are of two kinds. The firſt is linear, whoſe length is conſiderable in proportion to its breadth, and whoſe elementary particles lie in a ſtraight line, and thus generally parallel to thoſe contiguous. We ſee examples of this kind of fibre in bone, moſt eaſily in thoſe of the fœtus, and alſo in tendons, ligaments and muſcles, always recollecting that the eye ſees not the moſt minute fibres, but only the larger ones compoſed of theſe, and ſimilar to them in ſtraightneſs and ſlenderneſs. That

the

the ultimate fibres are perfectly fimilar, we are convinced by the microfcopes of Muys and Leeuwenhoeck, in which the mufcular fibres, even the moft minute, appear exactly like the larger ones, and perfectly linear.

VIII. The fecond kind confifts of laminæ, in which, a breadth often greater, is conjoined with a fhorter length. A loofe web of thefe has got the name of Cellular Tunic, though the term Tunic is on many accounts improper.

IX. This cellular fubftance is compofed of an infinite number of fmall laminæ, which, by their various directions, inclofe fmall fpaces and cavities, and join all the parts of the human body, affording an extenfive and firm union, with fufficient mobility. But in this web there is the greateft diverfity in the proportion of the folids to the cavities; in the breadth and firmnefs of the laminæ; in the nature of the contained liquor, which is either more watery or more oily; and in the admixture of fibres and filaments, of which there is a great quantity in fome places, as in the coats of the arteries, in others almoft none, as under the fkin.

X. Of this cellular fubftance when compacted, from the laminæ concreting, and being compreffed by the action of the incumbent mufcles, diftending liquid, or other caufe, broad plates are formed, which are either rectilineal in general, and more properly called Membranes; or convoluted into cylinders and cones, with liquids flowing through their cavities, and denominated Veffels; or extending round fome place in a plane parallel to it, get the name of Tunics. That tunics are formed of cellular fubftance, is proved in the aorta, fkin, pericardium, and dura mater, by ocular infpection, and efpecially by maceration. The coats of the mufcles, are alfo evidently cellular, and fimilar to other tunics. The fame thing is alfo proved from the eafy change of the dartos, and the nervous membrane

membrane of the inteſtines, into cellular ſubſtance, by inflation; and from the hard and thick membranes formed in encyſted tumors, which are mere productions of cellular texture. In the integuments, being very cloſely compacted in continued gradation, it forms the true ſkin lying under the epidermis; and being thence continued, it is at laſt partly reſolved into the ſubcutaneous cellular texture filled with fat.

XI. The veſſels which colour the tunics are an addition to the cellular ſubſtance, and in no wiſe eſſential to the nature of membrane, but ſuperadded to the membrane formed of the cellular ſubſtance. Between the meſhes of the inteſtinal network of veſſels, when moſt perfectly filled by the Ruyſchian art, white cellular ſubſtance remains, even then greatly exceeding the bulk of the veſſels, although being preternaturally diſtended, they occupy a greater ſpace. But I do not know any membranes compoſed of fibres interwoven with, and decuſſating each other; unleſs you conſider as ſuch the ligamentary or tendinous fibres which are ſpread over true membranes.

XII. Cellular ſubſtance is found in the human body, wherever there is a veſſel or muſcular fibre, without exception, as far as I know.

XIII. The other elementary ſubſtance of the human body, (II.) which cannot be truly called either a fibre or cellular laminæ, is a mere extravaſated gluten, concreted, not into fibres, but in the ſpaces betwixt them. This is manifeſt in the bones, whoſe fibres are ſeen very diſtinctly in the fœtus, with veſſels running in the intervals between them; ſo that the ſkull in every part, reſembles a comb. This fabric is ſo altered in the adult, that the intervals being filled up by fluid, extravaſated in the ſpaces betwixt the fibres, as happens with the juice of madder, and the edges being

being agglutinated, laminæ are formed. The cartilages ſeem to be ſcarcely any thing elſe than concreted gluten.

xiv. But here the order of nature ſeems to be, that the fibres above mentioned (iii.) are all originally formed of this gluten. That the cellular ſubſtance (vii.) is thus formed, appears from thoſe cellular fibres, produced in the thorax from concreted vapour, which joins the ſurface of the lungs to the pleura, and perfectly reſembling the true and natural cellular ſubſtance, even though compacted of inſpiſſated pus. The ſame appears alſo from a compariſon of the fœtus with the adult; for, inſtead of the abundant ſubcutaneous cellular ſubſtance, the fœtus has a mere jelly interpoſed betwixt the ſkin and muſcles, which have already acquired greater firmneſs; from the morbid diſſolution of the membranes of the muſcles into a mere gluten; and from a ſimilar change into glue of the ſkin, tendons, and ligaments of animals, by means of boiling water. Clots of coagulated blood; the ſanguineous membranes of Ruyſch; Albinus's membranes formed of mucus, polypus, ſilk and glue, alſo illuſtrate this theory. Laſtly, that the bony fibres 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 ſubſtances by Papin's digeſter.

xv. It ſeems, then, that an albuminous fluid, with a ſmall portion of earth, firſt concretes into filaments, from ſome preſſure, whoſe cauſes we now paſs over. Theſe by the mutual attraction of coheſion, leaving, however, ſpaces between them, compoſe the cellular texture, after having acquired ſome firmneſs from the cloſeneſs of the earthy particles, which follows the expulſion

ſion of the too aqueous gluten. This ſubſtance, wherever its laminæ are ſubjected to greater preſſure, turns into fibres and tunics; and, laſtly, with unorganized gluten (XIV.) concretes into bone. (XV.) Hence, in general, all parts of the body, from the ſofteſt to the hardeſt, ſeem to differ only in the latter having more of the earthy particles, and theſe more cloſely compacted, with leſs aqueous gluten; while in the ſoft parts there is leſs earth and more gluten.

XVI. The cellular texture is made up of fibres and laminæ (VIII.) which are neither hollow nor vaſcular, although it is coloured by acceſſory veſſels, but ſolid. The following are its chief varieties. In ſome parts it is looſe, and formed of long and diſtant liminæ; in others thin, and compoſed of ſhort fibres. I find it ſhorteſt betwixt the ſclerotica and choroides of the eye, eſpecially of animals, 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 veſicles of the lungs, under the pulp of the glans penis; and between the ſmall kernels of the viſcera and glands. It is compoſed of ſtill longer fibres, where it accompanies the veſſels, under the name of Vagina, through the viſcera, and particularly the liver and lungs; and is vaſtly firmer in the veſſels which go to the head and limbs. Its principal uſe is to bind together the contiguous membranes, veſſels, and fibres, in ſuch a manner as to allow them a due degree of motion. But the cellular ſubſtance, as hitherto deſcribed, hardly ever contains any fat; but is moiſtened by a watery, gelatinous and ſomewhat oily vapour, exhaled from the arteries, and received again into the veins. The truth of this is eaſily demonſtrable from injections of water, iſinglaſs or oil, made in all parts of the body. When this vapour is want-

ing,

ing, the filaments cohere, and the contiguous membranes are united, with lofs of motion.

XVII. The cellular texture is more lax, and formed of laminæ rather than fibres, where it divides the mufcular fibres, even the moft minute; where it loofely accompanies and fuftains the veffels; and within the cavities of the bones, where it is compofed of bony as well as membranous laminæ. That is likewife very lax, which, under the furface of the body, is every where interpofed betwixt the mufcles and the fkin; but the laxeft of all is that which furrounds with very wide cells the genital parts of the male.

XVIII. Into the empty mefhes of this cellular texture (XVII.) there is poured almoft every where, in the fœtus, firft a gelly, then a grumous, and laftly, under the whole fkin, and in its pits, a clotted fat. This fubftance is lighter than water, infipid, inflammable, becomes folid in the cold, is found in greater quantity about the kidneys and in graminivorous animals; in fifhes, while alive, and probably alfo in man, nearly fluid, though apt to coagulate. In it an acid falt, almoft in the proportion of one-fixth, is united with oil.

XIX. Through this cellular texture the bloodveffels run and are divided; from the arterial extremities of which, the fat is depofited and abforbed by the venous. The paffage, from the arteries into the adipofe cells, is fo immediate and free, that they muft open by very large mouths, fince they admit injected mercury, air, water, fize, and oil, which is always very fluggifh, even in living animals. It is not fecreted by any long ducts of particular fabric, but tranfudes on all fides through the whole extent of the artery; infomuch that, when an artery is filled with water, there is no part of the furrounding cellular fubftance which is not moiftened. The warm fat, during the pulfation of the arteries, eafily finds out the fame paffages.

How

How quickly it is collected, appears from the ſpeedy renovation of fatneſs after acute diſeaſes.

xx. But that this fat is abſorbed by the veins, we are taught from the ſudden effects which muſcular exerciſe has in conſuming the fat, more eſpecially of animals in which it abounds; alſo from its conſumption in fevers; from the cure of dropſies, where the water effuſed into the cellular ſubſtance is in a manner abſorbed and thrown out by the inteſtinal tube; and, laſtly, from the venous tranſudation of water and oil, when injected by the ſyringe, obſerved in every part of the body. Are nerves diſtributed upon the adipoſe cells? It is certain they run through this ſubſtance, and every where divide in it, into the minuteſt filaments, ſo that they can no longer be traced by the knife. That they terminate in it, is not probable; for the fat is both inſenſible and unirritable.

xxi. The meſhes betwixt the laminæ of the cellular membrane, are every where open, and unite in forming one continuous cavity throughout the whole body. This appears from the inflation of the ſkin over all the body, which butchers, and likewiſe the ſurgeons of Ethiopia, effect by a ſingle wound; from emphyſema, in which the air received by a wound of the ſkin, being retained, cauſes a ſwelling throughout the whole body; from the paſſage of bodies, put under the ſkin, to a place remote from that at which they entered; from the paſſage of pus, from an inflamed place to remote ulcers; and, finally, from diſeaſes, in which water depoſited in all the cellular ſubſtance of the body, is completely evacuated by a ſingle inciſion. That none of the cellular texture is excepted, appears from a caſe of emphyſema in which the vitreous body of the eye itſelf was inflated; and from a diſeaſe, in which the gelatinous

gelatinous ſerum of a dropſy was transfuſed even into the cavernous bodies of the penis.

xxii. The great importance of this cellular ſubſtance will be evident to all who conſider, that from it alone proceeds the due firmneſs and ſtability of all the arteries, nerves, and muſcular fibres, and conſequently of all the fleſh and viſcera formed of theſe: but even the figures of the parts, their juſt length, cavities, curvatures, flexures, depend entirely on the cellular membrane, being in ſome places of a laxer, and in others of a denſer fabric: for when divided, every part is lengthened and collapſes. Of this ſubſtance, with veſſels, nerves, muſcular and tendinous fibres, (a great part of which are however formed of it,) all the viſcera, all the muſcles, glands, ligaments and capſules, are compoſed; on it alone, and its different length, tenſion, quantity or proportion, the diverſity of our glands and viſcera depends; and, laſtly, it certainly conſtitutes by far the greateſt part of the body itſelf, if indeed the whole be not formed of cellular filaments of this kind.

xxiii. It poſſeſſes a contractile power, different from irritability, which, though not demonſtrable by experiments, diſpoſes the cellular fibre to ſhorten itſelf, though for the moſt part ſlowly, after having been ſtretched. This power, excited by cold, renders the ſkin rigid; raiſes the hairs; draws up the ſcrotum; and, after geſtation, reſtores the ſkin of the abdomen, and the uterus, to their former ſize. The ſame force, by a gentle but continual contraction, promotes the ſecretion of fat of the liquors of the ſubcutaneous and other glands, and of pus: in the veins and receptacles, it reſiſts dilatation; and, when that is taken off, it regains its former ſhortneſs. In the fœtus, this gentle force is among the principal cauſes of the changes that happen to the body.

xxiv. The ufes of the fat are various: it every where facilitates the motions of the mufcles, lef-fens their attrition, and prevents rigidity: it fills up the fpaces between the mufcles, and the cavities about many of the vifcera, in fuch a manner, that it readily yields to their motions, and yet fupports them when at reft: it principally conftitutes the weight of the body; conducts and defends the veffels: it uniformly diftends the fkin; ferves as a cufhion to the body, and renders the whole comely: it probably, by mixing with fome humours, abates their acrimony: it has a principal fhare in forming the bile; and, by tranfuding through the cartilaginous incruftations of the bones, it mixes with the articular liquid, and by abforption, it lubricates their fibres: by exhaling through the pores of the fkin, it refifts the drying fharpnefs of the air; alfo, by exhaling in a living perfon from the mefentery, mefocolon, omentum, and round the kidneys, it lubricates the furfaces of the vifcera with a bland vapour; and, by being interpofed, prevents their concretion.

xxv. The fat is depofited into the cells during fleep, reft of body and mind, and diminifhed force of circulation. When collected in too great a quantity, it proves injurious; by compreffing the veins; and, impeding the action of the heart, it produces afthma, apoplexy and dropfy. The fame humour is taken up by the veins; and, being more rapidly moved along the arteries, by violent exercife, venery, watchings, cares of the mind, falivation, diarrhœa, fever, fafting, it is carried beyond the excretory pores: it is confumed by fuppuration. When reftored to the blood, it increafes acute difeafes, tinges the urine, and forms a part of its fediment. After being fuddenly confumed, it is foon renewed again from healthy humours: but, in a languid habit, a gelly, inftead of fat, is depofited into the cells, caufing anafarca, and external hydrocele.

CHAP. II.

VESSELS.

XXVI. THE membranes will be better defcribed fingly. There are many things common to the arteries. They are long extended cones, decreafing according to the number of their branches. But where arteries run for fome length, without fending off large branches, their convergency is not very evident, if any; and at length, where they are called capillaries, and wherever they give paffage to a fingle globule, they are either cylindrical, or diminifh very imperceptibly; their tranfverfe fections are every where and without exception circular, when the artery is full. Where they fend off large branches, the caliber is fuddenly diminifhed, infomuch that they may be reckoned a chain of cylinders, of which every one is narrower than the preceding. If you reckon them cones, then the bafis of the cone, common to all the arteries is in one or other of the ventricles of the heart; and the apex of the cone, either in the beginning of a vein, or in the beginning of the cylindrical part of the artery, or unlefs it is cylindrical, in an exhaling veffel. In fome places they feem to dilate; at leaft they certainly become wider, after they have been filled and diftended with wax; poffibly from fome obftruction which caufes the injected wax to diftend that part of the artery more than the reft. Examples of this kind we have in the vertebral artery, at the bafis of the fkull; in the fplenic; in the flexure of the carotid, according to Mr. Cowper's injections; and, laftly, unlefs I be much deceived, in the fpermatic arteries. In all places, likewife, where the ramifications begin, the diameter of the artery is a little increafed.

XXVII.

XXVII. There is no external coat proper and common to all arteries. They derive an external and merely incumbent integument, in the thorax from the pleura, and in the abdomen from 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 encircles the aorta, returns back with the veſſels to the heart. The dura mater imparts a capſule to the carotid, as it paſſes out of the ſkull. But the firſt true membrane of the arterial tube, is every where cellular, and ſometimes adipoſe as in the thorax.

XXVIII. The external ſurface of this cellular coat is of a looſer texture, coloured by a great many ſmall veins and arteries, and permeated by nerves not very minute. It is ſometimes ſo abundant, that its external layers ſeem hardly to belong to the artery, but appear like an extraneous texture added to it. It is of this appearance in the neck, and round the inguinal, ſubclavian, meſenteric, cœliac, and hepatic arteries, being chiefly compoſed of long filaments. Theſe are the Vaginæ of the Arteries, of ſome eminent men.

XXIX. As this cellular coat advances more inwardly, and nearer to the cavity of the artery, it becomes more denſe, ſolid, and fibrous, and may be called a proper coat of the artery. That there is no tendinous coat of the arteries diſtinct from this cellular ſubſtance, is evident from maceration, by which the inmoſt ſtratum of this arterial tunic becomes cellular.

XXX. Within the former, and nearer the cavity of the artery, we find fibres, in general orbicular; recollecting, however, that no fibre any where makes a complete circle; but that many of them conjoined, with their extremities turned off ſideways, ſeem to form one ring. Theſe fibres, in the larger trunks, form many ſtrata, ſufficiently apparent from their

their reddiſh colour and ſolidity; 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 longitudinal. Under this membrane, but more difficult to demonſtrate, is an exceedingly ſhort cellular texture, into which the tophaceous matter is poured when an artery oſſifies.

XXXI. The innermoſt coat of the artery is thin, and finely poliſhed by the current of blood; it covers with an uninterrupted lining the fleſhy fibres, which are not ſufficiently continuous, and prevents the blood from inſinuating itſelf into the intervals. It is every where ſmooth and without valves; although, from a ſort of mechanical neceſſity, ſometimes certain folds, raiſed into a ſemicircle at the origin of branches, project, as we ſee, at the branches ſent off from 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.

XXXII. The arteries themſelves have arteries, particularly in their external cellular coat, ſpringing on all ſides from the adjacent ſmall arteries, numerous, branchy, reticular, all very minute, even in the fœtus, without injection, very numerous. Nerves every where deſcend, for a great way along the ſurface of the arteries, and vaniſh in the cellular ſubſtance; of which we have examples in the external and internal carotids, and arch of the aorta. From theſe, do not the arteries derive a contractile ſpaſtic force, different from ſimple elaſticity? Do not fevers, faintings, palſy with atrophy, and the paſſions of the mind, prove ſomething like this? But arteries are inſenſible and unirritable; and if they are conſtricted by poiſons, they have that property in common with the dead ſkin.

XXXIII. The ſections of arteries are circular, becauſe they are elaſtic; this is the reaſon why, even from

from the ſmall arteries of the teeth, hæmorrhages are ſometimes fatal. The aorta, indeed, in the thorax and abdomen, the carotids in the neck, and ſome other arteries of the dead body, when not diſtended, appear flat; but their round figure, and circular ſection, are always reſtored by injection. By their elaſticity, arteries ſtrongly compreſs the finger that dilates them, and more tightly in the dead than in the living body. In the living body, indeed, it yields to the action of the heart; but when the heart is relaxed, inſtantly contracts, and regains its former diameter; this conſtitutes the pulſe, whoſe full explication will properly follow the hiſtory of the heart; at preſent, it is ſufficient to ſay, that all arteries pulſate, although the ſyſtole and diaſtole can be perceived by the finger, only in the larger, not in the ſmaller ones; and though in the ultimate inflections of the arteries, it almoſt vaniſhes; for, by an increaſed motion of the blood, even the ſmaller arteries beat violently, as we ſee in inflammations. They contract lengthwiſe ſtrongly, and are rendered ſhorter when cut entirely acroſs.

XXXIV. The ſtrength of the arteries is conſiderable enough: but the denſe, hard texture of the outer cellular coat, as it refuſes to yield to a diſtending force, breaks without much difficulty, almoſt more eaſily than the coats of the veins; hence ariſe aneuriſms. The trunks are almoſt every where weaker, and the branches ſtronger, ſo that the impulſe of the blood may have conſiderable effect upon the former, while in the limbs it has very little. Hence, aneuriſms, are moſt frequent near the heart. In the lower extremities, the ſtrength of the arteries, and of the veins, is increaſed, as well as in the ſecreting organs.

XXXV. Nature has diſtributed arteries over the whole animal body, excepting a few membranes, where they have not yet been demonſtrated. But ſhe

ſhe has diſpoſed of the trunks every where in places of ſafety, becauſe wounds cannot happen to the ſmall ones without danger, or to the large ones without loſs of life. The ſkin has numerous ſhort and ſmall twigs; but the larger trunks, defended by the ſkin and muſcles, creep near the bones. In general, the arteries are in proportion to the parts of the body to which they are ſent, yet larger branches go to the ſecretory organs, ſpleen and brain; and ſmaller ones to the muſcular parts.

XXXVI. The proportion of the ſolid part of an artery to its cavity, is not every where the ſame, nor is it conſtant even in the ſame artery. This proportion, in the firſt place, is leaſt of all at the heart, and increaſes as the arteries remove farther from it. Secondly, in a full fed plethoric animal, whoſe blood paſſes freely, and with great force, through its arteries, the proportion of the ſolid part is leſs than in a famiſhed extenuated creature, whoſe blood moves feebly.

XXXVII. From each arterial trunk, branches are ſent forth, and from theſe again proceed ſmaller ramifications by repeated diviſions, of which you will ſcarcely find the end, though you may, perhaps, trace a ſeries of twenty. The calibers of any two branches taken together, always exceed that of the trunk from whence they come, in nearly a ſeſquilateral proportion, or ſomewhat leſs. In the capillaries this law does not obtain, and the ſum of the calibers of the branches, does not exceed that of the trunk. The ſmalleſt arteries which tranſmit a ſingle globule, have nearly the ſame diameter with a globule, that is, the three thouſandth part of an inch. Every trunk, above its diviſion, expands a little. The angles, at which the branches go out, are generally acute, either half right angles or nearly ſo; which angle, even in mechanics, carries projectiles fartheſt. Inſtances of their going off at right angles,

or

or nearly ſo, we have in the lumbar and intercoſtal arteries; of a retrogade courſe, we have one inſtance in the coronaries of the heart, and another in the ſpinal arteries, which are produced by the vertebrals, and ſeveral in thoſe of the limbs, as in the tibial and brachial. But moſt of thoſe which are eſteemed retrograde, are ſent off, at their origin, at acute angles; ſuch as the aſcending artery of the pharynx, the deſcending one of the palate, the umbilical and mammary arteries, and the nutritious ones of the large bones. Beſides, it is common for larger branches to ariſe under leſs angles, and ſmaller ones under greater angles. It is rare that two arteries of a large diameter run together into one trunk. An example of this, however, exiſts in the artery formed 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, they have repeated flexures, ſo that the artery undulates around a ſtraight line, in alternate obtuſe angles. This happens moſt frequently wherever the diameter of the part to which the artery goes, is occaſionally much increaſed, 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 of circle, as the carotids under the mammillary proceſs.

XXXVIII. They are frequently conjoined by intermediate branches, in ſuch a manner, that the twig of one artery ſhall run to meet one of the ſame kind, from a neighbouring artery, and unite with it into one trunk. We find inſtances of this, in large trunks in the inteſtines, among the middling ones in the kidneys, womb, &c. and among the ſmaller ones in all parts of the body; ſo that there is no part of the human body, in which the neighbouring arterial branches, whether

whether of the ſame or of different denominations, are not joined by intermediate branches. Of circles formed by arteries diverging laterally, and uniting again with each other, we have inſtances in the eye and brain. The extremeties of the arteries which are either cylindrical or nearly ſo, ſend off ſmaller branches, which, in the ſame extent, are more numerous, and are generally reticular; ſo that each branch, by its ſmaller twigs, forms anaſtomoſes with thoſe of its neighbouring branches: and thus we find it in all membranes. By this means it happens, that, though the paſſage from the heart to any part of an artery be obſtructed, the blood may nevertheleſs flow through the neighbouring arteries into all the branches of the obſtructed one. Thus, gangrene and langour are very powerfully prevented, and obſtructions are more eaſily reſolved by the repulſion of the obſtacles into the larger part of the trunk.

XXXIX. Laſtly, the minute arteries terminate in veins, either by a continuation of their canals, ſo that the ultimate little artery, which is generally reflected, having paſſed the angle of its reflection, has now become a ſmall vein; or elſe a branch, ſent out at right angles from the artery, is inſerted under a like angle into the branch of a ſmall vein. Both theſe kinds of mechaniſm are demonſtrated to us by the microſcope, and by the eaſy return through the veins, of injections thrown into the arteries. Theſe veſſels are ſometimes large enough to receive ſeveral globules, and ſometimes admit only one. A large artery never terminates in a vein.

XL. In the viſcera we do not find their diſtribution ſo truly reticular but varied, the ſmall branches deſcending, crowded together, bruſhy, arbuſcular, parallel to the trunk, ſerpentine or villous, according to the various natures of the parts.

XLI. Sometimes the arteries end in another manner, namely, by being converted into veſſels of ſmall-

er orders. Thefe are fometimes continuous with the arteries and are real trunks, as in the ophthalmic artery, if you examine the arteries of the tunica choroides, then the circle of the uvea, and laftly, the colourlefs ones of the iris. That a network of pellucid arteries is continuous with the red branches in the tunica conjunctiva, is evident from inflammation, and the rednefs of the part when relaxed by vapour, or by cupping, from injection, and the microfcopical obfervations of Lieberkuhn upon frogs, in which colourlefs globules were feen to pafs from red arteries into lateral veffels. In a fabric of this kind, the red blood is eafily forced into the fmaller veffels.

XLII. In other places the fmaller veffels feem to proceed laterally from the trunks of the leaft fanguiferous arteries, as branches fmaller than the trunks. Thefe are called Excretory Ducts. It is with difficulty that thefe are filled through the red veffels; of this we have, however, examples in the kidneys, the liver, and breafts. And the blood, when vitiated, penetrates the excretory ducts of the whole body without hurting the veffels, fince that aberration has no bad confequence.

XLIII. Another termination of arteries is in exhaling veffels; and this is frequent in all parts of the body. The whole fkin, all the membranes of the human body which inclofe any cavity, all the ventricles of the brain, both chambers of the eye, all the adipofe cells and pulmonary veficles, the whole cavity of the ftomach and inteftinal tube and air paffages, are all of them replenifhed with exhaling arteries of this kind. Thefe emit a thin, watery, gelatinous humour, which, by ftagnation, congeftion, and accumulation, from difeafe or death, is converted into a watery, but coagulable lymph. The truth of this is eafily demonftrable from the exudation that enfues from injecting the arteries with warm water. In fome places, indeed,

deed, they pour out, not a thin vapour, but blood itſelf, as we ſee in the heart, the cells of the penis, urethra, clitoris, and nipple of the female breaſt; in all which the blood itſelf is poured out in its natural ſtate. Is not every ſecretion in true glands or cryptæ, analogous to this exhaling fabric?

XLIV. In every part of the human body, do veſſels ariſing from the ſanguiferous ones, but carrying a humour thinner than blood, again ſend out other ſmaller veſſels, to be ſubdivided into ſtill leſs orders? We ſeem, indeed, not to want examples of this, as pointed out by men of eminence. That the aqueous humour is ſecreted by minute veſſels, generated from the colourleſs arteries of the iris, is very probable. That the red coloured veſſels in the cortical ſubſtance of the brain, by the intervention of another order of veſſels, ſeparate a juice pervading the medullary ſubſtance, is almoſt certain. Eryſipelas, and the yellow inflammation, ariſing from the yellow or ſerous globules impacted into ſmaller veſſels, ſuggeſt the ſame opinion.

XLV. Are there then yellow arterial veſſels of a ſecond order, which ſend off lymphatic ones of a third, from whence, by degrees, ſtill leſs kinds of veſſels branch out? Such a fabric does not ſeem agreeable to the eaſy tranſition of blood, mercury, or wax, into the exhaling, perſpirative, uriniferous and adipoſe veſſels and pulmonary cells; nor is it very difficult for the blood to ſtray into the lactiferous, lymphatic, and lachrymal veſſels, whither it ſhould ſeem not able to penetrate, if it went through any other intermediate vaſcular ſyſtem, ſmaller than the blood-globules. Nor is this opinion admiſſible, from the great retardation which muſt ariſe to the humours in a third, and much more in inferior orders of veſſels.

XLVI. 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. In most parts, they run parallel with the arteries, contiguous to them; but they differ in various respects.

xlvii. The fabric of the veins is thin, every where smooth, difficultly separable into membranes; of which the inmost is like that of the arteries, and round it is a condensed, but very easily distended, cellular membrane, surrounded in a single instance, above and below the heart, with transverse muscular fibres. The cellular substance, which connects them to the rest of the body, is, however, like that of the arteries, every where very lax. Notwithstanding this slender fabric, the veins are every where sufficiently firm, and do not easily burst when inflated with air; being, in most instances, stronger than the arteries themselves. But they burst more easily in man while alive, as appears from morbid instances in the leg, arm, face, &c. Nor do they support themselves after being divided, but collapse so as to make their apertures appear like slits; unless they be prevented by some strong cellular substance placed round them, as we see in the liver and womb. They are moderately irritable, and not by stimuli alone, unless they be chemical; but, in that case, they contract more than the arteries. They have no pulsation, unless, if we may trust all accounts, when 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 falls back from the brain.

xlviii. The veins are much larger than their corresponding arteries, having the square of their diameter often double or triple that of the latter; and sometimes almost quadruple, as near the root of, and in the vessels of the kidneys. In general, however, the

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 more reticulated, and unite by more frequent anaſtomoſes, not only of the ſmall branches, but even of the large trunks, occurring every where amongſt the neighbouring veins, upper with lower, and right with left. They prefer the ſurface of the body ; and through the limbs, neck, and head, they run a long way, perfectly cutaneous, which is very rarely the caſe with arteries ; from which, on that account, they ſeparate. Then the veins follow the ſurface, without a correſponding artery, which, in the mean time, runs at a conſiderable depth, attended by ſome ſmaller venous branch. In the ſmaller branches, and membranous reticulations, and in the internal fabric of the viſcera, the veins and arteries commonly run contiguous. The veins are generally leſs tortuous.

XLIX. In the larger ſanguiferous veins, valves are found in great numbers. The innermoſt membrane riſes double into the cavity of the vein, in the manner of a curtain, and being on either ſide extended deeper along the courſe of the vein, forms what may be called its cornicles : but the baſis, where it ariſes from the vein in the ſhape of a ſegment of a circle, is ſtronger, and conſtitutes its agger. With the ſides of the vein as it proceeds, they incloſe a curtained ſpace, of which the exterior ſide is the vein itſelf, and the interior the valve, which by its convexity projects into the cavity of the vein. The baſis of this almoſt parabolic ſpace, or the mouth of the valvular cavity of the veins, always looks towards the heart. They

are

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, which, however, is rare: in the ſmaller branches they are ſingle. There are none in the veins of the deep ſeated viſcera; and, therefore, none in the brain, lungs, heart, or liver, or in the whole ſyſtem of the vena portarum, or in the kidneys or womb, (except one or two valves in the ſpermatic vein;) or, laſtly, in thoſe ſmaller veins, which are leſs than a line in diameter. Sometimes, though rarely, they have been ſeen in the vena azygos. In the cava, at the mouths of the hepatic and renal veins, I have obſerved a ſort of wrinkles in their place. In the ſmaller branches, the ſolitary valves are long and very acutely parabolical, almoſt proportionately longer as the vein is ſmaller. Theſe ſeem to oppoſe the reflux of the blood more powerfully than the larger ones.

L. The origin of the veins we noticed in ſpeaking of the arteries. They ariſe continuous from minute arteries, by inſerted branches, or the reflection of a trunk. Others, again, are either continued from veins of inferior orders, or receive additions and roots from them; as, for inſtance, in the lymphatic veſſels and thoracic duct. Others of a bibulous kind take their origin from the abſorbing veins diſperſed over the whole body, in the cavities of the eyes, inteſtines, breaſt, peritonæum, pericardium, and ventricles of the brain. Hence the venous exudation, eaſily imitable over the whole human body, by injecting the venous trunks with an aqueous liquor; hence water, jelly, or oil, paſs from the vena portarum into the cavity of the inteſtines; hence water, injected into the abdomen of a living animal, quickly diſappears. But of theſe things

things we ſhall ſpeak again more fully in their proper places.

LI. Little different are thoſe veins which ariſe from every part of the cellular membrane, and carry back to the maſs of blood, dropſical waters, moiſt vapours, diſſolved fat, extravaſated and corrupting blood, and the poiſon of opium introduced into the cellular texture ; or bring back the blood itſelf from the cellular fabric of the penis, clitoris, or nipples of the breaſts, after the venereal orgaſm. That, into all the glands, veins of this kind open, is highly probable, which, by abſorbing the thinner humour, leave the remaining maſs of a thicker conſiſtence, as, for example, the bile, ſperm, mucus, &c.

LII. That there are ſmaller orders of veins, as of arteries, reſembling thoſe which convey blood, appears from experiments. Thus, in the eye there are the ſmall veins of the iris, and not a few trunks in the adnata ; and, without doubt, veins return from the vitreous humour, which, in health, are pellucid.

LIII. But, in moſt parts of the human body, other veins are found, full of a reddiſh, yellowiſh, or almoſt pellucid liquor, coagulable by heat ; formed of a very tender coat, and excitable by chemical ſtimuli. They are intercepted by double valves, for the moſt part ſo very frequently, that they almoſt ſeem jointed when they are turgid. By degrees uniting, either the whole or greateſt part of them meet in the thoracic duct. They ariſe from the cellular texture throughout the whole body, as I had long ago learned of the lactiferous veſſels of the breaſts, the vaſa efferentia of the teſticles, and, laſtly, of the lymphatics originating from the meſenteric glands ; and is now ſhewn of the lymphatic veſſels of the teſticles, ſpleen, and other parts. From analogy, and from the analogy of diſeaſes, eſpecially of dropſy, we are induced to believe, that they ariſe likewiſe

wife from the large cavities of the body; nor is it contradictory to suppose, that this kind of vessels receive a thin humour from very minute veins. But all the lymphatics, in their course, meet with a peculiar kind of glands, called Conglobate, into which they enter, having become arterial by the convergence of the venous cones, and dividing into branches; and again issue from them, to unite into new trunks.

LIV. These glands themselves consist of lymphatic vessels, connected by cellular texture, into which a fluid brought by the arteries, exsudes, and from which it is taken up by the vessels which carry away the lymph. They are covered with a continuous membrane, generally of an oval shape, whether they are simple or compound; and they follow the course of the larger blood-vessels; especially of the veins, through the whole trunk of the body, to the insertions 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, crural and popliteal veins, and likewise the vessels of the stomach, spleen, mesentery, and mesocolon.

LV. They are found on the surface of the viscera, in the thorax and abdomen; and more easily in brutes: in the lower part of the face, muscles of the tongue and parts adjacent, in 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 anterior and posterior mediastinum, and wherever we find conglobate glandules, either in the neck or thorax; in the whole lumbal region that is contiguous to the aorta; in the mesocolon, pelvis, vessels and surface of the testicle; and in the lower limbs, wherever they are supplied with conglobate glandules, as far as the knees. Whether they extend further, and exist in every part of the body, in the brain, eye, hand, foot,

foot, back, fore part of the peritonæum, &c. is not confirmed by ſufficiently accurate or numerous obſervations on the human body. They are every where fonnd on the ſurfaces of the viſcera. They are almoſt every where collected into bundles, which lie 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.

LVI. Of what ſervice theſe glands are to the lymphatic veſſels is not yet well known. In the fœtus, as well as the thymus and glandulæ renales, they are turgid with a milky liquor; but it is not certain that this fluid is poured out into the cellular ſpaces. It is however rendered probable by late experiments, that in theſe glands ſome kind of fluid is prepared which is mixed with the lymph; ſince thin fluids, injected into the arteris, enter the lymphatic veſſels. In the progreſs of life, this fluid vaniſhes; and the glands themſelves, being dried up, almoſt diſappear. The very frequent ſchirroſities in theſe glands ſeem to indicate, that the motion of the fluid paſſing through them is retarded.

LVII. Their valves (LIII.) are compoſed of two ſemicircular membranes, which give way to the fluid that goes toward the larger trunks; and by applying themſelves to the ſides of the veſſel, leave a free paſſage. But the ſame valves, if the liquor return from a larger trunk towards the ſmaller branches, being filled, ſwell, expand, and ſhut up the tube.

CHAP.

CHAP. III.

OF THE CIRCULATION OR MOTION OF THE BLOOD THROUGH THE ARTERIES AND VEINS.

LVIII. THE arteries and veins hitherto defcribed, contain either blood or lymph. The red blood, whofe nature we fhall explain when we treat of fecretion, fills the arteries and veins commonly known, which we call red, or thofe of the firft order, and which have their origin in the heart. Thefe it fills, in a living perfon, in fuch a manner that at one time they are very loofely and imperfectly diftended by it, and at another, they are rendered very full and turgid. After death, the veins are found very full of blood; but occafionally, the fmall veins, chiefly fome time after death, have been found diftended with air. The arteries in the dead body, commonly contain only a fmall quantity of blood.

LIX. This blood is rapidly moved through all the veffels of the living body. The truth of which is demonftrated by wounds, from which, even a mortal lofs of as much blood as is neceffary for the maintenance of life quickly enfues, almoft inftantly from the larger arteries, and fometimes very fuddenly from the fmaller ones, but more difficultly from the veins, unlefs very large; yet are there not wanting inftances of fatal hemorrhages from wounds of the vein in the inner corner of the eye, or of that under the tongue. Laftly, experiments made upon living animals, fufficiently prove the powerful impulfe with which the blood is moved, particularly through the arteries. In the large arteries it runs moft fwiftly; in the fmall ones, fomewhat flower. In the large veins, the blood moves more flowly than in the arteries, in the fame proportion as the calibers of the arteries are lefs than thofe of the

the veins, almoſt twice or thrice. Another argument is derived from the compreſſion and relaxation of a vein, by which the motion of the blood is promoted from valve to valve. This motion in the veins, is equable enough; but, in the arteries, it is alternately greater, ſo that the veſſel at one inſtant rebounds ſtrongly, and at the next is relaxed. This is confirmed in living animals by ocular inſpection.

LX. The direction of the motion of the blood through the red veſſels, is ſhewn by experiments of this kind. Firſt, it is certain, that all the arteries and veins communicate; becauſe, from one, and often a ſmall artery, and ſometimes alſo from a vein, all the blood ſhall be diſcharged, even cauſing death and extreme pallidity of the whole fleſh, not only of the limb wounded, but of the whole body. Fatal examples have occurred from arteries of the noſtrils, gums, fingers, teeth, from a cutaneous pore, lachrymal point, cupping, and the bite of a leech. There muſt therefore be paſſages by which the blood ſpeedily flows from the venous into the arterial ſyſtem.

LXI. 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 tying up the artery of a living animal. For if an artery be ſtopped by a ligature, a ſwelling enſues in that part betwixt the heart and the ligature, whilſt the other part beyond the ligature, and more remote from the heart, becomes empty, has no pulſation, nor, if wounded, bleeds. The effect of a ligature is alſo produced by diſeaſe; as when ſome tumor, by compreſſion, or an aneuriſm, intercepts the motion of the heart. Experiments have been made on moſt of the arteries even by myſelf. Sometimes anaſtomoſes, or the eſcape of the blood by ſome channel into a neighbouring branch, and the retroceſſion of the blood in a dying animal, ſeem exceptions.

LXII.

LXII. There have been doubts with regard to the motion of the venous blood, and all the ancients were perſuaded, that the blood flowed alſo in the veins from the heart, or certainly from the liver, to all parts of the body. Few have diſcovered the error: ſeveral, indeed, in the pulmonary vein: in the vena cava, fewer; perhaps only Andreas Cæſalpinus, and as an uncommon appearance, Veſalius.

LXIII. Harvey firſt eſtabliſhed, by experiments, the courſe of the venous blood which returns from every part to the heart, ſo as to remove every doubt. And, firſt, the valves point out this truth; for the common office of theſe valves is, that every preſſure, however applied to the veins, determines the blood towards the heart, ſince they take away the poſſibility of its returning into the branches, after having once entered a trunk. For, ſince the valvular portions are concave upwards, towards the heart, the refluent blood enters into and expands them. Thus, that part of the valve which projects looſely within the cavity of the vein, approaches towards the axis, until it meet the oppoſite ſide, and ſhut up the tube. This we know from inflation, ligatures, and injections; for we never can force a liquor eaſily into the veins againſt the valves. They do not, indeed, every where ſhut up the cavity entirely; but they always do it in a great meaſure.

LXIV. Another office of the valves in the veins ſeems to be to ſuſtain the weight of the blood, that its upper columns may not gravitate upon the lower, nor the blood, flowing through the trunks, impede that coming through the branches. For if, from the ſlower motion of the blood, it ſhall happen that its weight ſhall bear too great a proportion to the impulſive force, and any part of the ſanguineous column begin to deſcend by its weight, the neareſt valve ſupports it in its relapſe, prevents it from preſſing on the ſucceeding column, and affords time for

for ſome contiguous muſcle, by its preſſure, to free the valve, and propel the column. This is the reaſon for the ſituation of valves in the veins of the limbs and neck; in which parts they are both more numerous and more robuſt than elſewhere. This alſo explains the cauſe of varices, when the blood, entering the valves, preſſes their ſolid convexity downwards, and forces them to deſcend and dilate. 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.

LXV. Moreover, the valves placed in the right ſide of the heart, are ſo conſtructed, as we ſhall hereafter ſee, that they freely permit blood, air, or wax, to paſs from the venous trunks of the cava into the heart, but allow nothing to eſcape from the heart.

LXVI. Beſides, in a living perſon, ligatures make the thing evident. When either by deſign or accident, the veins of the ham, arm, or leg, are tied with the limb itſelf, the limb every where below the ligature ſwells, the veins become diſtended and turgid, and, when opened, freely diſcharge blood; nothing of this kind happens above the ligature, nor are any veins to be ſeen there. The ſame happens when the veins are compreſſed by ſchirrous viſcera, or enlarged glans; and from polypi, tumors of the large veins are frequent. Ligatures retain the blood in any limb round which they are tied, and prevent it from returning to the heart, and from being loſt through a wound in another part.

LXVII. The experiments which have been made on living animals, are ſtill more accurate. From them, even from our own, it appears, that, by tying, in a living animal, any vein, whether belonging to the cava or to the pulmonary veins, that part always ſwells which is moſt remote from the heart, and is diſtended with the blood retained by the obſtacle, while that next the heart becomes pale and flaccid. Laſtly, if both the arteries and veins be tied, the

veins

veins collapſe; but, upon removing the ligature, the veins are immediately filled.

LXVIII. In like manner, the injection of poiſons or medicines ſhews, that, into whatever vein you inject chemical acid ſpirits, the blood even to the heart is coagulated by the force of the poiſon. But the affection of the brain by the narcotic power of opium, of the inteſtines by purgatives, and of the ſtomach by emetics, clearly proves that the blood, with which theſe ſubſtances were mixed, had paſſed from the venous branch to the heart, and from thence through the whole body.

LXIX. Moreover, from the transfuſion of blood, it appears that the living blood of one animal, injected into the vein of another, completely emptied of blood, repleniſhes its heart, arteries and veins, ſo as to reſtore vigour, turgidity, and even to produce plethora.

LXX. But that the blood paſſes from the minute arteries into the minute veins, we are taught by injection; filling, without much difficulty, by one arterial trunk, the arteries and veins throughout the whole body, provided the liquor be watery and fluid; and with very great eaſe thoſe of the head, meſentery, heart and lungs.

LXXI. Laſtly, microſcopical obſervations on the pellucid tails, feet and meſenteries, of animals, prove, beyond all doubt, that the blood, carried to the extreme parts by the arteries, is poured either into ſmall veins, continuous with the reflected arteries, or through communicating branches from an arterial trunk into a parallel vein, and that it returns by the veins to the parts nearer the heart. This tranſition happens both in the moſt minute veins, which are capable of receiving only one globule, and in thoſe ſomewhat larger, which admit two globules. That there is no where any ſpongy or parenchymatous ſubſtance interpoſed between the arteries and veins, is proved both by the microſcope

croſcope and by injections, which, if there were any cellular ſpace betwixt the arteries and veins, would be extravaſated in ſhapeleſs maſſes.

LXXII. The circulation of the blood, is, therefore, now received as a medical truth by every one; namely, all the blood of the human body is carried through the aorta, from the left cavity of the heart towards the extremities of the arterial branches; whence it is entirely tranſmitted into the minute veins; from thence it returns to the large veins, the cava and heart itſelf; in which courſe it perpetually circulates.

LXXIII. Yet inſtances occur, when, from paſſions of the mind, from a ſudden great revulſion by blood-letting, or from convulſion, the blood has retroceded from the ſmaller into the larger arteries. And, in like manner, from an obſtruction being formed in the venous branches above the valves, the blood has been known to return into the extreme branches. But theſe deviations, are, for the moſt part, tranſitory, and the blood ſoon returns into its natural courſe. They may be ſuppoſed to happen moſt frequently in the abdomen and vena portarum.

LXXIV. The courſe of the humours in the valvular lymphatic veins, appears from ligatures and from the valves: for every lymphatic vein when tied, ſwells between its ſmaller extremities and the thoracic duct; but grows flaccid betwixt the duct and ligature. All the valves, like thoſe of the veins, allow air and mercury to flow freely into the thoracic duct; but they reſiſt, and often obſtinately, the contrary courſe, although ſometimes in the dead body they have given way.

LXXV. The vapour that moiſtens the cellular ſubſtance, the halitus of the abdomen and other cavities are conveyed from the pellucid into the red veins, that theſe may tranſmit their contents to the heart. Hence, when a vein is compreſſed or tied,

œdema

œdema enſues, the fluid ſtagnating, from its paſſage being interrupted. In the other ſmaller veſſels, experiments cannot be made; but reaſoning and analogy ſupport the ſame concluſion. Experiments concerning the fluid, reabſorbed from the inteſtines, pulmonary veſicles and ſkin, ſhall be mentioned in their proper places.

LXXVI. Therefore all the fluids in the human body are expelled from the heart into the aorta; and except thoſe which are exhaled out of the cavity of the body, or are excreted, they all return to the heart through the minute veins. It remains to diſcover a paſſage by which the blood may return from the right to the left ſide of the heart; but this paſſage ſuppoſes an acquaintance with the hiſtory of the heart and pulmonary veſſels.

CHAP. IV.

HEART.

LXXVII. THE thorax, compoſed of bones and cartilages, on the whole, reſembles a truncated cone, as we ſhall hereafter mention. The lateral parts of this cone, are two membranous bags, having at their upper end an obtuſe termination, above the firſt rib, at which place they are contiguous, and ſeparated only by ſome cellular ſubſtance. Their obliquity is ſuch, that the right bag is wideſt, and adheres to the middle of the ſternum, but as it deſcends it inclines to the left ſide, and comes from the very margin of the ſternum. The left bag deſcends not from the ſternum, but from the cartilages of the ribs. The inner and oppoſite ſides of each bag, form what anatomiſts call the mediaſtinum. Theſe bags have no communication whatever, and the right may be opened and its lung deſtroyed, without injuring the left. But the membrane

membrane which forms them, is ſimple, denſe, externally ſurrounded by cellular ſubſtance, is called the pleura, is harder than the peritonæum eſpecially towards the back, ſofter anteriorly, and is naturally inſenſible. The cavity of the mediaſtinum, or interval between the right and left bags, broadeſt above, but alſo conſiderable below, contains the thymus, conglobate glands, fat, veſſels, and in ſome diſeaſes, pus.

lxxviii. Below, the ſame bags diverging, recede from each other, and leave a cavity central in all its dimenſions, which ſeparates them. This cavity is the pericardium. But the bags of the pleura, deſcending at the ſides of the pericardium, and before and behind it, terminate finally, about the fifth or ſixth rib, upon the diaphragm, and on it have their baſis, which is truncated obliquely, ſo that anteriorly it is ſhort, but poſteriorly deſcends farther, and is arched upwards. Within theſe bags are the lungs. Poſteriorly, theſe bags are more tender, contiguous and ſeparated in the ſame manner by cellular ſubſtance, which terminates on the pericardium, and includes, in ſome meaſure, the aorta, but more evidently the trachea and œſophagus. This is the poſterior mediaſtinum. Triangular productions of each lamina of the mediaſtinum form the ligaments of the lungs, one on each ſide.

lxxix. The pericardium, or third bag, which is looſely ſurrounded, firſt by cellular ſubſtance, and then on all ſides by the contiguous pleura, as an exterior lamina, touches the ſternum by a very ſmall part indeed; ſince the lungs when diſtended, cover the heart almoſt wholly before, and interpoſe themſelves betwixt the ſternum, and pericardium below; and the mediaſtinum, by gradually diverging towards the left ſide, has an interval, narrow indeed, under the lower end of the thymus, to each ſide of which, the lungs extend: but this ſituation

is diſturbed, unleſs you are careful in the manner of opening the thorax. The pericardium has a broad, ſomewhat round baſis, adhering to the tendinous, and by a ſmaller part on the left ſide, about the fifth or ſixth rib, to the fleſhy part of the diaphragm; in young ſubjects by looſe, but in adults by very firm, cellular ſubſtance. Towards the right it is broader, and towards the left it grows ſmaller. It is ſomewhat larger than the heart, that it may move freely in it. It never certainly was wanting.

LXXX. Upwards, the pericardium grows gradually narrower, ending above the heart in an obtuſe conical appendix, which adheres to the coats of the large blood-veſſels almoſt to the upper edge of the ſternum; 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 is higheſt; then downwards to the ſame veſſel, and the ductus arterioſus; hence to the left branch of the pulmonary artery, and at laſt to 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 left pulmonary veins, and to the auricle of the ſame ſide; then a long way from the pulmonary vein to the inferior cava, then to the ſeptum of the ſinuſes, then to the inferior cava. Beſides, it adheres to the pulmonary artery, its right branch, and the aorta below the origin of its great branches, ſurrounding each artery with a cylindrical production, ſo that it appears like a kind of partition between every two neighbouring veſſels. Thus alſo it contains the vena cava ſuperior in a ring; and the anterior and poſterior cavities of the pericardium are looſely 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 which it there ſerves as an external coat. But it ſends cellular ſubſtance like a ſheath, along with the great arteries and veins, to the lungs.

lxxxi. The pericardium has its arteries either from thoſe of the thymus, from thoſe which accompany the phrenic nerve above and below, from the larger phrenic arteries, from the mediaſtinal branches of the mammary, from the bronchial, œſophageal and poſterior mediaſtinal arteries, or from the coronaries which inoſculate with the bronchials and others. The trunks of the veins are analogous, but with more evident anaſtomoſes between thoſe of the right and left ſides. The nerves are from the ſuperficial cardiacs.

lxxxii. The membrane which properly conſtitutes the pericardium, is ſtrong, white, compact, more robuſt than the aorta itſelf, and through its ſubſtance the nerves of the heart and ſome ſmall veſſels deſcend. The ſurrounding cellular ſubſtance makes its outer ſurface ſomewhat rough, while internally, where it is in contact with the heart, it is very ſmooth, and moiſtened on all ſides by a watery vapour. This halitus, which we have always obſerved in the living animal, conſtitutes the water of the pericardium, ſmall in quantity, but always preſent, limpid, or tinged with yellow or red, ſomewhat viſcid, erroneouſly denied by ſome; and in ſome diſeaſes immenſely increaſed. The nature of this fluid is lymphatic, becauſe it thickens into a gelly by heat, and in diſeaſes, mixed with the mucus which every where exudes from the heart and its pericardium, it concretes into villi and cellular ſubſtance. This liquor is ſecreted, without any glands or viſible pores, from the exhaling arteries of the heart, auricles and pericardium; as may be proved by the tranſudation of water or ſize injected into the large arteries.

lxxxiii. The uſe of the pericardium is to contain this vapour, and the heart, ſo that it may have

a fixed point, to which, when in motion, as to a fulcrum, it may draw its fibres, without ſtretching the large veſſels, and that it may not ſhift, pendulous, on changing the poſition of the body. For theſe reaſons, we find it in all animals that have a true heart. A watery vapour bedews the very hot and very rapidly moved heart. It prevents friction, and its coheſion with the pericardium; for, when this vapour is dried up, the pericardium adheres to the heart, either in ſome particular place, or over its whole ſurface, ſo that it may ſeem to be wanting.

LXXXIV. Nature has given to moſt animals, and even to many inſects and vermes, a heart; ſhe has denied it to others, and indeed to the moſt ſimple animals, being thoſe which are irritable over their whole body, however large, as the holothuria hydra.

LXXXV. The veins which carry back the blood from the whole body to the heart, if we except thoſe of the lungs, are two. Anatomiſts call them the cava, but they either never form one ſingle trunk, or for a very ſhort ſpace. Of theſe large veins, the inferior is the largeſt, and in man aſcends in the right ſide directly above the diaphragm. Towards the right it is ſomewhat gibbous, that it may meet the ſuperior cava, and poſteriorly it forms the ſeptum, which intervenes between the right and left ſinuſes. But the left ſide of the vein unites with the right auricle, whoſe fibres are continuous with thoſe of the cava. The ſame is true of the ſuperior cava.

LXXXVI. A cavity is thus produced, whoſe right ſide is free, convex, and compoſed by the union of the two venæ cavæ, and which is filled with fleſhy fibres, variouſly interwoven between the two ſimple membranes. The ſame cavity, at its anterior and left part, is perpendicularly oblong, and almoſt oval; anteriorly it is dilated; and, laſtly, upwards, it has an acute blind termination, detached from the heart, and

and reſting upon the aorta. This cavity every where between the external membrane of the heart and its own very thin internal membrane, has very copious fibres, fleſhy, detached, almoſt parallel, yet obliquely interſecting each other, which ariſing from the right ſide of the whole cavity, and from the left, are extended round its anterior ſemicylinder, in the manner of parallel arches. Very minute oblique fibres connect theſe muſcular arches. This anterior and ſtringy part is called the auricle, but the right and poſterior portion is called the ſinus, which is ſmooth along the ſeptum of the auricles, and between the anulus ovalis and mouth of the heart to the left of the vena cava. In the auricle are three conſiderable muſcles, the anterior, poſterior, and inferior.

LXXXVII. Towards the left of the ſeptum, which divides the two auricles, almoſt in the middle between the two venæ cavæ, there is a depreſſion, as if imprinted, deeper above, leſs deep below, in which the ſeptum is exceedingly thin. I ſhall call it the foſſa ovalis. A fleſhy column bounds it on each ſide, by the junction of which, is formed an arch, convex upwards, whoſe fleſhy fibres are ſtretched around in the form of arches, while their lower and thinner roots are turned backwards towards each other. This I call the anulus ovalis; others, the iſthmus.

LXXXVIII. Where the aſcending cava opens into the right auricle, from the left tumid column of the foramen ovale ariſes a membrane of a creſcent ſhape, naturally entire, but from its thinneſs ſometimes reticular in adults; which being extended round the lower edge of the auricle, always growing thinner as it returns incurvated to the right, circumſcribes almoſt half the circumference of the auricle, and ſeparates it from the vena cava, in the manner of a ſeptum. It is called the valve of Euſtachius.

ſtachius. The foramen ovale we ſhall deſcribe hereafter.

LXXXIX. Into this ſinus and auricle, which, however, compoſe but one porch of the heart, the blood of the two venæ cavæ is impelled by the muſcular power which reſides in each of theſe veins; for as far as they lie within the breaſt, they are endowed with ſtrong and irritable muſcular fibres, by whoſe contraction the blood is driven into the neighbouring auricle.

XC. In like manner the auricle, when irritated, contracts in every dimenſion. Firſt, by the conſtriction of the muſcular lacerti of the auricle, its anterior ſemicylinder is reduced to a plane, while, by contracting at the anterior extremity or beginning of the heart, and at the poſterior, or ſinus, they draw the middle of the arch backwards. Then the appendix of the auricle deſcends and contracts tranſverſely, while the lower part aſcends; and thus the auricle is ſhortened. Laſtly, the left ſide approaches evidently to the right, and the right ſomewhat to the left, and thus the auricle is rendered narrower. Into the mouth of the heart, now free, the blood is impelled like a wedge through the aperture of the valves, ſo that the flat ſides of the valves in the right ventricle are every where applied to the ſides of the heart. The blood is now hindered from returning again into the lower cava, on the contraction of the auricle, both by the reſiſtance of the ſucceeding blood from the abdomen, and by the Euſtachian valve; and from returning upwards it is prevented, both by the ſubſequent blood and its gravity. It is driven back, however, both ways, if there be any obſtacle in the lungs.

XCI. The heart itſelf, in ſome meaſure, reſembles half a cone. The ſection, paſſing through the axis of the cone, and dividing it, is almoſt triangular, but with an obtuſe nearly bifid point, and flattened

to

to the form of the diaphragm, refts upon, and is fuftained by it. But the convex furface of the cone is fo inclined within the pericardium, under the great blood-veffels, that its thicker femicircular cavity lies in the fuperior and left fide, the obtufe margin of the moderns; while below, and anteriorly, it is extenuated into a kind of edge, or the acute margin. The point is turned a little forwards. This is the fituation in man; for, in brutes, the heart being almoft parallel to the larger axis of the thorax, its apex only touches the diaphragm.

xcii. The whole heart is hollow; and continuous with the right auricle and finus, as they are called, it has its properly anterior, though formerly called its right ventricle, broad, refembling the fourth part of a cone, not fo long as the left ventricle, but larger, and terminating in the fhorter tip of the bifurcated apex. The mouth of this ventricle, where it opens into the auricle, is elliptical, and terminated by a white margin, not fo much tendinous, as callous and glutinous, on which a ftratum of flefhy fibres refts, and externally fome fat.

xciii. From this margin is extended, within the heart, a membranous ring, formed by a reduplication of the internal membrane of the auricle, floating within the auricle and fo far entire. But this fame ring, in that part which hangs within the ventricle, is divided into three unequal trapezic portions, in fuch a manner, that you may, in fome meafure, give them the name of valves; and reckon three of them. They are, however, continued parts of one ring, only broader here. Thefe were, by the ancients, named triglochines.

xciv. The furface of thefe valves which lies next to the fides of the heart is ftrengthened by tendinous fibres, which, meeting together in their courfe, are inferted by fome very ftrong cords, lying in rows on each other, partly into the fides of the heart, and partly into papillary or cylindrical mufcles,

mufcles, arifing towards the right from the left part of the right ventricle, bifid, trifid, or even branchy. The largeft is that which anfwers to the biggeft of the valves, which is both the uppermoft and that which anfwers to the adjacent mouth of the pulmonary artery. The middle valve lies next the feptum of the heart. The leaft of them is the loweft, and moft anterior in the acute margin.

xcv. The ufe of this valve is evident; for, on the contraction of the right auricle (xc.) the blood contained in the right porch of the heart being forced into the open extremity of the auricle, that is, the mouth of the heart, feparates, in the manner of a wedge, the pendulous portions of the ring, called valves, and preffes them to the fides of the heart. Thus the right ventricle of the heart is filled, while the uppermoft valve (xciv.) fhuts the pulmonary artery, left the blood, with the weak impulfe of the auricle, fhould enter that artery; but that being firft received into the heart, by its ftrong contraction it may be more powerfully expelled into the artery.

xcvi. By this blood, copious, warm and heavy, the fenfible flefh of the heart is irritated and excited to contraction: for that the heart, on being irritated, will contract itfelf in a moribund, or recently dead animal, is proved by the injection of water, and inflation of air, renewing the motions of a heart after having become quiefcent.

xcvii. The motion of the heart is performed by mufcular fibres; the origins of which, in general, are from rings formed of firm cellular fubftance, fuch as I have defcribed in xcii. and with which all the large blood-veffels of the heart are furrounded. The fibres from thence defcend gradually in an oblique courfe towards the left fide, and to the apex, in many ftrata, fometimes a little decuffating, of which the middle ones are more tranfverfe, the outermoft and innermoft more direct. In the flat fide

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of the heart (XCI.) the fibres are few; and fo thin, that next to the fat, the cavity is found almoft uncovered. The ventricle, which is denominated the left, is furrounded by very firm fibres; which, in the feptum, flightly decuffating, are interwoven with thofe of the right fide. Many of thefe fibres, in their progrefs towards the apex, defcend into the cavities of the heart, and being interwoven, even repeatedly, in the manner of a net, intercept mefhes hid amongft the mufcular lacerti, and form the flefhy columns mentioned at XCIV. Others, at the apex, convoluted in a fpiral direction, terminate the bifid ventricles with a firm mafs. A very thin and fmooth membrane covers both the external and internal furface of thefe fibres; but the external membrane, efpecially about the coronary veffels, contains much fat. I have not been able to obferve with fufficient precifion, any thing further in the human heart; becaufe it is the peculiar property of the fibres of the heart to be joined by branchy appendices, fo that they cannot be feparated any where without laceration.

XCVIII. But eminent anatomifts, whofe ingenuity and candour I refpect, have publifhed the evolution and defcription of thofe fibres. They allege, that the external fibres of the heart defcend to the apex, common to both ventricles; that in their courfe, fome infert themfelves into the feptum, while others perforate the left ventricle near the point, and being reflected, return along the inner furface of that ventricle, to the bafis, in a contrary direction. But there are other middle fibres, betwixt the aforefaid inner and outermoft ones, which being varioufly inclined, and towards the bafis principally tranfverfe, form the feptum. Other anatomifts have given figures and defcriptions of many layers of fibres, of which the external and internal have contrary directions, and the intermediate are tranfverfe. As thefe do not differ very much from my own obfervations,

vations, I by no means undertake to deny them, although I have never ſeen this diſpoſition ſufficiently manifeſt, and am acquainted with great anatomiſts who have not been more ſucceſsful than myſelf.

xcix. Theſe fibres of the heart, like other muſcles, are furniſhed with nerves of their own, numerous and of various origin. The firſt and uppermoſt, on the left ſide, come from the uppermoſt cervical ganglion of the intercoſtal nerve. With it are joined others from the pharyngeal plexus, formed of the ſoft nerves, proceeding from that ganglion, and from the gloſſo-pharyngeal nerve; others are added from the trunk of the intercoſtal nerve; others from the middle ganglion ſeated on the ſtraight muſcle about the paſſage of the thyroid artery, which has branches both from that uppermoſt nerve, and from the trunk of the intercoſtal and phrenic nerves; and others from the recurrent nerve of the eighth pair. The nerves of the heart, originating from theſe ſources, woven together into a plexus, partly before the aorta, on which thoſe, hereafter mentioned, are alſo added; and partly after forming ſeveral ſmall plexuſes between the trachea and the large arteries iſſuing from the heart, form one or more plexuſes, in which the nerves of the right and left ſide are united, though ſometimes they remain diſtinct. From this plexus, or plexuſes, ſome branches paſs between the aorta and pulmonary artery to the right artery of the heart; others croſs the pulmonary artery, and go between it and the auricle of the ſame ſide to the left coronary artery; others behind the pulmonary artery to the ſame coronary; and others, again, deſcend very deeply behind the right pulmonary artery to the left ſinus and flat ſurface of the heart. To the plexus, above deſcribed, other large nerves are added from the fifth and lower cervicals, and ſometimes from the phrenic nerve, and from the loweſt cervical ganglion of the intercoſtal, with which

which are united very large roots from the loweſt cervical nerves. Theſe, larger, very ſoft, and tranſverſe, are partly mixed with the former plexus, and partly go to the lungs. Laſtly, ſome ſmall branches, uncertain as to courſe and number, come from the recurrent and eighth pair of nerves, variouſly inoſculated with the intercoſtals, and blended with the eighth pair. Thoſe nerves, which ſome eminent anatomiſts have ſeen aſcending through the foramen of the vena cava, from the great abdominal plexus, to the heart, I have never been able to find; although it is eaſy to diſcover the diaphragmatics ariſing in that place, of which, though having ganglions peculiar to themſelves, thoſe anatomiſts make no mention.

c. That theſe nerves conduce powerfully to the motion of the heart, is the opinion of eminent anatomiſts, from a conſideration of the common nature of muſcles; and from the increaſe of motion in the heart, on irritating the eighth pair of nerves, or brain, or ſpinal marrow, and from the languor that enſues upon tying thoſe nerves, for the moſt part either immediately fatal, or certainly within a few days, although it is poſſible to tie only a few of them, for the intercoſtal, and ſtill more thoſe from the uppermoſt thoracic ganglion, cannot be tied.

ci. But that ſomething elſe is comprehended in the cauſe, appears from the motion of the heart remaining undiſturbed in the living animal, after exceſſive irritation of the nerves; from its continuing after the moſt extenſive wounds of the head, and even of the cerebellum and medulla ſpinalis, nay, even in the heart, when torn out of the breaſt, chiefly in thoſe animals in which the lungs, being pervious, make no reſiſtance to the powers of the heart; moreover, from the lively action of the heart in the fœtus before the brain is completed, and in animals wanting the head. And all our experiments agree, that the quieſcent heart, in moribund, and finally

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in dead animals, when irritated by warmth, vapour, cold, poiſon, and eſpecially by a current of air, watery liquors, wax, or blood, or by an electric ſpark, is immediately contracted, and all its fibres excited to quick and violent motion, ſometimes general throughout the whole heart, and ſometimes confined to one part of it.

cii. Thus, then, there reſides in the fibres of the heart an impatience of ſtimulus; ſo that in various places of the viſcus, even when almoſt dead, wrinkles, and motions, appear to be propagated through it, as if from radiating points: again, the heart, when torn out and cold, on being pricked, inflated, or irritated, contracts itſelf; and the fibres of a diſſected heart, corrugate themſelves orbicularly, when it is no longer ſupplied either with nerve or artery. This irritability exiſts in a greater degree, and remains longer in the heart than in any other part of the body; ſo that, 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 more irritable, as well as larger, in proportion, than in adults; and very tenacious of its mobility, even in the cold. This mobility is inherent in the heart, and is neither derived from the brain, nor the ſoul; ſince it remains in the dead animal, and in the heart when torn out of the breaſt; and cannot be accelerated or retarded by volition.

ciii. The heart, therefore, when ſtimulated by the venous blood thrown into it, contracts. This convulſive contraction is made with great celerity, and a manifeſt corrugation of the fibres; and the whole heart becomes ſhorter, thicker, and harder. The left ventricle is drawn ſomewhat towards the ſeptum of the heart, and the right one more ſo. 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

diffecting living animals; fo that thofe learned gentlemen muft have been fome how deceived, who have afferted, that the heart is elongated during its contraction. But the heart does not feem to turn pale in warm blooded animals. Even the feptum of the heart is rendered fhorter, and draws itfelf towards the bafis. By this action, the flefhy parts of the heart fwell inwardly, and comprefs the blood, as they do the finger when introduced within it. But that the heart is completely enough emptied, appears both from the event; from the evident palenefs in animals whofe heart is white, as frogs and chickens; and from the uneven internal furface, which has every where eminences and correfpondent hollows, and thick reticular columns interrupted by furrows. Befides, the apex of the heart, being turned a little forwards, like the radius of a circle, and being, moreover, driven forwards by the left venal finus, which is at that time, particularly filled, ftrikes againft that part of the pericardium next the thorax, about the fifth or fixth rib. In ftrong exfpiration, it is carried with confiderable force upwards and forwards. Both facts are proved by experiment.

CIV. The blood, preffed by the contracted heart, (CIII.) endeavours to efcape in all directions; but fince the contraction begun in the fides of the heart drives the blood towards the axis of the ventricle, that part of the blood which lay betwixt the venous ring (XCIII.) and fides of the heart, carries the ring before it, and extends its loofe extremities inwards. As this happens to the whole circumference of the ring, it becomes extended, throws back a part of that blood which had defcended into the cone of the open valve, into the right auricle; and, laftly, fhuts up the venous orifice more clofely as the heart contracts more ftrongly, and without doubt would force the tricufpid valves, as they are called, invertedly into the auricle, if the papillary mufcles (XCIV.) did not keep down their edges, and

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by their contraction, which is the fame with that of the heart, retain them firmly in that pofition in which the chords connected with the valve are extended, without being injured.

cv. But the fame effort of the blood opens to it another paffage. Whilft the right larger valve (xciv.) approaches towards the axis of the heart, it leaves the mouth of the pulmonary artery, which it clofed, and the blood opens it, preffes the valves placed in the artery clofe to its fides, and rufhes into the artery.

cvi. From the upper part of the pofterior, or, as it is called, the right ventricle, a paffage leads into the artery, received as it were between productions of the flefh of the heart, and ftrongly connected to the heart by a cellular, callous ring, from whence the artery afcends to the left and backwards, and paffes behind the arch of the aorta. The ftrength of this artery is moderate, being much weaker than the aorta. From the inner furface of the artery, where it is joined to the heart, the femilunar valves arife. Each of thefe is formed by a reduplication of the arterial membrane, extended from the part of the artery next the heart, upwards, in an obtufe and fufficiently flat arch. On the whole, they are parabolical with a loofe and moveable margin. The middle of the edge is generally divided, fometimes in the fœtus itfelf, by a fmall callous body, almoft conical, but made up of inclined planes; fo that the margin, which would otherwife have the fhape of a crefcent, is now divided into two crefcents. Betwixt the two membranes of the valve, arifing from the edge and firm root of the valve, appear fome mufcular or tendinous fibres, partly tranfverfe, fome of which even bind the valve to the contiguous fide of the heart, leaving fometimes fpaces betwixt them in a reticular manner. Other fibres afcend from the bafis of the valve; and adhere to the

the callous corpuſcle. Theſe draw back the valve, and open it.

CVII. Each of theſe valves with the ſide of the artery at this part ſomewhat enlarged, intercept a parabolical ſpace, which towards the heart is impervious; but open upwards, as we obſerved of the valves in the veins (XLIX.) When, therefore, the blood is impelled towards the axis by the contraction of the heart, it eſcapes in the direction of that axis; penetrates like a wedge, betwixt the valves, preſſes their looſe membranous edges againſt the ſides of the pulmonary artery, and flows out freely. This appears from the mechaniſm, from injection, from ligatures, and from the increaſed ſize of the cavities of the right ſide of the heart, when the lungs, being obſtructed, prevent them from being emptied.

CVIII. The blood received into the pulmonary artery, circulates through the lungs. That artery is firſt divided into two branches; of which the left is leſs and ſhorter, and enters immediately into the lungs of that ſide: but the right branch, larger and longer, paſſes tranſverſely behind the arch of the aorta to its correſponding lungs. From each of theſe, by ſucceſſive ſubdiviſions, very minute twigs are produced, of which, a part exhale a watery liquor into the cells of the lungs, and a part are continued into the veins. That the blood flows in this direction, is proved by the mechaniſm, by the application of a ligature, which, intercepting the blood between the heart and lungs, dilates the artery; by polypuſes obſtructing the mouth of the pulmonary artery, in which caſe the right cavities of the heart become monſtrouſly enlarged, and at length burſt, while the left remain empty; and by injection; for water, ſize and milk, are very eaſily thrown from the pulmonary artery into the vein, and into the left ſide of the heart. But in frogs, the anaſtomoſes themſelves of the arteries with the veins, are ſeen by means of the microſcope.

CIX.

CIX. Nor can the blood, which has once entered the pulmonary artery, return into the heart; becauſe the valves (CVI.) are of ſuch dimenſions, that, when diſtended, they perfectly ſhut up the opening at the heart; and are ſo ſtrong, that they are able to reſiſt a much greater force than the contraction of the pulmonary artery. However, ſometimes, from the great preſſure of the contracted artery, they grow callous; or one of the membranes is lacerated, and oſſeous 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 ſtrikes againſt the open mouths of the valvular ſpaces, (CVII.) enters them, expands the valves, and forces them towards the central axis; when expanded, they ſhut up the paſſage, ſo that not even a ſlit remains, for that is prevented by the hard corpuſcles (CVI.)

CX. The pulmonary veins, of which we ſhall ſay more hereafter, are gathered into branches, and, at laſt, into four, ſeldom two, and ſtill more rarely into five trunks; to which cuſtom has affixed the ſingular name of pulmonary vein. Theſe trunks enter the cavity of the pericardium, from whence they receive an external covering; and are then inſerted into the corners of the ſquare, left, or poſterior, or as it is ſometimes called the pulmonary ſinus. The upper veins deſcend, the lower ones aſcend. That theſe veins bring their blood in that direction which leads to the ſinus, is proved by ligatures, which, by impeding the blood, cauſe a turgeſcence of the vein betwixt the ligature and lungs.

CXI. This left ſinus, almoſt cubical, firmly conſtructed of various faſciculi of fibres running between two membranes, has, on the anterior and right ſide, the ſeptum, common to it and the right ſinus, (LXXXVI.) but, at its anterior and left edge, it terminates in a conical appendix, notched and creſted with proceſſes, which, making two or three ſerpentine

tine turnings, is called the left auricle, and with its point directed forwards refts upon the left ventricle. As in the right auricle, fome of its fibres being bent into the form of an arch, contract the auricle; others, coming from the origin of the appendix, and inferted into its apex, deprefs it. This finus, with the left auricle, are fomewhat lefs than the right finus and auricle.

cxii. In this finus, the blood waits for the relaxation of the heart; at which time the nifus of the blood acting againft the venous valves, and ftronger than the action of the finus, remits. Then the left finus ftretches itfelf forward acrofs the heart, and at the fame time is contracted tranfverfely, and the appendix becomes evidently fhorter and narrower. Thus the left porch impels the blood into the left ventricle of the heart, in the fame manner as the right auricle impelled its blood into the right ventricle (xcv.) For, as in that, there is a valvular oval membranous ring, which has fimilar productions, called mitral valves, and which are ufually reckoned two in number. Thefe are longer and ftronger than thofe of the right fide. They have, in like manner, flefhy mufcles, one and one only to each, but much ftronger. And, more frequently than in the valves of the right fide, the valves, being fubjected to the powerful action of the heart, abound every where at the beginning of the tendinous chords with cartilaginous tumours.

cxiii. Therefore there comes into the left ventricle the blood, which the venæ cavæ had fent into the right auricle (lxxxix.) this auricle had poured into the correfponding ventricle (xcv.) the ventricle had propelled into the pulmonary artery (cv.) and from it, being received into the pulmonary veins, was conveyed into the left finus (cx.) and driven by it into the left ventricle (cxii.) This conftitutes the lefs circulation, and was known to many of the ancients (lxii.) It is proved, by the increafed

increafed bulk of the left pulmonary veins, and of the veffels of the right cavities of the heart, on the entrance into the left ventricle being obftructed.

cxiv. The left, or pofterior, or upper ventricle, the firft formed, and in many animals the only one, occupies that part of the half conical heart, which we called obtufe (xci.) It is narrower than the right ventricle, a little longer and rounder, and its cavity, on the whole, fmaller. For, the capacity of this ventricle is about two ounces, while that of the right amounts even to three. Its texture internally is in like manner reticular, but more minute; and alfo at the mouth of the artery fmooth. Its force is greater, as the mufcular flefh, with which it is furrounded, is much, almoft three times, ftronger. The feptum of the heart belongs moftly to the left, but fome part of it alfo to the right ventricle: the whole of it is equally reticulated; but folid, and does not fuffer any injected liquid to pafs from one ventricle to the other.

cxv. The left ventricle, from the fame irritable nature, already fpoken of, (ciii.) being ftimulated by the blood thrown into it, contracts, and with great energy forces the blood contained in it towards the axis and bafis, while the cone of the heart is retracted nearer to the bafe. And fince there is the fame apparatus of valves, the blood diftends the venous ring, and removes the right divifion of the valve from the mouth of the aorta which it fhut up, opens to itfelf that mouth, preffes the femilunar valves, there placed, againft the fides of the aorta, and rufhes into that artery with a violent impetus. This is proved by ocular demonftration in living animals, and by the enlargement of the left ventricle on obftructing the paffage into the aorta.

cxvi. The valves of the aorta are not very different from thofe in the pulmonary artery. Only as the aperture is here greater, fo the valves themfelves are larger and ftronger, and are feldomer

without thofe callous globules. The fibres too of the valves, both tranfverfe and afcending, are fomewhat more confpicuous.

cxvii. After the contraction of the heart, follows its relaxation or diaftole, in which it becomes empty, lax, and foft, recovers its former length, the ventricles dilate from the feptum, and the bafis recedes from the apex. But as the blood diftending the auricles, lies immediately at the orifices of the ventricles, it rufhes through the valvular apertures, and feparates the oppofite fides of the heart, which is thus rendered both larger and longer. After the auricles have emptied themfelves of the blood they contained, they become in like manner relaxed, and their oppofite fides feparate from each other. Thefe ventricles are then filled with the blood, collected in the venæ cavæ and pulmonary veins, by the contraction of the veins; and, like the ventricles, are increafed in every dimenfion, and even the proceffes of the crefted margin are diftended and expanded. That there are in the heart dilating fibres, is contradicted by the connection of its fibres, which, being bound together by intermediate branches, cannot be feparately moved, and by the diffections of living animals which fhow that the whole heart is contracted at the fame time.

cxviii. But it muft be obferved, that thefe motions of the right and left auricles, and of the right and left ventricles, are not performed in that fucceffion in which, for the fake of method, we have defcribed them; for both the auricles are contracted, while the ventricles are relaxed, and the contraction of the auricles precedes the contraction of the ventricles; as we are convinced, from manifeft experiments on dying and on cold blooded animals. But both auricles are filled in the firft inftant, and both of them are emptied in the fecond inftant; and both the ventricles are contracted in the third inftant, which however correfponds to the firft;

and both ventricles, being evacuated, are relaxed in the fourth inftant, which correfponds to the fecond. Thofe who have taught otherwife, have not taken fufficient affiftance from experiments on living animals. That the auricle, near death, makes frequent palpitations, before the ventricle of the heart performs one contraction, and that the motion of the right continues after the left has ceafed, is certainly true. The auricle, with its finus, forms one cavity, and both are filled at one time, and both emptied in the fame inftant.

CXIX. But it may be afked, why the heart, with inceffant motion during fo many years as there are in a lifetime, during fo many days as there are in a year, and when, in each hour, in a healthy perfon, it contracts not much lefs than 5000 times, never refts, but contraction perpetually fucceeds repletion, and repletion contraction, in conftant fucceffion; nor is the heart fatigued or pained by fo exceffive an action, that no other mufcle could endure it even for a few hours? To this queftion, different profeffors have given different anfwers, founded upon a compreffure of the nerves betwixt the large arteries; upon an alternate repletion of the coronary arteries and heart, &c.

CXX. But to me the fimplicity of nature feems very confpicuous. When the auricle is relaxed, it is filled by the mufcular force of the contiguous veins, and fo the heart in like manner contracts itfelf, when it is irritated by the blood conveyed through the auricle. Therefore, the heart, when it has received the blood, in confequence of that irritability and ftimulus by which its fibres are excited to action, contracts, empties itfelf of the blood, and, being freed from the ftimulus, refts and becomes relaxed. But being now relaxed, it is again filled by the contraction of the auricle, which the fame ftimulus of the venous blood excites, fince the inceffant action of the heart and arteries continual-

ly ſupply blood to the auricle. That this is the fact, is proved from obſervation; which readily diſcovers the ſucceſſion of repletion and contraction in the vein, auricle, ventricle, and artery, in an exhauſted animal; but more evidently, in thoſe animals which have but one ventricle; as the tortoiſe, frog, ſnake, fiſhes; and in the chick in ovo, which, inſtead of a heart, has only a crooked canal. The ſame is alſo confirmed by the quieſcence of the heart, upon tying the veins; and by its motion, on removing the ligatures, if this obſervation be correct, but more certainly on the injection of air or fluids; and laſtly, by the perpetual contraction of the heart of a frog, upon a veſicle of air blown into it; which, it will force into the auricle, and receive, alternately, for many hours. The left ventricle firſt ceaſes its motion; then the auricle of that ſide; then the right ventricle; after that, the right auricle; and, laſt of all, the pulmonary veins, and venæ cavæ. The motion aſcribed to the venæ cavæ, proceeds from the auricle, repelling into both theſe veins the blood, which the heart, when dead, does not receive.

CXXI. Nor do I believe any thing more required, than a continual ſtimulus applied to a part irritable in the higheſt degree. For, even in the article of death, the very coldneſs of the limbs, which the warmth of life has left, conſtricts the veins, and drives the blood to the heart; at which time the lungs, being impermeable for want of reſpiration, tranſmit no blood to the cavities of the left ſide. On the other hand, the heart, thoroughly emptied, remains at reſt. It is, therefore, poſſible to tranſfer the prerogative of dying laſt from the venæ cavæ and right auricle, to the left auricle, and ventricle; if you contrive that the right cavities be emptied, and that the left be irritated by blood. But thoſe, who attribute the quieſcence of the heart to the compreſſion of its nerves, are refuted by the appearances

appearances in thoſe auricles, whoſe nerves are not compreſſed; as, for example, in fiſhes, and in the chick in ovo, where there is no ſuch compreſſion. If you deduce the quieſcence of heart from the coronary arteries, this is contrary to experience; ſince they are not covered by the valves of the aorta, and ſince, from the coronaries, when divided, the blood ſprings to the greateſt height during the ſyſtole of the heart.

CXXII. Nor, with the powers of the heart, do I conjoin the oſcillation of the minute veſſels, which is refuted by experiments: nor the influence of external heat; ſince 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 the blood is not moved more eaſily through the contractile arteries, than even through the rigid arteries of the ſmaller animals.

CXXIII. But the celerity and force with which the heart propels the blood, are variouſly computed. The more modern writers have calculated upon the following poſitions. In determining the celerity, they ſuppoſe two ounces of blood to iſſue out of the heart with ſuch a celerity, that that part of the pulſe, called its ſyſtole, is finiſhed within the third part of a whole pulſation, or within $\frac{1}{225}$ of a minute; and the area of the mouth of the aorta, they have eſtimated at 0.4187 parts of an inch: ſo, by dividing 3.318 inches, the ſpace filled by two ounces of blood, by the area of the aorta at its mouth, and by multiplying by 225, or number of pulſations, this quotient $7\frac{2309}{3140}$ inches, or length of cylinder of the aorta which is filled by two ounces of blood, they find 149 feet and two-tenths of an inch for the ſpace through which the blood would run in a minute, if it proceeded and paſſed through the

the cylindrical aorta with the ſame velocity with which it was expelled from the heart. But the weight of blood preſſing upon the heart, they have computed by the jet with which the blood ſprings from the aorta in a living animal, being ſeven feet five-tenths; and from the area of the ventricle, 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, propels a weight of 51 pounds, with a velocity by which it may run through 149 feet in a minute; and this four thouſand eight hundred times in an hour.

CXXIV. Although into theſe calculations many things enter, which are neither eſtabliſhed, nor perhaps ever to be cleared up; although the mouth of the diſtended aorta is wider in a living animal; though the menſuration of the area of the ventricle is uncertain, and the jet of blood perhaps too low, if we conſider, that, in the living animal, the blood iſſues with violence from very minute arteries; laſtly, although we cannot determine what part of an entire pulſation the ſyſtole of the heart takes up, variations in which will, however, greatly alter the whole computation; yet, in the mean time, it will plainly appear, that the machine we call the heart is very powerful. This opinion is ſupported by experiment, which ſhews, that by anatomical injection, it is very difficult to fill all the red blood-veſſels, and impoſſible to fill all the ſmaller ones; while the heart not only gradually diſtends with blood all the large, ſmall and minute veſſels, but beſides, propels the blood with great rapidity. Even into the moſt minute arteries, the blood is driven by the heart with ſuch force, as to make its alternate motions perceptible. Likewiſe in the veins, and laſtly, in the ſmaller veſſels, both in cold blooded animals, and in the chick in ovo, there is no other force beſides that of the heart, by which the

the blood is driven through these veſſels. And, from very ſmall arteries, I have ſeen the blood projected ſeveral feet, deſcribing a parabola, whoſe height was four, and its extent ſeven feet; and ſome aſſert, they have ſeen the blood thrown out of the aorta to the height of twelve feet.

cxxv. Moreover, in eſtimating the force of the heart in living animals, we muſt conſider the powerful obſtacles it overcomes: we muſt compute the enormous weight of the whole blood; for the entire maſs, weighing fifty pounds and upwards, when at reſt, is eaſily ſet in motion by the heart alone, as in the inſtances of fainting and reſuſcitation from drowning. We muſt, moreover, conſider the great decreaſe of velocity, ariſing from the greater capacity of the branches, which, even in the inteſtines, it ſeems we might compute at the 24th or 30th power of the root $\frac{3}{2}$. And yet fluids are carried with velocity through the ſmalleſt veſſels, of which we have examples in the Sanctorian perſpiration, which in ſubterraneous caverns I have ſeen riſing with great velocity, in the manner of ſmoke; and in the motion of the blood in fiſhes. Beſides, as friction in every machine conſumes the greateſt part of its powers, it will be readily conceived, that, in the human body, in which a liquid, much more viſcid than water, flows in canals ſo narrow, that they admit but one globule at a time, and not even that, without a change of figure, an exceſſive retardation muſt ariſe from friction, and that the power muſt be immenſe, which moves ſuch a maſs, in ſpite of ſuch obſtacles and diminutions of its force. But even aneuriſms and arteries are burſt by the force of the heart; and great weights along with the human body are elevated by the force of its ſyſtole.

cxxvi. The blood, when driven into the aorta, finds the mouths of the two coronary arteries near to the valves of the artery, but higher up and not

covered

covered by them. Into theſe, firſt of all, it ruſhes, and thus the heart ſupplies itſelf with blood. Theſe arteries are almoſt conſtantly two, and ariſe from the heart at an obtuſe angle with the trunk ; 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 branches are ſurrounded with much fat. Their cavity is not intercepted with valves any more than other arteries. Theſe arteries communicate, by ſmall branches, every where about the ſeptum and tip of the heart ; but they do not make a complete ring round the heart. They terminate in two ways.

cxxvii. Their firſt termination is in the veins, of which the branches accompany the arteries, but the trunks neceſſarily ſeparate. The left artery is therefore accompanied by the great coronary vein, which is inſerted by a large opening, ſecured with a valve, or ſeveral little membranes, into the auricle to the left of the Euſtachian valve. It is diſtributed on the baſe of the left auricle, and accompanies the ſuperficial branches of the left artery.

cxxviii. The ſecond 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 on its flat ſurface ; and may be properly called the median coronary. The third tranſverſely ſeeks the root of the right auricle, and terminates within, or at leaſt very near, the large opening of the coronary vein, (cxxvii.) or in an anterior vein. It ſupplies that part of the right ventricle which lies in the flat ſide of the heart ; and often receives the vena innominata, immediately to be deſcribed.

cxxix. There are ſtill ſome other anterior veins of the heart ; but one, more conſiderable, which runs along that part of the right ventricle next to the margin, and winding in an oblique courſe, ſometimes between the membranes, is inſerted into the

moſt

moſt anterior part of the right auricle, and ſometimes into the trunk of the upper vena cava. This anterior vein ſends off along the root of the right ſinus, another which runs concealed through the very ſubſtance of the heart, and being again inſerted into the great coronary vein, completes the venous circle round the heart, like the arterial circle which ſome have deſcribed, but which to me is unknown.

CXXX. But there are a great many more veins, uncertain in their number and poſition, which, hid amongſt the origins of the large veſſels, belong to the deep ſeated and difficultly acceſſible parts of the baſis of the heart. Theſe open by numerous ſmall mouths into the right ſinus and auricle; and, though more rarely, 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 the other ſide into the greater coronary vein. I have ſeen another concealed betwixt the mouth of the coronary vein and the aorta, inſerted into the right ſinus; and another along the remains of the foramen ovale, 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 alſo ſeen a vein ariſing from the left ſinus, inſerted into the vena cava.

CXXXI. There are other ſmaller veins, whoſe little trunks are ſhort, and cannot eaſily be traced by diſſection. Theſe open by oblique ſhort mouths, through all thoſe innumerable pits of the right and left ventricles, and into the ſeptum of the heart, and into both auricles. Theſe are demonſtrated by injecting water, air, or mercury, eſpecially into the coronary arteries, after having tied all the correſponding veins; or even into the veins themſelves, after having ſecured the inſertion of the largeſt trunks.

trunks. For, drops of coloured water, bubbles of air, ſpherules of mercury, exude through the whole extent of both ventricles; and this, without any violence that can be ſuppoſed to have burſt the veſſels. The paſſage from the arteries into the cavities of the left ſide, is, however, more difficult.

CXXXII. There are ſome who ſuppoſe that the coronary arteries are filled with blood, not by the contraction of the heart, but of the aorta. Their opinion is founded on the retrograde angle of their origin, on their mouths being covered by the valves, and on the paleneſs of the heart when contracted. But the two laſt of theſe are contrary to fact; and the firſt perhaps ſomewhat retards or leſſens, but certainly does not obſtruct the entrance of the blood; for the injections of air or mercury into the ſeminal and biliary veſſels every where, demonſtrate, that in a diſtended veſſel, even more retrograde angles do not prevent fluids from entering the branches. Moreover, in the coronary artery, the pulſe is ſynchronous with the other arteries in the animal body, and the blood, during the contraction of the heart, ſprings to a greater height (CXXI.)

CXXXIII. Concerning the reflux, there is leſs room for doubt: into the ventricles and auricles of the heart, right and left, but more into the latter, all the blood of the coronary veſſels is diſcharged, both by the large orifices, (CXXVII. CXXVIII. CXXIX.) and by the ſmall ones, (CXXX.) and by thoſe minute ones, (CXXXI.) which, when the large veins are tied, readily tranſmit injections. This circulation ſeems to be completed in a very ſhort ſpace of time, on account of the very great velocity the blood receives from the immediate action of the heart itſelf. I do not, however, think that it is effected during one pulſation; for the blood-veſſels of the heart neither loſe their colour, nor are completely evacuated. There is a very free

paſſage

paſſage from the arteries of the heart into the fat. What are the uſes of the minute veins? (CXXXI.) They return the blood of thoſe deeply ſeated arteries, which have no larger correſponding veins.

CXXXIV. The humours of the heart, which are thinner than blood, return by the valvular lymphatic veins, which accompany the coronary veſſels, and aſcend towards the thoracic duct and ſubclavian vein; they are very rarely to be ſeen, but I have obſerved them in brute animals.

CHAP. V.

NATURE OF THE BLOOD AND HUMOURS OF THE HUMAN BODY.

CXXXV. THAT liquid which is contained in the pulſating arteries and their correſponding veins, is called, by one common name, the blood. When ſuperficially viewed, it appears homogeneous, coagulable throughout, and redder in proportion as the animal is ſtronger and fuller fed; in a weak and famiſhed one it inclines to a yellow. Any admixture of white generally proceeds from chyle. But experiments of various kinds have demonſtrated the compound nature of this liquid.

CXXXVI. That fire is contained in the blood is proved from its heat, which, in man and ſimilar animals, is from 92 to 100 degrees, which is higher than the mean degree of atmoſpherical heat, but leſs than the greateſt. Beſides, from blood, when drawn, ſomething volatile or halituous, with a peculiar odour, intermediate between that of the ſweat and urine, eſcapes. When collected in proper veſſels, it appears aqueous, with a ſlight tincture of an alkaline nature.

CXXXVII.

CXXXVII. After the eſcape of this vapour, the blood of a healthy perſon, ſpontaneouſly congeals into a tremulous ſciſſile maſs; but with a degree of heat leſs than that of boiling water, (and indeed at 150°) it coagulates more completely even when perfectly healthy, though more eſpecially when taken from a febrile perſon. It ſometimes coagulates in the veins of a living perſon, and is found clotted in wounds of arteries. Even in a living perſon, and in one dying from the violence of fever, the blood has been coagulated into a tremulous jelly throughout all the veins. The principal part of this coagulum is the cruor, which has the red colour peculiar to itſelf, and imparts it to the other parts of the blood. This, condenſible by reſt, or a moderate degree of cold, and coagulable into a liver-like maſs by a heat of 150°, alcohol, or the mineral acids, is, however, ſoft, unleſs hardened by the attrition of life, or equivalent agitation. It is ponderous, and heavier than water by nearly an eleventh part; and, when freed from its water, it is wholly inflammable. In the maſs of blood, one half or upwards is cruor; and, in ſtrong robuſt people, the ſerum makes only a third part; in fevers, it is diminiſhed to a fourth or fifth part; and in diſeaſes from debility, it is increaſed.

CXXXVIII. From this coagulum there ſeparates, as it were ſweating out of its pores, but afterwards collecting in ſufficient quantity to allow the coagulum to ſink in it, another part of the blood which is white or ſomewhat yellowiſh, and alſo ſeemingly homogeneous, though it is not 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; coagulable by a heat of 150° or the addition of mineral acids or alcohol, or by agitation; it produces a firmer coagulum than the red cruor (CXXXVII.) and concretes into an inſoluble

ſoluble gluten, acquires a membranous appearance, and finally a horny hardneſs, with a friability like that of gum. Of it are formed the pleuritic cruſts, polypuſes, and artificial membranes. In the ſerum, beſides this coagulable albumen, there is contained ſimple water, which conſtitutes the principal part of the whole; and ſome mucous matter, capable of being drawn into finer threads than the red cruor; and not coagulable by fire or by acids as the albumen.

CXXXIX. Putrefaction alone, and the influence of a temperature of 96° diſſolves into a fetid liquor the whole blood, but eſpecially the ſerum; firſt the ſerum, and then the cruor more ſlowly; till, at length, the whole, both cruor and lymph, is changed into a volatile and feted exhalation; leaving very few feces behind. The blood, when ſomewhat diſſolved by putrefaction, both before it becomes fetid, and while fetid, evinces an alkaline nature, and effervefces with acids. Thence, in conſequence of putrefaction, it furniſhes leſs alkaline ſalt. When putrid, it cannot by any art be inſpiſſated; it is alſo very difficult to reſolve it after it has been coagulated by ſpirit of wine. By too ſevere exerciſe, heat of the atmoſphere, and malignant diſorders, the coheſion of the blood is diſſolved, and it aſſumes an alkaline nature almoſt as if from putrefaction.

CXL. Beſides theſe conſtituents of the blood, which are demonſtrated without ſubjecting it to any violence, it alſo contains a quantity of ſea-ſalt, which is diſcernible by the taſte, and ſometimes by the microſcope. Both nutrition and chemical analyſis demonſtrate, that the blood alſo contains earth, which is contained in the moſt fluid parts, and eſpecially united with the oil. By ſome very late experiments, it appears, that a conſiderable quantity of ferrugineous calx, eaſily reducible into a true metal by the addition of any inflammable body,

body, is contained in calcined cruor. Laftly, there is mixed with the blood condenfed air, and that in a very confiderable quantity; the exiftence of which in the blood and ferum is proved by putrefaction, or by removing the preffure of the ambient air. The blood globules are not, on this account, air bubbles, for they are fpecifically heavier than the ferum.

CXLI. 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 weak acids. By ftrong ones 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 like ftrong acids. It does not effervefce with any falt.

CXLII. Chemiftry has opened various ways for inveftigating the nature of the blood. From blood recently drawn and perfectly frefh, by expofure to a gentle degree of heat, there is diftilled a large quantity of water, compofing five-fixths of the whole or more, almoft infipid, though impregnated with fome fetid oil, more ftrongly as the diftillation proceeds.

The refiduum, expofed to a ftronger fire, yields various alkaline liquors; of which the firft, acrid, fetid, and of a reddifh colour, is ufually called the fpirit of blood; it confifts of volatile falt and oil, diffolved in water, and amounts to one-twentieth part of the original mafs of blood. There is, moreover, an acid in fat, and in flefh even when putrid, and in blood.

Both before, and along with the oil, that next afcends in the diftillation, a dry volatile falt arifes, and adheres in branchy fleeces to the neck of the retort; its quantity is fmall, about an eightieth part.

Another fluid, gradually thicker and heavier, at firft yellow, then black, and laftly of a pitchy tenacity,

nacity, acrid and inflammable, is the oil of human blood. Its quantity is ſmall, about the fiftieth part. There now remains, in the bottom of the retort, the ſpongy and inflammable cinder of the blood, which, being kindled, deflagrates, and leaves aſhes behind. From theſe, by lixiviation, is obtained a ſalt, conſiſting of ſea-ſalt, mixed with fixed alkali, and a ſmall quantity of inſipid earth. This fixed ſalt is ſcarcely the five hundredth part of the firſt maſs, and of this almoſt one-fourth is alkaline: when ſubjected to an intenſe degree of fire, it affords a little acid, which we ſuppoſe to ariſe partly from the ſea-ſalt, ſimilar to that demonſtrable in the ſpirit of blood; and partly from the vegetable nature of our aliments, not yet completely animalyzed. Hence it is found in herbivorous animals, as well as in man. But the earth, which is about the hundred and fiftieth part, contains ſome particles which are attracted by the loadſtone.

cxliii. This analyſis ſhews that the blood contains various fluids, ſome more heavy and tenacious than others, ſome aqueous, others inflammable, and that moſt of them impart to the blood a putrid or alkaleſcent tendency. For, the blood, when healthy, and not injured by putrefaction, or too violent a degree of heat, is neither alkaline nor acid; but bland, and ſomewhat ſalt, although, in ſome diſeaſes, it is very acrid and almoſt putrid; as, for inſtance, in ſcurvey, where it corrodes its containing veſſels; and in dropſies, the waters of which are nearly alkaline. In inſects, there is found an alkaleſcent calx which efferveſces with acids.

cxliv. By viewing with the microſcope freſh blood in a ſmall glaſs tube, or while it is yet moving in the veins of a warm blooded living animal, as a chicken, or of a cold one, as a frog, we perceive in it red globules; which doubtleſs, conſtitute the cruor mentioned in cxxxvii. Or are they

they rather lenticular particles of the fame kind with thofe obferved by Leeuwenhoeck in fifhes, and lately difcovered in our own fpecies; it is difficult to determine: nor, often as I have ufed the microfcope, have I ever miffed thofe fhadows in the globules which indicate thicknefs and convexity.

CXLV. The colour of thefe globules is red; and fo much the deeper, and more inclined to fcarlet, the ftronger the animal is: and in the fame proportion, their number increafes, when compared with the yellow ferum. Their diameter is fmall, being between $\frac{1}{2000}$ and $\frac{1}{3000}$ of an inch. They are faid to change their figure into an oblong egg like fhape, which I have never been able to obferve with fufficient certainty. They are alfo faid to break down into other leffer globules of a yellow colour, which I have neither obferved myfelf, nor can eafily admit.

CXLVI. Fibres are obtained in great quantity from the blood, and more fparingly from the ferum, by gradually wafhing it, when poured on a linen cloth, with much water; or by beating with rods, blood poured into water: they will amount to one eighty-fifth part of the whole. Thefe are formed of the gluten, and do not exift in the living animal; fince they neither are perceived by the microfcope, which yet fo eafily renders vifible the red globules, although fo much fmaller; nor is their long thread like figure adapted for receiving motion.

CXLVII. From the preceding experiments compared together, arifes that knowledge, which we at prefent have of the blood; namely, that the cruor is compofed of globules. The inflammable nature of thefe globules is proved by the inflammation of dried cruor, and the preparation of pyrophorus from human blood: and, from thefe, moft probably, proceeds the greater part of the

 pitchy

pitchy oil that is obtained from blood by the action of fire.

CXLVIII. The ferum of the blood, fubjected to the action of fire, yields almoft the fame principles with the red blood, viz. falt, oil, and earth, but more water and no iron. Similar principles, but with a lefs proportion of oil and falt, are obtained from the aqueous humours formed from the blood; as the faliva, and mucus.

CXLIX. The quantity of blood, contained in the whole body, cannot be very certainly computed. The weight of the fluids, however, is much greater than that of the folids; but many of them, as the gluten in various parts, and the fat, do not circulate. But if we may be allowed to form a judgment, from thofe profufe hemorrhages that have been fuftained without deftroying the life of the patient; from experiments made on living animals by extracting all their blood; and from the capacity of the arteries and veins; there will be at leaft fifty pounds of fluids which circulate, of which about twenty-eight will be true blood: the arteries contain about one-fifth, and the veins the other four parts.

CL. Nor are the proportions of the elements, which we have hitherto mentioned, conftant: for, an active life, manhood, and fever, increafe the cruor, rednefs, coagulability, cohefion of the parts, firmnefs of the coagulated ferum, weight and alkaline principles. The ferum, and the mucus it contains, are increafed by the contrary caufes; a lefs mature age, inactive life, and a watery and vegetable diet; by all which, the craffamentum of the blood is leffened, and its watery part increafed. Old age, again, augments the cruor, and diminifhes the gelatinous part.

CLI. On thefe principles, conjoined with a confideration of the folid ftructure, the diverfity of temperaments depends. For plethora arifes from

an

an abundance of the red globules; a phlegmatic temperature, from a redundancy of the watery part of the blood; a choleric difpofition in the fluids feems to proceed from a more acrid and alkalefcent nature of the blood; as in thofe who live on flefh, and in anthropophagi, who appear to be more fierce than thofe who live on vegetable food. In the folids, greater irritability, and hardnefs, with mobility, are attributed to a choleric habit; a lefs irritability, with a more moderate denfity, to a fanguine habit; and lefs denfity, and lefs irritabilty, to a phlegmatic temperament. There is alfo a fluggifh temperament, in which remarkable ftrength of body is joined with little irritability. In the melancholic, exceffive irritability feems united with debility. But we muft be cautious not to clafs too fyftematically the temperaments, which in nature are not four or eight, but infinite in their varieties.

clii. The generation of heat feems to be the principal ufe of the red cruor, as its quantity is in proportion to the temperature of the blood. Being confined, by the largenefs of the globules, within the firft order of veffels, it hinders them from collapfing; and, in receiving the common impulfe from the heart, on account of the greater denfity of its parts, it acquires a greater impetus, and fets in motion the inferior orders of humours. Nor is it improbable, that the heart is more duly excited by the ponderous cruor. The globular figure of its parts, imparts to it fluidity connected with denfity; that quality, and perhaps the power of generating heat, are increafed by the quantity of iron and of oil. Hence, when the red part of the blood is too much diminifhed by bleedings, there follows a ftagnation in the fmaller veffels; fatnefs and dropfy. From the fame reafoning, a due proportion of cruor feems neceffary for the generation of new blood. For, in confequence of hemorrhages, the blood degenerates

generates from its red and denſe nature, into a pale and ſerous ſtate.

CLIII. The coagulable ſerum is more eſpecially deſigned for the nutrition of the parts, as will be hereafter ſhewn, chap. XXX. The thinner fluids ſerve various purpoſes; as, the diſſolution of the aliments, the moiſtening the external ſurface, and ſurfaces of the internal cavities of the human body, to preſerve the flexibility of the ſolids, and conduce to the motion of the nerves, the ſight, &c. The ſaline particles ſeem proper for diſſolving the aliment, and ſtimulating the veſſels. The properties of the aërial part are not yet ſufficiently known. The heat produces its fluidity, and is not eaſily raiſed to ſuch a degree as to coagulate the fluids of the human body.

CLIV. Therefore, health can neither ſubſiſt without the thick blood, and a diminution of its quantity cauſes a ſtagnation in all the ſmaller veſſels, and univerſal paleneſs, coldneſs and debilty: nor can the functions of human life or health ſubſiſt without the fluids of the inferior orders, ſince the cruor, deprived of its watery part, congeals and obſtructs the paſſages of the veſſels, and produces too great a heat.

CLV. Is there any difference betwixt the arterial and venous blood? It ſeems probable, as the former has lately ſuffered the action of the lungs. But, in experiments, I ſcarcely find any difference obſervable, either in colour, denſity, or any other property; although, in other ſituations, I have ſeen it very apparently, for the bright red colour of the arterial blood ſeems to diſtinguiſh it from the duſky dark coloured blood in the veins; but this, in the plain example of the chick in ovo, ariſes only from the ſeries of globules being deeper in the thicker vein. Nor is there any eſtabliſhed difference in the blood of different arteries.

CLVI.

CLVI. From the ſame blood, driven into the aorta, are generated all the fluids of the human body. Theſe are reducible to certain claſſes. The means by which they are ſeparated, ought to be accounted for by the fabric of the glands. But we muſt firſt conſider what the blood ſuffers from its containing veſſels.

CHAP. VI.

OF THE COMMON FUNCTIONS OF ARTERIES.

CLVII. THE blood, driven from the left ventricle of the heart into the aorta, which, at its origin from the heart, bends firſt a little towards the right, and then to the left, and backwards, in a very acute arch, ſtrikes, in a maſs, firſt againſt the right ſide of the aorta, and is then reflected to the left ſide; whence, with a rotatory motion, as much as their fulneſs permits, it proceeds through the arteries, alternately ſtriking and rebounding from their ſides. The ſize of the aorta is a little increaſed, where it ariſes from the heart.

CLVIII. The arteries are, in a living perſon, always full of blood; ſince the blood ſpringing from an artery, is not interrupted by alternate ſtops during the relaxation of the heart, but flows on in a continued ſtream, and 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 contract themſelves completely, or entirely evacuate theſe tubes. Therefore, when into the full arteries there comes a new wave of blood, although it ſcarcely exceeds two ounces, and bears a ſmall proportion to the arterial ſyſtem throughout the body; it, however, overtakes the preceding wave, which being farther from the heart, moves ſlower; it conſequently drives the ſame forwards, lengthens

lengthens the cylindrical artery, augments its diameter, preſſes the membranes cloſer to one another, urges the convex parts of its flexures outwards, and produces more ſerpentine turns, as injections demonſtrate. This dilatation of the artery, and change of its caliber, 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. It is peculiar to life, and reſults from the heart only, and is not natural to arteries left to themſelves. Hence, when the motion of the heart is intercepted, whether its impulſe be obſtructed by aneuriſm, or ligature, there is no pulſation; and hence, the ſudden ceſſation of the pulſe, in a living animal, on the heart being perforated. The artery is proportionally more dilated, the more ſlowly the preceding wave of blood eſcapes, and the more the velocity of the new wave exceeds that of the former.

CLIX. The contraction of the artery ſucceeds its dilatation. For the heart, having emptied itſelf, and removed the ſtimulus of the blood, becomes quieſcent. But the artery, at that inſtant, by the innate elaſticity reſiding in its circular fibres, being irritated by the ſame ſtimulus of blood thrown into it, contracts itſelf, and expels as much of the blood as it had received above its mean capacity: the whole of this quantity paſſes either into the ſmaller veſſels, or into the veins; for the ſemilunar valves of the aorta prevent its reflux into the heart. So ſoon as the artery has freed itſelf from this wave, being no longer ſtimulated, it remits its contractile action, and immediately yields to a new wave, propelled by the heart; and a new diaſtole enſues.

CLX. That the arteries contract, and by that means propel the blood, is proved by their contractile nature; by the evident remiſſion of the dilatation cauſed by the heart; by the ſpontaneous evacuation

cuation of an artery through its lateral branches, included between two ligatures; by the return of the blood to the heart, after its artery is tied, which blood, therefore, is not propelled by the heart; by the jet of blood from arteries being greater during the relaxation of the heart, as obſerved by eminent anatomiſts; by the vigorous projection of blood from the aorta when tied, below the ligature; by the evacuation of the arteries during the perfect quieſcence of the heart; by the veins being fuller than the arteries after death; by the conſiderable jet of blood, to the extent of two feet, from the aorta in an animal after death; by the ſmall caliber of the ill filled arteries in a famiſhed animal; by the cloſing of their orifices in wounds; and by the ſphacelation of limbs, whoſe arteries are oſſified, and the veins being in that caſe diſtended with blood.

CLXI. The mean velocity of the blood may be computed, by diminiſhing its velocity during the ſyſtole, as much as we increaſe what remains of it during the diaſtole, to be nearly ſuch, as to move at the rate of two feet in a ſecond. The conſtant plenitude of the arteries, is the reaſon why we cannot perceive any ſucceſſion in the pulſations of different arteries, and that in the human body they all ſeem to beat at one inſtant, and at the ſame time that the heart ſtrikes againſt the breaſt. However, there certainly is a ſucceſſion, and the contractions of the aorta appear to follow in the ſame order, as its repletion with the blood, expelled by the heart, ſo that the part of the artery next to the heart contracts firſt, and that thus the contractions proceed gradually to the ultimate arteries. This is apparent in the example of the inteſtines, and may be ſeen in inſects, whoſe long and knotty heart manifeſtly contracts ſucceſſively from the beginning to the end. But the mind of the obſerver cannot diſtinguiſh

tinguish the minute portion of time, which amounts only to a few thirds.

CLXII. Where does the pulse cease? In my opinion, in the ultimate and cylindrical arteries. We have noticed with what velocity the blood issues from the heart. But that velocity continually decreases. It is certain, that the aggregate capacity of the small arteries, always bears a larger proportion to the capacity of the aorta, as their division proceeds farther; and thus, notwithstanding the difference in the proportion between the trunks and their branches always decreases, this proportion will be greatest, although it may be variable, between the aggregate capacity of the small arteries in their ultimate division, and the capacity of the aorta at its origin; and there will be a similar retardation of blood to that which occurs in aneurisms. Besides, the proportion of the coats of the arteries to their calibers always increases as they are smaller, until it is greatest where they transmit the globules singly. This is proved from dissection; from inflation, by which every thing being reckoned, they are always more difficultly ruptured as they are smaller; and by calculation, which estimates the size of the globules by the cylindrical membranes of the ultimate arteries. Add to this, the friction of a liquid passing through minute and long tubes, bent and uniting at angles; which kind of friction diminishes remarkably the velocity even of fluid water passing through simple and merely long tubes, and this always in proportion to their smallness; and besides, the smaller an artery is, the greater number of globules come in contact with its sides, and rub against them. In consequence of the conical form of the arteries, the broader wave of blood coming from the trunk cannot pass without resistance through the smaller aperture of the branch, and without endeavouring to distend the branch: but also, the inflections and folds retard the

the blood; ſince ſome part of the impelling force is always ſpent in impinging on the convex part of the fold, and in the change of the figure of the inflected veſſel. Large angles likewiſe diminiſh the velocity, in proportion as they are more obtuſe, and recede from a ſtraight line. Moreover, the viſcidity of the blood itſelf muſt be taken into conſideration; ſince, by reſt alone, it immediately concretes into clots; and ſince it is from the circulatory motion only that this mutual attraction of coheſion in its parts is overcome, ſo as to prevent it from adhering to the ſides of the arteries, as it adheres in aneuriſms and wounds; and the globules from concreting together, as they uſually do after death. The oppoſition it meets with in the branches, leſſens the velocity of the blood likewiſe in the trunk: the oppoſite currents of blood in anaſtomoſes alſo deſtroy ſome part of its motion. Hence the immenſe retardation of the blood in the minute veſſels. We may eaſily perceive that it is very conſiderable, although it is difficult to eſtimate it. In the living animal, the blood flows in the trunk with the rapidity of a torrent: in the minute arteries, it for the moſt part begins to move ſlowly, and then to be coagulated. It is alſo well known to ſurgeons, that a ſmall branch of an artery near the heart or aorta, bleeds more dangerouſly than a much larger one that lies at a greater diſtance. The weight of the incumbent atmoſphere, of the muſcles and fleſhy parts lying above the arteries, and the contractile power of the veſſels, make a reſiſtance indeed to the heart, but do not leſſen the velocity of the blood, for they add as much during the diaſtole of the heart, as they take away from its powers during the ſyſtole.

clxiii. It is certain, however, from inciſions made in living animals, that the globules of blood, which move ſingly, do not loſe ſo much of their velocity as, by calculation, they ought to do. There

muſt,

muſt, therefore, exiſt ſome cauſes, which diminiſh the powers impeding their motion. And, indeed, it is certain, that, in the minute veſſels, the calibers of the branches do not bear ſo great a proportion to the trunk; their great ſmoothneſs alſo diminiſhes the friction. The facility, likewiſe, with which the blood returns through the veins, expedites its paſſage through the ultimate arteries which immediately communicate with theſe veins. No great effect can be expected from the weight of the blood, from the action of the nerves, or from their plexuſes, of which the firſt may both retard and accelerate occaſionally, and in living animals, the two laſt have no effect whatever. The power of derivation, whatever that is, and muſcular action, are capable of producing an increaſe of velocity.

CLXIV. The pulſe is therefore generated by the anterior wave of blood flowing more ſlowly, while the ſubſequent wave flows faſter; ſo that the former is an obſtacle to the latter (CLVIII.) But ſince the motion imparted to the blood by the heart weakens in its progreſs, and the contractile power of the arteries increaſes, therefore the exceſs of celerity of the poſterior wave, which comes from the heart, above that moved by the contraction of the minute veſſels, will be continually leſſening, till, arriving at a part where there is no exceſs, the pulſe will there ceaſe, from the anterior and poſterior waves both flowing with the ſame velocity, and therefore in one ſtream. This place will not be in the larger branches; for in them, the wave, laſt coming from the heart, moves quicker than what goes before; as is evident from the inflammatory pulſation, eſpecially of the ſmall arteries of the eye. But, in the ultimate arteries, the pulſe vaniſhes. This is evident from the equable motion of the blood in the minute arteries, often ſeen by the microſcope in frogs. Even in veſſels ſomewhat larger, the ſixth part of a line in diameter,

diameter, the pulfe ceafes to be perceptible in the living animal. In the veins vifible by the microfcope, there is no pulfation or acceleration of the blood, whilft the heart contracts, demonftrable either by the microfcope or in any other way.

clxv. Even in the veins, the blood preffes againft their fides, as appears from the furrows hollowed out in the bones, and the fwelling of the veins on being tied. Why do not the veins beat? for we do not allow that to be a pulfe which is caufed by refpiration, or by the regurgitation of blood from the right auricle, or mufcular part of the vena cava. The reafon feems to be, that the blood, when it immediately leaves the heart, is more retarded, and in the ultimate arteries, lefs. Hence the fhort fpace of time by which the velocity of the laft wave exceeds the foregoing, is greateft at the heart, and grows gradually lefs, till at laft it totally vanifhes. The following experiment is appofite. Water forced in jets through a leathern tube, by means of a fyringe, flows out of a bit of fponge fixed at the end of the tube in one uniform and continued ftream; and alfo the analogous experiment, where the fame happens when water is thrown, in alternate jets, into the mefenteric arteries; for even then the water flows out of the veins in one continued ftream.

clxvi. The pulfe is the meafure of the powers exerted by the heart, becaufe it is the immediate and full effect of thofe powers. Hence, all things confidered as alike, the pulfe is flow in the ftate of perfect health, where there is no ftimulus, no refiftance acting as a ftimulus, and the heart propels the blood freely and eafily, except where there is fome obftacle, by which the blood is prevented from entering the aorta. From that caufe, the pulfe in afthmatic people is flow: and alfo from the debility or infenfibility of the heart, the ufual ftimulus is incapable of exciting it to contraction,

traction. A full pulſe is cauſed by the fullneſs of the artery, joined with a ſtrong force of the heart; a ſmall pulſe by the emptineſs of the artery, and a ſmaller wave of blood ſent from the heart. A hard pulſe denotes ſome obſtacle or ſtimulus, or increaſed action of the heart, with a greater thickneſs of blood, or a greater rigidity or obſtruction of the artery. A quick pulſe denotes ſome ſtimulus, obſtacle, or greater ſenſibility and irritability of the heart. The pulſe is beſt felt where the artery lies expoſed and ſupported by bone; but obſtructions ſometimes render the pulſe perceptible in the moſt oppoſite ſituations.

clxvii. The pulſe is ſlower in animals as they are larger; becauſe the heart is proportionably leſs than in ſmaller animals, and, as well as the other parts of the body, is leſs irritable, and propels the blood to a greater diſtance; and becauſe there ſeems to be a greater increaſe of friction, than of power in the heart. Hence ſmall animals are more voracious; and large ones, as the whale and elephant, eat leſs. The pulſes of a healthy adult in the morning, are at leaſt 65 in a minute; in the evening they amount to 80; during the night they again become leſs frequent, and gradually return to the morning number. For muſcular motion, the action of the external and internal ſenſes, the warmth of the atmoſphere, and food and drink, urge the venous blood to the heart, which being thereby oftner ſtimulated, makes more frequent contractions. This is the cauſe of the evening paroxyſms obſervable in all fevers. Sleep retards the blood and every other motion.

clxviii. A frequent pulſe is different from a quick one; and it is poſſible for the pulſe to be at the ſame time quick and unfrequent. But it is difficult to obſerve a quick pulſe. The frequent pulſe is what is commonly called a quick one. It is frequent in children, and becomes leſs frequent in the

progreſs

progrefs of life. In the falient point, the pulfes are 134; in new born infants, 120; and in old people, they decreafe to 60. The febrile pulfe begins from 96. In fevers, or in an adult after mufcular action, 110 or 120 is a moderate frequency: 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, often by 10 ftrokes; and under the torrid zone, it increafes to 120. The paffions of the mind difturb the pulfe in various ways. Whatever obftructs the circulation, accelerates the pulfe; not from the laws of hydroftatics, or on account of the canal being made narrower, or from the action of the foul; but fimply becaufe the heart being with more difficulty freed from the ftimulating blood, contracts itfelf more ftrongly, and at fhorter intervals. Irritation from acrid blood is frequently the caufe of the febrile pulfe.

CLXIX. Through the minute veins the blood moves flowly, partly by the force of the heart, and partly by the contractility of the arteries. The firft is proved by a renewal of the motion of the blood, in perfons drowned, which is effected folely by the excitation of the heart. But the contractile force of the arteries is proved by what we faid in CLX. After death, the blood is moved by its own gravity, and by the elaftic air, generated during its putrefaction.

CLXX. The blood moves fafter in the larger veins. For wherever the impelling powers fuffice, and the conveying tubes are rendered narrower, the motion muft be accelerated; for venous trunks are fmaller than the branches of which they are formed, in the fame manner as arteries are lefs than the branches into which they divide. Therefore, if the motion of the venous blood loft nothing in its way, the proportion of its celerity in the vena cava, to its celerity in the veins of the thirtieth divifion,

would

would be exactly the thirtieth power of the proportion of the ſum of the calibers of all the ultimate veins, to the caliber of the vena cava. At the ſame time the friction is diminiſhed, and the contact of the blood with their ſides.

CLXXI. But ſince the blood moves very ſlowly in the ultimate arteries and incipient veins, and as the weight of the blood itſelf, in many places, impedes its return remarkably, and as, from the very thin coats of the veins, but little contractile power can be expected, nature has uſed various precautions, leſt, from the ſlowneſs of its motion, the venous blood ſhould ſtagnate or concrete. Therefore ſhe has reſtored to the veins, the halitus and fluid lymph, in larger quantity, as it ſeems, than what the arteries loſt, on account of the great exhalation from the lungs.

CLXXII. She has likewiſe placed the veins near the muſcles, which, by their ſwelling, compreſs the interpoſed veins; and ſince every preſſure of the veins, on account of their valves, determines the blood towards the heart (LXIII.) therefore all this force is entirely employed in accelerating the return of the blood to the heart. Hence that wonderful quickneſs of the pulſe (CLXVII.) heat, redneſs, and quick reſpiration after muſcular action.

CLXXIII. Moreover, thoſe muſcles, which ſtrongly compreſs on every ſide all the parts contained in any of the common cavities, powerfully promote the motion of the venous blood. In the abdomen, this is effected by the conjunct preſſure of the diaphragm and abdominal muſcles. Laſtly, the pulſations of the arteries, every where contiguous and parallel with the veins, promote the return of the venous blood; ſince, as we have before ſhewn, every impulſe acting on the veins can determine their blood to the heart only.

CLXXIV. To theſe is added the power, not yet ſufficiently known, of derivation, by which the blood

blood is brought from a place where it is more compreffed, to one more lax, and where it meets with lefs refiftance. Laftly, refpiration is of great efficacy; in which the blood is alternately brought by the power of derivation from all parts of the body into the fpongy lungs; and again, in exfpiration, is driven into the trunks of the veins in the head and abdomen. Hence the fwelling of the veins, even of the brain, in the time of exfpiration. The circulation is not indeed affifted by thefe caufes, but the blood is agitated and preffed forwards. The anaftomofes have the fame effects as in the arteries; for they facilitate the paffage of the blood from places where it is obftructed, to thofe which are pervious.

CLXXV. By thefe means, the blood in a healthy perfon, ufing fufficient exercife of body, moves with a velocity, which is fufficient to reftore, in each pulfation, to the heart, by the vena cava, as much blood as the aorta carried away. But corporeal inaction and debility of the contracting fibres of the heart and mufcles, frequently render the motion of the venous blood more difficult. Hence the varices in pregnant women; and hemorrhoids, to which the abfence of valves in the vena porta contributes much. Hence the menfes themfelves. And when the veins return their blood too flowly to the heart, the fubtle vapours being unable to return from the minute veffels to the heart, ftagnate and occafion that frequency of œdema in weak people.

CLXXVI. The time in which an ounce of blood, fent out from the left ventricle, 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 inquire concerning the ounce of blood, when propelled in the quantity we have mentioned, with 4500 pulfations, about feven and a half

half ounces will perform in an hour nearly twenty-three complete circulations and a half.

clxxvii. The effects of the action of the heart and arteries upon the blood, which follow from what has been mentioned, are various, and are estimated by comparing the blood of living with dead, of healthy with diseased, and of inactive with active animals. For the blood of a living animal is warm, is of a scarlet colour, seems homogeneous, although composed of mixed principles, is entirely globular, flows very readily through the most minute vessels, and exhales the volatile halitus, which we have already described particularly. In the dead animal, before it is tainted by putrefaction, it loses much of its red colour; it separates into heavier and lighter principles; exhales no vapour, and when drawn out from the veins, congeals either entirely or nearly so. But even in living animals, when weak, in which there is some pulse or respiration, though very small, the blood cools to a considerable degree. If, again, you compare the blood of a person inactive both in body and mind, with that of one addicted to violent exercise, you will observe in the latter, a greater heat, intense redness, greater compactness, specific gravity, and very great abundance of the volatile principles. All which appearances seem manifestly the effects of the action of the heart and arteries, since, with its increase, they increase, with its diminution, diminish, and with its cessation disappear.

clxxviii. 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 in expelling it, and of the arteries in alternately compressing it. And, indeed, the heart propels the blood with very great velocity (cxxiii.) The heart throws the blood into the crooked arteries, in a confused manner, so that the right globules, expelled into the mouth of the aorta,

aorta, ſtrike againſt the left ſide of the artery; from whence being repelled, they incline towards the right ſide, and thus all the particles of the blood are agitated with a confuſed and whirling motion. It neceſſarily follows, that the blood, impelled into curved canals, muſt impinge on their ſides, dilate them and increaſe their convexity; and laſtly, in the ſmaller veſſels, capable of receiving but few or only one of the blood globules, in which the greateſt number or all the globules come into contact with the ſides of the artery, they ſo exactly rub againſt them, that they are even obliged to change their figure in order to paſs.

clxxix. But the arteries, by their elaſtic force, repel the blood from their ſides towards the axis of their cavities, and react upon it preſſing againſt them, and laſtly tranſmit the globules, ſingly, into arteries through the circular mouths of the ultimate ſeries.

clxxx. In the arteries there is, therefore, a very great degree of friction; of the blood globules againſt the arteries; of the arteries contracting round the blood like an obſtacle; and of the particles of the blood amongſt each other by the confuſed and vorticle manner in which they are propelled. The effects of this friction are computed from the viſcid and inflammable nature of the blood, from the narrowneſs of the veſſels through which it runs, from the ſtrong impulſe of the heart, from the powerful reaction of the arteries, and from the weight of the incumbent parts raiſed by the force of the arterial blood. This friction generates fluidity, by perpetually removing the points of contact between its globules, reſiſting their force of attraction, mixing together the particles of different kinds, which become more fluid upon mixture, as in the inſtance of oil triturated with water. Then their rotation and mutual attrition diſpoſe the particles to aſſume a ſpherical figure; for by breaking off their protuberances,

tuberances, it renders thofe that are ill formed or branchy more fpherical. But even the fragments broken from the projecting furfaces of the ill formed globules, acquire a round fhape from the fame rotation, attrition, and circular caliber of the minute veffels. Hence blood coagulates in the veffels before death; and regains its loft fluidity by reftoring the motion of the heart, as we are taught by experiments made on living animals. Does the motion of the blood, and the denfity proceeding from it, produce the red colour, fince it is nearly in proportion to the denfity, and increafes or decreafes from the fame caufes? It feems to depend on the calx of iron triturated with the oil.

CLXXXI. Does the motion of the blood alfo generate its heat, as in experiments with all kinds of fluids, and even air, but more efpecially in a combuftible animal fluid, denfer than water, compreffed by contractile tubes, and rubbed in confequence of rapid inflection and extenfion of the canals themfelves? Is this proved by the blood being warm in fifhes which have a large heart, and cold in thofe which have a fmall one, as if the heat generated were in the proportion of the fize of the heart to the body; by the great heat of birds, whofe hearts are large; by the increafe of heat by every motion, even friction; by the certain congelation of all the human fluids, at a degree of cold in which man freezes and retains his blood warm as long as he lives; and by the coldnefs of perfons whofe pulfe is weak and obfcure? Nor does the heat proceed from any incipient putrefaction in the blood, fince the fluids, when perfectly at reft, do not generate that degree of heat nor is the evident phenomenon explicable from the action of fuch an obfcure thing as the vital power; and though fometimes the heat may be greater when the pulfe is flow, and lefs when it is more frequent, the difference may arife from the different

ent nature of the blood, from the different denſities of the veſſels, or from the abundance or ſcantineſs of the perſpiration.

CLXXXII. The ſame cauſe alſo checks putrefaction, by not ſuffering the inteſtine motion to be diminiſhed, by admixing antiſeptic particles, and by diſſipating others which have already begun to be corrupted.

CLXXXIII. But in conſequence of the different natures of the particles themſelves, which conjunctly conſtitute the blood, the impetus of the heart produces different effects on the different particles of the blood. Namely, thoſe particles move more quickly, whoſe greater denſity makes them receive a greater impetus, and whoſe apt figure and leſs extended ſurface meets with leſs reſiſtance in the fluid in which they move. Thoſe alſo move more quickly, which, either from their weight, or from the direction in which they paſs out from the heart, move in the axis of the veſſel. Beſides, thoſe which have the greateſt projectile motion will ſtrike againſt the convexities of the flexures; while thoſe which, from their greater gravity or lentor, have leſs projectile motion, will move ſluggiſhly along the concavity of the veſſel. In this manner is the blood diſpoſed for the ſecretions.

CLXXXIV. In the firſt place, the ſyſtole of the arteries produces compactneſs; ſince, by contracting round the blood as round an obſtacle, they compreſs it where viſcid and compreſſible, they expel the more liquid parts into the lateral mouths, increaſe the points of contact betwixt the globules, unite the larger, and compact 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 ſubſtance of theſe globules.

CLXXXV. Beſides, theſe very minute mouths, pervious to one globule, ſeem to be the meaſures in

in which the ſanguineous particles, being approximated to a ſpherical figure by having their points rubbed off, now aſſume it and become perfect ſpheres. This is another ſource of denſity, ſince, of all figures, the ſphere is the moſt capacious.

CLXXXVI. The anaſtomoſes of the arteries remove every danger of obſtruction, for to any part of an artery where there may be an incipient obſtruction or coagulation of the blood, they admit an oppoſite current, by which the obſtacle is repelled in a contrary direction into a larger part of the trunk, and is comminuted between it and the direct current of blood. The irremoveable obſtruction or the loſs of any veſſel, is alſo ſupplied by the ſubſequent enlargement of ſome contiguous branch, as is proved by ſurgical facts, in which the principal artery has been cut or tied. The colliſion of theſe oppoſite torrents of blood takes ſomething from its velocity; and the reticular diſtribution augments the friction of the globules.

CLXXXVII. In like manner as the velocity, ſo the ſlow motion of the blood in the ultimate veſſels has its peculiar effects. In the larger arteries, the moſt heterogeneous particles are whirled about amongſt each other; in the ſmaller branches, the progreſſive motion of the blood being diminiſhed, the lighter particles ſeparate from the very ponderous and red globules, and are forced towards the circumference and branches, while the compact globules remain in the axis. The attractive powers of the particles of the blood are alſo increaſed; hence, the oily particles which are both ſluggiſh and large, attract each other, and ſeparate by open lateral mouths; and other thinner fluids are ſent off through lateral branches of a ſmaller orifice, till at length little more than the red blood alone paſſes into the incipient vein. Heterogeneous particles are alſo mixed in a ſingle vein, that the blood may be prepared for certain uſes, as in the vena porta-

rum.

rum. But all theſe particulars which prepare the blood for the ſecretions, we ſhall conſider in the following chapter.

C H A P. VII.

SECRETION.

CLXXXVIII. THE fluids which, being depoſited from the blood into other veſſels, are ſaid to be ſecreted, ſeem reducible to four claſſes. The *firſt* conſiſts of viſcid fluids, coagulable by a heat of about 150 degrees, by alcohol, and by ſtrong acids; although generally, in the living animal, they eſcape in the form of vapour, and after death are compacted into a gelatinous ſubſtance. To this claſs belong the liquor and halitus of the ventricles of the brain, of the pericardium, pleura, peritoneum, tunica vaginalis, amnois, joints, renal capſules, and probably of the womb, with the juices of the ſtomach and inteſtines, and laſtly the lymph generally known.

CLXXXIX. The *ſecond* claſs conſiſts of fluids, of which ſome, in like manner, are exhaled, but more ſimple than the former (CLXXXVIII.) and more aqueous, are not coagulable by fire or by ſpirits of wine; and others are not exhaled, but, being depoſited in their reſpective excretory ducts, are excreted in their proper places by the common outlet of ſome gland. To the former of this claſs belong the perſpirable matter of Sanctorius, part of the tears, and the watery humour of the eye. To the latter of this claſs belong the remaining part of the tears, the ſaliva, pancreatic juice, and the urine. The ſweat ſeems to be a mixture of the perſpirable matter and the ſubcutaneous oil.

CXC.

cxc. The *third* clafs differs from both the preceding, being heavier than water, fluggifh and vifcid, but of an aqueous nature, not congealable into a jelly, but hardening into dry crufts by exhaling their water. Thofe do not effervefce with any falt, but are contracted and made thicker by acids. By lixivial falts they are diffolved. By fire they are refolved into wăter, a little volatile falt, and a little oil. Of this kind are the whole mucus in the human body, extended over all the internal paffages for air, aliments, or urine, and the cavities of the genital parts; and femen.

cxci. The *laft* clafs is that of the inflammable juices, which, when recent, are indeed thin and watery, but, by ftagnation and by evaporating their water, become thick, oily, inflammable, and often bitter liniments. To this clafs we refer the bile, earwax, tallow, the oily liniment of the fkin, the marrow in the bones, and all the fat throughout the human body; and caftor, and the yolk of the egg. The milk itfelf, fo far as it contains butter, belongs to this clafs.

cxcii. Other humours are compounded of thefe which we have defcribed as fimple: as the mik, of butter and water; and the liniment of the joints, of lymph and fat.

cxciii. Whoever confiders, that in the blood are found a coagulable ferum (cxxxvii.) an exhaling water (cxlii.) a fort of vifcid mucus (cxxxviii.) and laftly an oil (cxlii.) will begin to perceive the perfect poffibility of the foregoing claffes (clxxxviii. to cxci.) of humours being feparated from the blood, fince their principles exift in the fanguineous mafs. But in what manner it is brought about, that oil is feparated from the blood in one part, water in another, and mucus in a third, remains to be explained, and requires a defcription of the fecretory organs.

cxciv.

cxciv. The coagulable juices are feparated almoft every where, from the arteries themfelves, into excretory canals, continuous with the arteries, without any intermediate organ. The proof of this we have from injections of glue, water, and thin oils, which very readily exude from the red arteries, and are poured out into all the cavities in which that coagulable vapour is naturally found, without meeting with any intermediate knots or retarding cells. Finally, the blood itfelf, being poured out into moft of thefe cavities, without any permanent lefion, in confequence of ftagnation, retardation, or fmall increafe of impetus, fhows plainly that the paffage betwixt the red blood-veffels and thofe excretory ducts is neither long nor difficult, and that the yellow ferum does not differ much from blood.

cxcv. Another liquid, coagulable by acid fpirits and alcohol, is the albuminous humour of the joints, which being compofed of fat, medullary oil, and watery exhalation, conftitutes an exceedingly foft liniment, very fit for lubricating the cartilages, and leffening friction. For fecreting this, there are deftined certain conglomerate glands of a peculiar ftructure, which are fo fituated in the rough pits of the articulations of the bones, that they may be moderately compreffed, but cannot be crufhed.

cxcvi. The ftructure of thefe glands is peculiar. The larger clufters of glandular acini adhere, for the moft part, to the bone by a broad bafis wrapped up in fat. Thence, being extenuated into a crefted edge, they pour out their liquor from an exceedingly thin border, by open ducts, which however I do not find very evident. Other fmaller ones, placed every where in the capfules of the tendons, and between the diverging fibres of the ligamentary capfules of the joints, feem to be almoft of the nature of fimple glands, and are turgid with yellow mucous ferum.

cxcvii.

CXCVII. The uncoagulable juices (CLXXXIX.) of the firſt ſort are ſecreted in the ſame manner with the coagulable ones (CLXXXVIII.) to wit, from exhaling arteries, which ariſe from the red arteries, without any intermediate follicle. In the veſſels, which exhale the cutaneous perſpiration, and in the lachrymal veſſels of the firſt ſort having a watery fluid; injections of water, or thin ſize exude from the arteries, ſo as to remove every doubt of this. Theſe arteries are alſo irritable, ſo that, from the contact of an acrid ſubſtance, they diſcharge more juice in a given time, than in a ſtate of health.

CXCVIII. But in the latter kind, the ſalival, the ſecretion is made by means of conglomerate glands, which the ancients firſt diſtinguiſhed by their cluſter like fabric, and eſteemed glands. Theſe are compoſed of acini or roundiſh lobules, conjoined together into a larger maſs, by looſe cellular ſubſtance, which is often covered externally by ſome denſe cellular membrane, as a common envelope, as in the parotid and maxillary glands. Through the intervals, betwixt the cluſters, run the arteries which are here pretty large, and the veins. But moſt of the conglomerate glands ſeparate their fluids from the blood, and diſcharge it in the following manner: Each acinus ſends out an excretory duct, which joins with others of the ſame kind, into a larger trunk, forming at laſt, in the manner of veins, one canal, which conveys the humour, ſeparated by the gland, to the part for which it is deſigned, as the cavity of the mouth, inteſtines, ſurface of the eyes, &c. There are, indeed, ſome inſtances in which either there are no excretory ducts, or they have not hitherto been diſcovered; as the thyroid gland, capſulæ renales, and thymus, unleſs theſe approach to the nature of conglobate glands.

CXCIX. The acini themſelves are ſurrounded and limited by ſome firm cellular ſubſtance; and are

alſo

alſo ſubdivided into leſſer acinuli, as is evident to the eye, and by the microſcope. How does this ſubdiviſion end? Is every ſimple acinus hollow in its middle, receiving the humour tranſuding from the arteries in a follicle, and ſending it out by an excretory duct? Is this ſtructure rendered probable by eruptions, hydatids, and the kidneys filled with round ſchirri? Are the larger viſcera, appointed for ſecretion, conglomerated glands? Is this opinion made probable from the morbid round concretions formed in the liver, ſpleen, kidneys, teſticles, and cortical ſubſtance of the brain; or from the bunch like appearance which thoſe viſcera have in ſmaller animals? In the cellular ſubſtance that ſurrounds every part of the human body, even the extreme vaſcules, are there hollow ſpaces and cells, into which a ſecreted humour is poured?

CC. Nothing of this kind ſeems to be the caſe. For, indeed, the acini compoſing the viſcera of animals, are not elementary, but compoſite lobes, and large in proportion to the animals. The morbid concretions are almoſt all of them ſeated in the cellular ſubſtance, and in the limbs themſelves, where there is not the leaſt room to ſuſpect any thing of a glandular fabric; and are compoſed of oil, earth, and vaporous particles, extravaſated into ſome of the cellular cavities, where, ſtagnating and compreſſing the adjacent follicles, they form to themſelves proper membranous tunics. Beſides, the watery and fluid nature of the juice ſecreted in theſe glands (CLXXXIX.) is an argument that, during its ſecretion, it met with no retardation, no place in which it ſtagnated. For the fluids which remain at reſt in the warm cavities of the human body, which are full of abſorbing veſſels, are all inſpiſſated, and approach either towards a mucous or an oily nature. Moreover, anatomical injections would meet with more difficulty in paſſing from the arteries into the excretory ducts; which would be impervious to thick injections,

injections, and thin ones would be exhaled into the cellular ſubſtance. Yet we ſee, that the ſuperlative art of great anatomiſts has conveyed thick injections, like wax, directly from the arteries of the ſalivary glands, liver, &c. into continuous excretory ducts; and this without filling up any intermediate cavities, which, according to the foregoing hypotheſis (cxcix.) ſhould happen.

cci. Therefore, the acini appear to be compoſed of arteries and veins, divided and ſubdivided, parted and connected by the intervention of a good deal of cellular ſubſtance, which, becoming gradually more compact, aſſumes a ſpheroidal figure. This is ſupported, by analogy in the lobes of the lungs, in the lobules of the thymus, in the ſtructure of inſects; but more eſpecially in the teſticle, of which the lobules are evidently formed of excretory ducts, connected together into faſciculi by a very ſoft membrane. The glands do not ſeem to pour their fluids into cellular ſubſtance, as by it the paſſage to the excretory ducts would be obſtructed or prevented. The induſtry of anatomiſts has lately diſcovered very ſmall, white, cylindric veſſels, the real elements of the viſcera; and it is to be hoped that this diſcovery will be confirmed by future obſervations.

ccii. Thin fluids, neither coagulable nor exhaling, but aqueous, are likewiſe generated in other parts, without the aſſiſtance of conglomerate acinous glands. Thus, the urine is depoſited from the red arteries into membranous tubes, manifeſtly continuous, in a manner which readily admits the paſſage of air, water, or mercury. The nervous fluid ſeems to be ſecreted in the brain, in a ſimilar, though leſs apparent manner.

cciii. The third claſs of fluids, the mucous, (cxc.) is almoſt every where ſecreted from ſinuſes or hollow glands. The ſtructure of true glands or follicles, in general, conſiſts of an ample cavity, every where circumſcribed by a membrane; but in ſuch a manner,

a manner, that the fleſh itſelf of the part, to which the gland adheres, ſometimes forms the one ſide, and completes the hemiſphere of the follicle. In other places, a continued membrane forms the whole of the round or oval receptacle of the gland. The cavity is in general round; but ſometimes it is oblong, and ſituated obliquely 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, accelerate their ſecretions.

cciv. Into theſe follicles minute arteries, either from the fleſh in which it is ſeated, or from the membrane which conſtitutes its convex ſide, open by extremities extended into the cavity of each crypta, into which they pour their reſpective juice; after being received into the follicle, it is detained from the narrowneſs of the excretory duct, and inſpiſſated, the more watery parts being abſorbed by the veins, which correſpond to the exhaling arteries. The truth of this we are taught from the ſtructure of the ſimple follicles obſervable in the tongue, in which both the importing pores, and the excretory ducts, are even viſible to the eye; and from the tubuli of the ſtomach of birds, in which the ſecreting villi manifeſtly protrude into the cavity; and laſtly, from injections, which force wax colourleſs into the ſimple glands.

ccv. The long mucous ſinuſes, and round glands, are both furniſhed with excretory ducts, which, for the moſt part, are ſufficiently large; although, in the round glands, they bear no great proportion to the cavity of the gland. Theſe orifices often open into the common large cavity, into which the mucus is poured, without any intermediate duct; as in the back of the tongue, and in the ſimple glands of the ſtomach and inteſtines. Theſe have been denominated cryptæ by Ruyſch. The ſinuſes have often a ſimilar ſtructure, and open,

open, without an intervening duct, as in the urethra of the male.

CCVI. In another kind of theſe glands, there are many ſimple follicles contained in one common covering, which open with ample orifices into one common ſinus, without any true excretory duct, as in the tonſils. Theſe are called conglutinated glands.

CCVII. Other ſimple glands have an excretory duct, by which they excrete their mucus; namely, a membranous, cylindric, narrow veſſel, opening with its poſterior orifice into the cavity of the gland, and with its anterior orifice 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 windpipe. In ſome parts, the pore and duct are more eaſily demonſtrable than the follicle, as in the noſtrils, larynx, rectum, &c.

CCVIII. In other places, ſeveral of theſe ducts, ariſing each from its reſpective follicle, run together like the branches of a vein, ſo as to form one conſiderable excretory canal, common to a number of follicles. To this kind belong the compound glands of the inteſtines, and the blind ſinus at the root of the tongue, of the claſs of glands; and of the ſinuſes, ſome compound ſinuſes of the urethra, and the tubulous fibres of the ſtomachs of fiſhes and of birds. Glands of this ſort may be ſaid to be compounded of ſimple ones; but where they lie only contiguous, they may be called aggregate or congregated glands; as are thoſe of the fauces, ſtomach, inteſtines, &c.

CCIX. The inflammable juices (CXCIX.) are ſeparated by organs differing in their fabric. The fat and marrow are depoſited into cellular ſubſtance, without the intervention of glands, from the ſmall mouths of the arteries. The ſubcutaneous fat every where exudes through ſmall ducts and pores, without

without any glandular follicles. But the earwax and cutaneous fuet are fecreted by glands of different kinds. Many of the febaceous glands are vifible, with a naked mouth in the fkin, and without a duct of any length; as we fee in the ears, areolæ of the nipples, in the female nymphæ, and the groove betwixt them and the labia, and in the prepuce of the penis and clitoris. Thefe differ but little from the cryptæ (CCV.) except in the matter which they fecrete.

CCX. There are others of the febaceous glands, which have an excretory duct of fome length; as almoft all the cutaneous ones, which, being feated in the cellular fubftance, are neceffarily provided with a duct to perforate the fkin. This is moft evident in the face, where the length of the duct is indicated by maggot like fubftance preffed out; the bulk of which demonftrates, that a follicle lies under the flender pore.

CCXI. There are ftill other febaceous glands of the kind, mentioned CCVIII. in which the fmall ducts of many cryptæ meet together in one larger excretory duct. Thus, in the face, in feveral places, the large pores are in common to a number of cryptæ. Of this kind, alfo, are thofe febaceous ducts in the eyelids; and the unguinous glands in the fecretory organ of the mufk-goat, beaver, hyæna, civet-cat, and mufk-rat, which pour their febaceous matter into one common receptacle.

CCXII. The milk, which is compofed of water and oil, and perhaps of abforbed fat, and is a fluid of a peculiar nature, is fecreted in a conglomerate gland, fuch as we defcribed at CXCVIII. The bile is a matter of controverfy; but there are many arguments in favour of the vafcular ftructure, and of the bile being depofited in the pori biliarii, from the vena portarum, without intermediate follicles; efpecially the Ruyfchian art of injection, in which the wax paffes directly from the porta into the biliary pores,

pores, without meeting with any intermediate knots retarding it. The milk and bile are both of them however much thinner, and more watery, than the fat, or the ſebaceous matter in follicles.

ccxiii. It remains for us to inquire, how it happens, that from one common maſs of the blood, the ſame variety of peculiar fluids are conſtantly ſeparated, each in its reſpective place, and that milk is never ſecreted in the kidneys, bile in the thymus, or mucus in the ſebaceous glands. This problem will be at laſt perfectly ſolved by one who ſhall be intimately acquainted with the internal ſtructure of the ſecreting organs. In the mean time, I ſhall notice what is hitherto known with ſufficient certainty.

ccxiv. In the firſt place, the blood itſelf, from which any liquid is to be ſecreted, aſſumes in various places, that peculiarity of character, that it contains more particles, of a like nature with thoſe which nature wiſhes to predominate in the fluid to be ſecreted. In the liver, the venous blood arrives with a ſlow motion, loaded with oil, and the ſemi-putrid vapours of the inteſtines. To the teſticles, the blood is brought ſlowly, through long, ſlender and inflected canals, ariſing at very ſmall angles, under the ſkin, in a cold ſituation. In the carotids, it is probable that the ſtronger, ſpirituous, and denſe parts of the blood aſcend; ſo that that is more watery, which deſcends into the abdomen and to the kidneys, and forms the ſaliva of the pancreas, and the gaſtric and inteſtinal juices.

ccxv. Beſides, the blood is prepared for ſecretion, by its retardation in the minute veſſels, in conſequence of which, the red and denſer parts alone occupy the axis of the canal; while the other lighter, more ſluggiſh, and leſs quickly moved particles, recede to the lateral branches, impinge on the ſecretory mouths ariſing from the ſides of the veſſels, and adhere to them by their viſcoſity.

ccxvi.

CCXVI. Thefe orifices, though poffibly of different diameters, are always too fmall to admit the blood in their natural ftate. As from an increafed action of the heart, many of them admit blood, we may conclude, with probability, that they arife continuous with the red arteries, and are not much fmaller than the red globules. Hence the fame fecretory orifices refufe thick injections of wax or fuet, and generally admit thinner liquors injected into the arteries. Therefore, this is the firft and moft fimple mechanifm of fecretion, viz. that the caliber of the excretory duct admits only thofe particles, of which the greateft diameter is lefs than the diameter of the duct. It is only in this way that the yellow arteries convey a pure liquor from the blood, and that the uriniferous ducts exclude the red blood and coagulable ferum. But this is not the fole caufe, fince fimilar fluids are generated by large, as well as by fmall animals.

CCXVII. Merely according to this law, the fecreted juices may be of many different kinds: for the very minute orifices will only admit fluids of extreme tenuity, as in the fmall veffels of the brain; while the larger will admit water and jelly; and the largeft of all, fat. Moreover, if a number of fecretory organs arife, in fucceffion from one fecerning artery, and be provided with large orifices, thofe which arife laft from the artery will admit only the thinneft fluids. If, on the contrary, thofe which arife firft in order from the fecreting artery, be fmall, the laft ones will receive only the groffer liquids. It may be objected, that though the veffels in the 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 very different from the fat, bile, lymph, and urine of an adult.

CCXVIII. It is altogether in this way, that moft fecretions are made by veffels arifing immediately from

from ſanguiferous arteries (xlv.) Theſe ſeparate groſs juices; thick, coagulable, or watery; as the fat, urine, juice of the ſtomach and inteſtines, &c. But other ſecretions of thinner juices are performed by veſſels ariſing from the inferior orders of arteries, not ſanguiferous; to the orifices of which, not only no red blood, but no ſerum, fat, or other groſs fluids, can have admittance. Thus the more thin and pure humours muſt neceſſarily be ſeparated; as, for example, in the eye.

ccxix. Perhaps the angle, which the ſecretory branch forms with its trunk, contributes ſomething to ſecretion. For it is eaſily demonſtrated, that at right and reflected angles, only the viſcid and ſluggiſh juices are expelled, in conſequence of the ſtronger force of the particles keeping the middle of the canal; and that the liquids which preſerve their velocity, are thoſe ſent off at acute angles. For men of credit have obſerved, that, in living animals, the velocity is greater in acute angles, and leſs in right angles. The very ſtructure of the body convinces us, that theſe angles have ſome effect on ſecretion, ſince in different parts we find the angles at which the branches proceed from the trunks different, and the reticulations different. For the ultimate veſſels are, in general, arbuſcular, the trunks ſending out branches on every ſide, but at different angles; thus, at ſmall angles in the large inteſtines, and large angles in the ſmall inteſtines. Thus in the ſpleen, the ſmaller red arteries ariſe ſo thick from their trunks, that they reſemble a ſprinkler; in the inteſtines, they reſemble pencil bruſhes; in the kidneys they are ſerpentine; in the liver radiated; in the teſticle, they are curled up like a lock of hair; and in the uvea they are anular. But it is no improbable conjecture, that the Creator never made this diverſity of fabric in vain. We have not as yet, however, any account of theſe reticulations that is ſufficiently accurate; nor

does

does a ſimilarity in the fluids ſecreted ſeem to be connected with a ſimilarity of ſtructure. The veins too have ſimilar reticulations, for the purpoſe of facilitating the motion of the blood, and not for diverſifying the nature of the ſecretions.

ccxx. The inflexions of the ſmaller veſſels, as well arteries as excretories, greatly retard the motion of the blood; in which the greater part of the force received from the heart is evidently ſpent in the change of figure in the veſſel. The repeated inflexions, therefore, of the ſecretory arteries collect the viſcid parts of the fluids, by giving them time to attract each other. A ſtraight courſe of the veſſels is favourable to celerity of motion, rendering the ſecretion copious and eaſy, but impure, as we ſee in the urine.

ccxxi. That the ultimate arteries, and in like manner the ſecretory orifices, have different degrees of denſity, is not improbable, ſince we actually find it ſo by experiments in the larger branches. But the denſer the capillary arteries are, the more will they admit only the ſtrong, and at the ſame time minute particles, and exclude thoſe that are lighter, moved with leſs velocity, and groſſer. Irritability produces almoſt the ſame effects; for if the ſecretory orifice be irritated, 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 a ſimilar fluid, inſtead of the ſubcutaneous fat: the quantity of ſecreted liquor will alſo be increaſed; as, for example, in the tears.

ccxxii. Laſtly, the velocity is greatly increaſed, if the heart be near, if the artery be ſtraight, if it go off at a ſmall angle, or if the excretory duct ariſe near the extremity of a conſiderable arterial branch. The velocity is diminiſhed, if the ſecreting artery run a long way capillary, looſing the greater part of the motion of its blood, from friction, if it ariſe at a diſtance from the heart, and at a large angle.

Finally, from whatever caufe the diverfity may proceed, an increafe of velocity increafes the quantity of fluid fecreted, carries off the heavy liquids, and renders the fecretions thicker and more impure, though fluid, as it prevents ftagnation, by which they contract vifcidity: but flownefs facilitates attraction and vifcidity, and renders the fecreted juice more pure; as the fimilar particles, when brought together, can better attract and join each other, under a flow motion, fo as to retain the larger canal, while the thinner parts go off by the leffer lateral branches. Hence, from the impetus of the heart alone being too much increafed, all the fecretions become confounded.

CCXXIII. Thefe conditions, nature is able varioufly to unite or feparate, and to impart to each organ, in greater or lefs degrees; and thus, to modify the fecreted humours in various ways. Anatomy furnifhes examples, if you compare the fecreting apparatus of the bile or femen, which are thick juices, with thofe of the urine and tears, which are fluid ones.

CCXXIV. From all that has been advanced, we may perceive, that, fince the blood contains particles of various kinds; fome fluggifh and mucous; fome coagulable, but fluid; fome denfe and red; fome watery and thin; and others fat and vifcid (CLXXXVIII. *et feq.*) among all thefe particles, thofe which are the largeft and moft denfe, fuch as the cruor, will continue in the axis of the veffel, and in the trunk, fo as to pafs on in a continued courfe into the fanguiferous vein (XXXIX.)

CCXXV. Thofe particles which are grofs and fluggifh, fuch as the fat, muft go off by the larger orifices arifing laterally from the fanguineous artery, by fhort ducts; for in long ducts the oil would ftagnate, from its fluggifhnefs. The phenomena of the fecretion of fat (XIX.) agree with this defcription. Such as are coagulable, but fpecifically heavier

ier than thoſe which are merely watery, and which continue fluid in the living animal, paſs from the red arteries, into others which are pellucid, but continuous to the red ones, and ſmaller; whether theſe pellucid ones be continued on as trunks, ſending off other ſmaller branches, ſuch as the arteries of the inferior orders (XLI.) or whether they exhale their contents by a ſhort extremity, like the veſſels of CLXX.

CCXXVI. Thin watery fluids may evidently paſs off by any veſſels continuous with the ſanguiferous, or inferior orders of veſſels (XLIV.) provided they be only ſmall enough to exclude the groſſer juices: whether theſe proceed from the ſides of the larger veſſels; or whether all the proper fluids being ſent off through the larger canals, the ſmaller canal be continued as the trunk, as in the eye. To the production of theſe fluids, the moſt ſimple fabric, even the direct continuation of the ſecretory artery itſelf into the excretory duct, is ſufficient, as ſeems probable in the urine. Therefore, in this caſe, the ſtructure is direct and ſimple, with few inflections, and with little diminution of velocity.

Such juices as, being watery, are light, but viſcid at the ſame time, and conſequently ſluggiſh and tardy, eſcape eaſily by ſhort tubes appended to the ſanguiferous arteries, and leſs than the adipoſe veſſels; and, therefore, it is evident, that theſe will be ſeparated from the blood more abundantly in ſome parts of the body, where the velocity derived from the heart is leſs, the flexures of the artery more frequent, and the length of the capillaries greater.

CCXXVII. Has each part its particular ferments, form of pores, ſpecific weight, and filters filled with their own peculiar humour, and refuſing whatever is not analagous to it, which determine the nature of the fluids to be generated? Let thoſe who adopt theſe ideas, conſider the great varieties

there are in fluids, feparated in the fame part of the body, according to the difference of age, courfe of life, &c. In the fœtus, the bile is fweet; the femen thin, and without animalcules; the milk watery or abfent; the urine watery, mucous, and infipid; the uterine mucus very white; the cutaneous veffels full of a red fluid; the aqueous humour red; and the fat gelatinous. In the fame organs, in an adult perfon, the bile fecreted is acrid; the femen thick; the milk butyraceous; the urine, yellow, thin, and alkalefcent; the menftrual blood, and the aqueous humour, very limpid. But, even in the adult perfon, how different the aqueous urine, the concocted urine, and the heavy febrile urine, replete with falts and oils? The paffions of the mind, which make no change in the body except upon the tenfion of the nerves, yet wonderfully change the fecretions, and expel even the blood and bile through the veffels of the fkin. Add to this, the frequent difturbance and alteration of the fecretions from flight caufes; fo that, different augmentations of velocity fhall caufe different liquors to be fecreted by the fame organ: for blood has been known to pafs into almoft all the paffages of all the fluids; of the fweat, tears, mucus of the noftrils, and of the womb, milk, femen, urine, and fat. A true milk has been feen feparated by glands in the thigh. When the urine is not excreted, on account of fome defect of the kidneys, ureters, or bladder, it has been exhaled into the fkin, ventricles of the brain, or into the whole cellular fabric. The perfpirable matter of Sanctorius, though fo fluid, by cold is fent off by the urinary paffages; and by fear, or by medicines, through the excretory villi of the inteftines. That exhaling vifcid matter of the cellular fubftance is fecreted and abforbed, and by the fame organs, alternately with the fat, fo different from it (XVIII.) Salivation fupplies the place of the exhaling fluid of Sanctorius, the exhal-

ing

ing fluid ſupplies the internal. The bile, when abſorbed, evidently paſſes into the veſſels of the eyes. It appears, that there is not any thing in the particular fabric of any of the viſcera or glands, that can ſo fix or maintain the nature of the ſecreted fluid; that in perfectly entire organs, different fluids may not be ſeparated, by an increaſe or diminution of velocity, or alteration of the ſtricture of the nerves. The ſpecific gravities of the viſcera and ſtrainers do not correſpond, even according to their authors, to the ſpecific gravity of the humours which they ſecrete; nor are they at all known by experiments that can be depended on.

ccxxviii. It now remains for us to diſcover, how the pure ſecretions are formed in a healthy perſon. For all the fluids, when recently ſecreted, without excepting any, not even the oil, are mixed with a great deal of water; nor does it ſeem poſſible, that any of the thicker juices could be formed, without having a mixture of the thinner ones: how then do the ſemen, bile, oil, and mucus, get rid of their ſuperabundant water, and acquire their proper viſcidity and other qualities?

ccxxix. For this end, nature has framed glands and follicles, large and ſmall, for thoſe fluids from which the watery parts are to be ſeparated, in order to render the remaining part more ſtrong and viſcid. A ſlightly mucous water, differing at firſt very little from the perſpirable vapour or from tears, is depoſited in the follicles of the noſtrils, windpipe, and inteſtines. This is not continually diſcharging, becauſe the excretory orifice being leſs than the follicle (cxcvi.) and the excretory duct being ſometimes long and ſlender, at others repeatedly bent, and inflected or tranſmitted through hard cellular texture, or cloſed by ſome force equivalent to a ſphincter, the fluid is ſo retarded that it can ſcarcely eſcape without the aſſiſtance of extrinſic preſſure; unleſs perhaps the follicle being irritated by

by its quantity or acrimony, prefs out the liquor incommoding it, by a kind of periftalic motion. This appears from the morning difcharges of mucus by blowing the nofe, coughing up from the lungs, and by fneezing after the nocturnal ftagnation. In the mean time, the patulent veins, extended into the cavity of the follicle, abforb the more aqueous parts from the thin mucus, fo that it becomes thicker as it is retained longer; but if, by the force of fome ftimulus, it be directly difcharged after it is fecreted, it comes out thin and watery. Examples of this we have in the urethra, in the noftrils, and in the earwax; as alfo in the bile, which, at its firft feparation in the liver, is watery, and has but little yellownefs or bitternefs. It is therefore detained in a bladder, and there digefted by the vital heat; its thinner parts are abforbed by the veins, or exude through the membranes themfelves; whence the remainder becomes more thick, bitter, and oily. The fame mechanifm takes place in the femen; which, being preferved in the feminal veficle, is there thickened, fo as to be very vifcid after long chaftity; while after repeated venery it is expelled very fluid. In fome places nature has made this recepticle double or triple in the fame organ, that the fluid might attain the utmoft degree of vifcidity. In the feminal paffages, the rete teftis and termination of the epididymis, conftitute a large canal, and a large veficle; while the veffels of the tefticle, vas deferens and proftate duct, are narrow. Hence there are nowhere real glands, except for fecreting a vifcid liquor. And if a vifcid liquor be feparated from arteries without a follicle, it always ftagnates in fome confiderable follicle. The femen, bile, liquor of the joints, and fat, afford examples of this.

ccxxx. The fluids may be likewife changed in their receptacles by the affufion of fome new liquor.

quor. Thus the ſemen is thickened by the addition of the liquor of the proſtate; the chyle is attenuated by mixture with the ſaliva of the pancreas and the gaſtric and inteſtinal juices, and by the affuſion of the bile it becomes alkaleſcent; the albumen of the joints is tempered by the two kinds of fat (cxcv.)

ccxxxi. Laſtly, what is abſorbed, may have its uſes in the animal economy, after it is taken into the blood; thus the ſemen gives a ſurpriſing ſtrength to male animals. For the moſt part, likewiſe, in fluids which are detained, an acrimony of an alkaleſcent nature is generated, which alſo hath its uſes, as in the bile and ſemen.

ccxxxii. But the moſt important uſe of the follicles and receptacles is to preſerve their peculiar fluids, for thoſe times in which alone they are ſubſervient to life, and that a large quantity of them may be collected to correſpond with their uſes at certain periods. Thus the bile is reſerved for the time of digeſtion, the ſemen for due venery; and the mucus of the noſtrils is accumulated in the night to moderate the force of the air paſſing through them in the day.

ccxxxiii. Therefore, as nature has framed machines which retard the fluids in large or ſmall follicles, ſo ſhe has made others to expel them at proper times. To ſome glands ſhe has given particular muſcles; as in the teſticles of brutes, the urinary bladder, and the gall bladder, and in the inteſtines, and ſtomach; or ſhe has ſubjoined contiguous muſcles to promote the diſcharge, as the biventer, maſſeter, muſcles of the abdomen and diaphragm; or elſe ſhe has given them a kind of nervous irritability, which, being excited to action by an indeſcribable ſtimulus, opens the ſhut paſſages to the milk, ſemen, tears, &c. or from the contact of any thing acrid, as already mentioned, accelerates the diſcharge of the fluid; as happens

pens to the bile, liquor of the ſtomach and inteſtines, and to the ſebaceous matter.

CHAP. VIII.

RESPIRATION.

CCXXXIV. THE bags of the pleura (LXXVII. LXXVIII.) are filled by the lungs; by which we underſtand two viſcera, one right and another left, in figure correſponding with the bags themſelves which they fill, having a broad baſis below, and being terminated above at the firſt rib by an obtuſe cone. Anteriorly their ſurface is flat, laterally convex, and poſteriorly it is rounded; internally it is concave, eſpecially that of the left lungs, for the purpoſe of containing the heart. The right lung is the largeſt, and is moſt frequently divided into three lobes; which is ſeldom the caſe with the left. They are freely ſuſpended by the great blood-veſſels; unleſs you call that a ligament which is formed at the baſis of the diaphragm by the external membrane of the pleura going off to the lungs. Between the lungs and pleura is found a watery vapour, of a coagulable nature, like that of the pericardium (LXXXII.) which tranſudes from the ſurface of the lungs and of the pleura, continually in the fœtus, and not unfrequently in the adult. In dropſy, this vapour is increaſed, or thickens to a kind of ſebaceous matter; or, laſtly, it concretes into fibres, forming adheſions of the lungs.

CCXXXV. The external membrane of the lungs is ſimple, and thinner than the pleura, although continuous with it. It ſpreads, from the adheſion of the great blood-veſſels of the heart, over the lungs in every direction, and, when entire, may be eaſily inflated, even after being ſeparated from the

the lungs. The ſame membrane paſſes over the intervals between the lobules, like a bridge. It is joined to the lungs by cellular texture.

ccxxxvi. The lungs are made up of lobes ſeparated by intermediate intervals, in which there is looſe cellular ſubſtance. Their firſt diviſion is into two large lobes, and one middle one of a ſmaller ſize ; which, however, cohere together : they are afterwards repeatedly ſubdivided into ſucceſſively ſmaller lobes, always ſurrounded by cellular membrane, till at laſt the lobules are reſolved into very ſmall membranous cells, which, in adults, are filled with air, are of various figures, and communicate on all ſides with each other. The elementary parts of the lungs, therefore, are not oval bags, ſurrounded by muſcular texture, with a ſingle orifice which receive the air from the windpipe, but they admit the air exhaling from the ultimate branches of the trachea, ſo that being effuſed into irregular ſpaces, it paſſes and repaſſes freely from any one portion of the lungs into all the others. This is demonſtrated by inflation, for air blown into any, even the moſt minute lobule, through its branch of the trachea, paſſes into all the reſt. In man and in the ſmaller animals, the cellular fabric of the intervals is neither ſhut up from the veſicles of the lungs, nor are the lobes ſurrounded by any peculiar membrane ; in the largeſt animals, there is no communication between the air veſicles and the cellular ſpaces which ſurround the lobules.

ccxxxvii. The air paſſes into theſe veſicles through the windpipe. The windpipe ariſes from the larynx (hereafter to be deſcribed,) and receives the air through it alone. Its firſt part ſingle and ſimple, partly fleſhy and partly cartilaginous, the œſophagus lying below it and to its left, is ſupported on the broad and flat vertebræ of the neck ; in other words, within the cellular ſubſtance that ſurrounds

furrounds the windpipe, there is fituated a canal, compofed of alternate cartilaginous and mufcular rings. The cartilaginous rings, thin and elaftic, anteriorly fomewhat flat and thick, are joined together by their pofterior extremities, which are thinner; and the circle is completed by ftrong tranfverfe mufcular fibres, adhering to both the loofe extremities of the cartilage. The lower circles are lefs; the uppermoft is often augmented by an appendix, that next to the divifion is perpendicular.

ccxxxviii. The flefhy rings, fituated alternately with the cartilaginous ones, are compofed of red mufcular fibres. Some of thefe are tranfverfe, connecting the detached ends of the annular cartilages; others defcend from each upper to the next lower ring. But other mufcular fibres again, defcend from the cricoid cartilage, and having reached below the divifion of the bronchia, vanifh upon the lungs. The tranfverfe fibres contract the windpipe; the longitudinal ones fhorten it. Within the lungs, between the imperfect rings, there is a fort of mufcular fabric, but lefs uniformly difpofed.

ccxxxix. In the cellular coat which furrounds the mufcular one, but efpecially behind, in the interval between the cartilages (ccxxxvi.) are placed numberlefs fimple glands, which, by very fmall ducts, like pores, opening into the cavity of the windpipe, depofite within that cavity a watery and pellucid mucus, not coagulable into films, and very bland, which is of the greateft ufe in defending the exceedingly fenfible membrane from the impurities of the air, which is loaded with particles, irritating by their mechanical figure or chemical acrimony. Numerous conglobate glands are fituated around the trachea and its bronchia, but thefe are of the lymphatic kind, although their black fluid frequently penetrates into the trachea. Laftly,

ly, the internal tube of the windpipe is lined by a membrane, covered by epidermis, continuous with the ſkin and membranes of the mouth, ſmooth, ſoft, and very irritable. It is connected with the muſcular coat by cellular ſubſtance.

ccxl. The veſſels of this entire part of the windpipe, in the neck, come from the lower thyroids; in the thorax, from other ſmall branches of the ſubclavian trunks, or the mammaries, or the bronchials properly ſo called. Its nerves, ariſing from the recurrent and intercoſtals, are numerous.

ccxli. In the upper part of the thorax, the windpipe is received between the laminæ of the poſterior mediaſtinum; and at the third vertebra, or a little above, is divided into two branches ſimilar to the trunk, formed in like manner of imperfect cartilages, and furniſhed with ſimilar glands; each of theſe enters the lung to which it correſponds, and the right is ſomething ſhorter and larger than the left. Having entered the lungs, the cartilaginous rings gradually degenerate into fragments, become more difform, gnomonic, angular, triangular, and intermixed with a larger portion of membrane, till at length, by the diminution of the cartilages, the ultimate branches of the bronchia become membranous.

ccxlii. Its ultimate branches are inviſible, and exhale air into the cellular ſpaces of the lungs in adults, and from the ſame ſpaces receive the arterial expired vapour.

ccxliii. The veſſels of the bronchia, are the bronchial veins and arteries. The latter are generally 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, goes to the left lung. Sometimes there are more; as when there are three, by the addition of a ſecond from the aorta. At other times,

times, there is only one artery common to both lungs. The thoracic part of the bronchia, ſituated without the lungs, has its proper veſſels from the aorta, or from the ſubclavian, or the mammary, or the intercoſtal. The bronchial veins are very commonly two; the right from the vena azygos, the left from a peculiar branch of the ſubclavian vein, the left ſuperior intercoſtal. Theſe blood-veſſels accompany the branches of the trachea; and deſcend into their membranes, the arteries inoſculate with the pulmonary arteries, and the veins with the veins, forming a vaſcular web in the internal cellular ſubſtance. There are ſome inſtances where the pulmonary vein itſelf has given ſmall branches to the lungs, to the windpipe, and to the ſurface of the lungs.

CCXLIV. But there are other larger veſſels belonging to the lungs, the pulmonary artery (CVI. CVIII.) and the vein (CX.) The great artery, in the fœtus larger than the aorta, and in the adult but little leſs, has two branches; the right larger but ſhorter, the left narrower and longer. In the fœtus, the trunk itſelf is continued into the deſcending aorta, and is known by the name of ductus arterioſus. In the adult, that trunk degenerates into a ſolid ligament. The four pulmonary veins accompany the branches of the artery and of the trachea, through the lungs, ſurrounded by a good deal of cellular ſubſtance; which ſubſtance, being increaſed, at laſt compoſes the lungs themſelves. Within this cellular fabric, the air-veſſels and blood-veſſels are ſubdivided, and in the ultimate cellular ſpaces, the ultimate veins and arteries ſpread, reticularly interwoven; and here the ſmall arteries exhale a plentiful vapour into the aërial cells of the lungs, and the veins abſorb a watery vapour from them. Hence coloured water, the whey of milk, or thin wax, being injected into the pulmonary artery, flow with froth into the windpipe; or, on the contrary, penetrate from the

the bronchia into the pulmonary artery. In like manner, injections paſs from the pulmonary vein into the bronchia; or from thence, into the veins. Laſtly, they readily paſs from the arteries into the pulmonary veins; or return from the veins into the arteries.

ccxlv. The lymphatic veſſels, as in other parts, form a network upon the ſurface of the lungs, from whence branches run to the cavity of the poſterior mediaſtinum, to the glands ſeated on the œſophagus, and to the thoracic duct. The nerves are ſmall, eſpecially the anterior, the poſterior ones being ſomewhat larger: they come from a nerve of the eighth pair; but they receive ſome addition, accompanying the large blood-veſſels, from the recurrent, and likewiſe from the cardiac plexus. Hence the lungs have but little ſenſation; but that of the little nerves, divided upon the ſubſtance of the bronchia, is very acute. Nor are the lungs of an irritable nature.

ccxlvi. The quantity of blood which enters into the lungs is exceedingly great, equal to (or even perhaps greater than) that which is ſent in the ſame time throughout the reſt of the body; which, therefore, indicates this viſcus to be ſubſervient to ſome very important purpoſe. That this uſe depends manifeſtly upon the air, appears from the univerſal conſent of nature, in which we ſcarcely find an animal which does not reſpire; alſo from the ſtructure of the lungs in the fœtus, in which being uſeleſs, on account of the abſence of air, they receive only a very ſmall portion of that blood, which the pulmonary artery conveys from the heart. We come, therefore, to ſpeak of reſpiration, or the inhalation and expulſion of air by the lungs.

ccxlvii. Air, phyſically conſidered, is an element, fluid, inviſible, elaſtic, with an indeſtructible ſpring, and ſoniferous. But the air, which we commonly receive into the lungs, is impure, filled with a great quantity of watery and other vapours, alſo with

with ſalts, and the univerſal acid, with the ſeeds of plants and animals, and other foreign particles; and is ponderous; weighing, however, 850 times leſs than water, a cubic foot of air being between 610 and 694 grains. This air, which ſurrounds the earth on all ſides, being compreſſed by its incumbent columns, perpendicularly and laterally, enters with great force wherever it meets with leſs reſiſtance, as appears from experiments made in vacuo, and from the phenomena of the air-pump; ſo that its preſſure on the human body is not leſs than 30,000 pounds. It is repelled chiefly by the pores of membranes, though theſe are permeable by water: it likewiſe penetrates oil or mucus with difficulty.

CCXLVIII. The ambient air is excluded from all parts of the human body, by denſe ſkin, which, even when dry, is impervious to the air; by the fat lying under it; by the narrowneſs of the abſorbent veſſels, and by the equability of the reſiſtance. We muſt inveſtigate why the air enters the lungs, which in an adult are always filled with air, and therefore reſiſt the preſſure of the whole atmoſphere with an equivalent force. That the lungs always contain air, is evident; becauſe, however you compreſs them, they are ſtill lighter than water; and even after they have been inflated but a few times, they always ſwim; whereas, in the fœtus, before air has been admitted into them, they ſink to the bottom.

CCXLIX. On the equilibrium being deſtroyed, the air invariably deſcends in every direction to that place where it meets with leaſt reſiſtance (CCXLVII.) But air that is denſe and heavy deſcends more eaſily than that which is light, whoſe force ſcarcely exceeds that of the air in the lungs, nor is able by the ſame force to overcome the reſiſtance of the bronchia, and of the force by which the air contained in the lungs is compreſſed. Hence an animal lives with greater eaſe in a denſe than in a light atmoſphere: although that air is always better tolerated, which

which is pure in proportion to its levity; ſuch as that of the higheſt mountains of the Alps. Therefore, that the air may 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 rarefied: but this effect will be produced, if the cavity of the breaſt, which is filled by the lungs, be dilated. The air, which is always in the lungs, expands into this increaſed ſpace, by which, being weakened in its ſpring, it makes leſs reſiſtance to the external air; conſequently a portion of external air deſcends into the lungs, ſufficient to reſtore to the air, now contained in the lungs, the ſame denſity with that of the external air.

ccl. We muſt, therefore, deſcribe the powers which dilate the breaſt. The breaſt or thorax is compoſed of bones, muſcles, and cartilages; being almoſt of the ſhape of an elliptic barrel, ſomewhat compreſſed before, but behind divided by an eminence, whoſe hoops are the ribs, and of remarkable ſtrength. In the lateral parts of this ſtructure, the lungs are ſituated; the central and lower parts contain firſt the pericardium, and then ſome of the abdominal viſcera.

ccli. The baſis of the thorax is formed by a column, a little curved, at the upper part gibbous backwards, ſo that its ſummit is ſituated moſt behind. To this twelve vertebræ are affixed. But they alſo coaleſce, by the union of their bodies into a ſingle column, which projects forwards between the two cavities of the breaſt; divides the right from the left; and is plain in the forepart, and broad towards the ſides. A ſlight ſinuoſity receives the ribs into that place where the arch ſeparates from the body. They are bound together into one column, both by the elaſtic plate interpoſed between the bodies of every two, and coaleſcing with both; and by other ligaments and ſpines lying upon

on one another, and by the junction of the ribs; on which accounts they scarcely admit of motion amongst themselves. The sides of the breast are formed of twelve ribs. These are in general bent in the form of an irregular arch, having a consider-able curvature laterally and backwards, but extend-ing in their forepart towards a right line. The bony parts of the ribs are, however, parallel with each other. The greatest part of the rib is bony; of which the posterior portion is round and thick, and the anterior thin and flat. The anterior remain-ing part of the rib consists of a cartilage; which in general preserves the figure of the rib, broad, flat, adhering to an irregular hollow of the bony part; and which does not change into bone, unless in ex-treme old age.

CCLII. The posterior, bony, and thick part of each rib terminates in a head. These are inserted into pits scooped out of the bodies of the upper-most and two lowermost vertebræ, and in the con-tiguous margins of each of the other two. The vertebræ are tied to the ribs by strong ligaments, of which the principal is distributed upon each adja-cent vertebra, in a radiated manner from each rib; other ligaments tie the transverse process to the tu-bercle of the rib, and others connect the contiguous ribs, and also the transverse processes, with each other. Moreover, between the angle of incurva-tion and the articulation with the vertebræ, each of the ten upper ribs has a tubercle, which, being con-nected with the plain side of the transverse process of the corresponding vertebra, are tied by short and strong ligaments to that process, in such a manner, that, while the juncture is very strong, the rib can ascend and descend for a short way.

CCLIII. Of the anterior cartilages, the seven upper-most reach to the sternum, and strengthened by short ligaments, they enter with a double head into lateral depressions in that bone, which are incrusted with cartilage.

cartilage. Of the five remaining ribs, the uppermoſt is agglutinated by ſtrong cellular ſubſtance to the ſeventh, and each lower one to the one immediately above it, ſo that they form a continuous margin, which is itſelf faſtened to the ſternum. The cartilages are connected with each other both by proper ligaments, and by cartilaginous appendages joined by cellular ſubſtance: 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.

ccliv. The firſt rib is the ſhorteſt and moſt ſolid. As they follow in ſucceſſion to the ſeventh and eighth, every two of them form larger and more moveable circles. The eighth is the longeſt of all; and below it, they always become ſhorter, the lower they are.

cclv. The upper rib deſcends; the ſecond joins the ſternum almoſt at a right angle, while the others aſcend both to the vertebræ and to the ſternum, but more to the latter. The bony part of the ribs is placed in ſuch a direction, that the uppermoſt have their anterior ſurface declined forwards, almoſt tranſverſely. About the third rib it is placed almoſt perpendicularly; and below the middle ones, it projects a little forwards. Beſides, the ſtrength of the ribs is very different. The uppermoſt, being ſhort, tranſverſe, rather united than articulated with the ſternum, and, laſtly, often conſolidated, make the greateſt reſiſtance. The mobility of the lower ribs increaſes ſucceſſively to the loweſt, which, adhering only to muſcles, moves moſt freely of all.

cclvi. The ſternum in general is a thin ſpongy bone, in adults of a ſingle piece, but in the fœtus variouſly multiplicate. Its upper part is broader, octagonal, and ſupported by the clavicles, which are united with it by a triangular head, and very ſtrong articulation, and by the firſt rib on each ſide.

The next part which is longer and narrower, grows broader downwards, and its ſides receive the ribs into proper angular cavities. The lower part, which is leſs and ſhorter, is obtuſely ſhaped like a tongue. This is continued into a detached appendage, partly bony, and partly cartilaginous, which is called the enſiform cartilage; of various ſhapes, being ſometimes obtuſe like a little tongue, ſometimes pointed, ſometimes bifid, and ſometimes perforated.

CCLVII. In order, therefore, to dilate the ſeat of the lungs, and thus to produce that condition which cauſes the external air to deſcend into the lungs, the thorax muſt be elevated. For thus all the ſections of the thorax form right angles, and its capacity is increaſed. This motion is performed by various muſcles, which either operate conſtantly, or only at certain times. The whole of the intercoſtal muſcles, always elevate the ribs. Under this name we comprehend 22 muſcles; of which 11 are external or ſubcutaneous; and as many internal, ſeparated from the pleura only by fat and cellular ſubſtance. The origin of the external intercoſtals is at the poſterior articulation of the ribs (CCLII.) their anterior termination is in the bony part of each rib, at ſome diſtance from the cartilage, ſo that the remaining ſpace between the cartilages, all the way to the ſternum, in place of the muſcles, is filled with an aponeuroſis. Their direction is ſuch, that they deſcend obliquely forwards, from the lower edge of the upper rib to the upper edge of the lower rib. Almoſt all authors agree, that they elevate the ribs; becauſe they deſcend from the upper and more fixed, to the lower and more moveable rib, in ſuch a manner, that their lower point lies more diſtant from the vertebral articulation, or fulcrum of the lever of the ribs.

CCLVIII.

CCLVIII. But the internal intercoſtals ariſe at ſome diſtance from the vertebræ, near the outſide of the tubercles (CCLII.) From thence they proceed as far as the ſternum, into which the firſt of this kind are inſerted above. Except the anterior part of the firſt internal muſcles, their direction is contrary to that of the former; ſo that they deſcend backwards, from the lower margin of the upper rib, to the upper edge of the lower rib. Therefore their action is diſputed, becauſe their lower inſertion is made into a point of the rib, nearer its articulation with the vertebræ, which, therefore, ſeems to be the leaſt moveable: however, they elevate the ribs notwithſtanding this; for the immobility of the upper rib, ariſing from its articulation, weight, and ligaments, far exceeds the mobility produced by its greater diſtance from the fulcrum. This is proved by the diſſection of living animals; in which it appears, that the internal muſcles act during the elevation of the ribs, and reſt when they are depreſſed; by threads fixed to a flexible human ſkeleton, and drawn in the direction of the internal intercoſtal muſcles, which always and invariably raiſe the inferior rib towards the ſuperior; and by the firmneſs of the upper ribs, which ſerve as a fixed point to the lower ones: for the firſt ribs are from eight to twelve times leſs moveable than the other true ribs; while the difference of diſtance from the centre of motion, is ſcarcely the twentieth part of the whole lever. And laſtly, by experiment on the dead ſubject; for, on raiſing its thorax, the internal intercoſtals ſwell.

CCLIX. 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, behind are but little moved, while with their anterior extremities, they deſcend and form larger angles both with the ſternum and vertebræ;

and in the middle of their arches, they aſcend and raiſe their lower edges forwards. At the ſame time, the ſternum is thruſt forward from the vertebræ and from the junctures with the ribs. Thus the ribs are both farther from the vertebræ, and the right ribs recede from the left; and both diameters, from the right to the left, and from the ſternum to the vertebræ, are increaſed by almoſt two lines each; and as this occurs in every imaginable ſection of the thorax, the cavity of the breaſt will be ſufficiently dilated. This happens eſpecially in women, and in men whoſe breathing is ſomewhat laborious. Theſe effects are produced leaſt of all by the firſt ribs, but more by the ſucceeding ones. In ſtrong inſpirations, the ribs deſcend both behind and before, and, along with theſe, the ſternum; and the ſpaces between the cartilages are leſſened. But this dilatation is neither ſufficient for healthy reſpiration, nor is it almoſt obſervable in men; although even then, the intercoſtal muſcles, by retaining and elevating the ribs, very much aſſiſt the inſpiration in a ſecondary way, by affording a fixed point to the diaphragm, ſo that the whole force of that muſcle may be ſpent, not in depreſſing the ribs, but in lowering itſelf. The greater part, therefore, of the ſpace which the thorax gains in inſpiration, ariſes from the action of the diaphragm.

CCLX. By the diaphragm we underſtand a muſcle expanded in a curvilineal plate, which, in general, ſeparates the pulmonary bags from the abdomen in ſuch a manner, that the middle and tendinous part is the higheſt, and ſupports the pericardium; that the lateral portions, which ariſe from the ſolid parts of the thorax and loins, are every where lower; and that its poſterior portions are loweſt of all. The fleſhy fibres of this muſcle ariſe from the internal or poſterior ſurface of the enſiform cartilage to the very point, and from the ſixth, ſeventh, eighth, ninth, tenth, eleventh ribs, and

and apex of the twelfth; after which follows an interval, in which the naked pleura is contiguous to the peritonæum. Thereafter mufcular appendages of the diaphragm, much ftronger, collected into two, three, or four round mufcles on each fide, arife flefhy from the tranfverfe procefs of the firft lumbal vertebra, and from the fide of the body of the fecond; and tendinous from the middle of the body of the fecond, third, and fourth, and from the cartilages placed between them, on the whole higher up in the left fide, and lower down in the right.

CCLXI. All thefe fibres (CCLX.) becoming tendinous, form the centre of the diaphragm, which refembles, in figure, an obtufe gnomon, and fupports the pericardium with its middle and broader angle, while the lateral wings, of which the left is narrower, defcend backwards. This central portion is more moveable than the reft; but in the middle tendinous part, and neighbouring mufcular fubftance, it is refifted by the heart; the lateral wings and contiguous portions are the moft moveable. The fibres of this tendon form a moft beautiful web, principally indeed on the upper part; which ftretches from each mufcular portion, to the mufcular portion oppofite to it: and then they form remarkable inferior fafciculi, tranfverfe, right, left, and pofterior, which laft portion is the uppermoft.

CCLXII. There are two holes in the diaphragm; of which the right, in the right fide of its tendon, is obtufely fquare, and circumfcribed by four ftrong tendinous fafciculi; the left, which is elliptical, lies betwixt the right and left flefhy portions, arifing from the middle of the bodies of the lumbal vertebræ: under this opening they decuffate and crofs each other once and again, but above they end in the tendon. Therefore it is probable that the latter is contracted during the action of the diaphragm, and that the former remains immoveable.

able. For tendons are but little changed during muſcular motion.

CCLXIII. The ſtructure of the parts, and the diſſection of living animals, demonſtrate, that the fleſhy portions of the diaphragm, by aſcending on all ſides from fixed points to middle and moveable parts, depreſs theſe, and by that means draw downward the lateral bags (LXXVII.) of the thorax, which contain the lungs; and thus augment the perpendicular diameter of the breaſt. The muſcular portions are more depreſſed; the tendon leſs, both becauſe it is fixed to the pericardium, and becauſe its own ſubſtance does not contract. The œſophagus and even the vena cava are compreſſed, while the diaphragm acts. The diaphragm almoſt alone performs the office of reſpiration in a healthy man who is at reſt; and alſo in thoſe whoſe ribs are fractured, or the ſternum burſt, or where the perſon will not make uſe of his ribs on account of pain. The force of the diaphragm alſo, in dilating the breaſt, is greater, according to calculation, than all the reſt of the powers which contribute to reſpiration. The extent of an inſpiration is thus far limited, becauſe, during the extreme action of the diaphragm, the lower ribs are drawn inwards, and the breaſt is ſo far ſtraitened. To oppoſe this, the intercoſtal muſcles interfere in a moderate inſpiration; in an exceſſive one they are not equal to the diaphragm. The phrenic nerve, when irritated, more evidently than in moſt other muſcles, forces the diaphragm to perform its office. The lungs themſelves are entirely governed by the air, ribs, and diaphragm; being in immediate contact with theſe, as appears through a large inciſion, or through the pleura, or pellucid part of the diaphragm, when the containing parts remain entire.

CCLXIV. In violent inſpirations, occaſioned by an increaſed quantity of blood driven into the lungs,

lungs, or by any obſtacle occuring in them, ſeveral other powers elevating the thorax, aſſiſt in dilating the breaſt, which are inſerted into the thorax, clavicles, or ſcapulæ; ſuch as the ſcaleni muſcles, maſtoidei, trapezii, cervicales deſcendentes, ſerrati ſuperiores, pectorales, and levatores parvi, for which anatomy muſt be conſulted.

CCLXV. Thus, there are powers which increaſe the capacity of the thorax in all its three dimenſions (CCLXIII. and CCLIX.) By theſe the cavity of the breaſt is dilated, ſo that it compreſſes the lungs leſs than before: into that ſpace the lungs ſtrive to extend themſelves, ſince they are never deſtitute of air, which, as ſoon as the preſſure is taken off, becomes rarefied, and expands itſelf. Independent of the action of the muſcles, the lungs poſſeſs no peculiar inherent power of attracting air: and, even when they are moſt full of air, on cloſing the trachea, the animal, however, attempts to inſpire, by the efforts of its intercoſtal muſcles and diaphragm. It follows, that the air (CCXLVII.) gravitating, and preſſed on all ſides by the incumbent columns of the atmoſphere, muſt enter the thorax; and with greater force the leſs air is in the lungs; and with the greateſt, if they contain no air: but air will not enter the thorax, if the air, being admitted to the lungs through a wound in the breaſt, compreſs their ſurface. In this action, therefore, which is called inſpiration, the bronchia are every way increaſed, both in length and breadth; becauſe all the diameters of the thorax are increaſed, and the inflated lungs remain immediately contiguous to the pleura. At the ſame time, the veſſels, which are joined with the bronchia by a cellular ſheath, become longer and are extended, and the ſmall angles become larger; by which means, the circulation is facilitated. Beſides, when the veſicular ſubſtance of the lungs is filled with air, the ſpace through which the capillary

lary veſſels of the lungs run, is increaſed, the branches of the arteries and veins are ſtretched out at greater angles, the lobes preſs leſs upon each other, the compreſſion of the neighbouring parts is leſſened, and, therefore, the blood ſent from the heart will flow with greater eaſe and celerity through the large and ſmall arteries of the lungs. Hence, by inflating the lungs, and by that means facilitating the paſſage of the blood to the left ventricle, moribund animals are reſuſcitated, and in the ſame way perſons who are taken out of the water apparently drowned. But, on account of its great levity, the preſſure of the air upon the blood does not deſerve notice, as being three hundred times leſs than the force of the heart; and inſufficient to force the air againſt the blood, which may eaſily be done by a ſyphon.

CCLXVI. Is air contained between the lungs and the thorax? Is this air rarefied in inſpiration, and afterwards becoming condenſed, and compreſſing the lungs, does it cauſe exſpiration? Is this opinion confirmed by the analogy of birds, of which it is ſtrictly true? Every thing concurs to confute this opinion: behind the pleura, in living quadrupeds, as well as in dead human bodies, the naked lungs are viſible, without any intermediate ſpace betwixt them: on perforating the pleura, the lungs retract themſelves towards the vertebræ, as ſoon as the air comes in contact with them. In birds, the lungs, being pervious, admit the air through large holes into the cavity of the thorax. But in theſe there is a manifeſt ſpace betwixt the lungs and the pleura, which would be equally manifeſt in quadrupeds, if the lungs were not contiguous with the pleura. Large wounds, admitting the air into one cavity of the thorax only, diminiſh the reſpiration; but ſuch wounds, as let the air into both cavities, ſuppreſs it. When the thorax is opened under water, it emits no bubbles of air through the ſaid water;

water; but in birds, in whofe thorax there is air, it does. The imaginable fpace betwixt the lungs and the thorax is filled by vapour, or a very little water. Adhefions of the lungs injure the refpiration but in a fmall degree; which ought entirely to ceafe, if any intermediate air betwixt the lungs and thorax were neceffary to refpiration. Finally, the external air, being admitted to any of the membranes of the human body, inflames them, if they be not defended by plentiful mucus, and of this the pleurâ is deftitute.

CCLXVII. Refpiration, whether by the admixture of a fubputrid vapour, or in fome other way, certainly vitiates the air, and renders it unfit either for inflating the lungs or fupporting flame; and laftly, it deprives that element of its elafticity. It is probable that this happens from putrefaction, fince, by a crowd of men the air is rendered peftilential, and fevers of the moft malignant kind are generated in a few hours. In whatever way it happens, we are certain, that, in the lungs, the air is vitiated; lofes its elafticity; and cannot keep the lungs diftended, fo as to tranfmit the quantity of blood now increafed by the dilatation of the pulmonary arteries, into the veins. Nor can the will dilate the breaft beyond certain bounds, or affift the paffage of the blood. A ftate therefore will take place, in which the blood cannot pafs through the lungs.

CCLXVIII. Thus a new refiftance 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, efpecially of the head, ftagnates before the right ventricle of the heart, which is clofed up, becaufe it cannot evacuate itfelf into the lungs; and tumefies the face with rednefs, and fometimes burfts the veins of the brain, neck, inteftines, kidneys, or lungs, and even the right auricle of the heart. This is the caufe of exceffive

excessive anxiety of mind; this is the cause of death in compressed air, in persons drowned or strangled, which is much more sudden than is commonly imagined with regard to drowned people. A living person therefore, that he may remove those inconveniencies which arise from the passage of the blood being obstructed, slackens the powers of inspiration, and excites to action those of exspiration, in order to free the breast from the too greatly rarefied air.

CCLXIX. These powers are, first, the elasticity of the ribs, which being drawn upwards out of their natural situation, as soon as the elevating powers cease to act, spontaneously replace themselves at more acute angles with the sternum and vertebræ. There is also the elastic force of the bronchia and vesicles distended with air, by which they endeavour to contract. Hence exspiration is performed more easily and quickly than inspiration; and hence it is the last action of dying people.

CCLXX. These are assisted by the abdominal muscles; the oblique, straight and transverse. The former of these are fastened by one part to the lower ribs; and by another part, they are attached to the os pubis and ilium, which are immoveable, when compared with the breast. Therefore, the straight muscles, being contracted, flatten the arch into which the abdominal viscera were protruded by the depression of the diaphragm, reduce the convexity of the abdomen nearer to a straight line; force the abdominal viscera upwards and backwards against the diaphragm, which alone can give way; and press it up into the thorax, which is thus rendered shorter. The oblique muscles, for the same reasons, compress the lateral parts of the abdomen, carry the liver and stomach backwards, and press them towards that place where there is the least resistance. Lastly, all of them draw down the ribs which were elevated by the intercostals. The

transverse

tranſverſe muſcles, indeed, do not draw down the ribs; but they pull the cartilages of the falſe ribs a little inwards, render the whole abdomen much narrower, and force the ſame viſcera againſt the diaphragm. As acceſſory powers may be reckoned the ſternocoſtal, and the long internal intercoſtal muſcles, which are called depreſſors. By this joint force the elevated ribs deſcend; the middle ones more, the uppermoſt leſs, the loweſt moſt of all; their margins are drawn inwards: the cartilages aſcend, and return into acute angles with the ſternum; and the ſternum itſelf recedes backwards with the ribs. By theſe means the thorax, by the converſe of CCLIX. is rendered narrower in every direction and ſhorter, and expels as much air out of the lungs as is ſufficient to remove the uneaſineſs (CCLXVIII.)

CCLXXI. In violent reſpiration, when the inſpirations are fuller, the more powerful exſpirations derive aſſiſtance from ſome other cauſes, as the ſacrolumbalis, longiſſimus and quadratus muſcles. By this force, leaden bullets, weighing above a dram, may be blown 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, and the lungs are not ſo much emptied as in blowing.

CCLXXII. The effects of exſpiration are the compreſſion of the blood-veſſels of the lungs; the diminution of the angles of the bronchia; the reſting the weight of the adjacent veſſels on the reticular veſſels; the expulſion of the corrupted air from the lungs; the propulſion through the veins of that part of the blood which is impacted in the capillary arteries, to the left ſide of the heart, and the impeding that part of the blood which is coming from the right ventricle. Exſpiration, therefore, ſtops the ready entrance of the blood into the lungs; and as the whole thorax is compreſſed at the ſame time,

time, it repels the venous blood into the veins of the head, and fills the brain and its ſinuſes.

cclxxiii. In this manner the neceſſity for reſpiration ariſes anew, as often as the collapſed veſſels of the lungs reſiſt the blood expelled from the right ventricle of the heart: this is one cauſe of death in thoſe animals which expire in veſſels exhauſted of air. The lungs in thoſe which have remained long in vacuo, from having the air drawn out from them, become denſe, ſolid, and heavier than water; and, therefore, impervious to the blood. Of the ſame kind is the death of thoſe who are killed by lightning, and perhaps by the noxious vapours of caverns. Therefore, in conſequence of a moſt intelligent ſtructure, at the firſt perception of the uneaſineſs ariſing from the oppoſition to the paſſage of the blood through the lungs, the exſpiring powers become relaxed, the inſpiring powers are excited into action, and the motion of the blood through the lungs is rendered free and accelerated.

cclxxiv. Are there other cauſes of alternate reſpiration? Is any thing to be derived from the compreſſion of the vena ſine pari, of the phrenic nerve, or from the blood not being ſent to the brain? But theſe are diſproved by comparative anatomy; which, where there is no ſuch nerve or vein, finds the ſame alteration in reſpiration every where. Does it proceed from the alternate contraction of antagoniſt muſcles, among which, thoſe of exſpiration relax thoſe of inſpiration, and the reverſe? But, according to this argument, all the muſcles of the human body would be perpetually alternating in their motions.

cclxxv. From what has been ſaid, it ſufficiently appears, that reſpiration is abſolutely neceſſary to a healthy adult; becauſe, whether the lungs remain long in a ſtate either of exſpiration or of inſpiration (cclxxiii. cclxviii.) death will be the

conſequence.

consequence. Therefore, no animal, that has lungs like ourselves, after it has breathed for some time, so that the air shall have penetrated into the inmost parts of the lungs, and the pulmonary artery shall have brought a new quantity of blood to that viscus, can subsist longer than a few minutes without the use of air, without perishing, or at least falling into a state which differs from death only in the possibility of recovery. In an animal recently born, this necessity for air does not take place very instantaneously.

CCLXXVI. But the use of respiration is different from this necessity; which nature might have avoided, either by forming no lungs at all, or by constructing them similar to those of the fœtus. The use, therefore, of respiration, must be very considerable, since all animals are furnished either with lungs, or with gills, or with a windpipe distributed through all parts of the body.

CCLXXVII. To investigate this utility, let us compare the blood of the adult with that of the fœtus, and with the vital fluid in fishes. It appears, that in the fœtus the blood is destitute of its florid redness and solid density; that the blood of fish is cold, and has less density, and a tender crassamentum. It is therefore probable, that the blood acquires both these properties in the lungs.

CCLXXVIII. Is animal heat generated principally in the lungs? Does it arise from the alternate extension and contraction, relaxation and compression, of the vessels (CCLXV. and CCLXXII.) by which the solid parts of the blood are perpetually rubbed together, and suffer attrition from their constriction? 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 when the lungs are obstructed, ulcerated, and almost destroyed, morbid heat is increased in the human body: and in the lungs,

lungs, the cold air comes moſt nearly in contact with the blood.

CCLXXIX. The denſity is, indeed, promoted by the copious diſcharge of watery vapour from the veſſels of the lungs, by which the reſt of the maſs becomes ſpecifically heavier. In the ſame manner as in other arteries, the blood, being alternately retarded and accelerated, is figured by the moulds of the ultimate arteries, becomes ſpherical, and therefore denſer, having more ponderous globules, and leſs light fluid. The pulmonary vein alſo being ſmaller than its correſponding artery, is of conſiderable uſe in compreſſing the globules, and in increaſing their attraction. Nevertheleſs, cold animals, with very ſmall lungs, have denſe and coagulable blood; as alſo the chick in ovo. The courſe of the blood through the lungs is ſhorter: through the whole body the courſe is longer, and the artery weaker; the ventricle, by which the blood is propelled, is alſo weaker.

CCLXXX. Is the air itſelf received into the blood in the lungs, and does it there produce neceſſary vibrations? Is this demonſtrated from the reſiſtance of the body to the weight of the external air; from the air found in the blood-veſſels, in the cellular ſubſtance, and in the cavities of the human body; from the cracking produced by extending the joints; from air being manifeſtly poured from the trachea into the hearts of many animals, as the locuſt; from the eſcape of air from the blood and animal fluids in Mr. Boyle's vacuum; from the neceſſity of a vital oſcillation in the blood; and from the increaſed redneſs of the pulmonary blood?

CCLXXXI. That no elaſtic air is here received into the blood, is demonſtrated from its not being able to enter into the blood, if it retain its elaſticity; from the inutility of its reception, if its elaſticity be loſt in the blood; from the perfect immutability of the blood by cold; from the minuteneſs of

of the inhaling veſſels ; from the ſides of the veſicles being perpetually covered with mucus ; from the elaſtic nature of air being unfit to paſs through capillary veſſels ; and from its repulſion by water, that hinders it from paſſing through moiſtened paper, linen, or leather. Again, air thrown into the trachea never paſſes into the heart ; or only when it is driven with exceſſive force. In the veſſels and humours of the human body, air, from a ſtate of inelaſticity, becomes elaſtic in conſequence of putrefaction, froſt, or an external vacuum. But ſuch air exiſts in every liquid, and is taken into our bodies with the aliments, and with vapours, mixing ſlowly and difficultly. There never were any elaſtic bubbles of air obſerved in the blood of a living animal, unleſs after wounds ; air being inflated into the blood-veſſels of any animal, kills it certainly and ſpeedily. Nor is there any thing ſufficiently certain in the increaſed redneſs of the blood in the pulmonary veins. Laſtly, air indeed is abſorbed by moſt fluids, and by water, but ſlowly, and only at the end of ſeveral days after the former air has been exhauſted by the pump. It then likewiſe lays aſide its elaſtic nature ; and no reaſon has been advanced why the air ſhould either be more ſpeedily abſorbed by the blood, or why it ſhould retain its elaſticity after its abſorption.

cclxxxii. Is the blood cooled in the lungs ? Is this proved from the death of animals in air heated to the ſame degree with the animal, as is believed to have happened from very ſultry ſummer weather, and ſcorching eaſt winds ? Are the pulmonary veins, therefore, leſs than the arteries ? Does the deſire of cold in hard working people ariſe from thence ? That the blood is cooled in the lungs, is thus far true, that it warms the contiguous air, and therefore imparts to it ſomething of its own heat. But that this was not the deſign of nature, is evident ; ſince no one has ſaid, that the venous blood is

is hotter than the arterial, although ſome aſſert that it is colder; and nobody ever obſerved the left ventricle of the heart colder than the right. But the venous blood enters the lungs. If it be cooled there, it follows that the arteries muſt receive it ſtill colder. Therefore, the blood recovers that heat which it loſt, and even more: and beſides, a perſon may live in an air much hotter than the blood itſelf, of which we have a familiar example in baths, and warm climates. The ſize of the pulmonary artery in the fœtus, which does not reſpire, is greater; and the larger area of the right auricle and ventricle of the heart, which is likewiſe much greater in the fœtus, ſeems to be a receptacle ſubſervient to frequently neceſſary retardations, and the narrowneſs of the vein contributes to the acceleration of the blood.

CCLXXXIII. Does the blood derive its redneſs from the air? This is contradicted by what we ſee in cold animals, which, though they make almoſt no uſe of the air, have blood equally red with that of warm animals; by the certain connection of redneſs in the blood of frogs, with their having plenty of food, and of paleneſs with want of food; and by the air, as we have juſt now ſaid, having no acceſs to the blood. Nevertheleſs, redneſs is produced, and reſtored to the blood by the contact of air, and is deſtroyed by its removal. Does ſome ſubtle element from the air penetrate the blood, and cauſe its colour, as light is required for the colours of plants?

CCLXXXIV. Is the uſe of the lungs, to abſorb nitre from the air to the blood? Is this the cauſe of the florid colour, obſervable on the ſurface of a cake of blood, while the bottom part is black. Does this preſerve the animal from putrefaction? It is certain, that ſome volatile principle of acidity exiſts in the air, which, with a ſuitable earth, forms nitre; for nitrous earth, after being exhauſted,

when

when expofed again to the air, becomes reimpregnated with nitre. But the fame principle of acidity, we know by certain experiments, with different earths, forms a vitriolic falt, or alum, or fea-falt. For the caput mortuum of fea-falt, which remains after the diftillation of the acid, recovers from the air the property of furnifhing more acid by diftillation; and in fnow, there is cubical falt: from marcafites, true vitriol exudes; and colcothar recovers the acid, which was drawn from it, and alkali becomes vitriolated tartar. Is this, therefore, the ufe of refpiration? The quantity of thefe falts, which exifts in the air, is too fmall; and refpiration is moft falutary on the higheft mountains, where they are moft rare; nor have any marks of a nitrous falt ever been detected in our blood.

CCLXXXVI. Why do tortoifes, frogs, lizards, fnails, earwigs, and many other infects, live long without air? In them, the lungs are given, not fo much for the preparation of the blood, of which they have but a fmall quantity, as for affifting them in fwimming; hence their lungs are fupplied with veins from the cava, and with arteries from the aorta. Infects inhale and exhale air, through points in the fkin. Why do all animals, however fmall, fuch as little birds, perifh in air that is not renewed? Becaufe the air, which has once entered the lungs, is contaminated by inelaftic, watery, and alkaline vapours, and therefore it becomes noxious: not becaufe it becomes lighter; for the mercury falls but little in air, which has not been renewed, and which has killed an animal. Hence, on the other hand, animals furvive longer in air which is more compreffed than that of the atmofphere: for in that cafe, the proportion of the elaftic element is greater, and therefore the air is more flowly contaminated. But, even in other cafes, confined air becomes deleterious, and filled with vapours, by ftagnation alone. Why do animals fwell in an exhaufted receiver?

ceiver? From the expanfion of the air, which exifted in an inelaftic ftate in the blood.

cclxxxvii. There is a certain connexion between the pulfe and refpiration. According to the common courfe of nature, three or four pulfations are reckoned to one refpiration. If the quantity of blood fent to the heart be increafed, the frequency, both of the pulfe and refpiration, are increafed. This is the reafon of the panting in a perfon, taking exercife, which accelerates the motion of the venous blood (cxlii.) If the blood meet with much refiftance in the lungs, and do not pafs freely from the right into the left ventricle of the heart; to accelerate its courfe, both the number and magnitude of the refpirations are increafed. This is the caufe of fighing, yawning, and panting; of which the firft is a deep infpiration; the fecond flow, and very great; and the third, frequent and imperfect. The number of refpirations, however, does not always increafe with the pulfe; of which we have an example in fevers, in which the lungs are not affected.

cclxxxviii. The mucus, which lines the fenfible membrane of the bronchia, may become troublefome, both by its quantity and acrimony; it has been even known to caufe fuffocation in a dropfy of the lungs. Therefore, its fuperabundance, adhefion, or acrimony, is removed by coughing; namely, by irritating the refpirative fyftem, the mucus or concretions are loofened and expelled by large infpirations, and exfpirations, alternately fucceeding each other with rapidity, and by ftrokes of the abdominal mufcles.

cclxxxix. Laughter differs from coughing in its caufe, which refides commonly in the mind, or at leaft confifts in the titillation of fome of the cutaneous nerves; and alfo, becaufe, after one deep infpiration, there are frequent but imperfect exfpirations, through the contracted glottis, and the air is

not

not totally evacuated from the lungs. Hence laughter, in a moderate degree, conduces to health; becaufe, in place of one full infpiration, feveral infpirations and exfpirations happen in the fame time, and thus the concuffion is greater. Hence its danger, from ftagnation of the blood; becaufe the exfpiration is not full, and therefore the blood is admitted into the pulmonary artery, but is not fuffered to pafs through it. Weeping begins with a deep infpiration, after which follow fhort alternate infpirations and exfpirations; and it is finifhed with a deep exfpiration, which is immediately followed by an infpiration: hence it has nearly the fame good and bad effects; and, when moderate, it relieves the diftrefs arifing from grief. Hiccough is a very great, fonorous, and fudden infpiration. Sneezing confifts of one deep infpiration, fucceeded by a fingle powerful exfpiration; and by the torrent excited, the acrid matter, irritating the noftrils, is blown away.

ccxc. The fecondary ufes of refpiration are very numerous. It exhales copioufly, and removes from the blood fomething highly noxious; for by remaining in the air, it will caufe fuffocation; and the breath of many people, crowded in a clofe and fmall place, impregnates the air with a fuffocating quality. On the other hand, it abforbs from the air a thin vapour, of which the ufe is perhaps not fufficiently known. It is alfo a force, which perpetually compreffes the abdomen, and all its vifcera; it evacuates the ftomach, inteftines, gall bladder, receptacle of the chyle, urinary bladder, inteftinum rectum, and the womb; it comminutes the aliments, and forces the blood through the liver, fpleen, and mefentery. It caufes a kind of flux and reflux in the blood, fo that it is alternately preffed back towards the extremities of the veins, and a little after is propelled towards the heart by an accelerated velocity, as into an empty fpace. Moreover, infpiration

ration attracts the odoriferous particles from the air, and conveys them to the ſenſorium. But even ſucking, ſo neceſſary to the new born infant, is effected by inſpiration, and by forming a larger ſpace, in which the air contained in the mouth is rarefied, ſo that the preſſure of the external air forces the milk into that part where it is leaſt reſiſted. Laſtly, the voice itſelf depends upon the air, and ſeems to be the principal manifeſt effect of reſpiration. This, therefore, appears a proper opportunity for deſcribing it.

CHAP. IX.

VOICE AND SPEECH.

CCXCI. THE principal organ of the voice is the larynx; for, when it is 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, connected with it by ligaments and muſcular fibres. Among the larger of theſe cartilages, the annular and ſcutiform in adults oſſify internally. The anterior and larger part of the larynx, which lies almoſt immediately under the ſkin, is compoſed of two cartilages; the thyroid and cricoid, to which the lateral parts of the larynx alſo belong in ſuch a manner, that the portions of the cricoid cartilage always become larger, as they are higher ſeated. The back part of the larynx is compoſed firſt of the ſaid annular cartilage, and afterwards of the arytenoid cartilages, connected by muſcles. The epiglottis, looſely connected with the thyroid cartilage, is either raiſed or inclined over the larynx. The veſſels ariſe from the upper and lower thyroids; the nerves are numerous;

merous; the inferior ones come from the recurrents; the ſuperior ones from the eighth pair, inoſculating in various ways; ſome alſo from the intercoſtal. The former of theſe nerves is remarkable for its origin in the thorax; for its reflection round the aorta and right ſubclavian; for its giving riſe to ſome of the nerves of the heart, and for the experiment, which proves, that the voice is deſtroyed, by tying this nerve.

CCXCII. All theſe cartilages are connected together by various muſcles and ligaments, ſo that the whole may poſſeſs mobility, while ſome of its parts are firm, and others extremely moveable. The ſcutiform or thyroid cartilage, ſituated on the forepart, is compoſed of two, almoſt quadrangular plates, inclined to each other in an obtuſe angle, projecting forwards. In theſe plates, two apertures, one on each ſide for the internal veſſels of the larynx, are found ſometimes, though rarely. The upper proceſſes of this cartilage, terminating in a thick point, inclining upwards and backwards, are connected with the horns of the os hyoides, by ſtrong ligaments, ſometimes mixed with bone. The lower proceſſes are ſhorter, are adapted to the ſlightly hollowed, and almoſt flat ſurfaces of the cricoid cartilage; and are connected by a very firm articulation, on account of the ſhortneſs and ſtrength of the cellular ſubſtance, which unites them. The middle anterior part is joined by ſtrong perforated ligaments, to the middle of the annular cartilage; and likewiſe by other ſuperior ligaments, proceeding from the deſcending horn of the ſcutiform cartilage, to the upper part of the annular cartilage.

CCXCIII. The cricoid cartilage, anteriorly thick and hard, is increaſed backwards, in form of a ring unequally truncated; and, in the middle, it is divided into two cavities by a protuberant line. It is firmer than the reſt of the cartilages, and forms their

their bafis. From it longitudinal mufcular fibres and ligaments defcend to the windpipe (ccxxxviii.) The pharynx connected with each of thefe cartilages by many mufcular layers, receives the larynx into its cavity. From this cartilage a fhort ligament proceeds to the arytenoid cartilage on each fide.

ccxciv. The figure of the two arytenoid cartilages is very complex. It fpontaneoufly divides into two parts, of which the lower is larger, and is connected by a moderately concave bafe with the thick cricoid cartilage, forming a moveable articulation. It fends a procefs forwards, which feparates the glottis, and fuftains the inferior part of the ventricle of the larynx. They afcend upwards, of a triangular figure: the pofterior bafe is hollow, and the anterior fide is convex, and divided by three furrows. They are extenuated upwards, till they are at laft terminated by a pretty thick, oval, cartilaginous head fixed on them. The lower part of thefe cartilages is connected by numerous mufcular fibres, partly tranfverfe, and partly oblique; of which the different directions are evident, though they cannot be feparated. Thefe are called the arytenoid mufcles. In their upper part, the arytenoid cartilages are feparated by a perpendicular chink, which has been improperly by fome called the glottis.

ccxcv. The arytenoid cartilages are connected with the thyroid by tranfverfe ligaments, for the moft part fufficiently ftrong and elaftic, but covered with the common mucous membrane of the larynx. Thefe ligaments arife below the middle of the arytenoid cartilages, and are inferted into the flat angle of the thyroid cartilage (ccxcii.) and may be feparated from each other, by removing the arytenoid cartilages from being in mutual contact, and may be again brought into contiguity by the

cartilages

cartilages approaching each other. This conftitutes the true glottis, and is continuous, but at right angles with the above mentioned chink (ccxciv.)

ccxcvi. From the fame angle of the thyroid cartilage, under a notch, from a firm ligament, a cartilage arifes, with an erect flender ftalk, of an oval fhape, convex before, behind concave, and with its fuperior extremity reflected backwards and concave. It is kept erect by its own elafticity, fo that it rifes upright behind the tongue; but it can be fo inclined whenever the root of the tongue is preffed backward, that, having become tranfverfe, it completely fhuts up and protects the paffage into the larynx, which defcends between this, the epiglottis, and the arytenoid cartilages. The epiglottis is joined to the tongue by pale membranous fibres, and to the os hyoides by much membranous expanfion. It either has no fibres from the thyro-arytenoidal and arytenoidal mufcles, or they are too minute to counteract its elafticity.

ccxcvii. At the fides of the ligaments of the glottis (ccxcv.) two other upper and fofter ligaments, lefs tendinous or elaftic, proceed parallel from each arytenoid cartilage to the thyroid. Betwixt thefe two (ccxcvii. and ccxcv.) ligaments of each fide, a peculiar cavity or ventricle defcends, having the figure of a compreffed parabolic fpace, extending downwards betwixt the double membrane of the larynx, with its fuperior orifice, of an elliptic form, conftantly open into the larynx.

ccxcviii. Laftly, all the internal cavity of the larynx is lined with the fame foft, irritable, mucous membrane, we before defcribed in the windpipe (ccxxxix.) This membrane is moiftened by a great number of glands. The uppermoft are fmall, and compofed of fimple glands (ccviii.) They are feated on the anterior convex part of the epiglottis, and fend prolongations through its various perforations and larger finufes, to its concave fide, which

which are there continued into fimilar firm glands. Moreover, upon the anterior furrowed furface of the arytenoid cartilages (CCXCIV.) there is on each fide a gland, of a loofe conglomerate fabric, refembling much a gnomon, compofed of round acini, doubtlefs mucous, of which a loofe portion defcends on each fide as far as the annular cartilage. In the ventricles, there are numerous mucous finufes. Laftly, all the internal furface of the larynx is full of large mucous pores. All thefe glands fecrete a thin and watery, but at the fame time, vifcid mucus.

CCXCIX. Has the thyroid gland any fimilar ufe? It is of the conglomerate kind, but foft, the coverings of the lobules being much more tender than in the falival glands, it is very large, is anteriorly feated upon the thyroid and cricoid cartilages and windpipe, furrounding with lateral productions the fides of the thyroid, is joined to its companion by an ifthmus, which is narrow and emarginated below; and by a middle very thin procefs it afcends on the forepart, almoft to the os hyoides. This gland is full of a ferous, yellowifh, and fomewhat vifcid humour: Does it difcharge this fluid into the windpipe, or into the œfophagus? Into neither are ducts certainly known to open. Does it retain its fluid entirely, and afterwards reftore it to the veins, like the thymus, which is analogous in its ftructure? Is it a conglobate gland? That the ufe of this gland is very confiderable, appears from the remarkable fize of the arteries which it receives from the carotids, and of its inferior ones from the fubclavians. The veins return into the jugulars and fubclavians. It has a peculiar mufcle, not however conftant, arifing from the margin of the os hyoides, and fometimes from the lower edge of the thyroid cartilage towards the left, which defcends without a fellow, and fpreads its tendinous fibres over the gland, upon which alfo the fternohyoidei and fternothyroidei mufcles are incumbent.

CCC.

CCC. The whole larynx is ſuſpended from the os hyoides, both by ligaments inſerted into the ſuperior horns of the thyroid cartilage, and by the middle of its baſis, united to the junction of the plates, conſtituting that cartilage. The larynx, and os hyoides connected with it, may be raiſed conſiderably, even half an inch above its mean altitude. This is performed by the biventer muſcles, together with the geniohyoidei, genioglοſſi, ſtyloglοſſi, ſtylohyoidei, ſtylopharyngei, thyropalatini, hyothyroidei; either conjunctly or partially. During its elevation, the glottis is rendered narrower, and the ligaments before mentioned (CCXCV.) approach nearer together. Thus, by the aſſiſtance of the action of the arytenoid muſcles, both oblique and tranſverſe, the glottis may be accurately cloſed, ſo as to reſiſt with and incredible force the preſſure of the whole atmoſphere.

CCCI. The whole larynx may alſo be depreſſed about half an inch beneath its ordinary ſituation, by the ſternohyoidei, ſternothyroidei, and coracohyoidei, as they are called; and, when theſe are in action, by the anterior and poſterior cricothyroidei. By this motion the arytenoid cartilages remove from each other, and the glottis becomes wider, which is alſo drawn open by the muſcles laterally inſerted into the arytenoid cartilages, and by the cricoarytenoidei poſtici and laterales, and thyroarytenoidei: theſe alſo, by reſting upon the ventricles of the larynx (CCXCVII.) are capable of compreſſing them. The particular cartilages which form the larynx, can ſcarcely be moved ſeparately.

CCCII. From the larynx the air comes into the mouth and noſtrils. By the mouth, we here mean that large and irregularly ſhaped cavity, ſituated between the ſoft and hard palates, both concave in the middle, and the muſcles lying under them, and the lower jaw. The noſtrils aſcend forwards above the

the ſoft palate; they are two broad cavities, included between the ſeptum medium, and the oſſa cavernoſa, and ſome other parts. They are every where bony and cartilaginous.

CCCIII. The tongue lies in the middle of the mouth; it is a broad piece of fleſh eaſily changeable into any kind of figure, and readily moved without delay to any part of the mouth: 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, it may with great facility be made to aſſume any poſition or figure. It is drawn forwards by the geniogloſſi and geniohyoidei muſcles; backwards by the ſtyloglofſi, ſtylohyoidei, ceratoglofſi, baſioglofſi, chondroglofſi, and biventer; downwards, by the ſternohyoidei, and ceratohyoidei; and upwards, by the ſtyloglofſi, ſtylohyoidei, by the biventers, and likewiſe by the mylohyoidei.

CCCIV. So much for the anatomy. It remains that we demonſtrate what effects are produced by air, when expelled, during exſpiration, by the powers above deſcribed (CCLXIX. CCLXX.) from the lungs through the windpipe into the larynx, and from thence forced through the glottis into the mouth variouſly configured. Theſe effects are, voice, ſpeech, and ſinging. Sound only is produced when the air is expelled with ſo great a velocity through the contracted glottis, that it impinges on the ligaments of the glottis, and thus produces in the larynx that tremor, which, being vibratory on account of its elaſticity, it continues and increaſes. Therefore, from the united vibrations of the ligaments (CCXCV.) and of the cartilages of the larynx, a ſound is produced, which we call the voice, peculiar in every claſs of animals, and which depends entirely on the larynx and glottis. When there are no vibrations, a whiſper is produced.

CCCV.

CCCV. The ſtrength of the voice depends upon the quantity of air expired, and the narrowneſs of the glottis; and, therefore, upon capacious lungs eaſily dilatable, an ample, cartilaginous and elaſtic larynx and windpipe, the free reſonance of the noſtrils, and a powerful exſpiration. But the acuteneſs or gravity of the tones, we obſerve to ariſe from various cauſes. The former proceeds partly from the narrowneſs, and partly from the tenſion of the glottis, and the latter from its relaxation and dilatation. For hence, the air, in a given time, impinges upon the ligaments of the contracted glottis with more numerous undulations, and cauſes more frequent vibrations; 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 ſound, the whole larynx is drawn upwards and forwards; and with greater force as the voice is required to be ſharper, inſomuch that the head itſelf is ſometimes inclined backwards, that the muſcles elevating the larynx may exert their full powers. The truth of this is confirmed by experiment, for by applying the fingers to the larynx when acute ſounds are emitted, the elevation of the larynx, which is about half an inch for the octave, is eaſily felt: and by comparative anatomy, which demonſtrates the glottis to be very narrow and cartilaginous in ſinging birds, and wide in hoarſe animals, and ſuch as are low or mute. This is alſo illuſtrated by whiſtling, where the ſharpneſs of the ſound evidently proceeds from the contraction of the mouth: and by muſical inſtruments, in which the narrowneſs of the opening admitting the air, and the celerity with which it is impelled, are the cauſes of an acute tone.

CCCVI. Gravity of the voice is produced by oppoſite circumſtances, the depreſſion of the larynx by

by the causes (cccı.) already described; a wide glottis and a very ample larynx. This is proved by the touch, which easily perceives the descent of the larynx in persons singing, in like manner about half an inch for every octave; by the greater gravity of the voice in males, and by the lowest tones of the voice degenerating into a silent breathing.

cccvii. Does every diversity of tone proceed from the length of the ligaments of the glottis, which is augmented when the scutiform cartilage is drawn forwards, and the arytenoid ones backwards? Is it according to this rule, that the most acute tones are produced, by the ligaments being rendered very tense, and therefore vibrating with great celerity? This is asserted by some late anatomists, from experiments, which have been also repeated by some eminent men; they 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 trachea; that this voice was rendered more acute by stretching the ligaments, and more grave by loosening them; 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, and consequently immoveable and inextensible, glottis of birds; from the certain production of more acute sounds, 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; and from the total absence of machinery for stretching the ligaments, and drawing the thyroid cartilage forwards from the annular one.

one. But ſince it appears from experiments, that the tenſion of the ligaments ſuffices for producing acute ſounds, without the contraction of the glottis, it is probable that difference of tenſion in the glottis contributes more than a difference of its diameter to the diverſity of voice.

cccviii. Singing, is when the voice, modulated through various degrees of acuteneſs and gravity, is expelled through the larynx, while vibrating and ſuſpended between contrary powers, which chiefly diſtinguiſhes it from ſpeech. It is a laborious action, on account of the perpetual action of the muſcles poiſing the larynx; and it increaſes the animal heat, becauſe acute tones require a contracted glottis, which retards the exſpiration, and at the ſame time a great deal of air to give them ſtrength (cccv.) and, therefore, deep inſpirations are neceſſary. It tends very much to dry the windpipe, from the accelerated paſſage of the air; and renders a great deal of mucus neceſſary, which is the reaſon why there are ſuch numbers of mucous receptacles in the larynx, amongſt which I very much ſuſpect the ventricles before deſcribed (ccxcvii.) ought to be numbered.

cccix. Speech is performed when the larynx is at reſt, in tones differing but little in acuteneſs and gravity: by variouſly modifying the voice by the organs of the mouth. Canorous ſpeech has both variations in the tone, and modifications of the voice by the organs of the mouth.

cccx. All ſpeech is reducible to the pronunciation of letters, which differ in various nations, although they agree in the greateſt number over the whole world. Of theſe, ſome are called vowels, which are expreſſed by the mere emiſſion of the voice through the mouth, without the application of the tongue to any part of the mouth. But conſonants are formed by a colliſion of the tongue againſt ſome part of the mouth, lips, or teeth. The nature

nature of our work forbids us to be more particular, and prevents us from explaining a moſt ingenious art, which, a rare occurrence in phyſics, has ſo clearly determined all the corporeal cauſes of each letter, that, by mere inſpection and touch of the organs during their pronunciation, it has taught ſpeech by imitation.

CHAP. X.

BRAIN AND NERVES.

CCCXI. THE remaining actions of the human body we ſhall conſider according to the order in which they receive the blood. Of the coronary arteries we ſpoke, when we gave the hiſtory of the heart. Next to thoſe, the carotids ariſe from the aorta.

CCCXII. The aorta, which comes out from the anterior part of the heart (CLVII.) in order to bend itſelf towards the vertebræ of the thorax, inclines backwards, and to the left, in an angle that is round indeed, but not very large, forming a conſiderable arch. From the convexity of this arch, three branches ariſe. The firſt aſcends towards the right ſide, and is immediately ſubdivided into two large arteries, of which the lowermoſt proceeds in the direction of its trunk, under the denomination of the ſubclavian. The other aſcends along 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, and is ſomewhat leſs than the right. At the origins of theſe branches, the continuous ſide of the aorta is a little thicker, and projects a little to the left. Variations from this courſe are rarely obſerved.

CCCXIII.

CCCXIII. The carotid artery, inclofed along with the jugular vein and nerve of the eighth pair, in copious and denfe cellular fubftance, commonly arrives at the upper part of the thyroid cartilage, without fending off any branches. There it divides into two trunks. The anterior, which is called the external carotid, is more in the direction of its trunk, and rather larger. It fends off the thyroidea fuperior, the tortuous lingualis, and then the labialis; and from its pofterior part, clofe by its divifion, the pharyngea afcendens, which, befides the pharynx and mufcles of the velum palati, fupplies to the dura mater, through the foramen common to the jugular vein and nerve of the eighth pair, a confiderable branch, fent off at the bafis of the os petrofum, near to the foramen magnum, and cuneiform procefs of the fphenoid bone.

CCCXIV. Then, from the exterior fide of the external carotid, fprings the occipital artery; which alfo fends a branch to the dura mater, which is diftributed, at the bafis of the cerebellum, through a peculiar foramen of the dura mater in the angle which the os petrofum forms by departing from the mamillary procefs: another branch paffes over the atlas to the dura mater, both under and into the fkull; and a third fometimes goes through the foffa jugularis to the dura mater. The next artery, the auricularis, goes to the back part of the ear, to the membrane of the tympanum, and to the temples.

CCCXV. 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 eyelids, it fends out, in the firft place, the temporalis, which is confiderable. The trunk of the carotid, being inclined behind the lower jaw, lofes itfelf under the denomination of maxillaris interna.

In that place, it directly fends off a large trunk to the dura mater, which paffes through a peculiar opening of the broad pterygoid wings, to the

the vicinity of the middle foſſa of the brain; and is largely diſtributed upon the dura mater, in the region of the temples and forehead, as far as the falciform ſinus. Sometimes this artery is double, and often ſends a conſpicuous branch to the lachrymal gland of the eye. Moreover, the ſame maxillary artery enters the upper part of the noſtrils by a triple trunk, where it is ſpent, after having given off branches to the teeth of the lower and upper jaws, the infra orbitalis, a branch to part of the face and eyelids, and the palatine to the bone of the palate, with ſmall twigs to the dura mater, both through the ſmaller pores of the great wings, and accompanying the third and ſecond branch of the fifth pair of nerves, and the dura mater filling up the lower orbital fiſſure.

cccxvi. But the other trunk, which is poſterior, and commonly called the internal carotid (cccxiii.) aſcends without a branch. This artery, having firſt made a remarkable ſerpentine flexure, enters through a peculiar foramen in the os petroſum, where it is ſurrounded with a vagina from the dura mater, like that which comes out through all the openings of the ſkull: aſcending upwards, then inclining forwards, it penetrates into the cavity of the ſkull, and aſcends tortuouſly bent along the ſella equina, in the middle of the blood of the cavernous ſinus, having given ſmall branches to the fifth pair of nerves, dura mater, and infundibulum, with one larger to the eye, part of which returns again through a peculiar hole into that part of the dura mater, which lies upon the middle of the orbit. The rete mirabile is peculiar to ſome animals, and does not exiſt in man.

cccxvii. But the trunk of this internal carotid paſſes over the anterior part of the ſella equina; and being incurvated backwards, and received within the arachnoid membrane, after giving branches to the pons and crura of the brain, and a twig to the

the choroid plexus, and a branch 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 anaſtomoſis, is then incurvated backwards and upwards, along the corpus calloſum, and goes to the middle and poſterior part of the brain, and ſometimes ſends branches to the falciform proceſs, and at its very origin to the third ventricle, the fornix and thalami. The latter, being joined by a moderate anaſtomoſis with a branch of the vertebral artery, unleſs that ariſe from the undivided trunk of the carotid, afterwards aſcends a long way through the foſſa of Sylvius to the lateral part of the brain; and alſo ſends branches to the choroid plexus. All the branches of the carotid, contained within the ſkull, have a thin, ſolid, and more brittle ſubſtance than the other arteries of the body.

cccxviii. The vertebral artery commonly ariſes from the ſubclavian of the ſame ſide, (though the left has been ſometimes ſeen to ſpring from the trunk of the aorta,) in a deep ſituation, and without giving branches, it enters the foramen in the tranſverſe proceſs of the ſixth vertebra of the neck; after which, it aſcends with alternate flexures through the proceſſes of the other vertebræ of the neck; through each interval, it ſends off ſmall branches to the muſcles of the neck, and communicates with the lower thyroidal: with other branches, ſomewhat larger and poſterior, it accompanies each nerve to the pia mater of the ſpinal marrow; and by anterior branches, not ſo numerous, but larger, it communicates in the ſpinal marrow with its anterior artery. Laſtly, having become tranſverſe by a ſmall flexure at the ſecond vertebra, and by a large one round the proceſs of the firſt, having there given off two conſiderable branches to the muſcles of the neck, and during its paſſage through the foramen magnum, having ſent ſmall ones to the

 dura

dura mater of the foramen magnum and neighbouring cavity of the cerebellum, it finally enters the cavity of the ſkull through that foramen. There, while it aſcends along the medulla oblongata, the right trunk gradually approaching the left, unites with it at a very acute angle (a moſt uncommon circumſtance) into one artery, the baſilary, which being ſtretched under the pons Varolii, is ſuſpended in the pia mater. From the vertebral arteries, before they are conjoined, or from their common trunk juſt formed, arteries both going to the lower ſurface of the cerebellum, and entering deeply into the fourth ventricle and the internal ſubſtance of the cerebellum, ariſe. Theſe ſend off the ſpinal arteries. There are inſtances where theſe ariſe from the united trunk; or from the trunk in one ſide, and from a branch in the other. Then the baſilaris, beſides branches to the medulla oblongata and crura of the brain, ſends off other lower arteries of the cerebellum. Amongſt theſe branches alſo ariſes the artery, which accompanies the auditory nerve. Finally, the baſilaris, at the forepart of the pons, divides on each ſide into two branches. One of theſe goes to the upper part of the cerebellum, to the fourth ventricle, to the crura of the medulla of the cerebellum, the nates, teſtes, and pineal gland: in place of this, alſo, there are two trunks. The other, the profunda cerebri, is diſtributed to the poſterior lobe of the brain, the choroid plexus, the plexus lying on the pineal gland, that gland itſelf, the thalami, corpora ſtriata, fornix, and whole anterior ventricle.

cccxix. From the foregoing hiſtory of the arteries belonging to the brain, it appears, that in every pulſation a great quantity of blood is ſent to this organ, equal to a ſixth part or more of the whole blood in the human body, and conveyed by trunks which ariſe very near the heart, and from the convexity of the aorta. It is therefore not improbable,

probable, that the ſtrongeſt parts of the blood, and thoſe moſt retentive of motion, go to the head. Is not this evident from the effects of mercurials being almoſt confined to the head; from the ſudden action of inebriating ſpirits upon the head; from the ſpeedy ſtupor excited by camphor; from the face being oftner affected by heat and ſweat, than any other part of the body; and from the eruption of highly volatile miaſmata upon the face? The ſafe ſituation in which the arteries of the head aſcend, defends the large and important veſſels from injury. The frequent reciprocal inoſculations of the trunks going to the head, as well as of their branches, diminiſh the danger of obſtruction. Hence, when the carotids are tied, animals neither die, nor ſeem to be very uneaſy. The conſiderable flexures of the vertebral and carotid arteries, 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. Some reputable authors have obſerved, that the arteries are ſomewhat larger at this place.

cccxx. The hiſtory of the brain properly commences with its integuments. A part ſo tender and ſo neceſſary to life, is, in the firſt place, ſurrounded by an oſſeous ſphere compoſed of many pieces, which, therefore, admits of extenſion, while it effectually reſiſts external preſſure. To every part of the internal ſurface of this ſphere, a very ſtrong membrane adheres, compoſed of two plates ſufficiently diſtinct. It is firmly attached by an infinite number of ſmall veſſels, even penetrating to the exterior parts of the head, as by ſo many footſtalks; in a healthy perſon it is no where detached, but adheres ſomewhat leſs firmly to the very ſmooth bones, but with exceſſive ſtrength to the commiſſures of the bones of the ſkull, which, from their figure, are called ſutures. In young ſubjects, the

adhesion of the dura mater to the skull is so great, that the fibres to which it is connected are separated at the same time with it. In adults, many of the vessels being effaced, the dura mater becomes less inseparable: but yet it cannot be detached from the skull without some violence. Hence those bloody drops which appear on removing the cranium. Hence all that has been advanced concerning the motion of the dura mater is erroneous. As to the motion which has been remarked in wounds by some observers, it arose either from the pulsation of the arteries, in a place whence the resistance was removed, while the rest of the cranium afforded insuperable resistance to the action of the heart, or from the turgescence of the brain. The dura mater has neither irritability nor sensibility, and is destitute of nerves, though those going to other parts have been, by some, ascribed to this membrane.

CCCXXI. It is the external lamina of the dura mater, which adheres to the bones, and serves them for a periosteum. It passes out of all the holes of the skull along the nerves and vessels, and coheres with the periosteum of the head, vertebræ, and, lastly, of the whole body; from which circumstance, the name of mater given to it by the barbarians, is derived. The internal plate of the dura mater is, in most parts, continuous with the former: but, in some, it recedes a little from it, as in the great sphenoidal wings; at the sides of the sella equina, where a good deal of blood is poured betwixt them; and upon the sella equina itself: having left the external lamina, which adheres firmly to the bones, it descends double to form the falx, which arises first from the multiform bone behind the crista galli, then from the crista, afterwards from the whole juncture of the two frontal and parietal bones, and, lastly, from the middle and back part of the occipital bone; it becomes broader

broader as it proceeds backwards; it is interpoſed betwixt the hemiſpheres of the brain; and hangs over the corpus calloſum, at a greater diſtance in the forepart, but very near behind, where it alſo is extenuated to an edge. That there are ſhining fibres in this part, diſperſed towards the longitudinal ſinus, from its junction with the tentorium, in the ſhape of palm branches, is certain; but it does not therefore follow, that they have any muſcular motion: betwixt theſe fibres frequently there is no membrane, ſo that they form natural foramina. The falx is joined to the middle of the tentorium, and is continuous with it. In the ſame manner, but in a different ſituation, the ſame lamina forms the ſhort falx of the cerebellum, ſeparating its lobes, together with the ſtrong tentoria, which, ariſing from the cruciform protuberance of the occiput, are interpoſed tranſverſely betwixt the brain and cerebellum, and, at laſt, adhering to the petrous bones and anterior clinoid proceſſes, leave an aperture nearly oval for the medulla oblongata. Theſe productions of the dura mater, prevent any part of the brain from preſſing on the reſt, in any ſituation of the body; and, likewiſe, one lobe from compreſſing another, in concuſſions of the brain. Hence, in the ſwifteſt quadrupeds, where the danger from concuſſion is greater, the brain and cerebellum are divided by a bony partition.

CCCXXII. Upon the external ſurface of the pia mater, not far from the ſinus of the falx, are placed glands, ſeated in the reticular texture of the dura mater, which partly are inclined towards the ſinus and its cavity; ſo that ſome of them are contiguous to the cavity of the ſinus, while others are ſo placed at the inſertion of the large veins into the pia mater, that, together with the former juſt mentioned, they make up a continued ſeries; theſe are ſometimes ſoft, oval, and white, ſometimes red, and hard, like warts. They have alſo been noticed in the

the tentorium cerebelli. But the vapour, which exhales from the ſurface of the pia mater, is not ſecreted by theſe glands: for every where, even where there are none of thoſe glands, as in the ventricles, a copious vapour tranſpires from the ultimate arteries, as is proved by injections of water or ſize, which exude from every part of the ſurface of the pia mater.

CCCXXIII. The next covering of the brain, much cloſer to it, and expreſſing its figure, as the former does that of the cavity of the ſkull, has been denominated, from its tenuity, arachnoid. Pellucid as water, very thin, and as far as its thinneſs permits, firm, it completely envelopes the brain, paſſing over its larger and ſmaller furrows, and incloſing the larger veſſels, ſo that they lie between the arachnoides and pia mater. It is not a lamina of the pia mater, from which it differs in ſituation, in being connected with it by cellular ſubſtance, and in the example of the ſpinal marrow, although it is reſolved into a cellular nature between the hemiſpheres of the brain.

CCCXXIV. The third covering of the brain, is the pia mater, or ſoft membrane of the brain. This immediately inveſts the whole ſurface of the brain and ſpinal marrow on all ſides, is tender, and compoſed of a vaſt number of ſmall veſſels joined together by cellular texture: but theſe veſſels it ſends into the brain in a regular order, like little roots. It deſcends into all the ſinuoſities, and inſinuates itſelf into the fiſſures of the brain, cerebellum, and ſpinal marrow, and is the bond by which the lobules of the brain are joined together, being poſſeſſed of conſiderable firmneſs in proportion to its tenuity. Being received into the cavities of the brain, it changes its fabric, and becomes ſoft and almoſt of a medullary conſiſtence, eſpecially when the ſubject is diſſected ſome time after death, although the veſſels ſtill point it out.

CCCXXV.

cccxxv. The veins in the brain are not conſtructed as in other parts of the body. For neither have they any valves, nor do they accompany the arteries, nor have their trunks the common ſtructure which prevails in other veins. Therefore, from the innermoſt cavities of the brain, the veins which reſt upon the ridges of the ſtriated bodies, the veins of the choroid plexus, of the lucid ſeptum and of the anterior ventricles, are collected into trunks, which at laſt meet in one great vein, or often two, which, being accompanied with many ſmall arteries of the choroid plexus, deſcends backwards 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, and meets with a ſinus or vein, included in a reduplication of the inner lamina of the dura mater, and being changed into this ſinus, it generally deſcends into the leſs tranſverſe ſinus, moſt frequently of the left ſide, though ſometimes dividing, it ſends a branch to each ſide. This is called the fourth ſinus.

cccxxvi. The ſuperior and ſuperficial veins of the brain are large, and ſpread in the windings with which the brain on all ſides abounds. Into thoſe veins, over the whole ſurface of the brain, are inſerted ſome veins of the dura mater; while others of them enter by peculiar orifices into the falciform ſinus. Then the veins being gradually collected into trunks, proceed, the greateſt number of them forwards, a few either directly, or backwards, and theſe moſt eſpecially from the forepart, and inſert themſelves, with their terminations obliquely truncated, into the long falciform ſinus which is formed by the internal lamina of the dura mater, from the right and left ſide meeting together below in the upper edge of the falx. Therefore it is of a triangular figure, convex in its upper ſide. It begins with a ſlender origin at the foramen cæcum,

cæcum, which lies before the criſta galli; it aſcends and follows the courſe of the falx; where that joins the tentorium, being generally inclined to the right, it takes the name of the right tranſverſe ſinus, and goes by a peculiar channel impreſſed in the occipital and temporal bones, firſt tranſverſely, then incurvated, to the foramen jugulare, where, becoming very large, it receives the inferior petrous and the occipital ſinuſes, and empties itſelf into the jugular vein. But the left tranſverſe ſinus, reſembling the former, and alſo leading to the jugular vein, is rather inſerted into its right ſide, than continued as its trunk. Into it the fourth ſinus (cccxxv.) and the occipital one, uſually inſert themſelves. But there are ſome inſtances of a reverſe arrangement, ſo that the longitudinal ſinus terminates in 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 a middle ſinus joins the tranſverſe ones. There even have been found two ſimilar ſinuſes parallel to each other.

CCCXXVII. Irregularly parallel with the lower and thicker margin of the falx, runs a ſlender and rounder ſinus, more reſembling a vein; it receives veins from the falx itſelf, which alſo communicate with the upper ſinus; and from the adjacent hemiſpheres of the brain, and from the corpus calloſum. Where the falx joins with the forepart of the tentorium, it is inſerted into the fourth ſinus.

CCCXXVIII. The lower veins of the brain, which lie next to the baſis of the ſkull, are variouſly inſerted. The anterior veins coming from the foſſa Sylvii, collected into ſome trunks, are inſerted into the cavernous ſinus, or that triangular interval, between the external and internal plates of the dura mater, which is at the ſide of the ſella equina.

Other

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 ſinuſes in the tentorium.

CCCXXIX. The upper veins of the cerebellum, meeting together in large trunks, partly terminate in the fourth ſinus, and partly in the tranſverſe ſinuſes. The lower veins, from the cerebellum and medulla oblongata, inſert themſelves into the upper ſinus petroſus; and ſome of theſe alſo into the tranſverſe ſinus very near the place where it goes out.

CCCXXX. There are many ſinuſes, beſides thoſe now mentioned. The moſt anterior of them, which commonly has a circular appearance, ſurrounds the pituitary gland, and between the clinoid proceſſes, communicates with the cavernous ſinuſes; and between theſe proceſſes and the carotid, with the lower petrous ſinuſes, and laſtly, by the way of the ſixth pair, with the upper petrous 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 co-exiſts with it.

CCCXXXI. The upper petrous ſinus runs backwards in a groove of the os petroſum. It ariſes from the anterior extremity of the ſulcus of the os petroſum, where it communicates with the cavernous ſinus; it receives veins of the dura mater which are inſerted into it, and ſometimes anterior veins of the brain itſelf, mentioned before (CCCXXVIII.) and is inſerted into the angle of the tranſverſe ſinus, where it begins to be bent, and ſometimes into the inferior petrous ſinus. Another vein, paſſing along the top of the os petroſum, is in like manner inſerted into the angle of the tranſverſe ſinus. The lower ſinus petroſus, which is ſhorter

and larger, goes round the root of the bone of this name, and communicates with is fellow behind the clinoid procefs; after twice communicating with the cavernous finus, and with the upper finus, under the nerve of the fifth pair, it is finally inferted into the jugular foffa; it alfo receives fome veins of the dura mater from the region of the vertebræ. To the fame outlet alfo, the pofterior occipital finus on each fide leads. Thefe are pretty large, go round the margin of the foramen magnum, till, arriving at the falx of the cerebellum, (cccxxi.) they are fooner or later inferted, generally after being conjoined into the fourth finus, and with that into the left tranfverfe one, or immediately into this finus itfelf, or laftly, by a divided extremity into each of the tranfverfe finufes. It receives the lower and pofterior veins of the dura mater, and fome from the vertebræ.

cccxxxii. The anterior occipital finus, irregular and multiform, partly tranfverfe, and partly defcending to the great foramen, is united in various ways with the lower petrous finufes; from whence branches either accompanying the nerves of the ninth pair, or paffing through a peculiar foramen, communicate with the external vertebral vein; while other branches, going downwards, open into the venous circles of the fpinal marrow. But the cavernous finus of the dura mater, (cccxxv.) which is furrounded with a good deal of cellular fubftance, befides the finufes (cccxxix. cccxxx.) and large veins already defcribed, alfo receives the ophthalmic and principal vein of the dura mater; it likewife tranfmits peculiar veins, accompanying the firft, and fecond, and third branches of the fifth pair, the principal artery of the dura mater, (cccxvi.) and the internal carotid, (cccxvi.) and alfo through a foramen in the great wing, which is not conftant; it fends branches which inofculate with veins on the outfide of the fkull belonging to the jugulars, and efpecially with the large pterygoid plexus of the nafal veins.

In

In the fame manner, the veins of the pericranium pafs through foramina in the parietal bones into the longitudinal finus, the occipital veins through the maftoid hole into the tranfverfe finus, and the external vertebral veins through the anterior canal of the occipital bone, into the foffa jugularis; and others from 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 efcape from the finufes, wherein it is often collected in too great quantity, in various directions, according to the laxity or declivity of the part. Hence no violent fymptoms follow upon tying a vein, however large, or even both the jugulars.

CCCXXXIII. The quantity of blood which goes to the brain, the great impulfe with which it is fent into the carotid arteries, (CCCXIX.) the immunity of a part defended by bones from every kind of preffure; the flow motion of the blood through the abdominal vifcera and lower extremities; the perpetual exercife of the brain and fenfes, which determines an influx of blood to thefe parts, and other circumftances, caufe the head to be furprifingly filled with blood, immediately on any increafe of the circulation. Hence the rednefs of the face, the turgefcence of the eyes, the fparkling, the head-ach, the throbbing, the hæmorrhages from the nofe, which are fo frequently produced by violent exercife. Therefore, it is evident, that, if the veins in the brain were thin and round, the imminent danger of rupture and apoplexy, even now frequent, could not poffibly be avoided. On this account, to the veins which carry out the blood from the brain, nature has given another form more eafily dilatable, becaufe it makes an unequal refiftance; and another texture, of great firmnefs, and more difficultly ruptured, efpecially in the large finufes, which perform the office of trunks; for the fmaller finufes are either rounder, half cylindrical, or of

of an irregular figure. Within, nature has furniſhed the ſinuſes with croſs braces, formed of ſtrong membrane, paſſing from the right ſide of the bottom of the ſinus to the left, which, in exceſſive diſtentions, ſtrengthen the acute angle which is moſt diſtended, and ſecure it from rupture. She has likewiſe, in theſe veins, provided numberleſs inoſculations, both mutually amongſt themſelves, and with the external veſſels of the head, and with thoſe of the ſpinal marrow, that they may, with greater facility, diſcharge their ſuperabundant blood, (CCCXXXII.)

CCCXXXIV. Is arterial blood alſo poured into the ſinuſes of the brain? Do they pulſate, by being excited by that blood? It is allowed, that they have no pulſation; becauſe the dura mater every way adheres to the ſkull, and moſt firmly in the regions of the ſinuſes. They certainly receive liquors injected by the arteries. Whether are theſe exhaled through the ſmall veſſels, or do they, in the firſt place, circulate through the veins? The latter opinion is much more probable.

CCCXXXV. All the blood of the brain is finally conveyed into the jugular veins, which are very dilatable, and for that reaſon protected by valves, againſt the regurgitation of blood from the auricle, and ſurrounded with a great quantity of cellular ſubſtance. For the blood, which comes from the head to the vertebral veins, is very inconſiderable. The jugulars, ſo directly correſpond with each of the principal branches of the vena cava ſuperior, that they bring back the blood to the heart in the ſhorteſt way, and that the right one proceeds in a ſtraight line from the right auricle. They ſeparate nearly as the arteries, into a facial and cerebral branch.

CCCXXXVI. The external jugular is a cutaneous vein of the neck, which gives off the temporal one: it is united by a broad anaſtomoſis with the internal jugular at the baſis of the lower jaw; and ſends a branch

branch through the os mamiliare into the tranſverſe ſinus. The internal vertebral empties itſelf through the tranſverſe proceſſes of the neck into the tranſverſe ſinus, when the canal belonging to it is open.

CCCXXXVII. The ſinuſes of the ſpinal marrow, which are two in number, and lateral, run along its whole length, are joined at each vertebra by a ſemicircular arch, and are finally united with the jugular and occipital ſinuſes: they ſend branches, however, to the ſpinal marrow, communicating with the anterior and poſterior ſpinal veins.

CCCXXXVIII. In conſequence of the innumerable anaſtomoſes of the veins, the blood returns with the greateſt facility from the head, of which the repletion is attended with much danger. During inſpiration, the brain is alſo more eaſily evacuated, and ſubſides when the ſkull is opened; during exſpiration, on the contrary, it ſwells. Hence, blowing the noſe, ſneezing, and coughing, are dangerous to thoſe whoſe brain is turgid with retained blood.

CCCXXXIX. Have lymphatic veſſels been ſeen with certainty in the brain? They have been deſcribed in the large choroidal plexus, amongſt the fibres of the olfactory nerve, and in the pia mater. For my own part, I have never ſeen them, and it is probable that there are none, ſince there are no conglobate glands in the brain, which are always found near theſe veſſels. As for the various accounts which are given of the pituitary gland, of the infundibulum, and of the ducts which lead from thence into the veins of the head, abſorbing water from the ventricles, they are not ſupported by any anatomical demonſtration: which makes it probable, that the vapour, which is ſecreted into the ventricles of a healthy perſon, is, in like proportion, abſorbed again by the inhaling veins; and that if there be any exceſs, it deſcends through the bottom of the ventricles to the baſis of the ſkull, and into the

the looſe cavity of the ſpinal marrow. That this is the caſe, appears from palſies, which enſue after apoplexies; and from the watery tumours in the lower part of the ſpinal marrow, in hydrocephalic patients.

cccxl. It now remains for us to ſpeak of the encephalon itſelf. There are ſeveral parts included under this general denomination. By the brain, properly ſo called, we underſtand the upper part of that viſcus, which is contained in the ſkull, and which alone occupies its anterior portion; but behind, it lies above another part, called the cerebellum, which is ſituated in the poſterior and lower cavity of the occipital bone, under the tentorium. Its lower, middle, and white portion, lying under the brain, and before the cerebellum, is in part called the pons, and in part the medulla oblongata.

cccxli. The figure of the brain reſembles that of half an egg, which is deeply divided longitudinally, not through the whole, but through more than the half of its length, into hemiſpheres, reſembling the quarters of an egg. Both the upper and lower ſurfaces in man, are full of convolutions, which, with alternate round angles, pretty deeply divide the brain into undulated lobes. 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 theſe lobes, lies the cortex, which is extremely ſoft, and of an aſh colour, tinged with yellow or red. It is the moſt tender of all the parts in the human body. The internal parts are occupied by the medulla, which is almoſt white, but redder in the fœtus; perforated by very numerous, rectilineal and ſimple arteries, more ſolid and more capable of ſuſtaining its figure, notwithſtanding it is very ſoft, and in greater quantity than the cortex. The greater poſterior branch of the carotid artery (cccxvii.) divides each hemiſphere of the brain into a ſmaller anterior lobe, and a larger poſterior lobe.

cccxlii.

CCCXLII. The fabric of the cortex was long a ſubject of controverſy; but it is now ſufficiently evident, from anatomical injections, that much the greater part of it conſiſts of veſſels, which ariſe in every part from the branches of the pia mater, like footſtalks, enter into the cortical ſubſtance, and convey a fluid thinner than blood; and ſometimes, in diſeaſes from ſtrangulation, and in animals, eſpecially in birds, they receive even the true blood. 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 diſſimilarity, which would lead us to conjecture one part of it to be tubular, and the other part ſolid, is apparent in the cortex, in its healthy ſtate. Beſides, of the apparently uniform cortex, a greater portion becomes vaſcular, the greater the induſtry which has been employed in filling the veſſels, and the greater the tenuity of the injection. The idea of its being glandular, has been diſcarded by univerſal conſent; nor indeed was there ever any opinion received with leſs probability than this.

CCCXLIII. In order to underſtand the nature of the medulla, we are to conſider the internal ſtructure of the brain, compared with the brains of brute animals and fiſh. That part of the brain which lies immediately under the external convolutions, is of a white colour, and becomes gradually broader and more abundant; ſo that at length, it compoſes the whole oval ſection of the brain, except only cortical covolutions on its ſurface. In this part, the two hemiſpheres of the brain, which I before obſerved were not entirely divided, are united by a central portion of medulla. That part of the medulla which lies under the falciform proceſs, but at ſome diſtance from it, is called the corpus calloſum; in the upper ſurface of which run two parallel white ſtripes, formed by the pulſation of the arteries, diverging forwards, and terminated at the anterior

anterior commiſſure, and in like manner divided backwards. The anterior extremity of the corpus calloſum, is loſt in the ſubſtance of the crura cerebri, coming from the anterior lobes of the brain: the poſterior extremity, which is broader, with its ſhorter termination bent in the ſhape of a talon, penetrates inwards, and deſcends with another portion into the inferior horn of the ventricle; and with its longer termination is continued into the hippocampus. Moreover, the whole ſurface of this ſubſtance is ſtreaked with tranſverſe fibres, which are continued, but extenuated, into the adjacent medulla of the brain. Even its interior ſubſtance is of a ſtriated nature, and its lower ſurface has its raphe and tranſverſe fibres.

CCCXLIV. What follows is more difficult to be underſtood; for the brain is not ſolid, but from the bottom of its medullary portion, which is incumbent upon the multiform bone, where the greater crus of the brain paſſes out from it, a cavity commences, covered only with the pia mater, which gradually aſcends backwards, and then turning, continues its courſe forwards and upwards. Then it divides itſelf near the poſterior extremity of the corpus calloſum; and with its ſhorter poſterior portion it ends in the poſterior lobe of the brain, with its extremity directed inwards, and filled with the talon mentioned above; but its anterior portion is extended along the ſide of the corpus calloſum, parallel to the horizon, and with a horn increaſing in breadth outwards, it terminates in the anterior lobe of the brain. The cavity thus formed, of which there is one in each hemiſphere of the brain, and which do not communicate, is called the ventriculus anterior or tricornis. It is naturally filled with vapour, which is frequently condenſed into water or jelly.

CCCXLV. This cavity has no vacuity, for the upper and lower portions of the brain mutually touch each other.

other. Below, its floor is variouſly figured. Anteriorly, it conſiſts of a horn, having in its lower part an eminence, which is ſlightly convex, long, diverges backwards, is covered with an extremely vaſcular membrane, and is outwardly cinereous. They are called the corpora ſtriata; becauſe inwardly they exhibit, intermixed with much cortical ſubſtance, alternate white oval ſtreaks, parallel to one another, and longer behind, beſides leſſer ſpots and points, as if of medullary ſubſtance. More inwardly and poſteriorly, two other ſimilar eminences, more of an egg like ſhape, towards the third ventricle and other parts in a great meaſure cinereous on the outſide, and obſcurely ſtriated, incline towards each other, ſo that they frequently cohere on the upper part, by the intermixture of their cortical ſubſtance: theſe, going inwards and deſcending through the horn of each anterior ventricle to the baſis of the ſkull, generate the optic nerves, of which they are called the thalami. Between the corpora ſtriata and thalami, there is an intermediate, parallel, and white band of medullary ſubſtance, which is called the centrum ſemicirculare geminum, produced from the anterior commiſſure, and frequently from the crura of the fornix; but eſpecially from the medulla of the brain itſelf, before the thalami. This commiſſure, which is broad and ſtrong, joins together the anterior part of the brain before the thalami. The centrum geminum, which is broadeſt behind, ariſes with many fibres from the junction of the pes hippocampi with the medulla of the brain. The corpora ſtriata, with the thalami, conſtitute the medullary crura of the brain; which, in the baſis of the cerebrum, paſs over the medulla of the cerebellum, and are joined together at the anterior extremity of the bridge, to be deſcribed hereafter. Where they approach neareſt to one another, each ſends out an hemiſpherical eminence, called mamillary. The fibres of the medulla of the brain itſelf,

interwoven with the medulla of the cerebellum, defcend into the medulla oblongata; and, being then collected into a bundle, they go to the corpora pyramidalia.

CCCXLVI. The corpus callofum projects in the middle over the common axis of thofe ventricles. Behind, it refts contiguoufly upon the fornix. Before, two fimilar medullary partitions, which are called the feptum lucidum, triangular, united below, with their vertex inclined backwards, and including an anonymous central cavity, defcend from this body along the corpora ftriata, even to the union of the thalami. This feptum below is continued to the fornix, which is a ceiling fupported on four pillars, having its anterior origin from the medulla of the brain, and fometimes from the mamillary protuberances, and the commiffure which we have mentioned; and behind that, particularly under the thalami, often both from the centrum geminum and curved line of the thalami. This fornix is incumbent upon the interval between the corpora ftriata, and upon the interval between the thalami; and degenerates partly into a broad thin fimbria, the pes hippocampi, where it is divided into toes; and partly into other tubercles, which are continuous both with the fornix and corpus callofum, but more evidently continued from the latter, as larger, and are femi-cylindrical, having the fimbria attached to them. Thefe defcend into the lower anterior horns of the ventricles; and at laft terminate in an arch, convex outwards, and commonly divided by ten furrows, imprinted on it by the convolutions of the brain, and in a four toed hoof, whence the name of hippocampus, which is externally covered by an exceedingly thin medullary lamina, but internally confifts of cortical fubftance. At the beginning of the divifion of the pes hippocampi, the tænia ends in two white ftriæ, a long and a fhort one, inferted into this foot and into the brain, or in one inferted

into

into the moſt internal unguis. A like protuberance, continuous with the corpus calloſum, enters into the poſterior horn of the ventricle, crooked inwards at its extremity, like the ſpur of a bird, the poſterior part of the deſcending horn of the ventricle being occupied by a column continuous with it. Between the diverging poſterior crura of the fornix, the medullary portion, which is behind the middle plexus of the ventricles, and marked generally with tranſverſe and palmated ſtreaks, is called the pſalterium.

CCCXLVII. In the anterior and lower part of the ventricles, on each ſide, begins the choroid plexus, included in the pia mater only, lying naked in the reſt of the cavity of the ſkull, made up of a great many ſmall arteries (CCCXVII. CCCXVIII.) and veins originating from the large trunk, (CCCXXV.) all which numerous veſſels, joined together by the pia mater, reſemble a curtain variouſly folded. It is often, but not always, intermixed with many pellucid glands of a round figure, reſembling hydatids. It aſcends from the baſis of the brain, through the deſcending horn of the ventricle, and becomes dilated as it proceeds upwards; but afterwards becoming narrower, it goes along the optic thalamus, to the poſterior extremity of the ſeptum lucidum. When theſe plexuſes have reached the anterior extremity of the thalami, they cohere, and are continued with a remarkable vaſcular plexus, which gradually deſcends along the roof of the third ventricle as far as the pineal gland, and is continued into the pia mater of the poſterior lobes of the brain. From this proceeds the internal warmth of the brain, and it undoubtedly exhales and inhales. The choroid plexuſes are very broad where the anterior ventricles begin to deſcend; contracting gradually downwards, they project in the inferior anterior end of the ventricle, covered only by the pia mater.

CCCXLVIII. Between the thalami, applied to each other almoſt with a plain ſurface, there is a natural

 fiſſure,

fiſſure, which is terminated by the crura of the brain meeting together in the baſis of the ſkull: this is called the third ventricle. It leads by a perpendicular funnel, forwards into a cortical column; it is hollow in brutes, leſs evidently tubular in man, and connected to the pituitary gland.

CCCXLIX. This gland, flattened on both ſides, ſimple, of uncertain ſtructure; in the anterior larger part, almoſt round, and of a reddiſh colour; in the poſterior part leſs, cinereous, tranſverſely broad; covered with the pia mater of the brain; lies upon a proper depreſſion of the ſella turcica, and ſeems to be a kind of appendix to the brain.

CCCL. Backwards, the thalami, are conjoined in the bottom of the ventricle, by a central medullary faſcia, or poſterior commiſſure, and by a ſmaller tranſverſe chord; from which, on each ſide, an arched white band goes out in the upper part, which loſes itſelf in the centrum geminum, and in the anterior commiſſure, and ſometimes in the crus of the fornix. On the fore and upper part, the thalami have a protuberance, which is formed by the triangular fornix ſituated between the two thalami.

CCCLI. This eminence ſeparates the upper triangular cavity of the third ventricle, filled up with the fornix, from the inferior calamus ſcriptorius, ſo that the cavity is continued both to the anterior and poſterior extremity of the third ventricle, from the top to the bottom. But the anterior commiſſure is alſo a medullary band which unites the thalami before the anterior crura of the fornix.

CCCLII. For a poſterior, tranſverſe, figured eminence is applied to the thalami, which conjoins the medulla of the right and left poſterior lobes of the brain. It is marked behind by four oval eminences, which are outwardly ſmaller, called the nates and teſtes, and which conſiſt externally of ſome medulla, and internally of cortical ſubſtance.

The

The ſuperior ones in man are the largeſt, and are called the nates. Upon theſe is ſeated a cortical gland, ovally conical, ſupplied with many veſſels, into which the choroid plexus degenerates: this is the celebrated pineal gland ſo frequently diſeaſed, which is joined to the brain by ſmall footſtalks ſent into the linea alba through the thalami in their paſſage forwards. Between this eminence, marked with theſe four protuberances, and the crura of the medulla oblongata, a canal reſembling an aqueduct, and manifeſtly open, paſſes from the third to the fourth ventricle.

CCCLIII. The whole medulla of the brain below, is collected together in its baſis, into two very thick compreſſed columns, having their ſurface longitudinally marked with lines, and conſiſting externally of medulla with ſome cortical ſubſtance internally. Theſe 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 other deeper tranſverſe fibres, which ſeparate the inner fibres that come from the cerebellum from the preceding, conſtitute, together with the medulla cerebelli, the beginning of the medulla oblongata.

CCCLIV. 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 by a central ring of the ſame fabric with itſelf, called the vermis, at the ſide of which there is a broad ſmooth eminence of the ſame nature with the cerebellum. This part of the encephalon contains a great deal of the cortical, and little of the medullary ſubſtance. And here, likewiſe, the cortex is placed in the circumference, but marked with furrows, which are moſtly parallel, ſo as to form circular arches. Thus the lobules are defined,

ed. but not deeply, each of which contains its medulla, and by the gradual union of many of theſe medullary branches into one trunk, an arbuſcular appearance is produced. This medulla, collected together into the large crura of the cerebellum, and internally marked with ſerrated and intricate cortical lines, has a threefold termination. One part aſcends towards the baſis of the nates, where it joins the medulla of the brain under the teſtes; and the right is alſo joined to the left by a tranſverſe medullary band 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. The ſecond portion deſcends into the ſpinal marrow, and terminates in peculiar ſtudded protuberances, having other cortical protuberances adjacent, both of which are anonymous. The third portion, which is larger, and ſituated in the middle, going tranſverſely downwards, paſſes under the crura of the brain, which it embraces; and being twice alternated with their medullary fibres, (CCCLII.) by its own tranſverſe fibres, it is in a great meaſure blended with them.

CCCLV. Thus, from the crura of the brain deſcending over thoſe of the cerebellum, and from the medulla of the cerebellum tranſverſely ſurrounding that of the cerebrum, there is produced, in the firſt place, the pons, which is almoſt oval, but more flattened on both ſides, depreſſed in the middle, and every where marked with tranſverſe fibres. Then, continuous with the pons, the medulla oblongata is formed, which is internally variegated and ſtreaked with ſome cortical ſubſtance, is of a conical ſhape, and deſcends directly to the great foramen. This medulla has two pairs of tubercles before the pons; the outermoſt of the figure of an

an olive, and the innermoſt of a pyramidal ſhape, diminiſhing conically downwards: theſe are divided in the middle by a furrow, into which the pia mater enters. But betwixt this medulla and the vermiform proceſs of the cerebellum, is formed a cavity, limited by the four leſſer proceſſes, which aſcend and deſcend; at firſt it is narrower, but above the tubercles (cccliv.) it grows broader, and is of a rhomboidal figure: it is called the fourth ventricle, and is ſhut behind by the valvula magna, or medullary velum, which unites the proceſſes going from the cerebellum to the nates, and the vermis, with the tranſverſe band lying under the teſtes, and ſhuts the ventricle behind, (cccliv.) This ventricle has a moderate furrow, bounded on each ſide by tumid edges, inſcribed on the medulla oblongata, and correſponding to a canal which is covered by the nates and teſtes, and is called the aqueduct, (cccxlviii.) In this laſt ventricle, as in the foregoing, there is a plexus choroides, only leſs, and a ſulcus called calamus. Each of theſe ſulci is continued down along the medulla ſpinalis, the anterior moſt evidently, the poſterior leſs ſo. In the former, tranſverſe fibres are detached from the right to the left ſide, both in the medulla oblongata and ſpinalis. But two or three of the tranſverſe ſtreaks of the fourth ventricle, terminating in the ſoft nerve, ariſe from the eminences incloſing the ſulcus; others go to the eighth pair, and others of the ſame kind aſcend to the crus of the cerebellum.

ccclvi. All the medulla of the brain and cerebellum paſſes out from the ſkull, through different openings, to the places for which it is deſtined. The ſmaller bundles of this medulla we call nerves; but the larger, which is a continuation of the oblongata, we call the medulla ſpinalis. The nerves are medullary faſciculi, very ſoft in their origin, and compoſed of chords of fibres meeting from the brain,

brain, even there in ſome examples, diſtinct, ſtraight and parallel in the nerve. Theſe chords, after having proceeded ſome way, and being covered with the pia mater, which is ſomewhat red and firm, are united into a more conſtant faſcia; and then, conjoined with others of the ſame kind by cellular membrane, divided, and contiguous, go on to their proper opening in the dura mater, and run along its canals and intervals, till they meet with an opening in the ſkull, out of which they paſs through a funnel of the dura mater. The nerve, having arrived without the ſkull, is commonly ſurrounded by the dura mater, and becomes ſolid and firm. This is the caſe 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 naked and leſs defended, amongſt the muſcles, are compoſed of chords, each of which has its medulla, and its ſheath of pia mater. The ultimate chords of this kind unite into other larger chords, ſurrounded by much cellular ſubſtance, through which run many ſmall arteries and veins; and ſometimes fat itſelf is depoſited. But the general covering, common to the whole nervous bundle, is formed by ſome indurated cellular ſubſtance, often reſembling a true membrane, which envelopes them all, and combines them into one nerve.

CCCLVII. The whole of the nerves of the head ariſe from the lower part of the medulla of the brain or cerebellum. The olfactory nerve ariſes by a lateral fibre from the interval betwixt the anterior lobes of the brain, and by a direct fibre from the medulla of the anterior lobe itſelf. A great part of the optic nerve ſprings from the thalami, (CCCXLV.) but ſome part likewiſe from the crus of the brain, while the nerves decuſſate it. The third pair ariſes from the bottom of the crus of the medulla of the brain,

brain, behind the mamillary proceſſes. The fourth, whether ſimple or bifid, proceeds from the ſide of the proceſs of the cerebellum to the teſtes. The fifth ariſes plainly from the peduncles of the cerebellum. The ſixth from the bottom of the pons, from the deep ſulcus (cccliv.) between it and the medulla oblongata. The ſeventh ariſes with one portion, which is ſofter, poſterior and larger, from the medulla oblongata, and by two tranſverſe ſtriæ, from the fourth ventricle itſelf; and with another harder portion, from that part of the crus of the cerebellum next the pons. The eighth from the interval between the corpora olivaria and pyramidalia, out of a furrow of the medulla oblongata; and, according to the obſervation of other eminent anatomiſts, from the fourth ventricle itſelf. The ninth ariſes from the corpora olivaria and pyramidalia. The tenth is a nerve of the neck, as appears from its double root, its conjunction with the upper and lower adjacent nerves, and its place of origin. Therefore, no nerves ariſe properly from the cerebellum, unleſs the fifth and fourth; for the anterior nerves, the olfactory, optic, and third pair, come from the brain only; and all the reſt from thoſe parts where the medulla, both of the brain and cerebellum, are conjoined.

ccclviii. The ſpinal marrow is a very ſoft medullary rope, which deſcends from the medulla oblongata, as low as the ſecond vertebra of the loins. In the neck it is flat before and behind, and gibbous at the ſides; in the back it is almoſt quadrangular. It is largeſt where it goes out from the head; from thence it becomes ſmaller in the top of the neck, then larger at its lower part; again it is ſmaller throughout almoſt the whole back, but thicker at bottom; and laſtly, it ends in tubercles, one conical, another oval. Like the brain, it is inveſted with its own pia mater, which enters deeply into its anterior fiſſure, and almoſt divides the medulla

dulla into two. Within it has fome obfcure cortical fubftance; its anterior artery arifes in the fkull, from the branches of the vertebrals; it is retrograde, defcending through the whole length of the pia mater, perpetually making alternate finuous flexures, forming inofculations about many, but not all of the nerves, with branches of the vertebral, intercoftal, lumbar, and facral arteries; till at laft, covered with a peculiar coat from the pia mater, it goes out at the coccyx and difappears. Two pofterior arteries, fimilar, but fmaller, arife from the lower arteries of the cerebellum: thefe are more ferpentine, and have frequent mutual inofculations. The fpinal veins accompany the arteries in their defcent from the brain itfelf, and fend out branches in like manner, accompanying the nerves into as many circular finufes, fituated in the dura mater, as there are vertebræ, all of which fo communicate one with another, that each communicates with thofe above and below it, by a ftraight duct, in each direction, and, by a branch fent outwards, unites with the vertebral, intercoftal, lumbar, and facral veins. The uppermoft of thefe finufes inofculates with the anterior occipital finufes, (CCCLII.)

CCCLIX. But the fpinal marrow is furrounded by another covering, loofely and at fome diftance, which is not vafcular, but pellucid like water, tolerably firm and continued from the brain. It is called arachnoid, is longer than the pia mater, being extended to the bottom of the os facrum, and there it alone includes the bundle of contiguous nerves. But in what manner it accompanies the nerves in their paffage out, has not been hitherto defcribed. Between that membrane and the dura mater, there is a vapour, which is frequently condenfed into a reddifh water, and produces a true dropfy.

CCCLX. Laftly, the dura mater of the fpinal marrow is continuous with that of the brain, furrounds the

the arachnoides, in like manner defcends to the bottom of the os facrum, larger at its beginning, at the bottom of the neck, and at the loins, but flenderer in the back, and at laft terminates in a flender cone, attached by many ligaments to the periofteum of the os facrum. As the nerves pafs through this membrane, it gives them an external covering, which directly enlarges with them into a ganglion, or hard, oval, reddifh knot. To this dura mater in the intervals between all the nerves, a denticulated ligament internally adheres, which arifes from the fkull near the paffage of the ninth pair of nerves, and connects the arachnoid to the dura mater by triangular productions, in each of the intervals, between the anterior and pofterior bundles of the nerves down to the bottom, and twelfth vertebra of the back. Externally, the dura mater is furrounded by fome lubricating fatty matter, and then by the internal covering of the vertebræ, which are themfelves fo conftructed into a canal, that the fpinal marrow is not compreffed by it in any of its flexions.

CCCLXI. The fibres of the fpinal marrow appear diftinct in dropfical fubjects, and in brute animals. Thefe arife from the whole anterior and pofterior furfaces of the fpinal marrow; and commonly the anterior chords included in the pia mater, converge like rays into a larger fafciculus; to which a fimilar fafciculus of the pofterior filaments accedes, forming one nerve, which, paffing out through a hole of the dura mater, between every two vertebræ, produces a nerve. The vertebral nerves 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, fmaller; but fo that the lower and larger ones are commonly contiguous to one another. The large and long lumbar ones join to form the cauda equina. The loweft nerves of the os facrum are very fmall, the

the uppermoſt ones large. Many of the dorſal nerves, together with the lumbar and ſacral ones, covered with their proper pia mater, accompanied by their arteries, and incloſed in the arachnoid membrane, conſtitute that chord which is called the cauda equina.

CCCLXII. Thoſe nerves are diſtributed to all parts of the body in a very complicated manner, which does not admit of a deſcription in this place. But the following particulars cannot be paſſed over. All the ſpinal nerves, except one or two in the neck, after paſſing out of the vertebræ, have both an anterior and poſterior trunk. The former is ſent to the muſcles only. The latter forms a nervous root, which joining with its fellows, and with a ſmall acceſſory branch, which comes through the pterygoid canal, from the ſixth nerve of the brain, and the ſecond branch of the fifth, 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 to all the viſcera of the abdomen. It has as many ganglia as it has roots from the ſpinal marrow, unleſs when ſeveral of them join into one ganglion. It communicates variouſly with the crural, brachial, and diaphragmatic nerves, alſo with the par vagum and ninth pair. Another principal nerve is the eighth or par vagum, 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 chords, of which the larger ſends branches to the larynx, throat, the cardiac plexuſes themſelves, (XCIX.) lungs, œſophagus, ſtomach, and liver. The third of theſe is the phrenic nerve, ariſing from moſt of the lower nerves of the neck, and having received an augmentation from the brachial nerves, and ſometimes from the root of the ninth, it deſcends along the pericardium, and inſerts itſelf into the upper ſurface of the diaphragm; below, it is ſupplied from the great

great plexus of the intercoſtal nerve. Laſtly, the acceſſory nerve, ariſing by many ſmall roots from the ſix or ſeven uppermoſt poſterior cervical nerves, and from the medulla oblongata, returning into the ſkull, joins the eighth pair and ſeems to produce ſome ſympathy betwixt that important nerve and the ſpinal marrow. Finally, the nerves of the limbs originate from plexuſes, and are on account of their length, harder and larger, than the nerves which go to the viſcera : thoſe which go to the hand, ariſe from the four lower nerves of the neck, and firſt and ſecond of the back ; thoſe of the lower extremities from the nerves of the loins and os ſacrum.

CCCLXIV. The nerves divide into branches like the blood-veſſels, but in acute, and often manifeſtly retrograde, angles, growing gradually ſofter and ſmaller, though ſometimes they become thicker, as they recede from the brain ; at length, with 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 they are never divided in any ramification, but only recede from each other, where they had been connected by cellular ſubſtance. This appears from diſorders, confined to ſome particular parts, not extended to the whole, produced by affections of the brain ; as a loſs of the voice, deafneſs, dumbneſs, and palſies of particular muſcles. They are connected by cellular ſubſtance to the adjacent parts, have hardly any elaſticity ; do not contract on being divided, but only expel their medulla by the contraction of their integuments. In whatever way they are irritated, they do not contract, nor are they rendered ſhorter during the motion of the muſcles which they excite. A great many nerves are ſent into the muſcles ;

cles; many to the ſkin; fewer to the viſcera; very few to the lungs; and none to the dura or pia mater, arachnoides, tendons, capſules, ligaments, and laſtly the whole ſecondary membranes. Like the veſſels, they make frequent anaſtomoſes with each other, or out of one trunk they are divided into many branches: and it is principally in the concourſe of branches, ariſing from different trunks, that the ganglia are found. Theſe are hard nervous tumors, for the moſt part vaſcular, and included in a firm membrane, of which the uſe and ſtructure are uncertain, and in which the ſtraight courſe of the nervous fibres is interrupted. They are not found in the nerves of the ſenſes, or in the eighth pair; or in the phrenic nerves; or in the nerves of the extremities; but are peculiar to the ſpinal nerves, to the intercoſtal, which is in fact a ſpinal nerve, and to the fifth pair.

CCCLXV. Theſe are nearly what we have learned from anatomy concerning the brain and nerves; the phyſiological uſes of theſe parts remain to be inveſtigated. Every nerve which is irritated, by whatever cauſe, produces an acute ſenſe of pain. Senſation is a change of the mind, produced by a change of the body. It is the medullary part of the nerve which feels. If a nerve be appropriated to any peculiar ſenſe, that ſenſe periſhes when the nerve is compreſſed or divided; and the ſenſibility of the whole body is deſtroyed, when the brain is compreſſed; or of thoſe parts whoſe nerves originate below the ſeat of preſſure, if you compreſs the ſpinal marrow. If certain parts of the brain, from which particular nerves ariſe, be compreſſed, then theſe ſenſes only are loſt, as the ſight or hearing. Thoſe parts of the body which receive nerves, poſſeſs ſenſibility moſt acutely, when they receive many, as the eyes and penis; obtuſely, when they receive few nerves, as the viſcera; and thoſe which have no nerves, as the dura mater, tendons, ligaments,

ments, ſecundines, the broad bones, and cartilages, have no ſenſation.

CCCLXVI. It is extremely probable, that all ſenſation ariſes from the impreſſion of a ſenſible object on ſome nerve of the human body; and that the ſame being tranſmitted to the brain along that nerve, is at laſt repreſented to the mind, after it has reached the brain. It therefore 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, by the entire ceſſation of pain when a nerve is compreſſed, and by the diſeaſes of the ſenſes from injuries of the brain. That the effect of the ſenſes is preſerved in the brain, is evident from the loſs of memory which ſucceeds compreſſions or injuries of the brain; 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.

CCCLXVII. Another office of the nerves is to excite the muſcles into powerful action. When a nerve is irritated, the muſcle to which it goes is immediately convulſed; or the muſcles, if it ſend branches to ſeveral. This happens during the life of the animal, and a little after its death while all the parts are ſtill moiſt. By great irritation, other muſcles are thrown into convulſions, and even the whole body. Nor is it neceſſary that the nerve ſhould be entire; for even when it is cut, on being irritated, 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 again recover their mobility, when the compreſſion is removed, provided the nerve has received no injury.

CCCLXVIII. When the medulla of the brain is deeply wounded or irritated in its crura, dreadful convulſions enſue throughout the whole body; the difference of the part irritated produces no exception; nor does the brain, cerebellum, or corpus calloſum, enjoy any perogative in this reſpect. The ſame conſequences follow, if the ſpinal marrow be irritated. But if the encephalon itſelf be compreſſed, in any part whatever, there enſues a loſs of ſenſe and motion in ſome part of the body, which appears to be exactly that which has its nerves from the part compreſſed, according to obſervations of injuries of particular portions of the brain, in which the origin of the nerves being compreſſed, the voice is loſt; or the motion of one arm or leg, or of one ſide of the pharynx. In injuries of the ſpinal marrow, it is ſtill more evident, that thoſe parts which receive their nerves from the place injured, are convulſed if that be irritated, or rendered paralytic if it be compreſſed. But when any more conſiderable portion of the brain is compreſſed, either from blood, water, ſcirrhus, an impacted bone, or other mechanical cauſe, the greateſt part, or the whole of the body, loſes its power of motion; the voluntary organs, if the leſion be in a leſs degree, and all of them when it is greater; all theſe diſorders ceaſe upon removing the compreſſing cauſe. Laſtly, if the ſpinal marrow in the neck be injured, death quickly enſues; becauſe, from that part the nerves of the heart (XCIX.) principally ariſe.

CCCLXIX. Theſe things being conſidered, there ſeems to be no doubt, that all motion in the human body, proceeds in a great meaſure from the brain, and its annexed cerebellum and ſpinal marrow; and that it is thence conveyed through the nerves, to all the muſcles and parts of the body. Beſides, the cauſe of motion cannot reſide in the parts themſelves, ſince it would then remain after the brain is deſtroyed,

and would not be increaſed by irritating the brain, or weakened by compreſſing it.

CCCLXX. Is there in the brain any principal part, which is the origin of all motion, the end of all ſenſation, and where the ſoul has its ſeat? Is this proved by the frequent obſervation of the integrity of the ſenſes, and power of motion remaining after ſevere injuries of the brain? Is it in the corpus calloſum? Is this ſhewn by the greater mortality of wounds or diſeaſes in the corpus calloſum? Is this body ſufficiently connected with the nerves? Are there any experiments which derive from it the fifth, ſeventh, and other nerves? Does not the ſame, or even greater mortality, accompany wounds of the medulla ſpinalis? Yet this is not the ſeat of the ſoul, ſince, though it is compreſſed or even deſtroyed, the perſon will ſurvive a long time, with the perfect uſe of all his ſenſes. Nay this opinion is oppoſed by numerous 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.

CCCLXXI. Nor does the cerebellum enjoy the prerogative of exciting the vital actions, nor are the provinces of vitality and animality diſtinct; nor does the cerebellum generate 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, pterygoid, buccinator, temporal, and frontal muſcles, the ear, the eye, the noſtrils, all which are parts either moved by the will, or deſtined for ſenſe. Again, the ſame nerve, as the eighth, ſends vital branches to the heart and lungs, animal and voluntary ones to the larynx, and ſenſitive ones to the ſtomach. Laſtly, it is not even true, that diſorders of the cerebellum occaſion death ſo certainly and ſpeedily. For, from certain obſervations, even of

our own making, it has borne wounds and ſcirrhi, without taking away life; nor is it very different from the brain, being only ſofter and more tender; and, laſtly, we read, and that not very rarely, of wounds of the cerebellum being cured. The power, however, of this part, in exciting convulſions, is ſomewhat greater.

CCCLXXII. Concerning the ſeat of the ſoul, we muſt inquire experimentally. In the firſt place, it muſt be in the head, and not in the ſpinal marrow. For though the latter be affected, the integrity 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 not improbably, in the crura of the medulla, the corpora ſtriata, thalami, pons, medulla oblongata, and cerebellum. Finally, by another not abſurd conjecture, it lies at the origin of every nerve, ſo that the concurrence of the firſt origins of all the nerves, makes up the cenſorium commune. Are the ſenſations of the mind repreſented there, and 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 that would be a gratuitous ſuppoſition of immobility or inſenſibility, in ſome part of the nerve, though perfectly ſimilar to the reſt. Nor can the origin of motion (CCCLXIX.) be placed higher in the arteries, for they neither have feeling, nor are excited to voluntary motion. It therefore follows, that the ſeat of the mind, muſt be where the nerves firſt begin.

CCCLXXIII. We come now to the explanation of the manner in which the nerves are 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 our ſenſes and reaſon: but we ſhall endeavour to make

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as great an approximation to the truth as possible, by experiments. First, it is demonstrated, that sensation does not come through the membranes from the sentient organ to the brain, and that motion is not transmitted through the coverings from the brain into the muscle. For the brain itself, deeper than these membranes, receives the impressions of sense, and when injured 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 in all the nerves of the brain, more especially in the olfactory, optic, fourth and seventh pair, which continue their medullary fabric a long way before they receive the covering of the pia mater.

CCCLXXIV. We must, therefore, inquire into the nature of this medulla. It is a very soft pulp, harder in insects and idiots; in other respects every where alike. It is disposed, however, to be formed into fibres, or parallel threads, lying upon one another lengthwise. This appears from innumerable observations, especially in the corpus callosum, corpus striatum, thalami of the optic nerves, spinal marrow, in the brains of fishes, and especially in their thalami optici. Again, that the fibres of the brain are continuous with those of the nerves, so as to form one continued substance, appears very evidently in the seventh, 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.

CCCLXXV. But here a controversy begins concerning the nature of this fibre, which, with other similar fibres, composes the substance of the medulla and of the nerves. Many recent philosophers have supposed it to be a solid thread, and only moistened by vapour exhaling into the cellular fabric which surrounds the nervous fibres, and that, when it is struck by a sensible body, the vibration excited is conveyed to the brain.

CCCLXXVI. But the phenomena of wounded nerves will not allow us to imagine the nervous fibres to be folid. For, if a nerve when irritated, vibrate, (after the manner of an elaftic chord, which trembles when it is taken hold of,) the nerve ought to confift of hard fibres, fixed by their extremities to hard bodies, and tenfe; for chords which are foft, or not tenfe, or not fixed, do not vibrate. But all the nerves, at their origin, are medullary, and very foft, and exceedingly far from any kind of tenfion; and they retain the fame foft texture, and are not covered with membranes, where they pafs through well protected channels, as the intercoftal nerve and the fecond branch of the fifth pair; fome alfo are foft throughout their whole length; whatever fize they may be of: as, for example, the foft olfactory and acouftic nerves, in which laft we would moft readily expect tremor; as in found. Again, although the nerves be hard, they become foft in the vifcera, mufcles, and fenforia, before they act. Therefore, the nervous fibres, being neither tenfe in their origin, nor in their termination, cannot poffibly vibrate in an elaftic manner. But alfo, in particular and moft important cafes, they cannot vibrate; becaufe, through their whole length, they are firmly tied to folid parts, by means of cellular fubftance: for example, the nerves of the heart are tied to the great arteries, and to the pericardium. Finally, that the nerves are totally devoid of elafticity, is demonftrated by the experiment, in which the nerves, cut in two, neither become fhorter, nor draw back their divided ends to the folid parts; but are rather elongated from their laxity, and expel their medulla in form of a protuberance. Befides, the extremely foft medulla of the brain exhibits all the phenomena of pain and convulfions, which are produced by nerves, without any poffibility of tenfion.

CCCLXXVII. Add to this, that the motion of an irritated nerve is propagated downwards, and that muſcles that are ſeated above the place of irritation, are never convulſed. This is altogether inconſiſtent with elaſticity; for an elaſtic chord propagates its tremors from the point of percuſſion, to both extremities. But, if the phenomena of ſenſe and motion cannot be explained from the nature of elaſticity, the only probable ſuppoſition that remains is, that there is a liquor which comes from the brain, deſcends into the nerves, and flows out to the extreme parts of the body; the motion of which liquor, accelerated by irritation, operates only according to the direction in which it flows; and the convulſions cannot 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, by a ſenſible body, tranſmits its motion upwards to the brain; for then it is not reſiſted by a contrary ſenſorial torrent coming from the brain.

CCCLXXVIII. It is therefore probable, that the nervous fibrils, and the medullary fibres of the brain, which have the ſame nature, are hollow. Nor is the ſmallneſs of theſe tubes, which are not viſible by any microſcope, of any force againſt the propoſed arguments; nor the abſence of ſwelling in a tied nerve, which is not exactly true; with other arguments of the like kind, which indeed ſhow the weakneſs of our ſenſes, but have not any validity againſt the real exiſtence of nervous fluids. If they are tubes, it is very probable that they derive their fluids from the arteries of the brain.

CCCLXXIX. But the nature of this fluid is diſputed. Many, eſpecially the moderns, will have it to be extremely hard or elaſtic, ethereal, or even electrical; but the more ancient opinion is, that it is rather aqueous, incompreſſible, and albuminous. Indeed it is not to be denied, that there are

many

many arguments againſt admitting either of theſe opinions. An electrical matter is, indeed, the moſt powerful, and fitteſt for exciting motion; but then it cannot be confined within the nerves, but penetrates throughout the whole animal to which it is communicated, and fills with its energy the fleſh and fat, as well as the nerves. But, in a living animal, the nerves only, or ſuch parts as are pervaded by nerves, tremble when irritated; and, therefore, this liquid muſt be of a nature which permits it to flow through the nerves, and yet confines it within their tubes. Alſo a ligature on a nerve takes away ſenſe and motion, but does not ſtop an electrical current.

CCCLXXX. A watery and albuminous nature is common to moſt of the juices in the human body, and may be therefore readily imagined to exiſt in the nervous fluid, as indicated by the water which exudes into the ventricles of the brain from the ſame veſſels; by the gelatinons fluid, which flows out in cutting through the brain in fiſh, and the larger nerves of animals; and by the tumor which ariſes in tied nerves. But is ſuch a nature capable of explaining the wonderful force of convulſed nerves, obſervable in the diſſections of living animals, even the ſmalleſt, and in the great ſtrength of mad and hyſterical people? Is the hydroſtatic example of capillary tubes of any weight; which, although it may explain the ſtrength in the motion, is nevertheleſs inconſiſtent with the celerity?

CCCLXXXI. For, the nervous fluid, 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 imaginable loſs of time, and cannot receive the cauſe of its motions only from the heart. Moreover, it is very thin and inviſible, and deſtitute of all taſte and ſmell; yet reparable

reparable from the aliments. It is not on any account to be confounded with that viſible, viſcid liquor exhaling into the intervals of the nervous chords.

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

CCCLXXXIII. Therefore, upon the whole, it ſeems to be certain, that, from the veſſels of the cortex, a liquor is ſecreted into the hollow tubes of the medulla, which, being continued into the ſmall tubes of the nerves, and propelled to their extremities, is 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 cauſe, as motions ariſing in the brain.

CCCLXXXIV. The ſame nerves moſt evidently are ſubſervient both to ſenſe and motion; ſo that we are not allowed to adopt two diſtinct ſyſtems of nerves, one motory, the other ſenſitive. 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.

CCCLXXXV. What becomes of this nervous fluid, which cannot but be ſecreted in very great abundance, from ſo large a quantity of blood moved with ſuch velocity, if you compare it with the very copious ſecretion from more ſluggiſh blood, and at a greater diſtance from the heart, in the ſmall renal and meſenteric arteries? It is not improbable that it exhales through the cutaneous nerves; the laſſitude, ſupervneing in a few hours both to ſenſation and motion, and its removal by ſpirituous medicines,

medicines, ſhew that this liquid may both be loſt and repaired. Many have thought that it alſo exhales into various cavities of the body; as that of the ſtomach, and inteſtines. We may expect ſome part of it to be abſorbed, that the nobleſt fluid of the body may not be too quickly diſſipated. That it nouriſhes the body, is improbable: it is too moveable to expect adheſion from it: that is the office of ſlow and viſcid fluids.

CCCLXXXVI. What is the purpoſe of ſo many protuberances in the brain; of the ventricles, nates, and teſtes; of the diſtinction of the brain from the cerebellum; and of ſo many tranſverſe chords communicating from one ſide of the brain, cerebellum, and ſpinal medulla, to the oppoſite ſide?

CCCLXXXVII. The diſtinction of parts neceſſary for important uſes, ſeems to have produced the neceſſity of the ventricles. That the corpora ſtriata and thalami might keep their medulla diſtinct, it was neceſſary for a vapour to be interpoſed between them; and the ſame reaſoning is true with regard to the brain and cerebellum. Perhaps, likewiſe, the neceſſity of introducing warmth into the thick medulla of the brain, may have produced the neceſſity of a cavity through which the arteries may enter in great numbers and crowded together. Perhaps alſo it was proper, that, into 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.

CCCLXXXVIII. We are not yet acquainted with the uſes of moſt of the protuberances, and we ought to learn them from diſeaſes, and from anatomical experiments made on animals reſembling man. But we have little hopes of ſucceſs, in parts that are ſo ſmall, ſo deeply ſituated, and hardly ever to be touched, without inflicting a fatal wound. Do ſo many diſtinct provinces of ideas exiſt in them; as in

in the optic thalami? But moſt of theſe protuberances produce no nerves.

CCCLXXXIX. The internal bands and ducts ſeem to make ſome communication of motions, and perhaps of ſenſations. Some of theſe join the brain with the cerebellum; others join the ſpinal marrow with the nerves of the brain, as the acceſſory nerve; and moſt of them join the right and left parts together, as the anterior commiſſure (CCCXLV.) and the two poſterior (CCCL.) the corpus calloſum (CCCXLIII.) the ſtriæ between the proceſs from the cerebellum to the teſtes (CCCLIV.) and the medullary croſs bars, in the bottom of the third ventricle, and in the medulla oblongata and ſpinalis (CCCLV.) For this manifeſtly ſeems to be the reaſon why, as in infinite examples, from an injury of the right ſide of the brain, the whole muſcles of the left ſide of the body become paralytic, and the reverſe although it ſeems unaccountable, that this decuſſation does not always happen. Moreover, by this contrivance, nature ſeems to have provided, that, when any part of the brain is injured, the nerve ariſing from it is not always rendered uſeleſs. For if a nerve receive its fibres, both from its own hemiſphere of the brain, and from the oppoſite one, by communicating bundles, its office may, in ſome meaſure, be continued entire by the fibres which it receives from the oppoſite ſide, after thoſe of its own ſide are deſtroyed. Accordingly, we have numberleſs inſtances of wounds of the brain, even attended with a conſiderable loſs of ſubſtance, which yet have not been followed with permanent injury to any nerve, or to any of the mental faculties. Many of the other appearances, ſuch as the ſmaller ſtripes, reſemblances of nerves, and even protuberances, are produced in the brain from mechanical neceſſity, the pulſation of the veſſels, and the figure of the incumbent parts.

CCCXC.

CCCXC. We have ſaid, that the nerves are the organs of ſenſe and motion: we ſhall therefore proceed firſt to explain motion, becauſe it is more ſimple, uniform and perpetual, as it exiſts in the fœtus before moſt of the ſenſes.

CHAP. XI.

MUSCULAR MOTION.

CCCXCI. THE organ of motion in the human body is not ſingle. And, in the firſt place, in every animal and vegetable fibre, in hair, feathers, membranes, cellular ſubſtance, in the humid muſcular fibre, and, laſtly, in animal and vegetable gluten, there is a contractile power, by which they both reſiſt extenſion, and, when the extending power is taken away, acquire their former ſhortneſs; 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, and leave a wide gap in the middle; alſo arteries, when divided, contract themſelves in length.

CCCXCII. I call this force dead, becauſe it continues to act after death, and ſo far is different from the powers of life. In the living animal indeed it is ſomewhat more lively; for, both from cold and fear, the ſkin is ſtimulated, ſo that it grows harder, and erected, and along with this hardneſs contracts itſelf in length. Again, the cellular fibres are perpetually endeavouring 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

alſo

alſo reſiſts diſtention in another way, with a perpetual effort; and, by a gentle but continual approximation of its own elements, it propels the contained fat or water, or other bodies accidentally introduced. The ſame power alſo ſeems to limit the excretion of vapour; for when the fibres and plates of the cellular texture are preternaturally relaxed, an immenſe quantity either of fat or of watery humour is depoſited in that texture. 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. By an unknown or hidden power, it alſo ſeems to determine the ſhape of moſt parts of the human body; by expelling the gluten received into the cells, bringing the terreſtrial particles nearer to one another, and giving the proper ſolidity, curvature, and ſituation, to the different parts.

CCCXCIII. 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 a ſharp inſtrument. Theſe are the proper characteriſtics of the red muſcular fibre. The ſtructure of this fibre it is now neceſſary for us to conſider.

CCCXCIV. Muſcular fibres in the human body, are bundles of red threads, by which manifeſt motion is performed. When many of theſe fibres are collected together, and are evidently red, they are called a muſcle. The extreme ſimplicity of the fabric has been the cauſe of the obſcurity that prevails in underſtanding how ſmall and ſoft fleſhy fibres can produce, with ſuch ſtrength, moſt extenſive

ſive motions, both in man, and moſt eſpecially in the cruſtaceous inſects.

cccxcv. In every muſcle there are fibres, which are long, ſlender, ſoft, ſomewhat elaſtic, almoſt conſtantly parallel on the whole, and, ſurrounded with a good deal of cellular ſubſtance, are collected into lacertuli. Theſe bound together, by looſe cellular ſubſtance, generally with ſome fat, unite into larger bundles, which are always divided by cellular bands, and membranous partitions, till at laſt a number of them, either parallel or inclined, ſurrounded with a thin cellular membrane, continuous with their partitions, and ſeparated from the neighbouring muſcles by ſome coarſer cellular ſubſtance, conſtitute a ſingle muſcle. In every viſible fibre there appears a ſeries of filaments, which, by oblique extremities being mixed and agglutinated with others of the ſame kind, are combined into one larger fibre.

cccxcvi. The generality of muſcles, but eſpecially all thoſe which are inſerted into bones, and all which are preſſed ſtrongly by other fleſhy incumbent parts, do not conſiſt of fibres of one kind. For the fleſhy fibres (cccxcv.) being collected together, commonly compoſe the ſwelling in the middle of the muſcle, which is called its belly: theſe fibres degenerate by degrees at each end of the muſcle, become more ſlender and hard, and having laid aſide their red colour, acquire a ſilvery ſplendor, and being compreſſed cloſer together, are included in a ſmall quantity of ſhort cellular ſubſtance, are coloured with fewer veſſels, and become indolent and ſcarcely irritable: they are denominated tendons if they are collected into a narrow round chord, but if into a broad flat ſurface, aponeuroſes. The cellular texture which covers the whole tendon is called its vagina, and reſembles the coat of a muſcle. That fleſhy fibres actually change into tendinous, is rendered probable by comparing the fœtus,

fœtus, in which there are very few tendons, with a young perſon, in whom there are many more; and with an adult or old perſon, in whom are the greateſt number. Muſcles which are not inſerted into any bone, have commonly no tendons, as the heart, the ſphincters, the tongue, 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, and in that extremity which is moſt moveable. In the fœtus the muſcles are evidently inſerted into the perioſteum only; but in adults, where the perioſteum is intimately united with the bone, the tendons being blended with the perioſteum, adhere into the pits of the bone itſelf.

cccxcvii. 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, ſo that it grows thicker in its progreſs by continually receiving new fibres. This is called a pennated muſcle. Other tendons lie in the middle betwixt two plates of fibres, one on each ſide, meeting together in an obtuſe angle downwards. There are inſtances of ſeveral tendons pennated on each ſide, being conjoined into one muſcle. There are alſo other modes of union of the tendinous with the fleſhy fibres.

cccxcviii. Within the cellular tunic that ſurrounds the fibres, the arteries and veins are ſubdivided into rectangular reticulations, for the moſt part accompanying and contiguous to each other; thence the vapour and fat effuſed into the coarſe and fine cellular ſubſtance; thence their abſorption. Lymphatic veſſels run along the muſcles of the tongue, neck and face, but are difficultly demonſtrated in the limbs. Along with the blood-veſſels, nerves are alſo diſtributed through the cellular ſubſtance of the muſcles, more numerouſly than to other

other parts of the body, except the eye; they lay aſide their hard involucrum, become ſofter and vaniſh before they can be traced to their ultimate extremities. They enter the ſame muſcle in many parts, without preference to any particular one. In the tendons they cannot be demonſtrated. Nor are there any nervous fibres which ſurround and conſtringe the muſcular lacerti. Thoſe who have deſcribed them ſaw nothing but cellular ſubſtance.

cccxcix. The ſtructure of the ultimate fibre, conſidered as the elements of a muſcle, when inveſtigated by the microſcope in man and other animals, has always appeared ſimilar to the ſtructure of the larger fibres; and except very minute filaments, connected by cellular ſubſtance, nothing upon which we can rely has been obſerved. There is no ſeries of veſicles or chain of rhombs. Are theſe fibres hollow? Are they continuous with the arteries? Does the difference betwixt muſcular and tendinous fibres conſiſt in the latter being rendered ſolid by being compreſſed and having their fluids expelled? That the blood is not concerned, is proved by the ſlenderneſs of the fibres, which are ſmaller than the blood globules, by the whiteneſs of the muſcles, after the blood is waſhed from them, and by phyſiological reaſons (ccccxi.) And, in general, more ſtrength may be expected from a ſolid fibre.

cccc. A muſcle is endowed at leaſt with a threefold power. Firſt, the dead one, common to it with other animal fibres. Then another, which we have called the vis inſita, poſſeſſing different phenomena. For, in the firſt place, it is peculiar to life, and to the firſt hours after death, and it diſappears much ſooner than the dead one. Again, in moſt caſes, its action conſiſts in alternate oſcillations; ſo that moving to and fro, at one moment it contracts itſelf towards the middle; and at the next,

next, extends itſelf from the middle towards the extremities, and ſo on ſucceſſively for ſeveral times. Moreover, it is manifeſt, quick, and performs very conſiderable motions; the dead force, only ſuch as are ſmall and ſcarcely apparent. It is excited both by the touch of a ſharp inſtrument, and in the hollow muſcles by inflated air, by water, and every kind of acrimony, but more powerfully than by any other ſtimulus by electricity. Laſtly, it is peculiar to the muſcular fibre, and in no other part of the human body is it found poſſeſſed of the qualities above mentioned. But its phenomena deſerve to be more particularly explained.

cccci. It is natural to every muſcle to ſhorten itſelf, by retracting its extremities towards its belly or middle. In order to diſcover the moving power from the fabric which we have deſcribed, it will be of uſe to conſider the phenomena of muſcular contraction. Every muſcle when in action becomes ſhorter and thicker. This contraction of its length is various; leſs in ſome, more in others; and in particular inſtances very conſiderable, for example, in ſome of the ſphincters, iris, diaphragm and intercoſtals, inſomuch that it appears that the length of a muſcle may be contracted much more than one third, which computation was derived from an erroneous hypotheſis.

ccccii. The inteſtines are exceedingly tenacious of their vis inſita; they continue to contract, 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 the chick, and in cold blooded animals. Different muſcles are moſt readily excited, by different ſtimuli; as the bladder by urine, the heart by the blood, and the inteſtines by air. Though their nerves are removed, on their connexion with the brain cut off, muſcles loſe but little of their irritable nature. It appears alſo, that this irritable diſpoſition

diſpoſition is very widely extended through the animal fibre, from the examples of polypi and other inſects, which have neither brain nor nerves, and yet are exceedingly impatient of any ſtimulus; and from the analogy of plants, of which very many flowers and leaves open or contract, according to the various degrees of heat and cold, ſome even ſo quickly, that they are nothing inferior in this reſpect to animals. This power is totally different from any other known property of matter, and is new. It does not depend either upon gravity, or attraction, or elaſticity, for it is inherent in ſoft fibres, and is deſtroyed, when they become indurated.

CCCCIII. But that a cauſe of motion is conveyed through the nerves into the muſcles, is certain from the obſervations, already noticed (CCCLXVII. et ſeq.) For the nerve alone poſſeſſes feeling; alone conveys the dictates of the mind; and neither retains any influence over, nor receives any perceptions from any part, whoſe nerve is either tied or cut, or which has no nerve. 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 violently convulſed. When the nerve of any muſcle is cut or tied, or the part of the ſpinal marrow, or brain, from whence the nerve has its origin, is compreſſed, the muſcle becomes paralytic and feeble, and cannot by any power be recalled into action ſimilar to the vital one. But if the compreſſion be removed from the nerve, the muſcle recovers the power by which it is put into action. When the nerve is irritated below the place where it is cut, the muſcle to which that nerve belongs is contracted. Numerous experiments have been made, to prove this, eſpecially on the phrenic and recurrent nerves.

CCCCIV. This power is not the ſame with the vis inſita. The former is adventitious to the muſcle; whereas the latter is inherent in it. The former ceaſes

ceafes along with life; whereas the latter, according to certain experiments, fubfifts long after it. The former is fuppreffed, by tying a ligature upon the nerve, by injuring the brain, or by the exhibition of opium. The latter is not affected by thefe circumftances, but continues after the nerve is tied or cut, and even in the inteftines, though taken out of the body; it alfo exifts in animals deftitute of brain: parts of the body poffefs motion, which are deftitute of fenfation, while others poffefs fenfation, which are deftitute of motion. The will excites and removes the nervous action, but has no power over the vis infita.

CCCCV. In mufcular action, whether proceeding from the vis infita, or from the nervous power, the fibres are contracted towards the middle of its belly, and expand outwards: they are varied by tranfverfe wrinkles, and the whole mufcle becomes fhorter, and draws its extremities towards its centre, and therefore carries towards each other thofe parts with which it is connected, in the reciprocal proportion of their firmnefs. Mufcles, during their contraction, fwell, and at the fame time become hard, and, as it were, increafe their circumference every where. I have never obferved them to turn pale. Whether, on the whole, they are increafed in bulk, and acquire more in breadth than they lofe in length, is difficult to be known. They draw after them the paffive tendons, which of themfelves are neither moveable or irritable. The whole of a mufcle may be moved at once, or only a part of it: if one extremity is fixed to an immoveable part, that only is moved, which is capable of yielding.

CCCCVI. Do the arteries contribute in any way to mufcular motion, as indicated by the paralyfis of the lower extremities, produced by tying the aorta? Not at all, unlefs by preferving the integrity of the mufcles, and mutual relation of the parts, by fecreting vapour and fat, and by nourifhing them. For

by dividing or tying its artery, a muſcle does not become paralyſed, unleſs after a conſiderable time, when the muſcles begin to be deſtroyed by gangrene. The irritation of the artery has no effect on the muſcles. Moreover, it is impracticable to explain the motion of peculiar muſcles from a cauſe, which, proceeding from the heart, operates with equal force on all parts of the body. Laſtly, the influence of the will is confined to the nerves, and does not extend to the arteries or other ſolid parts of the body.

cccc VII. But the manner in which the nerves excite motion in the muſcles, is ſo obſcure, that we may almoſt deſpair of diſcovering it. And we do not even attempt to inveſtigate the vis inſita, which ſeems to be an increaſed attraction of the elementary parts of the fibre, by which they mutually approach each other, and accumulate contortions in the middle of the fibre. This force of attraction, which is implanted by nature in the moving fibre, is excited and increaſed by ſtimuli. The reſt is mere hypotheſis. As to nervous veſicles ſwelling by a quicker influx of the nervous fluid, they are inconſiſtent with anatomical truth, which demonſtrates the fibres to be cylindrical, and in no part veſicular; and likewiſe with the celerity with which muſcular motion is performed, and with the bulk of a muſcle being rather diminiſhed than increaſed during its action. The chains and rhombs of the inflated fibres are in the ſame manner repugnant to anatomical inſpection, and to the celerity; they would alſo occaſion an immenſe waſte of power, and render the muſcle but little ſhorter. The nerves want that irritable nature which is obſerved in the muſcular fibre; and beſides, it is by no means demonſtrable, that the fibres, ſo numerous, can ariſe from nerves, ſo few and diſtributed in a different direction, almoſt tranſverſely with reſpect to the muſcular fibres. The idea of nerves being diſpoſed round

arterial

arterial fibres, compreffing them by their elafticity, is founded upou a falfe ftructure of the fibre, which is gratuitoufly affumed to be filled with blood, and fuppofes nerves, where cellular fibres only can be demonftrated. Moreover, the phenomena of animals, which have neither brain or nerves, and are yet very capable of motion, demonftrate the fabric of the mufcles to be fufficient for their motion, even without nerves. Blood globules, filled with air, and the explanations derived therefrom, fuppofe a falfe nature of that fluid; namely, that elaftic air exifts, where it does not (CCLXXXI.) The animal fpirits are not of the nature of electricity.

CCCCVIII. If we may add any thing to the phenomena, we may fuppofe the nervous liquor to be of a ftimulating nature, forcing the elementary particles of the mufcular fibre to approach nearer to each other. The motive caufe which occafions the influx of the fpirits into the mufcle, fo as to excite it into action, feems not to be the foul, but a law eftablifhed by the Creator. For animals, newly born, or newly transformed, without any attempt, or exercife, know how to perform compound motions, very difficult to be defined by calculation. But the foul learns thofe things, which it performs, flowly, imperfectly, and experimentally. Mufcles, therefore, contract, which in a given time receive more of the nervous fluid, whether that be occafioned by the will, or by fome irritating caufe arifing in the brain, or applied to the nerve.

CCCCIX. Though the foul may be fuppofed to act in nervous motions, it cannot be admitted in thofe arifing from the vis infita. The heart and inteftines, alfo fome organs of the venereal appetite, are governed by the vis infita, and by ftimuli. Thefe powers do not arife from the will; nor are they leffened, or excited, or fuppreffed, or changed by it. No cuftom or art can fubject thefe organs of inherent motion to the will, or caufe a fatellite of vol-

untary motion to forget to obey the commands of the foul. It is fo certain, that motion is produced by the body alone, that we cannot even fufpect any motion to arife from a fpiritual caufe, except that which the will feems to excite in animals; and, even in the very organs of animal volition, a ftimulus will occafion the moft exceffive actions, in direct oppofition to the will.

CCCCX. There feems to be this difference between the mufcles obeying the will, and thofe which are governed by the vis infita, that the latter are more irritable, and are very eafily excited into action by a gentle ftimulus; as, for inftance, the heart and inteftines; which organs are moft manifeftly, and greatly, and conftantly, irritable. On the other hand, the mufcles which obey the will, are lefs eafily, and lefs durably irritable. Hence, they either need the agency of the will, or of a powerful ftimulus; by which, indeed, even thefe may be excited to action, independent of the will. Thus, it happens, that, in apoplexy, the mufcles which obey the will, being deprived of all influx from the brain, languifh, and become paralytic; while the vital mufcles, having no occafion for the operation of the brain, continue to be excited into contraction by their ftimuli; the heart by the blood, and the inteftines by the air and aliments.

CCCCXI. The ftrength of this action is very confiderable in all perfons, but more efpecially in madmen, and in fome ftrong men; fince frequently, with a few mufcles only, they will raife a weight, much greater than that of the whole human body. But even in healthy people, very flender mufcles have elevated 200 or 300 pounds. The mufcles of the back will even fuftain 3000. Notwithftanding this, much the greater part of the force or power exerted by a mufcle, is always loft, without producing any vifible effect. For all mufcles are inferted nearer the fulcrum, than the weights are appended;

ed; and therefore their action is leſſened, in proportion as their lever is ſhorter than that of the weight. Moreover, moſt of the muſcles are inſerted into the bones, eſpecially in the limbs, at very acute angles; whence, again, the effect which a muſcle exerts in action, is proportionably leſs than the effort which it exerts, as the ſine of the angle intercepted betwixt the bone and the muſcle, is leſs than the whole ſine. Again, the half of every muſcular effort is loſt, becauſe it may be conſidered as an elevating cord, drawing an oppoſite weight to its fixed point. Beſides, many of the muſcles are ſeated in the angle between two bones, ariſing from the one, and moving the other; and therefore, on that bone being moved, they are bent, and, like inflected cords, require a new force to extend them. Many of them paſs over ſeveral joints, each of which they bend in ſome degree, ſo that only a ſmall part of their effort remains to bend their proper joint. The fleſhy fibres themſelves of the muſcles very often form angles with their common tendon, whence a great part of their force is again loſt, and only that proportion of the whole remains, which is as the ſine of the angle of their inſertion to the whole. Finally, the muſcles move their oppoſed weights with very great velocity and eaſe, ſo that they not only overcome the equilibrium, but likewiſe add a conſiderable exceſs of velocity.

ccccxii. All theſe loſſes of power being computed, make it evident, that the force exerted by muſcles in action, is exceedingly great, and totally different from any mechanical proportion; ſince the effect is ſcarce $\frac{1}{60}$ of the whole force exerted by the muſcle, and yet a few muſcles, weighing but a few pounds, are able not only to raiſe ſome thouſands of pounds, but alſo with very great velocity. Nor is this to be reputed any defect of wiſdom in the Creator: for all thoſe loſſes of power were rendered neceſſary, on account of the

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ſymmetry of the body, of muſcular motion, and of the requiſite celerity and direction; whereas the contrary of all theſe is required in the mechaniſm of machinery. We may, however, certainly conclude from hence, that the action of animal motion is very powerful, ſince, in a ſmall organ, it can exert a force equal to ſome thouſand pounds for a conſiderable time, or even for entire days; nor does this ſeem to be otherwiſe explicable, than by the incredible celerity with which the influx of this fluid obeys the command of the will. But from whence this velocity proceeds, we are unable to ſay, and muſt reſt ſatisfied with knowing that there exiſts a law, by which, at a given volition, a given celerity is produced anew in the nervous fluid.

CCCCXIII. The equilibration of muſcular motion is aſſiſted by the action of antagoniſt powers. Namely, in all parts of the human body every muſcle is counterpoiſed by ſome counteracting weight, or by elaſticity, or by muſcles, or by a fluid which reacts upon hollow muſcles, by which it is expelled. This cauſe is the vis inſita, and operates continually, even while the muſcle acts; and ſo ſoon as the additional celerity derived from the brain remits, its action reſtores the limb or other part immediately to its former ſtate, in which there is an equilbrium betwixt the muſcle and its oppoſing cauſe. Whenever muſcles conſtitute the antagoniſt power, none of them can contract without extending their antagoniſts, by which the nerves being diſtended, and a ſenſe of uneaſineſs produced, a ſtill ſtronger endeavour towards reſtoring the equilibrium is excited. Hence, when a flexor muſcle is divided, the extenſor operates even in the dead body; and the reverſe.

CCCCXIV. But there are acceſſory means, by which the motions of the muſcles are rendered ſafe, certain and eaſy. The large long muſcles, by which the greater flexions are performed, are included in firm

firm tendinous ſheaths, which are drawn and tightened by other muſcles; for thus, while the joint is bent, the muſcle, though in a ſtate of contraction, remains preſſed againſt the bone, and a conſiderable loſs of power is avoided. But the long tendons, which are incurvated or extended over joints which are bent when they are moved, are received within proper braces, which have lubricated canals hollowed out in them, and which, at the ſame time that they do not interrupt their motion, keep the tendons ſteady, ſo that they neither can be diſplaced, nor get rigid under the ſkin, with pain and loſs of motion. In theſe tubular braces, a proper liniment is poured around the tendons. The ſame office is performed in ſome ſituations by perforated muſcles themſelves. In other parts, the tendons are either carried round eminences of bone, in order that they may be inſerted at greater angles into the bone which they move; or they are inſerted into another bone, from whence a different tendon deſcends under a much larger angle into the bone to be moved. In other parts, nature has carried the muſcles derived from convenient ſituations, in a contrary direction into the part to be moved, as it were round a pully. She has likewiſe ſurrounded the muſcles on all ſides with lubricating fat, both the fibrils, fibres, lacerti and muſcles; which fat, being compreſſed and effuſed amongſt the tumid muſcles and fibres, anoints the fibres, and preſerves their flexibility.

ccccxvi. Moreover, the effect of one muſcle is determined by the co-operation or oppoſition of others, which either hold firm the part from which the muſcle ariſes, or bend it, or elſe, by the concurrence of their action, change the action of the muſcle from its ſtraight courſe to its diagonal. Muſcles alſo aſſiſt each other, even though ſituated at a conſiderable diſtance, by the one keeping the bone ſteady, out of which the other ariſes. Therefore,

fore, the action of no muſcle can be underſtood from conſidering it alone; but all the others muſt likewiſe be conſidered at the ſame time, which are either inſerted into the muſcle itſelf, or into any of the parts to which the ſaid muſcle adheres.

CCCCXVII. By theſe muſcles variouſly conſpiring and oppoſing each other, are performed walking, ſtanding, flexion, extenſion, deglutition, and all the other functions of human life. But the actions of the muſcles are alſo generally uſeful. They accelerate the return of the venous blood, by compreſſing both the contiguous veins between the tumid muſcles, and the veins proper to the muſcles between their turgid lacerti, and by the force of that preſſure being determined by the valves towards the heart only, they aſſiſt the powers of the heart: they likewiſe return the fat to the blood; and agitate, and triturate the arterial blood, and ſupply it more quickly to the lungs. They influence the ſecretions and excretions, retarding or accelerating them; in the liver, meſentery, womb, &c. they promote the courſe of the contained blood, bile, and other juices, and leſſen the danger of their ſtagnation: they increaſe the ſtrength of the ſtomach, by the addition of their own, whereby digeſtion is promoted; inſomuch that all ſedentary and inactive courſes of life are contrary to the appointment of nature, and prediſpoſe to diſeaſes ariſing from ſtagnation of the fluids, and crudity of the aliaments. The large muſcles, which are placed round the belly, propel the blood contained in that cavity, and preſs it towards the heart. But by much action, the muſcles themſelves become indurated and tendinous, and they convert the cartilaginous and membranous parts upon which they are incumbent, into a bony nature; they increaſe the inequalities and proceſſes of the bones, and excavate the ſides contiguous to them; they obliterate the cells ſeat-

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ed in the diplöe, and bend the bones towards themſelves.

ccccxviii. Muſcles which are not excited by a ſtimulus, or for which the mind has no occaſion, become relaxed and ſoft; their wrinkles are ſmoothed out, their fibres are rendered longer, receding from the middle towards the fixed extremities; and the whole muſcle collapſes; the acceſſory cauſe of contraction, whatever it is, is removed; while that remains without which the muſcle never is, as long as it is alive. Nor is there any occaſion for antagoniſt muſcles, although they may aſſiſt. It has been aſked, What becomes of the ſpirit that is ſent from the brain? A part of it perhaps is exhaled; I ſuſpect a part to adhere to the fibre; and that this is the reaſon, that by exerciſe the muſcles grow ſtronger, and the limbs become thicker.

CHAP. XII.

TOUCH.

ccccxix. THE other office of the nerves and brain is ſenſation; that is, to ſuffer changes from the impreſſions of external ſubſtances in the parts of the body affected by them, and to undergo analagous changes in the repreſentations in the mind. We ſhall, therefore, firſt examine each of the ſenſes in particular; and then conſider what is common to all of them, and what happens in the mind from the changes in the organs of ſenſe.

ccccxx. Touch is underſtood in a twofold manner. For, by this term, in general, we call every change of the nerves, ariſing from heat, cold, roughneſs, ſmoothneſs, weight, moiſture, or dryneſs in external bodies, in whatever part of the body that change may ariſe. In this acceptation, touch is aſcribed

cribed to almoſt all parts of the human body, in a greater or leſs degree; as in different places of the body the nerves are more numerous, bare, or covered with thinner membranes; and in this ſenſe pain, pleaſure, hunger, thirſt, anxiety, itching, and the other ſenſations, belong to the ſenſe of touch.

CCCCXXI. But, in a ſomewhat different and more proper acceptation, the ſenſe of touch is ſaid to be the change from external bodies which is produced in the ſkin, more eſpecially at the ends of the fingers, and is repreſented to the mind. For, by the fingers, we moſt accurately diſtinguiſh the tangible qualities of bodies.

CCCCXXII. Indeed, in the ſkin we do not eaſily diſtinguiſh any particle which does not feel. But ſince the touch is commonly aſcribed in a peculiar manner to the papillæ, the ſtructure of the ſkin muſt be deſcribed. What is ſtrictly called the ſkin, is compoſed of a denſe web of very compact cellular ſubſtance, whoſe fibres are intermixed and interwoven, which renders it highly extenſible, contractile, and porous. Its ſtrata, which are expoſed to the air, and next to the epidermis, are more cloſely compacted; as they approach the fat, they are gradually relaxed, and reſolved into a ſofter cellular texture. It is more tender in ſome places, and in others firmer. It is pervaded by many ſmall arteries, which come from the ſubcutaneous ones: they are neither large nor long, but are numerous in ſome parts where the ſkin is red, as in the cheeks; in other parts they are fewer in number. The veins ariſe in great numbers from the ſubcutaneous reticulations: the nerves likewiſe in the ſkin are very numerous; but they vaniſh ſo ſuddenly, that it is very difficult to trace their ultimate extremities. Betwixt the ſkin and muſcles, there is cellular ſubſtance, into which the ſkin inſenſibly reſolved, degenerates, in moſt parts repleniſhed with

with fat, of which the little eminences form pits in the ſkin; but in ſome parts, as the penis, red part of the lips, &c. it is deſtitute of fat. There are very few parts in the human body where muſcular fibres are immediately contiguous to the ſkin, without any ſeparation by fat; for the dartos is only cellular ſubſtance, and has no muſcular fibres. There are ſome places where tendinous fibres are inſerted into the ſkin; as in the palms of the hands, and ſoles of the feet.

ccccxxiii. Throughout the ſkin in general, in moſt parts of the body of man or of the larger animals, on removing the epidermis, ſcarcely an unevenneſs is perceptible, unleſs very minute granulations, raiſed hardly any viſible height, and obtuſe. But in the ends of the fingers, papillæ, ſomewhat larger, but ſtill very difficult of demonſtration to the ſight, are ſeated in cavities of the cuticle, and receive nerves ſcarcely viſible; they are minute projections, formed of veſſels with one or more ſmall nerves, wrapped up in cellular ſubſtance. In the lips, after maceration, they appear long and villous; in the penis they are flaky; and in the tongue they are moſt evident, from the fabric of which we conclude, by analogy, with reſpect to the other cutaneous papillæ.

ccccxxiv. The ſkin is ſurrounded by another covering, which reſiſts completely the action of the air, and which coheres with the ſkin by an infinite number of ſmall veſſels, and by hairs paſſing through it. The outer ſurface of this covering, of a corneous nature, dry, inſenſible, not ſubject to putrefaction, deſtitute of veſſels and nerves, wrinkled in a particular manner, and reticular towards the ſkin, is called the epidermis. It is perforated by an infinite number of pores, of which the larger ones are perſpirative, and the ſmaller vaporiferous, and is connected with the ſkin by numerous minute veſſels reſembling down. By preſſure or burning,

ing, the cuticle grows thicker, by the addition of new plates, formed between it and the ſkin ; and is then ſaid to be callous. But even without diſeaſe, in negroes the two plates are diſtinct.

CCCCXXV. The inner ſurface of the cuticle, more ſoft, pulpy, half fluid, reſembling concreted mucus, is ſeparated with difficulty in Europeans, but eaſily in the African negro, in whom it is truly membranaceous, ſolid, and ſeparable ; and in the palate of brutes. It is incumbent on the ſkin, of which it receives the papillæ into ſoft pits. It is called the rete Malpighianum, although it be certain that it is not perforated in a conſpicuous manner, as a ſieve.

CCCCXXVI. That this reticular body is compoſed by the concretion of ſome fluid, tranſuding from the ſkin, ſeems very probable. The fabric of the cuticle is ſtill uncertain ; for ſince it is deſtitute of veſſels, is regenerated, and is inſenſible, it does not ſeem to belong to the organical parts of the body. Is it the outer part of the Malpighian mucus (CCCCXXV.) coagulated and condenſed by the air and by preſſure ; which is perforated in many places by exhaling and inhaling ducts, the mouths of which are cemented together by the interpoſed condenſed glue ? Is this opinion ſupported by the mucous expanſion upon the membrane of the tympanum ; by its diſſolution in water, as obſerved by eminent anatomiſts, though by others denied, in the cuticle of negroes ?

CCCCXXVII. Moreover, to the hiſtory of the ſkin belong the ſimple glands, which are ſeated in very many places under the ſkin in the cellular ſubſtance, and perforate it by their excretory ducts, and pour out upon the cuticle, in the hairy ſcalp, and in the convex ſurface of the ear, a fat ſoft half fluid liniment. Other ſebaceous glands, partly ſimple, and partly compound, generate in the face, though more ſlowly, a dry white liniment, but in the

the groins and armpits one more oily, with which the ſkin being anointed, ſhines, and is defended both from the air and from friction. They are found in all parts of the human body that are under the 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 great friction, as in the breaſts, armpits, groins, glans penis, nymphæ, anus and hams. They frequently ſend out hairs. Are follicles of this kind ſeated in all parts of the ſkin? Although anatomy does not demonſtrate them, yet it ſeems probable that they are preſent every where, as appears from the ſordes, collected about the whole ſurface of the body, ſeemingly of the ſebaceous kind. But another ſort of oily ointment (ccix.) is poured out upon the ſkin, through its pores, from the fat itſelf, without the intervention of glands, eſpecially where the ſkin is clothed with hair.

ccccxxviii. The hair and nails are alſo 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 ſkin of the head, cheek, chin, and breaſt in men; alſo, upon the forepart of the limbs, in the armpits, groins, and pubis. They ariſe from the ſubcutaneous cellular ſubſtance, originating from a little bulb, which is membranous, ſtrong, vaſcular, of an oval ſhape, and more lax towards the cellular texture, at which part it is alſo furniſhed with veſſels; in which little bulb another bulb lies hid, roundiſh at its beginning, but afterwards cylindrical, and ſurrounded with blood. In this ſecond bulb lies the hair, covered with a fatty humour. The hair, with both its cylindrical ſheaths, arrives at a cutaneous pore, goes out through it, and forces the epidermis into a ſimilar ſheath; whence the very great ſtability of the hair; after this the ſheath cannot be any longer ſeparated

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from the cortex; the filaments, and ſpongy and cellular matter, are continued throughout the whole length of the hair. The hairs grow naturally in the ſubcutaneous cellular ſubſtance; but, by diſeaſe, they are ſometimes formed in other ſituations within the fat. They grow continually; and when cut, are renewed by the protruſion of their medullary ſubſtance from the ſkin outwardly, and by the prolongation of the cuticle. In old age, the hairs, deſtitute of this medulla, dry up, ſplit, and fall off. Their colour is from the juice, which fills the internal cellular texture. They ſeem to exhale through their extremities, and poſſibly throughout their whole ſurface, as we may conclude from the conſtant protruſion of their medulla, which ought to have an end from the plica Polonica, and from the luminous rays that come out from the hairs of an animal electrified. The ſubcutaneous fat follows the courſe of the hairs, and is exhaled.

CCCCXXIX. The nails are of the nature and fabric of the cuticle, and fall off along with it, being in like manner inſenſible, and capable of reproduction. They are found upon the end of the fingers and toes, occupying their upper and back part, and correſpond to the tactile papillary apex, which they ſupport, and retain applied to the object felt. They ariſe from a ſquare root, between an internal ſtratum of the ſkin, mixed with perioſteum, and another external ſtratum, a little beyond the laſt articulation: they go out by a lunar cleft in the external plate of the ſkin, where the cuticle partly returns back towards the root of the nail, to which it adheres, and is partly laid over the outſide of the nail, and extended forward with it, forming its outer covering. The nail itſelf is ſoft when it is firſt produced, and in the part covered by the ſkin; but, by age, and contact with the air, it becomes harder, corneous, ſolid, and elaſtic, compoſed of long fibres cemented by gluten, ſeparated by ſulci,

ſulci, ſiſſile, and of many layers. The nail thus formed, extends itſelf to the extremity of the finger; and, through its whole extent, its internal ſtriated ſurface is lined by furrowed ſkin, blended with perioſteum, of which the filaments are firſt ſhort, afterwards longer, and thoſe which adhere near the point of the nail are the longeſt of all. Theſe are moſt intimately connected with the root of the nail. Beyond the adhering part of the nail, the ſkin again becomes free and unconnected with the nail, and has its own epidermis. A furrowed network is interpoſed betwixt the ſkin and nail, which is ſeparable and ſoft, for the protection of the papillæ; where the furrows are, it becomes gradually harder, ſo that at laſt it can ſcarcely be diſtinguiſhed from the nail. The tendons do not reach ſo far as the nail.

CCCCXXX. The ſubcutaneous cellular ſubſtance in very few places is without fat, on account of the neceſſary motion of the ſkin. Where it is repleniſhed with fat, it defends the warmth of the internal parts from the air; it renders the ſkin moveable upon the muſcles; it fills up the cavities between the muſcles themſelves; and contributes to the whiteneſs and beauty of the body. The ſkin, Malpighian mucus and cuticle, not only cover the external ſurface of the body every where, but likewiſe, where they ſeem to be perforated, returning inwards they gradually change their appearance. For the cuticle is manifeſt in the anus, urethra, vagina, cornea of the eye, auditory paſſage, mouth and tongue; nor is it wanting even in the ſtomach itſelf and inteſtines; although, by the perpetual emollition, its fabric be altered, and relaxed into their villous coat. Thus the true ſkin, being continuous with the internal fabric of the palate, tongue, pharynx, noſtrils, vagina, &c. changes every where into the white, thick, pulpy, commonly called nervous, coat of thoſe parts.

CCCCXXXI. What has been hitherto advanced, is sufficient to enable us to understand the nature of touch. The papillæ at the ends of the fingers, somewhat larger in the inside, beautifully disposed in spiral folds, probably somewhat erected by the attention of the mind, as appears from shiverings, from the nipples of women, from the prolapsus of an intestine, from the handling of tangible objects, and from gentle friction, receive the impression of the object on their nervous fabric, and transmit it to the trunks of the nerves, and to the brain. This is the sense of touch. It enables us to distinguish chiefly the roughness of objects; and has been possessed to so exquisite a degree by some persons, that they have been known to distinguish coloured surfaces by the touch alone. We perceive heat, when external bodies are warmer than our fingers; and weight likewise, when they gravitate more in comparison with their bulk than usual. Humidity we judge of by the presence of adhering water; softness, by the yielding of the object; hardness, by the yielding of the finger; figure, by the hard limits circumscribing them; distance, by an inaccurate calculation derived from experience, to which the length of the arm serves as a measure, &c. Touch corrects the errors of our other senses, although it sometimes errs itself, and though other senses, independent of touch, furnish animals with just perceptions.

CCCCXXXII. The mucous body of Malpighius moderates the action of the object touched, and preserves the integrity and softness of the papillæ. The cuticle excludes the air from the destructible skin; moderates the impressions of bodies, so that they may be only sufficient to affect the touch, without causing pain: and, therefore, when thickened by use, the sense of feeling is lost; but, if it be too soft, the touch becomes painful. The hairs defend the cuticle from friction, generate and preserve the heat,

heat, conceal ſome parts, and render the membranes of others irritable, which require to be defended againſt the entrance of inſects; and perhaps they excrete ſomething excrementitious, and afford a paſſage to the exhaled oil. The nails are ſubſervient to the touch, by reſiſting the object touched, ſo as to prevent the papillæ from yielding, and being bent back; they increaſe the power of apprehenſion, and aſſiſt in the handling of minute objects. In moſt animals, they ſerve as weapons of offence; and would be of the ſame uſe to man, if they were not cut.

CCCCXXXIII. Theſe are not all the uſes of the ſkin. For a moſt important office of that covering is to exhale from the body a large quantity of humours, and to abſorb others from the air. Accordingly, the whole ſurface of the ſkin, by an infinite number of ſmall arteries, both prolonged into the papillæ, and ſeated in the ſkin itſelf, exhales a vapour which exudes through correſponding pores of the cuticle; but when the poſition of the veſſels is changed, it is effuſed between the cuticle and ſkin. Theſe arteries are eaſily demonſtrated by injecting water or iſinglaſs into the arteries; for then, from all parts of the ſkin, an infinite number of ſmall drops exude, which being effuſed under the cuticle, rendered impervious by death, raiſe it up in bliſters.

CCCCXXXIV. During life, this exhalation is demonſtrated in many ways. A bright mirror, when held near the warm and naked ſkin, is quickly obſcured by a moiſt vapour. In ſubterraneous caverns, where the air is denſer, it moſt evidently eſcapes into the air, from the whole ſurface of the body, in the form of viſible and thick clouds.

CCCCXXXV. In man, and in ſome, though not in all animals, whenever the motion of the blood is increaſed, while at the ſame time the ſkin is hot and relaxed, from the ſmall cutaneous pores, inſtead of an inviſible vapour, ſweat exudes in the form

form of minute, but viſible drops, which, with others of the ſame kind, run together into larger drops. The hotteſt parts are moſt ſubject to ſweat, as the head, breaſt, and folds of the body. The experiment before mentioned (ccccxxxiii.) together with the ſimplicity of nature, the viſible denſity of the cutaneous and pulmonary exhalation (ccccxxxiv.) perſuades us, that ſweat is diſcharged through the ſame veſſels which are the organs of perſpiration, and that it differs only in its quantity and celerity, and by the admixture of the liquor of the ſebaceous glands (ccccxxvii.) and the ſubcutaneous oil, which being diluted by the more plentifully ſecreted arterial fluid, exude of an oily and yellow conſiſtence, and chiefly cauſe the ſmell and colour of the ſweat. Hence, it is more fetid and yellower in the armpits and groins, where thoſe glands are moſt numerous. Both blood and ſmall ſand have eſcaped from the ſkin along with the ſweat.

ccccxxxvi. The nature of perſpiration muſt be inveſtigated by experiments, and by its analogy with the pulmonary exhalation, which, in like manner, but more frequently becomes viſible in a cold air. That this exhalation is chiefly water, has been proved by experiments, in which the breath, being received into large veſſels, has condenſed into watery drops. This is confirmed by the tenuity of the cloud on the mirror, and its volatility, and by the familiar change of the perſpired matter, when obſtructed, into a diureſis or diarrhœa, and from the eaſy determination of warm liquors to aſſume the form of perſpiration by heat, or of urine by cold. This water is derived from our drink, which furniſhes a great part of the perſpiration, and from inhalation. Frequently, even the odours of our aliments may be plainly perceived in the perſpiration; there is alſo an admixture of the electrical matter in every perſon, and in ſome it is evidently lucid.

ccccxxxvii.

CCCCXXXVII. That it alſo contains ſome volatile particles of an alkaline nature, is evident, both from the nature of our blood, and from the conſiderable evils which ſucceed the retention of the perſpiration, moſt conſpicuouſly in acute diſeaſes, when, by being repelled inward, it renders the urine pale, and from the corruption of the air by reſpiration. This volatile alkaline matter ariſes from the particles of the blood, attenuated by perpetual heat and trituration, and changed into an acrimonious nature. Dogs trace theſe odours, and could not know their maſters unleſs ſomething of a particular nature were perſpired from each perſon.

CCCCXXXVIII. The quantity of the matter perſpired is very large, whether we conſider the extent of the organ ſecreting it, the quantity of vapour exhaled by the lungs alone, or the experiments of Sanctorius, by which it would ſeem, that of eight pounds of food and drink, five pounds, or, according to other experiments in a colder country, from thirty to fifty-ſix ounces areperſpired, which neither add to the weight of the body, nor eſcape by any viſible excretion, except the ſaliva, ſweat, and mucus of the noſe. But the cutaneous exhalation is even much larger than this ; ſince it not only throws off ſuch a proportion of the alimentary matters, but likewiſe rediſcharges what the blood acquires by inhalation (CCCCXLII.) In this, however, the different ſtates of the air, and of the body, have great influence. In warm countries, in the ſummer months, and in young active perſons, more goes off by tranſpiration, and leſs by the urine. But in cold climates, during the temperate and winter ſeaſons, in aged or inactive perſons, more goes off by the urine than by the inſenſible perſpiration. In temperate countries, making a computation throughout the whole year, ſomething more is perſpired than what paſſes off by urine ; and, by collating all the experiments made in different countries, both ex-

cretions are almoſt alike. It is alſo ſomewhat affected by the difference of time after eating; and the law which ſeems to obtain, is, that the perſpiration is moſt copious at that time when the alimentary matters, being moſtly digeſted, and received into the blood, are fitted for exhalation. It is naturally diminiſhed during ſleep, even in the warmer climates; but it is increaſed by the heat of the bedclothes.

ccccxxxix. In general, a plentiful and equable perſpiration, at the ſame time that the body is ſtrong, are good ſigns of health; for exceſſive perſpiration, when conjoined with debility, is obſerved to do more miſchief than its entire ſuppreſſion, if what has been written on this ſubject is ſufficiently to be depended on. It is a ſign of health, becauſe it denotes the perviouſneſs of the veſſels diſperſed throughout the whole body, and the complete digeſtion of the aliments, of which a great part is reſolved into halitus. When it is diminiſhed, it indicates conſtriction of the ſkin, weakneſs of the heart, and imperfect digeſtion. When exceſſive, it perhaps waſtes the nervous ſpirits. This diſcharge is, by moderate exerciſe, increaſed to ſix times that of a perſon at reſt, to the extent of a pound in an hour, or even in half an hour. It is farther increaſed, if aided by ſtrong and open veſſels, by warm, watery, and cordial drinks, by food of eaſy digeſtion, by a denſe and temperate atmoſphere, and by cheerfulneſs. It is diminiſhed or ſuppreſſed by the contrary cauſes; as a denſe ſkin, a moiſt, or a cold and dry atmoſphere, reſt, an increaſed flow of urine, the ſupervention of a diarrhœa; and laſtly, nervous agitation, from a diſagreeable affection of the mind. However, the continuance of life does not depend ſo intimately on this diſcharge, which is ſo eaſily, and without bad conſequences, increaſed or diminiſhed by ſlight cauſes; and is ſo inconſiderable, in many nations, anointing their ſkins with oil,

oil, and in many animals. When by being ſuppreſſed, it produces ſuch bad effects in fevers of a bad kind, it hurts chiefly by the putreſcent particles, which are retained by the perſpiration being ſuppreſſed.

CCCCXL. The ſweat is evidently of a ſaline nature; as appears both from its taſte, and from the cryſtals which form upon the clothes of glaſs blowers; and by diſtillation, which demonſtrates its alkaline nature. Hence, by this diſcharge, the miaſmata of the moſt peſtilential diſeaſes are frequently expelled. But, in reality, ſweat is always a preternatural diſcharge, and ought never to exiſt in a healthy perſon, unleſs by violent bodily exerciſe, he have induced a temporary diſeaſe. It alſo is frequently injurious in acute diſeaſes; by waſting the water of the blood, ſo that the reſt becomes thicker, and the ſalts more acrimonious. By violent exerciſe, or the heat of the climate, the ſweat is rendered extremely fetid, and even ſanguineous; being electrical, it ſometimes is lucid.

CCCCXLI. The uſes of perſpiration are, to free the blood of its redundant water, of its alkaline impurities, rendered more acrid by repeated circulations; and of an extremely volatile oil, probably prepared from the ſame blood. The ſame perſpiration likewiſe qualifies and ſoftens the cuticle, and preſerves the neceſſary ſoftneſs of the papillæ.

CCCCXLII. But the ſame ſkin, which has veſſels exhaling into the air, is likewiſe repleniſhed with veſſels, which abſorb thin vapours from the air, either perpetually, or at leaſt in a moderate degree of cold; in a moiſt atmoſphere; in the night time, when the body is at reſt, the mind depreſſed, and under circumſtances, contrary to thoſe mentioned above, (CCCCXXXVIII.) which increaſe perſpiration. Theſe veins are demonſtrated by anatomical injections, which, if thin or watery, exude through them in the ſame manner as through the arteries: moreover,

moreover, by the manifeſt operations of medicines, diffuſed in the air, or applied to the ſkin: of vapours, mercury, turpentine, ſaffron; of baths, mercurial plaſters, tobacco, coloquintida, opium, cantharides, arſenic; by the fatal effects of poiſons, abſorbed by the ſkin; as the venereal poiſon; by the living of animals, without drink, in hot but humid iſlands; by the perſpiration and urine being ſufficiently copious in ſuch ſituations, without much drink; and laſtly, by extraordinary morbid caſes, in which the quantity of urine diſcharged has far exceeded the drink taken in; in which it is probable, that the inhaling pores were more open; for that new ones were generated, is not credible. It is difficult to aſcertain its quantity; that it is very great in plants, in the night time, is proved by certain experiments.

CCCCXLIII. Both the exhaling and inhaling veſſels, may be contracted and relaxed by the nervous power. This appears from the effects of the paſſions of the mind; which, if lively and exhilirating, relax the exhaling veſſels, by increaſing the impulſe of the influx of blood; and by the remiſſion of the nerves; hence redneſs, moiſture, and turgeſcence of the ſkin. Thoſe paſſions which are languid and depreſſing, contract the exhaling veſſels; as appears from the dryneſs of the ſkin, produced by them; from the gooſe ſkin, by terror; and from diarrhœa, cauſed by fear. They alſo ſeem to dilate the inhaling veſſels, whence fear facilitates the action of the ſmallpox and the plague.

CHAP. XIII.

TASTE.

CCCCXLIV. THE organ of tafte differs but flightly from that of touch. It appears, by certain experiments, to be feated in the tongue chiefly; for neither does fugar, applied to any other part of the mouth, excite the leaft fenfe of tafte in the mind; nor any other fapid body, unlefs it contain fomething vehemently penetrating; in which cafe, the palate, root of the tongue, uvula, and even the œfophagus, are affected by the fapid acrimony. That fenfation, which is fometimes excited in the ftomach, œfophagus, and fauces, by the regurgitation of the aliments, feems alfo to belong to the tongue, to which the fapid vapours are applied.

CCCCXLV. Only the upper furface and lateral edges of the tongue are fitted by nature to exercife the fenfe of tafte. By the tongue we underftand a mufcular body, lodged in the mouth, obtufe, very broad in man, and divided in the middle by an obfcure fulcus. Its pofterior and lower parts are varioufly connected to the adjacent bones and mufcles; its anterior and upper parts are moveable. In that portion which conftitutes the organ of tafte, the fkin continuous with that of the face and mouth, adheres to the mufcular flefh, but is pulpy and foft, from the perpetual warmth and moifture. From this fkin arife innumerable nervous papillæ, of a more confiderable fize here than in other parts. Of thefe there are feveral kinds: the firft kind confifts of nine or ten, at the back part of the tongue, difpofed in a line on each fide of the foramen cæcum. Thefe, furrounded by a circular groove, for the moft part refemble an inverted cone, and have a deep finus in their middle; but are otherwife hard, and but indifferently adapted for tafting, although you can

can eaſily trace nerves into them. There are ſome other papillæ of the ſame kind found ſcattered before theſe upon the back of the tongue.

CCCCXLVI. Theſe degenerate into the fungiform claſs of papillæ, which are found diſtributed over the upper ſurface of the tongue, leſs and ſlenderer than the former, always becoming more pointed as they proceed forwards, till around the edges of the tongue they are crowded together, and diſpoſed in diverging lines. The third ſort of papillæ are conical. Theſe are by far the moſt numerous; are diſperſed among the former, and are ſpread copiouſly over the tongue. The moſt anterior of them in the apex of the tongue, are more inclined and fluctuate; they are moſt remarkably numerous in the edges of the tongue; there are even ſome behind the foramen cæcum. They are highly ſenſible, and conſtitute the true organ of taſte: other papillæ are intermixed, partly conical, and partly filiform; and of the conical ones ſome are larger, and others ſucceſſively ſmaller.

CCCCXLVII. Theſe papillæ, beſides numerous veſſels, are ſupplied with nerves which may be traced into the larger papillæ, and with which the tongue is more largely ſupplied than almoſt any other part. For, beſides a nerve of the eighth pair, which, with one of its principal three branches, enters deeply into the baſis of the tongue, covered by the cerato-gloſſus, near the os hyoides; there is alſo a conſiderable nerve that goes to the muſcles of the tongue, from the ninth pair; which having inoſculated with the firſt nerve of the neck, and with the large cervical ganglion, and having ſent a branch downwards, often uniting with the eighth pair, and conſtantly with the ſecond and third of the neck, and ſupplying the muſcles ariſing from the ſternum, and frequently communicating with the phrenic nerve, proceeds with the reſt of its trunk to the tongue. This communicates in the cerato-gloſſus,

rato-gloſſus, by many branches, with the fifth pair, and is chiefly ſpent upon the genio-gloſſus. Laſtly, the third branch of the fifth pair having ſent upwards or received the cord of the tympanum, and given other branches to the internal pterygoid, and biventer; to the maxillary gland, forming with theſe a ganglion; to the ſublingual gland, and croſſing with its principal trunk the cerato-gloſſus, where it is united with the ninth pair, comes to the tongue, in company with the deep ſeated artery, with which it penetrates to the tip of the tongue, where it becomes cutaneous. To this nerve, therefore, if there be any preference, the ſenſe of taſte is to be eſpecially aſcribed, which is even confirmed by morbid examples. Laſtly, the papillæ of the tongue are of a hard texture; a firm, pulpy, cellular ſubſtance uniting the arteries, veins and nerves into maſſes, of which many compoſe one large papilla.

CCCCXLVIII. The arterial and venous villi, which run between the papillæ, are for the purpoſes of exhalation and inhalation, and have nothing to do with taſte, farther than that they ſeparate from the blood, a liquor proper for diſſolving ſalts, and for keeping moiſt the papillæ, which they pour out on the back of the tongue. On the upper and back part of the tongue, are ſeated many ſimple muciferous glands, opening by one or more outlets, and of a round ſhape, formed by an hemiſpherical membrane, and the fleſhy part of the tongue. Some of theſe open into an obſcure blind cavity, of an uncertain figure, which is placed in the middle of the largeſt papillæ, (CCCCXLV.) and commonly contains ſome of them.

CCCCXLIX. The papillæ of the human tongue are covered only by a mucous, ſemipellucid membrane, which adheres cloſely to them, and ſerves them as a cuticle. But, in animals, a perforated network receives

receives the papillæ, which enter into hollow cornuted ſheaths.

CCCCL. Under the papillæ lies the muſcular ſubſtance of the tongue, compoſed of various muſcles, but in man hardly extricable. The lower part is in a great meaſure made up of the genio-gloſſus muſcle extended outwards from the commiſſure of the chin, and diſtributed like rays upon the tongue. The upper and lateral parts are compoſed of the ſtylo-gloſſus, whoſe fibres run to the tip of the tongue. Its middle part between theſe is compoſed of the proper lingual muſcle, which ariſing from itſelf before the pharynx, and from the ſtylo-gloſſus, but deeper, proceeding forwards, is terminated there, and in the genio-gloſſus muſcle, and between that and the ſtylo-gloſſus, conſtitutes a conſiderable part of the tongue. The back part is formed by the cerato-gloſſus, of which the fibres aſcend upwards and backwards, and which is included between the ſtylo-gloſſus and lingualis, and by the chondro-gloſſus, an entirely different muſcle, which ariſes from the ſmall bones of the os hyoides, and the neareſt part of its baſis, from whence paſſing outwards, covered by lateral layers of the genio-gloſſus, and joining the ſtylo-gloſſus, it diſappears in the tongue. By the action of theſe muſcles, the whole tongue is moveable in all directions, and is capable of varying its own figure, becoming concave when elevated by the ſtylo-gloſſi, being again flattened by the cerato-gloſſi, being rendered narrower and almoſt cylindrical, by the tranſverſe fibres of the tongue; beſides which, there are other orders in the human tongue inextricable and intermixed with much tenacious fat.

CCCCLI. The arteries of the tongue are numerous. The largeſt, which is deep ſeated and ſerpentine, comes from the external carotid, and extends along the lower part to the tip of the tongue; a ſmaller ſuperficial artery, incumbent on the ſublingual gland,

gland, and inosculating with the preceding, arises either from it, or from the labial. Other small posterior arteries arise either from branches of the labial, or from the tonsillaris. The veins of the tongue are variously intricated, and difficult to describe; one, lying deep, accompanies the nerve of the ninth pair; another, superficial, accompanies the mental artery, and, inosculating with the former, forms the ranular vein; but all of them tend towards that large vein, which is a different branch of the internal jugular, from the cerebral one. They variously communicate with the adjacent tonsillary, thyroid, pharyngeal, and cutaneous plexuses; and on the back of the tongue, before the epiglottis, those of the right and left sides are interwoven with each other. I find lymphatic vessels rather in the neighbourhood of the tongue, than in the tongue itself.

CCCCLII. The papillæ of the tongue, being larger and softer than those of the skin, and perpetually moist, perform the office of touch more exquisitely than those of the skin, which are dry and small; hence the tongue suffers more acute pain: moreover, the cutaneous papillæ receive no other sensations from salts than those of moisture or pain. But the papillæ of the tongue being erected and somewhat protuberant, to perform the office of taste, are affected in such a manner by salts dissolved in water, or saliva, and applied to their summits, that the mind distinguishes certain classes of taste, as sour, sweet, rough, bitter, salt, urinous, spirituous, aromatic, pungent of various kinds, insipid, putrid, and others partly purely saline, and partly changed, and compounded by the admixture of subtile animal or vegetable oils. All very acrid salts excite pain instead of taste. Does the diversity of flavours arise from the different figures of the salts? Does this appear from the cubical figure of sea-salt, the prismatical figure of nitre, or the particu-

lar

lar configuration of vitriol, ſugar, &c.? It does not ſeem probable, for even inſipid cryſtals have their particular figures; and in ſalts, very different in taſte and other properties, the figures are too much the ſame, and again are inconſtant in the ſame ſalt, as for example, in nitre, which may by art be rendered cubical. The cauſe of taſte ſeems therefore to reſide in the internal ſtructure of the elements, not perceptible by our ſenſes.

CCCCLIII. But the nature of the covering of the papillæ, of the ſaliva, of the fluids, and of the aliments lodged in the ſtomach, have great influence on the perception of taſtes; inſomuch, that the ſame flavours do not affect all ages alike, nor all temperatures; nor even the ſame perſon, according as he may be in health, diſeaſed, or habituated to it. In general, whatever contains leſs ſalt than the ſaliva does, ſeems inſipid.

CCCCLIV. The ſpirituous parts, more eſpecially of vegetables, are received either into the papillæ themſelves, or into the abſorbing villi of the tongue; as appears from the ſpeedy renovation of ſtrength by liquors of this kind, even when they are not taken into the ſtomach.

CCCCLV. Nature deſigned the diverſity of flavours, that animals might know thoſe things moſt proper for their food: for in general, there is no aliment unhealthy, that is of an agreeable taſte; nor is any thing ill taſted that is fit for the food of man. We here take no notice of exceſs, by which the moſt healthy food may become prejudicial, or of minerals, which are not furniſhed by nature, but prepared by art. Thus nature has invited man to take the food neceſſary for his ſubſiſtence, both by the pain called hunger, and by the pleaſure ariſing from taſte. But animals, which do not learn from example and the inſtruction of others, diſtinguiſh flavours more accurately, and, admoniſhed by that teſt, abſtain cautiouſly from unhealthy

unhealthy food; and, therefore herbiverous animals eſpecially, to which a very great diverſity of aliments mixed with noxious plants are offered, are furniſhed with ſuch long papillæ, and ſo elegant a ſtructure of the tongue, for which man has leſs occaſion.

CHAP. XIV.

SMELL.

CCCCLVI. TO the ſame uſe of diſcerning prejudicial food, the ſenſe of ſmelling is ſubſervient; by which we both perceive their noxious nature, before they be taſted, which might be dangerous; and eſpecially avoid putridity in our victuals, which to us is exceedingly hurtful; and diſcover what is grateful and wholeſome; although by habit, this advantage of ſmell is more conſpicuous in animals than in man. But men who have been left to themſelves, and whoſe ſenſe of ſmell has not been corrupted by variety, have been obſerved moſt certainly to retain that ſagacious faculty in diſtinguiſhing food in an eminent degree. Finally, the powers of medicinal plants are hardly to be eſtimated better than by the ſimple teſtimonies of taſte and ſmell. Hence, in all animals the organ of ſmell is placed near the mouth; and hence the ſmell is ſtronger, and the organs larger, in thoſe animals which have to ſeek their prey at a conſiderable diſtance, or to reject deleterious plants from among their food.

CCCCLVII. The ſenſe of ſmelling is performed by means of a ſoft, pulpy, vaſcular, papillous, porous membrane, which lines the whole internal cavity of the noſtrils, and is thicker upon the ſeptum and principal cavity of the noſe, but thinner in the ſinuſes. It is plentifully ſupplied with very ſoft nerves,

nerves, the middle ones of which deſcend from the firſt pair, (CCCLVII.) through the holes of the os cribroſum to 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 croſſes the pterygoid canal, and from another which deſcends through the canals of the palate; and in the maxillary ſinus from the infra-orbital branch, from the dental branch, and from the anterior nerve of the palate. Moreover, the anterior part of the ſeptum has a twig from the ophthalmic of the firſt branch of the fifth pair.

CCCCLVIII. The noſtrils are ſupplied with very numerous arteries; from the three naſal branches of the internal maxillary, above from both the ethmoidal branches, and the frontal and naſal branches, with lateral arteries from the ſmaller ophthalmic branch of the internal carotid, and from branches of the palatine artery, and in the ſinuſes from the infra-orbital, and from the ſuperior dental one. Theſe arteries have the property of exuding blood eaſily, and in great quantity, without any leſion of conſequence. The correſpondent veins form a very large plexus upon the external pterygoid muſcle; then communicate with the ſinuſes of the dura mater; and, laſtly, meet in the external branch of the internal jugular. The arteries ſupply nouriſhment, warmth, and mucus.

CCCCLIX. The head, eſpecially in man, being of a ſpherical figure, confines the organ of ſmell within a ſmall ſpace. That it may be extended internally, the noſtrils have been made complicated and cavernous in a ſurpriſing manner. In the firſt place, the noſtrils are that multiform cavity which begins at the anterior openings of the noſe, and, extending tranſverſely backwards over the roof of the palate under the ethmoid bone, terminates at the

the cavity of the fauces. This cavity is divided by a ſeptum, often unequally, which is bony in the upper part, and deſcends from the plate of the ethmoid; below, it is formed by the vomer, and in its forepart it conſiſts of a triangular cartilage, whoſe ſurface is large and very ſenſible.

ccccLX. Moreover, the lateral ſurfaces of the nares are increaſed by the ſpiral convolutions of the oſſa turbinata; the uppermoſt of which are the ſmall ſuperior and poſterior convolutions of the ethmoid bone. The middle ones belong to the ſame bone, are of a long conchoid form, convex inwards, externally concave, pointed at both ends, covered all over with pits, and internally filled with ſpongy cells ſuſpended tranſverſely, and ſupported by particular eminences of the palate and maxillary bones. The loweſt turbinata are ſimilar to the middle ones; like them reſemble in figure a limpet ſhell, but longer; are for the moſt part divided from the former, but ſometimes conjoined by a bony plate which is moſt frequently of a membranous nature. This appendix, being extended upwards in a ſquare form, completes the maxillary ſinus.

ccccLXI. The cavity of the noſtrils is ſtill further enlarged, by means of the various ſinuſes, which are receſſes or a kind of appendages to the noſtrils. The uppermoſt of theſe are the frontal ſinuſes, which are inconſtant and irregular, ſeated in the ſuperciliary ridge, and ſituated betwixt the anterior and poſterior plates of the frontal bone. They are not found in the fœtus, and ſeem to ariſe from the action of the corrugator and other muſcles, which draw the anterior plate outwards, and increaſe the diploë into cells, in the ſame manner as in the maſtoid proceſs. Theſe open in the upper part of the noſtrils into the anterior cell of the os papyraceum. There are inſtances of their being totally wanting, and growing after birth.

ccccLXII.

CCCCLXII. The ſecond in order are the ethmoidal ſinuſes; of which four or more on each ſide are found in the outer part of the os cribofum, like the cells of an honey comb; above, they are completed by the cellular diploë of the os frontis, before by the os unguis, and behind by the palate and ſphenoidal bone; they open into the upper part of the noſtrils in a tranſverſe line, by many ſmall tubes, even placed one above another. With theſe are continuous the cells in the bottom of the orbit, and thoſe excavated in the os planum and maxillare are outwardly continued from them. In the third place, the large cavity of the multiform bone on each ſide is alſo contiguous, and in ſome meaſure belongs to the ethmoid and palate bones. By the drying up of the cartilage, which is here of large extent in the fœtus, it gradually is formed in the ſolid bone, under the ſella turcica, is capacious, either ſingle or divided, and opens forwards by its aperture into the upper paſſage of the noſtrils.

CCCCLXIII. The laſt, loweſt, and largeſt of the ſinuſes, which in the fœtus exiſts in ſome degree, but in the adult, by the attenuation of the bony laminæ, becomes very large, is chiefly excavated in the upper maxillary bone. Its opening into the noſtrils is bounded by the os unguis, bone of the palate, proper lamella of the loweſt os turbinatum, and by membranes, ſo that it enters by a round aperture between the middle and loweſt ſpongy bones. But it likewiſe ſends forth an hollow appendix, ſtretching forwards under the orbits, which is formed by the os planum, unguis, and papyraceum, communicating likewiſe with the ethmoidal cells, and opening behind the oſtium lachrymale.

CCCCLXIV. The nerves of the noſe, being almoſt naked, require a defence from the air, which is continually inſpired and expired through the noſtrils, for the purpoſes of reſpiration. Nature has therefore

therefore ſupplied the noſtrils, in place of a thicker cuticle, with a viſcid, bland, inſipid mucus, fluid at its firſt ſeparation, but by the air condenſing into thick dry cruſts, and 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 the very numerous ſmall arteries of the noſtrils; and is depoſited partly into numerous cylindrical ducts, and partly into round viſible cryptæ, ſcattered throughout the noſtrils. The ſame mucus exudes over the ſurface of the whole olfactory membrane, and every where anoints it. In the ſeptum, a long ſinus, common to many muciferous pores, runs forwards a conſiderable way. The mucus accumulated in the night time, in too great quantity, is expelled during the day by compreſſing the noſtrils, and forcing the breath through them; or by its dryneſs and acrimony, it irritates the very ſenſible nerves, and is then expelled by the ſneezing excited. But the ſinuſes which abound with mucus, evacuate it according to the different poſtures of the body; by ſome of them always being at liberty to diſcharge it, whether the head be erect or inclined forwards, or to the ſide; yet ſo, that generally the maxillary and ſphenoidal ſinuſes are more difficultly emptied than the reſt. Moreover, the tears deſcend through a proper duct into the noſtrils, and moiſten them, and dilute the mucus.

CCCCLXV. The extremities of the noſtrils are covered by the noſe, which is lined inwardly with a membrane of the ſame nature, and is compoſed of two bones, and uſually ſix cartilages, two of which are continuous with the middle ſeptum (CCCCLIX.) The noſe may be moved by its muſcles, ſo as to be raiſed and dilated by a muſcle common to it and the upper lip, and to be contracted by its proper depreſſor and compreſſor, and depreſſor of the ſeptum. Thus the organ of ſmell is prominent, and expoſed to the action of odours, and may be dilated

for taking in a larger quantity of air, and again be contracted, when the fuperabundance is expelled.

ccccLxvi. The air, therefore, filled with the very fubtile, invifible, pungent, oily, faline, and volatile effluvia, which exhale from almoft every known body, being received into the noftrils, by the action of refpiration, (ccLxv.) and by a peculiar effort for drawing the air into them, carries thefe particles to the nerves, widely naked, and conftantly foft. By thefe there is excited in thefe nerves a kind of fenfation which we call fmell, by which we diftinguifh the feveral kinds of oils and falts, in a manner fomewhat indiftinct, difficultly reducible to claffes, difficultly recalled to the memory, neverthelefs fufficiently for our purpofes. This fenfe informs us of unwholefome putridity, of exceffive acrimony, and of the bland and ufeful nature of fubftances. And as falt, united with oil, is an object of tafte, and as oils, combined with falts, conftitute odours, the affinity of the two fenfes, which was neceffary to derive utility from either, is apparent. But volatile particles chiefly are diftinguifhed by fmell, and fixed ones by the tafte; perhaps becaufe the thick mucous cuticle, fpread over the tongue, intercepts the action of the more fubtile falts, which eafily affect the fofter and lefs covered nerves of the noftrils. We are ignorant of the reafons why fome fmells pleafe, and others difpleafe; perhaps cuftom may have fome influence in this refpect.

ccccLxvii. The action of fmells is ftrong, but of fhort continuance; becaufe particles in a very minute ftate are applied to naked nerves, in the immediate vicinity of the brain. Hence the deleterious and refrefhing actions of odours, by which people are refufcitated from faintings, and even from drowning. Hence the violent fneezing, excited by acrid particles, the evacuation of the bowels, by the fmell of purgatives, and the power of antipathies.

Hence

Hence the pernicious effects of exceſſive ſneezing, more eſpecially blindneſs, from the great ſympathy of the nerves. Amongſt the various parts of the noſtrils, the ſeptum, and the oſſa turbinata, and their anterior portions, eſpecially form the organ of ſmell: ſince theſe parts are multiplied in quick ſcented animals, forming beautiful ſpires in quadrupeds; and in fiſh, being diſtributed in parallel laminæ elegantly toothed.

CHAP. XV.

HEARING.

cccclxviii. AS the ſenſe of ſmelling diſtinguiſhes the ſmall bodies which float in the air, hearing perceives the tremors of the elaſtic air itſelf. Therefore, the ſenſitive organ of the ear is compoſed in a different manner from that of any of the other ſenſes; as it is in a great part made up, either of elaſtic cartilages, or hard bones, that it may communicate with accuracy the tremors received.

cccclxix. The external organ of this ſenſe is the ear, or that cartilage which is connected before and behind to the bones of the temple, by ſtrong cellular ſubſtance and proper ligaments, with ſome degree of mobility, which is diminiſhed by habit. This cartilage is of a compound figure; in its general ſhape, oval, but divided by projecting convolutions and intermediate grooves, to which other hollows and ridges correſpond in the oppoſite ſurface. The outer eminence, called helix, ariſes above the looſe lobe, and ſurrounding the ear, terminates in a projecting line dividing the concha. Below it, lies the anthelix, a bifurcated eminence, forming a ridge contained within the former, and terminating in a ſhort tongue called the antitragus. The remaining

part of the ear hollow before, and convex behind, growing gradually deeper, having a projecting line running through its middle, is called the concha, and is joined with the meatus auditorious, which is protected by a nearly round moveable appendix, called the tragus.

ccccLxx. All this part of the ear is only covered by a thin ſkin, and lean cellular ſubſtance; and is repleniſhed with many ſebaceous glands, ſupplying an ointment. It is moved by certain muſcles, which generally become uſeleſs, from habit and the cuſtom of binding them, which, however, it is probable were appointed by nature to perform certain offices. The uppermoſt of theſe muſcles ariſes thin from the frontal and from the aponeuroſis of the cranium; whence it is broadly ſpread over the aponeuroſis of the temporal muſcle, and is inſerted into the anthelix, or neighbouring helix, at the anonymous cavity. The poſterior muſcles, which are two or three, or more or leſs, are more robuſt than the former, almoſt tranſverſe, and ariſing from the aponeuroſis of the cervical muſcles, and from the membranes adhering to the maſtoid proceſs, are inſerted into the convex part of the conch, and without doubt dilate it. The anterior muſcle is the leaſt; this alſo is ſpread upon the aponeuroſis of the temporal muſcle, and is inſerted almoſt tranſverſely into the origin of the helix and into the neighbouring concha. But ſmaller, ſhort muſcles, hardly diſtinguiſhable, though ſomewhat red, probably make ſome change in the ear itſelf. The tranſverſe muſcle of the ear, joining the concha with the concave back part of the anthelix, opens the ear. The antitragicus, deſcending from the root of the anthelix to the upper part of the antitragus, widens the entrance of the conch. The tragicus, which lies upon the tragus, and is almoſt ſquare, dilates the aperture; the muſculus inciſuræ majoris, lies between the middle and third cartilages of the auditory

tory paſſage, brings them nearer together, and renders the meatus itſelf more elaſtic. The remaining muſcles, the longer or larger, and the leſſer of the helix, have hardly any great uſe; perhaps they have ſome influence when we wiſh to hear weak ſounds more accurately, and tighten the organ of hearing, and render the meatus auditorious firmer by drawing together the cartilages.

CCCCLXXI. With the concha is connected the meatus auditorious, of a round compreſſed figure, inclined inwards, leſſening as it proceeds, about the middle bent forwards, and for a conſiderable part bony. But, in its anterior and outer part, it is partly formed of three imperfect rings, the firſt ariſing from the tragus, the ſecond from the concha, and the third from the other two, connected with each other by intermediate muſcle, membrane, and cartilage, and finally adhering to the bone itſelf. The upper and back parts of the meatus are formed by mere membrane. This is the ſtate of it in adults; for, in the fœtus and new born infant, the meatus is wholly cartilaginous, and its oſſeous part is gradually formed.

CCCCLXXII. Into this auditory paſſage are continued the cuticle and true ſkin, which are gradually extenuated and exactly ſtretched over the bone, and are therefore very ſenſible of any irritation, pleaſure or pain; and by the irritable hairs with which it is furniſhed, intimation is given of the accumulation of any ſordes, and of the entrance of inſects. In the cellular ſubſtance, which is ſomewhat indurated and reticulated, eſpecially in the membranous portion, (CCCCLXXI.) there are numerous yellow round follicles, which, by ſhort ducts, depoſite into the cavity of the auditory paſſage a liquid, at firſt oily, but afterwards becoming gradually thick, bitter, and inflammable, which lines the ſenſible ſkin and membrane of the tympanum, and defends them from the air, and drives

away

away or keeps back infects; but, when accumulated in flothful or uncleanly perfons, it caufes deafnefs.

CCCCLXXIII. Into the ear the fonorous waves of the air flow, which, from the principles of mechanics, it collects. The elaftic air receives fonorous vibrations; and particularly tranfmits them, although fome other bodies alfo propagate fonorous vibrations, either alone, or at leaft in the greateft degree, if indeed water deprived of air be capable of vibrating. Hence, found is increafed in air that is condenfed, and is loft in vacuo. The air receives thefe tremors, either from fome body ftriking againft it, or from fome body againft which it rufhes, or laftly from the mutual collifion of bodies. But a body which produces found, muft vibrate and ofcillate in all, even in the leaft of its particles, fo as to form alternate arches rifing up from the former ftraight furface, and returning beyond the fame. This fpecies of curved line is called the excedens of the founding body. The tremor impels the neareft wave of air, and thus the anterior portion of air being compreffed, as foon as its elafticity overcomes the impelled tremor, rebounds and repels the air towards the founding body, where the air is now more rarefied and thin, and compreffes it. The fame portion of air, ftruck by the founding body, in like manner impels the portion of air contiguous to it, which alfo reacting in due time, repels the tremulous air backwards towards the body, and forwards to produce a new wave. Thefe ofcillations muft thus fucceed each other quickly, to render them audible, and muft not be fewer than 30 in a fecond.

CCCCLXXIV. Acute founds are, in general, emitted from bodies that are hard, brittle, and very tenfe: grave founds are connected with the contrary properties. Thofe founds in general are called acute

acute, which are produced by more frequent vibrations in a given time; and thoſe obtuſe, which are produced by leſs frequent vibrations. There is no limit between acute and grave ſounds, but what is arbitrary. Cords, or other bodies, that yield the ſame number of vibrations in a given time, are ſaid to be in uniſon. Octaves are produced when the one makes double the number of oſcillations that the other does; other proportions have different names aſſigned to them. The ſhorter cords produce the ſharpeſt tones, and the reverſe, in the inverſe proportion of their lengths; they are alſo more acute as they are tenſer in the ſubduplicate proportion of their tenſion, or the weights by which they are ſtretched. Experiments to this purpoſe are very eaſily made with a monocord, or a ſeries of cords ſtretched by weights.

CCCCLXXV. Sound, however produced, whether acute or grave, ſtrong or weak, is carried through the air with a velocity equal to about 1038 Paris feet in a ſecond, and that with an uniform velocity, without being diminiſhed by great diſtances. But a contrary wind, although much ſlower, retards in ſome degree the progreſs of ſound, and takes away about $\frac{1}{22}$ of its velocity. So likewiſe denſity and dryneſs of the air increaſe ſound; rarefaction and moiſture diminiſh it. The heat of ſummer augments its velocity; in Guinea, it has been tranſmitted at the rate of 1098 Pariſian feet in a ſecond.

CCCCLXXVI. Every ſound meets with particles in all adjacent bodies, even in water and mercury, in which it excites ſimilar vibrations, not only in ſuch as are in uniſon, which yield a more evident ſound, but alſo in other particles, which vibrate in a different ratio. Hence every ſound which we hear, is a mixture of the primitive tone, produced by the vibrating body, and of the ſecondary tones generated by the elaſtic tremors of the ſurrounding bodies. The ſtrength of ſound is increaſed, if the ſecondary

condary founds fucceed the primary one fo quickly, that they cannot be difcriminated by the ear; but if fo flowly as to be diftinguifhable by the ear, they produce an echo; but this requires an interval of fix thirds of time, or the diftance of 55 feet betwixt the body returning the found and the ear.

ccccLXXVII. Sound is reflected from hard bodies in angles equal to thofe of its incidence. But found emitted into the open air, being diffufed through an immenfe fphere, grows weaker: when fent through a cylinder, it retains its ftrength, and when collected into the focus of an ellipfe, as in the fpeaking trumpet, it is increafed, as it iffues from the focus of the parabola in parallel, not in diverging lines.

ccccLXXVIII. Therefore the fonorous undulations, propagated through the air, ftrike upon our ear, placed in an elevated fituation, and naturally inclined forwards and outwards. As that is elaftic, they are reverberated; and by alternate reflections, they are collected into the concha, and into the meatus auditorious, where they become as much ftronger, as the furface of the ear is larger than the caliber of the meatus. Through that paffage, in fome meafure cylindrical, they proceed inwards undiminifhed, and increafed by new refonances, excited by the percuffion of the elaftic cartilages and hard bones, and blended with the primitive found.

ccccLXXIX. The internal end of the meatus auditorious is terminated by the membrana tympani; in adults it is obliquely applied, of a roundifh figure but having an appendix above, projects inwards like a fhield, fo that the lower half, concave towards the meatus, projects as the bofs into the cavity of the tympanum, and the upper half is concave towards the tympanum, and convex towards the meatus. This membrane is compofed of feveral plates; the firft is white and mucous, not a perfect

fect membrane, and in the fœtus only; then the epidermis; and then the true ſkin, continuous with the membrane of the meatus, and vaſcular; the third is dry, rattling, ſhining, pellucid, and without blood-veſſels. It is formed from the perioſteum of the meatus, and of the tympanum. Some tender cellular texture intervenes between theſe. This membrane is not naturally perforated with any opening, ſo far as I have been able to diſcover, and the tranſmiſſion of ſmoke is fabulous. It is conſtantly ſtretched in the groove of the ring in which it is contained, which is proper to the fœtus, but after the birth coaleſces with the reſt of the os petroſum, ſo that there is no part of the human body more tenſe or more tremulous than this. Upon the ſurface of this membrane, and more eſpecially upon its conical cavity pointing inwards, the ſonorous waves ſtrike, after their laſt reflection in the auditory paſſage, and on account of its elaſticity, force it to vibrate.

CCCCLXXX. This membrane is ſtretched over a cavity of the os petroſum, called the tympanum; which is in general of an irregularly roundiſh figure. It is divided in its middle by a promontory, and in the adult it is increaſed backwards by the cells of the maſtoid bone, which in the fœtus are wanting. The tympanum is cellular alſo before, above and behind. It is lined with a vaſcular membrane, receiving ſmall branches from the internal carotid, from the branch of the artery of the dura mater, which paſſes through the fiſſure in the aqueduct, and from the external arteries of the tympanum, and from the ſtylo-maſtoidea. It is commonly full of mucus, poured into it from the Euſtachian tube, and is divided into a kind of cells by different membranes, which are productions of the perioſteum to the oſſicula auditus.

CCCCLXXXI. Within this cavity, the little bones of hearing are ſituated, three of them being larger,

ger, and the fourth lefs. The round head of the malleus, its upper part, is fituted in the roof of the tympanum, from whence its long handle defcends between the laminæ of the membrane of the tympanum, as far as its middle, accurately tied to it, with a broad extremity a little incurvated outwards. It is alfo connected with the long crus of the incus by a peculiar ligament; another membrane, near its long procefs, faftens the malleus. A fhort and conical procefs above its handle, preffes the membrane of the tympanum outwards. From the fame place, a procefs, very long, compreffed, and fomewhat broad, but of a variable figure, extends forwards into a fulcus of the tube. The head of the malleus is articulated with the incus by two protuberant lines, and an intervening fulcus, all of them oblique.

cccclxxxii. Three mufcles are commonly defcribed, as belonging to the malleus: the firft and largeft, the tenfer tympani, is internal, and is lodged in a particular canal of the tube, to which it runs parallel, arifing from a procefs of the multiform bone between the paffage of the cerebral carotid and the hole of the artery of the dura mater; it is inferted by its tendon reflected downwards and outwards, around a pully, into the beginning of the handle. The fecond mufcle arifes from a fulcus, connected with the fame tube, but external to it, fhorter than the former; and carried backwards almoft in the fame manner, but without being reflected, it adheres by a confiderable extent to the longer procefs; its mufcularity is doubted, not being remarkably different from red pulpy membrane. The third, which is faid to arife from the auditory paffage, to enter the tympanum, through a notch in the imperfect ring, to be inferted juft by the fhorter procefs into the malleus, and to relax the membrane, has never been feen with fufficient certainty, either by myfelf, or by the moft eminent anatomifts. The tenfor, by means of the malleus, adapts

adapts the membrane of the tympanum for the hearing of weak founds; the fecond mufcle, if it exift, moderates thofe that are too powerful, by drawing the malleus from the incus, and in that way, interrupting the propagation of the fonorous tremors. If the membrane of the tympanum be broken, or the fmall bones difplaced, the hearing firft becomes dull, and afterwards perfect deafnefs enfues; that part of hearing only being left, which is propagated through the bones of the fkull.

CCCCLXXXIII. The malleus imparts the tremors which it receives from the membrane of the tympanum, to the incus, which is a fhort thick little bone, articulated with it behind by a broad furface, with two fulci and a middle eminence. The fhorter leg of this bone, whofe little body is bifurcated, is notched, fufpended by a ligament, and is held firm in a peculiar fulcus of bone. The other leg defcends farther, parallel to the malleus; and, by its extremity bent inwards, is adapted to the fourth bone, which it receives, being convex on that fide, and flat on the other, and refts upon the ftapes, to which it communicates its vibrations.

CCCCLXXXIV. The ftapes, aptly fo called from its figure, lies in an inclined pofition, with a hollow head which receives the incus, with curved crura, efpecially the pofterior one, and with an oval bafis, but flatter below, with which it fills a hole correfponding to it, commonly called the feneftra ovalis. The crura, which are fulcated inwardly, are joined by a denfe membrane affixed to the flightly hollow bafis. The ftapes is governed by its own mufcle, which being included in a bony papilla, fends out a fmall tendon, which proceeds forwards, and is inferted under the incus into the head of the ftapes. It feems to draw the ftapes fo that its pofterior part may enter deeper into the feneftra ovalis, and its anterior part advance outwards. Thus the nervous pulp of the veftibulum

veſtibulum is compreſſed, both by the baſis of the ſtapes, and by the air of the tympanum. The whole ſeat of the ſtapes is ſeparated from the reſt of the tympanum by a peculiar membrane.

CCCCLXXXV. A ſmall roundiſh oval bone, ſlightly excavated on both ſides, is connected by one ſide with the longer leg of the incus, and by the other with the head of the ſtapes.

CCCCLXXXVI. Various canals 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 it, the cells in the os petroſum begin above the mamillary proceſs. Below theſe, that proceſs is excavated in the adult with various cells.

CCCCLXXXVII. Beſides, a peculiar canal, proceeding forwards from the anterior extremity of the tympanum, emerges from the bones between the ſphenoid and temporal bones, and correſponds with an elliptical diverging cone, partly cartilaginous, of uncertain ſtructure, and partly membranous, which opens behind the noſtrils into the cavity of the fauces, by a very large elliptical aperture, turned inwards and forwards: it is lined with a porous membrane, full of cryptæ, continuous, and ſimilar to the membrane of the nares. This forms the Euſtachian tube, which by the action of the circumjacent muſcles, may be compreſſed, and probably a little relaxed and opened again, by the circumflex muſcle of the moveable palate. By this canal, the air, during inſpiration, enters into the tympanum to be changed, and the mucus is poured around the little bones to defend them: nor is it improbable, that the air iſſues out of this tube, when the tympanum is preſſed inwards by powerful ſounds; likewiſe, ſounds received into the mouth, are conveyed by it to the organ of hearing. In inſpiration, the air preſſes the membrane of the tympanum outwards; hence

hence the humming and dulneſs of hearing in yawning; for then the air entering in greater quantity into the tube and tympanum, reſiſts the tremors of the external air.

CCCCLXXXVIII. Two other paſſages lead from the tympanum to the labyrinth, or innermoſt part of the ear. The feneſtra ovalis, (CCCCLXXXIV.) not covered by any membrane, leads into the veſtibulum; which is a round cavity, excavated in the very hard petrous bone, and lies near the inner part of the tympanum. In that cavity there is a ſuperior elliptical receſs, an inferior circular one, and a third reſembling a groove. There is a nervous pulp in the veſtibulum, ſeparated from its bony ſides by vapour ſurrounding it. Into this the five mouths of the three ſemicircular canals, the foramen ovale, and the paſſages of the nerves and arteries open.

CCCCLXXXIX. In the fœtus, the canals are formed of a diſtinct hard ſhell, which is ſurrounded with ſpongy bone; in adults, they are excavated in the exceſſively hard petrous bone, ſomething larger than ſemicircles, and have ample openings. The larger poſterior and lower of theſe is perpendicular; alſo the middle and upper one is placed perpendicularly; but the outermoſt and leaſt is horizontal. The inner mouth of the uppermoſt unites with the upper opening of the poſterior.

CCCCXC. But the cochlea is ſtill more wonderful. It is ſeated in an inclined poſition in the anterior portion of the os petroſum. Into its one cavity the veſtibulum opens, and into the other the feneſtra rotunda of the tympanum, which being covered by the promontory, lies hid in the bottom of the tympanum. The cochlea itſelf is compoſed of a nucleus of bone, of a conical figure, with its apex inclined inwards; divided into tubes, which are called ſcalæ, by a middle ſulcus, which is perforated, both in its baſis, and through its whole length, by innumerable

innumerable ſmall foramina, and terminates in the middle of the ſecond ſpiral. About this nucleus are wrapt two turns and a half of a canal; which, in the fœtus, is diſtinct, and has its own ſhell; but, in the adult, is united with the adjacent bone, and diminiſhes conically from the two openings mentioned above, towards the apex of the nucleus. This canal is bilocular, and divided by a partition called lamina ſpiralis, of which the greateſt part is bony, and ariſes from the nucleus, projecting from it at right angles into the hollow canal, is ſtriated, and included on both ſides in the internal perioſteum as in a capſule. The remaining and exterior portion is membranous, which completes the diviſion of the canal: thus there are formed two diſtinct ſemicanals, called ſcalæ. The interior and poſterior of theſe begins from the feneſtra rotunda, where it is ſhut by a membrane, and is called the ſcala tympani; the other anterior one ariſes from the veſtibulum, from which it has its name. From the apex of the nucleus a third cavity originates, ſhaped like a funnel. Into this the ſpiral lamina terminates by a membranaceous extremity, but ſo that the funnel communicates with each ſcala, by one ſmall hole on each ſide, and by many with the cavity of the modiolus, which is filled with nerve.

ccccxci. The blood-veſſels of the outer ear come from the temporal, and proper auricular branches; thoſe of the membrane of the tympanum from the temporal, from the ſtylo-maſtoideal, or from both; thoſe of the meatus auditorius come from the ſame; thoſe of the tympanum were deſcribed (cccclxxx.) and the veſſels belonging to the veſtibulum, cochlea, and ſemicircular canals, are from the vertebralis and ſtylo-maſtoidealis and meningea. The induſtry of late anatomiſts has traced abſorbent veſſels of a particular kind, from the veſtibulum into the tranſverſe ſinus, from the cochlea into the cavity of the ſkull.

ccccxcii.

CCCCXCII. It now remains that we defcribe the nerves fubfervient to the fenfe of hearing, of which the principal is that called the feventh, (CCCLVII.) This nerve enters into the internal auditory finus of the os petrofum, in the blind end of which it divides. The fmaller part of the nerve enters through the upper opening in the finus, into a canal, which is at firft tranfverfe, and afterwards reflected behind the tympanum. While it defcends there, it gives off a branch through a peculiar canal to the tympanum, which afcends betwixt the malleus and incus, goes out of the tympanum, through a fiffure behind the articulation of the lower jaw, and inferts itfelf into the nerve of the tongue, (CCCCLVII.) the reafon of which fecret communication is obfcure, but ferves to explain the fympathy between the teeth and fharp founds, and burning of the ear, &c. The reft of the nerve, efcaping by the fide of the ftyloid procefs, is diftributed on the external ear, the parotid gland, a large part of the face, and upper part of the neck, both cutaneous and mufcular; and in the face, forms numerous inofculations, both betwixt its own branches, and with thofe of the firft, fecond, and third of the fifth pair; with the eighth pair, and with the third cervical pair. To the organs of hearing, it fends either no branches, or very fmall ones. The anterior part of the outer ear receives other nerves from the third branch of the fifth pair, and the pofterior part, from the fecond and third cervicals.

CCCCXCIII. But the foft portion, which is larger, but more obfcure, arifes by very minute filaments, from the fourth ventricle of the brain itfelf, (CCCLVII.) and enters through exceeding fmall holes of the inner auditory finus, in part with from three to five branches, into the veftibulum, and in part into the fulcus of the cochlea. Thefe branches in the veftibulum form three pulpy maffes, which combine

bine to form the membrane ſuſpended in the veſtibulum, and which is continued through the whole of the ſemicircular canals. The other part, which enters the ſulcus of the cochlea, has an obſcure termination.

CCCCXCIV. With reſpect to the nerve which is diſtributed upon the veſtibulum and ſemicircular canals, there is no doubt that it is affected by the tremors of the external air, propagated to the ſtapes; which reach the pulp of the naked nerve, through the feneſtra ovalis. That part of the nerve, which enters the cochlea, is altogether leſs underſtood. It is probable, that ſmall branches from thence paſs through the little foramina, (CCCCXC.) to the perioſteum of the cochlea, and to the membranous part of the lamina ſpiralis. Do tranſverſe nervous filaments, ſucceſſively ſhorter, paſs out from the nucleus of the cochlea, along the lamina ſpiralis? Is it the organ of hearing? Theſe are queſtions, which we are yet hardly able to reſolve from anatomy; though the example of birds and fiſhes, which hear exquiſitely without a cochlea, ſeems to negative them. However this may be, it is probable, that the ſpiral plate, full of nerves, is excited to vibration by the oſcillations of the membrane of the tympanum, which agitate the air in the cavity of the tympanum, ſo that it impinges on the membrane of the round feneſtra, which again agitates the air contained in the cochlea.

CCCCXCV. It is an elegant conjecture, that ſince the lamina ſpiralis forms a true triangle, of which the apex is a very acute angle, it may be ſuppoſed to contain an infinite number of cords, ſucceſſively ſhorter, which correſpond harmonically, (CCCCLXXIV.) with the various acute and grave tones, ſo that they vibrate in uniſon with the greateſt number of ſounds; the longeſt cords in the baſis of the cochlea, with the graveſt ſounds; and the ſhorteſt

eſt cords neareſt the apex, with the ſharpeſt ſounds. Are ſounds perceived in the middle ſemicircular canals, ſince theſe alone are found in all claſſes of animals? Or are they perceived in theſe canals, in the cochlea, and in the membrane ſuſpended in the veſtibulum? This ſeems probable.

CCCCXCVI. It appears that the audable elaſtic undulations of the air, paſs through the outer ear and auditory paſſage, to the membrane of the tympanum; for when it is injured, and not repaired, the hearing is totally deſtroyed. It ſeems to be ſtretched, for hearing weak ſounds, by the muſcles of the malleus. From this membrane, the ſound is propagated through the ſmall bones to the veſtibulum; for theſe bones being deſtroyed, the hearing is again aboliſhed. The bony ſides of the veſtibulum vibrate, and agitate the aqueous fluid ſurrounding the nervous pulp. By it, the nervous pulp ſuſpended in the veſtibulum, ſeems to be affected, and that tremor to be continued through the continuous pulp of the cochlea and ſemicircular canals. Nothing farther is known: but, by undoubted experiments, elaſtic ſonorous tremors affect the auditory nerve, through the intervention of the Euſtachian tube, of the teeth, and of all the bones of the ſkull.

CCCCXCVII. The diſtinction of ſounds, without doubt, proceeds from the velocity of the tremors excited in the auditory nerve, according as they ſuceed each other more ſwiftly or ſlowly; it is not neceſſary the mind ſhould number them; it is ſufficient that the different numbers excite different changes in the mind. Does the gratefulneſs of ſounds ariſe from the number of conſonances? Does the mind, inconſciouſly, number the degrees of conſonance, and derive pleaſure from their facility and frquency? Theſe are denied by the moſt expert muſicians, who prove, that much pleaſure proceeds

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from founds having very little concordance, and related in very difficult proportions. Why are too acute founds intolerable? They feem to ftretch our nerves in the lamina fpiralis to fuch a degree, that they are even ruptured, as glaffes are broken by acute founds, and the fhrill whiftling of canary birds almoft deftroys the power of hearing.

CHAP. XVI.

SIGHT.

CCCCXCVIII. HEARING is the perception of the vibrations of the air; fight perceives thofe of light: the organ of hearing is bony, that it may admit of refonance; the organ of vifion chiefly confifts of humours, which refract: the complex nature of this organ was rendered neceffary for the defence of parts, fo very tender, and by the diverfity of the humours, to be contained each in its proper integuments.

CCCCXCIX. The moft external defence of the eye is afforded by the eyebrow, which is a protuberance of the fkin, fuftained by mufcles, at the bottom of the forehead, full of thick imbricated hairs, and along with the frontal mufcle, capable of being pulled down by the action of the corrugator, and orbicular mufcles, fo as to afford a fhade to the eye in too ftrong a light. After the eyebrow has completed its functions, it is again raifed by the frontal mufcle, which is inferted into it, thin and flefhy, immediately under the continuous fkin, faftened to the cellular membrane of the fkull, which is fhining, not very unlike an aponeurofis, and is drawn backwards by the rectangular occipital mufcle. The depreffion of the eyebrow denotes care, its elevation, tranquillity and ferenity of mind. It alfo turns afide

aſide the courſe of the ſweat, and keeps off inſects from the eye.

D. The eyelids furniſh a nearer protection to the eye. Theſe are folds of the ſkin, proceeding from that of the face, extenuated, lengthened out into an edge, as if divided, reflected upon itſelf, and retracing the courſe of the former lamina, from which it is ſeparated by ſome cellular ſubſtance; then having become membranous, vaſcular, and therefore red, and thin, it is carried over the ball of the eye, under the denomination of conjunctiva tunica, and covers the anterior portion of the ſclerotica, and finally the cornea. The epidermis accompanies it in its whole courſe, even where it adheres to the cornea. The upper eyelid is larger, and more moveable: the lower is ſmaller; and rather paſſive, than moved by any power of its own. The nerves, which give ſenſibility to the eyelids, are numerous, from the firſt and ſecond branches of the fifth pair, and from the portio dura of the ſeventh; they abound with arteries from the ophthalmics, temporals, branches of the internal maxillaries, infra orbitals, and facials.

DI. That the eyelids may ſhut together more exactly, each of them has a cartilaginous arch, called tarſus, upon that margin which touches the other. It is ſlender, of a lunar figure, extenuated outwards, and ſtretches the eyelid, preventing the formation of folds while it is elevated or depreſſed. The elevation of the upper eyelid is performed by a peculiar muſcle, ariſing from the involucrum of the optic nerve gradually ſpreading, and continued by its expanſion to the tarſus. This is conſiderably aſſiſted in its action by the frontalis, which is variouſly connected with the orbicularis, and draws it upwards. The upper eyelid is depreſſed by the orbicularis, as it is called; a broad muſcle, both widely expanded around the orbit, and contained in the eyelids, carried as far as both angles of the eye,

eye, and having, as fixed points, the ligament adhering to the procefs of the maxillary bone, and fome fibres inferted into the frontal and upper jaw bone. The fame mufcle elevates the lower eyelid, and covers the eye in fuch a manner that no duft or light can enter it during fleep. The lower eyelid is depreffed by two bundles of fibres, inferted into the upper lip.

DII. Finally, that the tumid margins of the eyelids may not fhut too clofely, they are provided with eyelafhes, or fringes of hair fpreading outwards, proceeding in many rows from the edges of the eyelids, which, by decuffating each other, increafe the fhade and obfcurity. Thefe are of ufe in more diftinct vifion, by excluding the extraneous rays, when we require a diftinct reprefentation of any object.

DIII. The eyelids are prevented from hurting each other by the febaceous glands of Meibomius, confifting of thirty or more follicles in each eyelid, which are fimple, bifid or trifid ; placed in general according to the length of the lid, and compofed of peculiar blind roundifh cavities, which unite into one larger ferpentine duct, of which the orifice is in the margin of the eyelid itfelf. Thefe difcharge a foft unctuous liniment, which mixes and wafhes off with the tears.

DIV. But the perpetual attrition caufed by the eyelids afcending and defcending againft the globe of the eye is prevented, the delicacy of the cornea is preferved, and any infects or other irritating fubftances which may have got into the eye, are wafhed away by the tears ; a faline, pellucid, and evaporable liquor, which never ceafes to be poured over the anterior furface of the eye, but never runs over the cheeks, unlefs accumulated from fome caufe. This liquor is exhaled partly from the arteries of the conjunctiva, as we fee from an imitation of nature by injecting water ; and in part it is believed

believed to proceed from a gland ſeated in a hollow receſs of the os frontis, ſomewhat hard, and of the conglomerate kind: divided into many lobes, intermixed with fat, and ſupplied with many blood-veſſels from the ophthalmics and internal maxillaries; and pervaded by many nerves ariſing from a peculiar branch of the firſt trunk of the fifth pair.

DV. From this lachrymal gland, ſix or more viſible ducts deſcend, which open on the inner ſide of the conjunctiva of the eyelid. In man theſe ducts have been lately diſcovered by credible authors. The ſecretion of the tears is increaſed by the repeated contractions of the orbicular muſcle, either from irritation, or ſome depreſſing paſſion, by which means the tears are conveyed over the whole eye, and the ſurface of the conjunctiva is waſhed.

DVI. After the tears have performed their office, ſome part of them being evaporated by the air, the reſt, that they may not prove injurious by their accumulation, are propelled by the orbicular muſcle, towards its origin next the noſe, and to the innermoſt part of the commiſſure of the eyelids; which from not having any tarſus, does not meet exactly together. There a caruncle, full of ſebaceous, hairy follicles, oblong, and conical outwards, interpoſes itſelf between the eyelids, and prevents them from meeting, and anoints with its liniment thoſe parts of the eyelids which have no Meibomian ducts. Before it, a ſmall third eyelid deſcends perpendicularly, and joins the true eyelids; it is larger in beaſts. At the beginning of this ſpace interpoſed between the eyelids, in which the tears are collected, in each margin a little papilla projects, having one orifice, ſurrounded by callous cellular ſubſtance, and perpetually open, unleſs when convulſively cloſed. This orifice, which is called the punctum lachrymale, abſorbs the tears from the ſinus in which they are collected, partly by attraction, and partly by the impulſe of the orbicular muſcle. If theſe

theſe points are obſtructed, the tears run over and excoriate the cheek.

DVII. From each point, a peculiar duct, much wider, thin, and included in the ſkin, proceeds, the one downwards above the caruncle, and the other more tranſverſely inwards, and under it; which approach each other, and are inſerted by two mouths into the lachrymal ſac, not quite at the top; which name is given to a cavity formed in the groove of the os unguis and upper jaw, lined firſt with a hard celiular, and as it were aponeurotic membrane; then by another, red and pulpy, continued from the membrane of the nares, pervious to the exhaling moiſture, and ſomewhat of an oval figure. From this veſicle the naſal duct deſcends a little backwards into the nares, and opens by an obliquely oblong aperture, covered by the lower os ſpongioſum, into their loweſt meatus. Through this the ſuperfluous tears deſcend into the noſe, which they in part moiſten, (CCCCLXIV.) A muſcle is by ſome aſcribed to this ſac; but it is not yet ſufficiently aſcertained.

DVIII. The eye, of a globular ſhape, compreſſed before, though not always in the ſame manner, longer from the brain to the cornea than from the right ſide to the left, is ſituated in the orbit, which is an oſſeous cavity, almoſt conical, compoſed of ſeven bones, interrupted in the back and outer ſides by larger fiſſures, and widening forwards, and by which it is defended on all ſides. But as this is larger than the eye, it is filled by much very ſoft fat, ſurrounding the globe of the eye, and allowing it free motion.

DIX. The eye begins from a nerve, by the expanſion of whoſe coats thoſe of the eye are formed. Its origin we have already deſcribed, (CCCLVII.) Having paſſed acroſs the crus of the brain, it joins with its fellow from the other ſide, and coheres with it for a conſiderable way, by much medullary ſubſtance; yet ſo that the right goes to the right eye, and the left to the left, though not without ſome

ſome reciprocal intermixture of medulla. The nerve then enters the orbit, a little inflected, and of a round form, ſomewhat compreſſed; and is inserted, not into the middle of the globe of the eye, but a little nearer to the noſe.

DX. The nerve having reached the eye, the inner plate of its dura mater, which it received in the opening of the ſphenoidal bone, is detached: or having become thicker, is extended around the eye, as its firſt coat, called the ſclerotic, or adheres to the ſclerotic, which perfectly reſembles it, and always ariſes from it. The other plate of the dura mater, the external, recedes and forms the perioſteum of the orbit; the pia mater, which is in this nerve very diſtinct and full of veſſels, having become entirely dark coloured and thin, lines the inſide of the ſclerotic. The remaining medullary central part of the nerve, continued from the brain, but divided by cellular plates, contracts into a depreſſed white conical papilla; which entering through the holes in the white circle of the choroid coat, and again expanding, produces the moſt internal membrane of the eye, the retina.

DXI. The ſclerotica is in general white, furniſhed with few veſſels, tough and compact, reſembling the nature of ſkin, of a figure very nearly globular, but compreſſed before, and is thicker at the back part. Before this coat, which is perforated by circular holes in its forepart, is placed, and obliquely connected with it, a more convex portion of a ſphere; pellucid, compoſed of many plates, whoſe veſſels are filled with pellucid water, and are difficult of demonſtration, inſenſible, and almoſt circular, circular towards the noſe, and oval towards the temples: it is termed the cornea, and through it the light paſſes into the inſide of the eye. It readily imbibes and exudes water. Before the anterior and flatter part of the ſclerotica, and before the cornea, the conjunctiva is detached from each of the

the eyelids, and is joined to the ſclerotica by proper cellular ſubſtance, which may be inflated, (D.) and is repleniſhed, partly with red veſſels, and partly with their pellucid continuations.

DXII. The origin of the choroid coat, is from the circumference of the white cellular circle, terminating the ſubſtance of the optic nerve, and through whoſe numerous foramina, and from which the retina and arteria centralis retinæ proceeds. At that place the choroides adheres to the ſclerotic, and to the circle above deſcribed. Then it is expanded concentrically, within the ſclerotic, with which it is united, perhaps by ſome cellular ſubſtance, and by many veſſels, which come from it to the choroides. Outwardly it is of a brown colour, but inwardly of a deep ruſſet or almoſt black, and at the ſame time villous; the two ſurfaces are ſeparable by maceration; and the innermoſt may be diſtinguiſhed by the name of Ruyſch; but it grows white through age. When it has reached the beginning of the pellucid cornea, it there becomes cloſely connected with the ſclerotica, by much cellular ſubſtance, having the appearance of a white circle, called orbiculus ciliaris, and then turns off in another direction; namely, the coat, which was before ſpherically expanded, is now ſtretched under the arch of the cornea, in the form of a circle, a little convex forwards, and incomplete, having in its centre a circular foramen called the pupil, which is ſeated nearer to the noſe, and is larger towards the temple. The anterior part of this ring is called the iris; and the back part, ſeparable from the former in the human body, by maceration, in ſome animals even by the knife, is, from the black pigment with which it is covered, called the uvea. On the anterior ſurface of the iris appear numerous radiated and branching ſtreaks, of various colours in different people, and entirely covered with flocculi. Theſe terminate

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on this ſide of the pupil in a ſerrated circle, from which other ſimilar ſtreaks extend, even to the edge of the iris. They are ſerpentine when the pupil is dilated, and ſtraight when it is contracted. On the poſterior ſurface of the uvea is much black pigment; which being waſhed off, ſtraight radiated ſtreaks appear, extending to the pupil, and not flocculent. Orbicular fibres, concentrical with the pupil, I have not been able to obſerve, either with the naked eye, or with the microſcope, even in the ox; but only in the uvea, an internal circle diſtinguiſhed by obſcurer rays, and leſs villous. In the human fœtus, the pupil is ſhut up, and the iris being continued, makes a complete circle. That part of it which extends acroſs the pupil is of a vaſcular texture.

DXIII. Though the iris has little ſenſibility, and is not endowed with any mechanical irritability; yet during life, in man, quadrupeds, and birds, the pupil is contracted by every greater degree of light, and is dilated by every ſmaller one; hence it is alſo rendered broader for viewing diſtant objects, and narrower for viewing ſuch as are near. The cauſe of this dilatation ſeems to be a remiſſion of the powers reſiſting the aqueous humour; as proved by the dilatation of the pupil, from debility, ſyncope and death. The contraction is leſs underſtood, and perhaps only depends on the ſtronger afflux of humours into the colourleſs veſſels of the iris, by which theſe veſſels are extended; and, at the ſame time, the iris is rendered longer, and ſhuts up the greater part of the pupil: ſo that this motion has ſomething in common with inflammation, as agreeing in their cauſe. In young people, the pupil is more evidently moved and contracted; as the eye gradually grows callous in old people, it becomes almoſt immoveable. In an animal twenty-three hours after death, I have ſeen the iris extended by heat ſo as to ſhut the pupil.

DXIV. Behind the uvea, from the ſame circle in which the choroides unites with the ſclerotica, more externally than the cornea, thick ſtriæ, elegantly plaited, ariſing from the choroides, white, with parallel veſſels running under them, with plumous, pendulous extremities, joined to the looſe and thin retina, and every where covered with a good deal of black pigment, depart, in the form of a perforated ring, inwards from the tunica choroidea, and proceed forwards behind the ciliary circle, and reſt upon the vitreous humour; and, laſtly, upon the capſule of the cryſtalline lens, but do not adhere to them. They are denominated the ciliary ligaments. The origin of the pigment is not known; nor have the ſecreting glands, which ſome have ſuppoſed, been found. Among its uſes, one ſeems to be, to keep the cryſtalline lens firm. In infants, this ſame mucus, behind the ciliary proceſſes, expreſſes the figure of a radiated flower.

DXV. The retina, which is a true continuation of the medulla of the optic nerve, and therefore very tender, mucous, and evaporable, is expanded within the choroides into a ſimilar ſphere, concentric with it; and immediately incloſes the vitreous humour. But when the retina has reached the ciliary proceſſes, it follows their courſe, ſupporting their arteries and ſtriæ, and proceeds to the cryſtalline lens, adhering to and covering its capſule, if the obſervations of ſome other anatomiſts, as well as my own are to be relied on; for in quadrupeds this termination of it is not perfectly certain, although in birds the internal lamina of the retina, covered with the ciliary body, is evidently continued to the cryſtalline lens; to the circumference of which it alſo adheres in man. The fabric of the retina is ſuch, that externally its ſoft and medullary globules form a thick and pulpy membrane, within which radiated fibres proceeding from the lamina cribroſa, and continued forwards, conſtitute a thinner

a thinner involucrum, very readily obferved in fifhes, and alfo in fome birds and quadrupeds, but not in man. Arterial and venous veffels with red trunks, form a net in the internal furface of the retina, which when accurately filled with coloured water compofe a membrane.

DXVI. Thefe coats, refembling the coats of a bulbous root, are fupported, and the fpherical figure of the eye is preferved by its humours: of which one is a folid, another a foft body, and a third truly a liquor. Firft, then, the concave furface of the retina is every where filled by the principal or vitreous humour, of which the ftructure confifts of a peculiar thin, pellucid, cellular membrane, in whofe cellular intervals is contained a very pellucid liquid, very rarely altering even in old age, completely evaporable by heat, nearly allied to the aqueous humour, and fomewhat denfer than water. Its veffels, which are moft manifeft in fifh, lie in the back part, moft beautifully radiated from the central trunk of the retina, embracing the convexity of the vitreous humour; and inferted into a circle formed not far from the lens by other arteries coming from the choroides, and which I have feen in the fheep. The vitreous membrane, which is tender confidering its body, adheres to the lens in two places, before and behind; fo that a hollow fpace is intercepted in the middle between the two infertions, around the cryftalline lens. This fpace is divided in different places by fome fibres. On its anterior furface the ftriæ of the ciliary body imprint their marks.

DXVII. But, in the forepart of the vitreous body, behind the uvea, there is an orbicular depreffion of confiderable depth, into the cavity of which the cryftalline lens, (alfo, though improperly, ranked amongft the humours,) is received. The figure of this lens, refembling frozen jelly, is compofed of

two

two elliptical convex ſegments, the anterior of which is flatter, and the poſterior more gibbous. It is conſtructed of concentric laminæ, connected by cellular fibres, which themſelves are compoſed of fibres elegantly diſpoſed through fine cellular membrane. Betwixt the plates of the cryſtalline lens, is alſo contained a pellucid liquor, but which, in old age, naturally acquires a yellow colour. The innermoſt ſcales are more cloſely compacted; and form as it were a harder nucleus; externally it adheres ſo very looſely to the capſule, that when that is broken, it very readily ſprings out; and ſome even ſay, that a little water is effuſed around it. It is ſupplied with an artery from the retina, which perforates the middle of the vitreous humour, and enters behind; for veſſels have not yet been diſcovered on the anterior ſurface. The whole lens is contained in a ſtrong, thick, elaſtic capſule of a pellucid membrane, more firm in the forepart, and which is lined poſteriorly by the vitreous tunic.

DXVIII. Laſtly, the aqueous humour, which is extremely pellucid and fluid, and which is renewed again if it be let out, ſwims in the ſmall triangular curvilinear ſpace betwixt the uvea and cryſtalline lens, and in that larger ſegment of a hollow ſphere which lies 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 by the correſponding veins, while ſome portion of it is abſorbed by and exhaled through the cornea. This humour alſo moiſtens the uvea and capſule of the lens. About the beginning of the preſent century, the ſpaces filled with this liquor were called the chambers of the eye; that between the cornea and iris the anterior one, and that ſmall one between the ſurface of the cryſtalline lens and the uvea the poſterior.

DXIX. The eye, thus conftructed, is provided with mufcles externally inferted into it, by which it is governed. Namely, into the circle of the fclerotica, which is contiguous to the cornea, are inferted four ftraight mufcles, arifing almoft in one circle from the dura mater of the optic nerve; where, departing from the nerve, it coheres with the periofteum of the orbit, and proceeding forwards with their bellies round the bulb of the eye, they terminate again by their aponeurofes, meeting together in another circle. Of thefe, the elevator is the leaft, and the abductor rather the longeft. The office of each of thefe mufcles appears very plainly; fince, being bent round the convex bulb of the eye, as about a pulley, they muft, of courfe, elevate, deprefs, or turn the eye either to the nofe or to the temples. Moreover, two of them acting together may move the eye diagonally; as upwards and outwards, upwards and inwards, &c. Laftly, when all the four ftraight mufcles contract together, there is fcarcely a doubt that they draw back the whole eye within the head towards their origin, and thus bring the cryftalline lens nearer to the retina.

DXX. But the fabric of the two oblique mufcles of the eye is more compound. The upper of thefe, arifing together with the recti, is long and flender, afcending forwards to a notch in the os frontis, which is completed into a hole by a double ligament, which on each fide fuftains a cartilage, excavated in the middle, and almoft quadrangular. Through this canal paffes the tendon of the obliquus, which being reflected backwards and outwards, included in a capfule of its own, is inferted into the globe of the eye behind the ftraight mufcles. This draws the globe forwards, as if out of the orbit, and inwards, and turns the pupil inwards and downwards. The other, the obliquus minor from the finus of the lachrymal foramen in the

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 to turn the point of its inſertion into the eye downwards and outwards; and, therefore, the oppoſite pupil upwards and inwards.

DXXI. But there are other minute muſcular motions performed in the eye, which preſuppoſe a knowledge of its nerves. Of the optic nerve we have already treated (DIX. DX.) The fourth pair goes only to the larger oblique muſcle, and the ſixth pair to the rectus externus. The third and fifth pair produce the principal nerves in the eye; the firſt or ophthalmic branch of the fifth ſends off a nerve at its entrance into the orbit, to the eyelid and lachrymal gland, which joins with the ſecond branch of the fifth pair, and with the temporal branch of the third of the fifth pair. On entering the orbit, its trunk divides into two. The upper branch, larger and bifid, is expended on the forehead and eyelids: but the lower, penetrating inwards above the optic nerve, ſends off a long ſlender filament at the outer part of that nerve, which, joining with another filament of the third pair forms the ophthalmic ganglion, and ſends off one or two ciliary nerves. Finally, after having given off the recurrent nerve of the noſe (CCCCLVII.) it is then ſpent upon different parts in the internal angle of the eye.

DXXII. But the third pair is of moſt importance. After giving off a branch upwards to the ſtraight muſcles of the eye, and to the eyelids, it proceeds with its trunk under the optic nerve, and at the ſame time ſends out three branches to the inferior, obliquus minor and internus; after this, or before, from its trunk, or ſometimes from the branch of the obliquus minor, it ſends off another ſhort nerve, much thicker than the root from the fifth, (DXXI.)

(dxxi.) which, under the abductor mufcle upon the optic nerve, forms the ophthalmic ganglion, which is oval and conftant, and fometimes arifes from the third alone. From that ganglion, and fometimes from the trunk of the third or fifth, four or five ciliary nerves playing around the optic nerve in a flexuous courfe, go to the globe of the eye, perforate the fclerotica almoft in its middle, in company with its longer fmall arteries or veins, run ftraight forwards along the choroides, and vifibly proceed to the iris, and feemingly to the ciliary proceffes. Other very fmall nerves, originating from the fame ganglion, remain in the tunica fclerotica.

dxxiii. The motion of the ciliary proceffes is obfcure and difficult of demonftration, (dxiv.) lying incumbent upon the furrows of the vitreous membrane, by their action they are believed to prefs back that body, fo as to bring the lens forwards, and remove it farther from the retina. But I have never feen, in all the animals I have diffected, any thing like a mufcle in this ciliary body, but only a membrane which fupports fmall veffels. The fphincter of the pupil and conftrictor of the cornea, mentioned by fome writers of eminence, and the moving fibres, which others have imagined proper to the cryftalline lens, are not confirmed by anatomy, nor are they confiftent with the conftant hardnefs of the lens and cornea in moft animals.

dxxiv. The hiftory of the eye alfo comprehends its veffels, which have a moft beautiful fabric. All thofe which belong properly to the eye itfelf come from the ophthalmic artery, a branch of the internal carotid, (cccxvi.) This, creeping under the optic nerve, fends off, as principal branches, the upper ciliary, one or more inferior ciliaries; the lachrymalis, from whence the nafalis recurrens pofterior, and internal part of the arch of the tarfus; afterwards the mufcularis inferior, the nafalis recurrens,

currens, anterior and poſterior, the muſculares ſuperiores, and the palpebralis, which, with the former branch, forms the arch of the tarſus. Laſtly, it goes to the face, noſe and adjacent parts. But the ophthalmic branches, belonging to the inner parts of the eye, are called the ciliaries; which, ariſing from the trunks now mentioned, and playing around the optic nerve, in four or more branches, in a ſerpentine courſe, partly cloſe by the entrance of the optic nerve, go to the choroides with forty or more branches, and make upon its external ſurface, ramifications divided at acute angles, which proceed forwards to the circle of the uvea.

DXXV. But moſt of the ſmall arteries of the tunica choroides gradually incline towards the interior parts of the eye; and, being covered with a kind of cellular down, go to the ciliary proceſſes, along each of which two ſmall arteries run, giving off on every ſide, vaſcular flocculi, and inoſculating at their apex.

DXXVI. Other ſmall arteries alſo, likewiſe ariſing from the ciliary ones, but few in number, moſt commonly two, go to the place, from which the uvea originates. There, ſpreading in various directions, they ſurround the root of the uvea with their branches, and join to form a circle, into which the anterior ciliaries inoſculate; which are ſmall arteries ariſing from the muſcular branches of the ophthalmic; and are inſerted into the circle generally by twelve ſmall trunks, near the origin of the cornea. From that circle, and likewiſe from the above mentioned anterior ciliary arteries, without the intervention of the circle, ſtraight, branched veſſels, are diſtributed, both on the iris, and on the uvea; the former full of a blue or dark coloured fluid; and the latter naturally white, but covered with a good deal of a black paint. In the uvea, at ſome diſtance from the pupil, they frequently form an imperfect circle.

DXXVII.

DXXVII. But from the ſame ophthalmic artery, from its trunk, or from the lachrymal branch, or from one of the ciliaries, one or more branches enter into the optic nerve; the principal, the central artery of the rétina, penetrates into the medulla of the nerve, and paſſing through the apex of the papilla, (DX.) enters the centre of the retina; from thence it ſpreads every way through the retina itſelf, by ſo many branches, when traced by a ſkilful anatomiſt, that that vaſcular network has been taken for a peculiar membrane. Sometimes a ſmall branch goes along the centre of the nerve to the retina, and is in like manner ramified through it. From comparative anatomy, it is certain, that from theſe branches the vaſcular branches of the vitreous tunic are produced, as well as the poſterior artery of the lens. The moſt internal of theſe arteries, is the celebrated porus opticus of the ancients.

DXXVIII. The veins of the eye, in general, ariſe from the ophthalmic vein, which on the one ſide comes from the facial vein, entering the orbit; and on the other, is inſerted into the cavernous ſinus. The internal veins of the eye perforate the middle of the ſclérotica, with fewer and larger trunks than the arteries, and form larger and more anterior reticulations, of a roundiſh figure, which commonly occupy the middle of the tunica choroides: ſome, which are long, are continued to the origin of the uvea: others anterior, ſimilar to the arteries; and another, the centralis nervi optici, correſponding with the artery, goes to the retina. The pellucid veſſels do not differ from the ſanguiferous. Lymphatic veſſels are ſaid to have been ſeen in the retina; but the obſervation has not been ſufficiently repeated.

DXXIX. So far with reſpect to the anatomy; but the action of the eye is entirely elucidated by phyſical experiments, from which it has been aſcertained, in the moſt incontrovertible manner, except

a few doubtful points. Light is the ſame matter with heat, or very nearly the ſame, poſſeſſing extreme fluidity and ſubtilty, penetrating through all bodies, very rigid, not exhauſted by any diſtance of its paſſage, and moving with exceſſive velocity, ſo as to arrive at the earth from the ſun in eight minutes and thirteen ſeconds. Light in our planet proceeds either from the ſun, which ſeems to have the power of arranging in ſtraight lines, the matter of light, otherwiſe confuſedly ſcattered; or from ſome other lucid point. From it, as from a centre, the light is diſtributed like rays, to all parts of the ſphere, ſo as to fall upon the ſurfaces of all bodies; from whence again it is reflected, and impinges on the eye, at angles equal to the angle of incidence, and renders the bodies, from which it comes, coloured and viſible.

DXXX. It is aſcertained, from experiments, that light is compoſed of rays in right lines, almoſt without any phyſical breadth; and yet, each of which may be ſeparated into ſeven more minute, permanent and immutable rays. The known properties of theſe rays are, that all of them, conjoined together, conſtitute a white beam; but when refracted, and ſeparated by the minute ſurfaces of bodies, they are ſubdivided into red rays, which are the moſt conſtant, hard, and leaſt refrangible; and afterwards into orange, yellow, green, blue, indigo, and violet; which are always weaker and more refrangible, as they are farther diſtant in order from the red rays. Shade ariſes from a deficiency of reflected rays. Colours are compounded of ſhade united with various rays.

DXXXI. The peculiar colours of bodies ariſe from the minute ſurfaces of their ſolid particles, by which their pores are limited, which refract the rays of light, according to the difference of their thickneſs, reflecting one kind of rays moſt copiouſly, and in a great meaſure ſuffocating by repeated internal refractions, the others admitted into their ſubſtance: ſo that the

the thickeſt and denſeſt particles reflect a white colour; the next red; and the thinneſt violet. Bodies are opaque, which retain all the rays, and tranſmit none, from the largeneſs of their pores, to the ſides of which the light is attracted; and which are filled with ſome matter that has a power of refraction, different from that of the particles of the body. Theſe principles we embrace, till a new theory, which aſcribes the diverſity of colours to vibrations of different celerities, ſhall be better eſtabliſhed; for it is not our buſineſs to aſcertain theſe matters.

DXXXII. Theſe rays, when they fall obliquely upon liquors of various denſities, in paſſing through them, variouſly recede from, or incline towards the perpendicular: this is called 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, attract the rays more to the perpendicular, than in proportion to their denſity. The proportions of the angles of incidence to thoſe of refraction, are conſtant; ſo that the ſine of the angle of refraction of rays paſſing from air into water, is to the ſine of the angle of incidence, as 3 to 4: and of rays, 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.

DXXXIII. Rays, which come through the air with but little divergency, as thoſe of the ſun on account of its immenſe diſtance; or as, in general, any rays that come from a diſtance of above 100 feet, when they fall upon a body, ſpherically convex, and denſer than the air, at a large angle, as at 48½ degrees, are reflected, and do not penetrate it. If the angles are ſmaller, they penetrate the refracting medium, and are refracted in it, ſo as to meet together in one point, which is called their focus. This point lies in the axis, or in the ray, falling

 perpendicularly

perpendicularly on the ſurface, and therefore not inflected; and in a ſpherical globule of water, the focus of rays coming from the atmoſphere, is at the diſtance of one ſemidiameter from the ſphere; and in a ſphere of glaſs, a fourth part of the diameter, and in a convex lens of glaſs, that is, a part of a ſphere not leſs than thirty degrees, and equally convex, it is alſo one ſemidiameter; but ſo that the rays meet, not in a point, but in a little circle.

DXXXIV. Therefore the rays of light, whether direct or reflected, fall in ſuch a manner upon the cornea of the eye, as to form a very acute cone, from the lucid point to the ſurface of the membrane: the baſis of which is the ſurface of the cornea, and the apex the radiant point; yet ſo, that the rays of the cone may be conſidered parallel, without any ſenſible error. Of theſe rays, all thoſe which fall upon the cornea at a greater angle than forty degrees, are reflected from the cornea without penetrating its ſurface. Others which enter the cornea, but ſtill at large angles, fall in betwixt the uvea and ſides of the cryſtalline lens, and are ſuffocated in the black paint that lines the uvea, (DXII.) and the ciliary proceſſes, (DXIV.) and thoſe rays only fall upon the ſurface of the lens, which enter the cornea at ſmall angles, not much diſtant from the perpendicular, or at about twenty-eight degrees. By this means, all thoſe rays are excluded, which the refracting power of the humours in the eye could not have been able to collect into one point of the retina; and which, therefore, would have painted the image on the retina too broad and confuſed.

DXXXV. Thoſe rays, therefore, coming from the air, which is ſo thin, and paſſing through the cornea, which is the ſegment of a ſphere, thick, denſer than water, and therefore almoſt a fourth part more refracting, are remarkably inclined towards the perpendicular. By the aqueous humour, which is ſmall

ſmall in quantity, and almoſt like water, but rather lighter, they are not altered, and fall upon the ſurface of the tranſparent lens, before they have formed a focus, becauſe of its nearneſs, nearly parallel, or rather converging; becauſe their divergency was abundantly corrected by the refracting power of the cornea. Moreover, the cornea being convex, and more prominent than the hemiſphere of the ſclerotica, receives and collects a greater number of rays than if its ſurface were flatter, and therefore ſmaller.

dxxxvi. That the refracting power of the cryſtalline lens, exceeds that of water, may be underſtood from its hardneſs and weight, although we have no ſufficiently certain meaſure. In this lens, therefore, and more eſpecially in its poſterior very convex ſurface, the rays converge very much, and paſs thence into the vitreous body.

dxxxviii. This ſubſtance is denſer than water, ſince it ſinks in it; but rarer than the cryſtalline lens; bends the rays a little more gently towards the perpendicular, till at length the rays, coming from a point of diſtinct viſion, are concentrated into the ſmalleſt poſſible point of the retina, where they paint an image of the object from which they come; but inverted, on account of the neceſſary decuſſations. The manner in which the images of objects are thus painted, may be ſeen in an artificial eye, or in a natural eye, when the back part of the ſclerotica is removed. But the image is painted on the outer ſide of the entrance of the optic nerve, at the termination of the axis of viſion, which is not limited to a mere point, but has ſome breadth; ſince we ſee many objects at once, whoſe images muſt be repreſented in different points. Viſion is there moſt diſtinct, becauſe the rays arrive thither nearly perpendicular. But frequently it does not fall on the ſame place in both eyes of the ſame individual. When the lens is deſtroyed, the

the vitreous humour alone collects the rays, though lefs powerfully.

DXXXIX. Is it entirely falfe that the object is painted on the retina? Is the picture reprefented on the choroides? Is this new opinion confirmed by the experiment, by which it appears, that the place where the optic nerve enters is infenfible? and which is thus explained, that there is in that place no choroides but only the bare retina, and that therefore, it does not poffefs vifion. But this is repugnant to a very well known obfervation, that the retina is a moft fenfible nervous medulla; and that the choroides almoft entirely confifts of a few fmall nerves, and of veffels which are moft certainly blind. This is likewife contradicted by the very great variety of the choroides in animals; by the equally great uniformity of the retina; and by the black fpots, which, even in man, obfcure the exterior furface of the retina. But, by this experiment, we perceive the reafon why the optic nerve is not inferted into the axis of the eye, but towards one fide. For thus, except only in the fingle cafe, where an impediment is fituated in the point of interfection of lines drawn through the centre of the optic nerves, the one eye fees and affifts that whofe blind portion is directed to the object.

DXL. But fince the neceffary functions of human life require that a diftinct object be painted upon the retina, not only by the rays which come from one certain diftance, but likewife that rays which come from various and very different fituations, more or lefs diftant, fhould excite a diftinct idea of the object from which they come: therefore, it is believed, that the neceffary change is produced in the eye by proper means. Some celebrated anatomifts have fuppofed the lens moveable by the powers before mentioned, (DXIX. DXXIII.) They affert this art of changing the eye is learned by experi-

ence,

ence, and is not poſſeſſed by thoſe on whom the operation of couching the cataract has been lately performed. Alſo in an artificial eye, the advantages 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 the removal of the lens farther from the retina, by which means the focus, which is more diſtant, on account of the divergence of the rays, falls upon the retina itſelf, which would otherwiſe have fallen behind the retina; for the refracting power of the eye being ſuppoſed to be ſuch, as will cauſe the focus of rays coming from the diſtance of three feet, to fall exactly upon the retina, it will not be able to collect together into the ſame point, rays which come from the diſtance of three inches; and the more diverging rays, when not collected by more powerful means, will be too late of uniting.

DXLI. But thoſe rays, which come from very remote ſituations, and may be therefore reckoned parallel, would meet in the vitreous humour before they reached the retina; and would again ſeparate as rays from the point of concourſe, as if from a lucid point: it is therefore believed, that the powers, (DXXIII.) remove the cryſtalline lens from the cornea, and carry it nearer to the retina, that the rays may meet at a greater diſtance from the lens, and that that diſtance may be accommodated ſo as to fall upon the retina. For an eye, that will collect the rays coming from a diſtance of ſeven inches, on the retina, will collect thoſe which come from a diſtance of three feet too ſoon, and before they reach the retina. So that it ſeems perfectly neceſſary for the eye to be made thus changeable, ſince we ſee diſtinctly at various diſtances. The point of diſtinct viſion is that in which the given object is painted on the retina in the leaſt ſpace poſſible. The powers collecting the rays, are often very different

ferent in the two eyes of the ſame perſon, ſo that the one eye is rather long ſighted, and the other ſhort ſighted.

DXLII. Theſe and other ſimilar opinions, commonly received, are taught, more eſpecially by the mathematical phyſicians, who more obviouſly perceive the neceſſity of theſe changes. Yet there is no power in the human eye which can either move the cryſtalline humour from its place, or compreſs it. And we do not perceive this faculty in ourſelves: for we move a book, which by being too far off we ſee confuſedly, nearer to our eyes, which we would not do, if by an internal change in 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 have ſome effect in enabling us to ſee near objects more dictinctly.

DXLIII. But this adaptation is not ſufficient in all perſons: for there are, and now more commonly than formerly, perſons leading a ſedentary life, and occupied with the obſervation of very minute objects, in whom the cornea is more convex and denſe; the cryſtalline lens more convex and ſolid; the eye itſelf, by the weight of the humours, more elongated; and the reſt of the humours themſelves probably more denſe; and in whoſe eyes one, or ſeveral, or all of theſe diſeaſes occur. In theſe perſons, the iris is ſenſible in a ſmall light; and therefore from their winking, they are denominated myopes. In theſe, the point of diſtinct viſion is very near to the eye, from one to ſeven inches from the eye; they ſee remoter objects obſcurely, without being able to diſtinguiſh their parts. The reaſon of this is evident; ſince, from the cauſes juſt mentioned, the too great refracting power of the humours, cauſes the diſtant and conſequently parallel rays to meet before the retina;

retina; and therefore diverging again from their focus, they fall upon the retina in many points. Thus alſo to a ſound eye, the perception of near objects is confuſed; becauſe the rays coming from theſe are ſpread all over the retina, without being collected.

DXLIV. The remedy, in the commencement of this diſeaſe, is to view diſtant places, to abſtain from minute objects, and concave glaſſes, and to look through a ſmall aperture, by which the light is weakened. When the diſorder is confirmed, it is alleviated by the uſe of a concave lens, which diminiſhes the refracting power in the humours, cornea, and cryſtalline lens, in proportion to its concavity; and thus removes the focus of diſtant objects farther from 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 by the naked eye, ſquared by the diſtance of diſtinct viſion in the eye furniſhed with a glaſs, and divided by the difference betwixt them. Short ſighted people may hope for ſome relief from the progreſs of life; for children are almoſt all myopes: but, as they grow older, the eye becomes flatter from the ſtrength of the ſolids, it becomes ſhorter, and the converging powers of the lens and cornea are diminiſhed.

DXLV. Another defect, the oppoſite of the former, troubles people who are in the habit of looking much at very diſtant objects, and is eſpecially frequent and incurable in old people. In it, 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 to them confuſed; becauſe the converging powers of the eye are not ſufficient to collect the rays into a focus upon the retina, and the rays arrive at it ſcattered, and have their focus behind the eye; hence their viſion is confuſed.

The

The point of diſtinct viſion among preſbyopi, is from fifteen inches to three feet.

DXLVI. Such perſons are, in ſome meaſure, relieved by looking through black tubes, 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, ſo as to meet ſooner in a focus, and upon the retina. The diameter of the ſphere, of which ſuch a lens ought to be a portion, is exactly as before (DXLIV.) There is no hope from age, which increaſes the malady.

DXLVII. The medium betwixt the ſhort and long ſighted eye is the beſt, with which a perſon can ſee diſtinctly objects that are both tolerably near and tolerably remote, and therefore may aſſume the properties both of the myopes and preſbyopi; of this kind we reckon an eye that is able to read diſtinctly at the diſtance of one foot. But other conditions are neceſſary, ſuch as perfect clearneſs of the humours; great mobility of the eyes; ſenſibility of the pupil; and a retina, neither too ſenſible nor callous.

DXLVIII. But by means of the eye, the mind does not receive a ſimple repreſentation of the image of the object on the retina, which is transferred to the ſeat of the ſoul; but many things are added from experience, which the eye does not really ſee, and other things are interpreted differently by the mind, from what they are repreſented by the eyes. And, firſt, the magnitude of an object is judged of by the optical angle intercepted between the radiating object as the vertical point, and the cornea as the baſe. From hence, things very near ſeem large, and remote objects ſmall. To this may be referred the power of the microſcope, by which objects are made to appear to us ſo much larger, as the diſtance of the focus of the glaſs lens is leſs than the diſtance of diſtinct viſion; and,

and, in reality, they do not appear larger, but only more diſtinct and lucid; whence the mind judges them to be nearer.

DXLIX. In the ſame external light, the ſtrength of illumination depends upon the ſame angle, and upon the number of rays, joined with the ſmallneſs of the point which they affect in the retina; near objects therefore appear brighter, and diſtant objects more obſcure; or if remote objects appear bright by their own light, the mind repreſents them as large, or near, or both.

DL. The place of a viſible object is eſtimated by one eye, to be in a line comprehended by two other ſtraight lines drawn to the extremities of the body. If the ſame body is beheld with both eyes, it will then ſeem to be in the concourſe of two lines drawn through the axis of each eye to the object.

DLI. We do not ſee diſtance; and a blind man, who has never ſeen, on acquiring the uſe of ſight, imagines every thing he ſees to touch him. After much experience, we at laſt make conjectures about diſtances, though always fallacious: but we judge of them both from the diminution of the known bulk of the body, and from the diminiſhed ſtrength of the light, and faint image of the object whoſe parts we diſtinguiſh leſs evidently, and from the number of bodies interpoſed, whoſe diſtance is known to us.

DLII. Convexity is not ſeen; but from experience, a body is reckoned convex, after we have learned, that a body, which is convex to the feeling, cauſes light and ſhadow to be diſpoſed in a certain manner. It is convex if the ſhade be in the ſide correſponding to the left hand, and concave if in the right. 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,

derſtood, by which the concave parts of a ſeal are made to ſeem convex, and the contrary.

DLIII. The parts of a viſible object are judged by the mind to have the ſame ſituation which they have in the object, and not inverted as they are on the retina. The mind poſſeſſes this power of correction, previous to experience in men who have been born blind, and in animals at birth, as appears by indubitable experiments upon men, who had been blind from birth, and acquired the power of viſion ſuddenly by the operation of couching.

DLIV. Another falſe perception of the mind ariſes from this circumſtance, that external ſenſations conveyed to the ſeat of the ſoul by the eyes, are repreſented during almoſt the ſpace of a ſecond of a minute, to the mind as objects really preſent. Hence proceeds the idea of a fiery circle from the circumrotation of a lucid body; and hence the continuance of the image of the ſun, and ſometimes alſo of opaque bodies.

DLV. Do we perceive only that object diſtinctly which is directly before that part of the retina which ſees moſt diſtinctly? And does the mind 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 in the eye? Concerning perfectly diſtinct viſion, this is moſt certain; but we can hardly affirm it of that which is leſs diſtinct. Why do we ſee only one object with two eyes? Becauſe the ſenſation is ſingle, and without difference, when we have ſimilar impreſſions of two objects. For, even without the decuſſation of the optic nerves, inſects who have numerous eyes perceive objects ſingle. Hence the images of two objects excite only one ſenſation in the mind, 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 of each eye. Whence proceed diurnal and nocturnal blindneſs?

blindneſs? The latter is common to many nations living in the very warm climates, and under the vertical ſun, and to old men. The former happens in inflamed eyes, and in young men of a hot temperament, and hence furniſhed with eyes vaſtly ſenſible. For great ſenſibility of the retina produces diurnal blindneſs; inſenſibility produces nocturnal blindneſs. How do animals ſee in the dark? From a large dilatable pupil, tender retina, and refulgent and very lucid choroides. Why do we become blind when brought out of a ſtrong light into a weak one? Becauſe the optic nerve, having ſuffered the action of ſtronger cauſes, is not affected by weaker ones. Why is the ſudden tranſlation from a dark place into the light painful? Becauſe the pupil, being widely dilated, ſuddenly admits unawares too great a quantity of light, and the retina having been but ſlightly affected by the weak light, now feels the ſtronger impreſſions very acutely. Do we ſee with one eye, or with both? Moſt frequently with one, eſpecially and generally the right eye: but by the aſſiſtance of the other, we ſee more objects, and more plainly; and we alſo diſtinguiſh more points of the ſame object, and judge better of diſtances.

C H A P. XVII.

INTERNAL SENSES.

DLVI. WE have conſidered the ſenſes apart. It is common to them all, that the medulla of the tender and pulpy nerve, being affected by external objects, tranſmits ſome change by the nervous ſpirits, to that part of the brain where the fibres of the nerve affected firſt ariſe from the arteries of the brain (CCCLXXXII.) We know nothing more, than that new thoughts are excited

excited in the mind, as often as a change of this kind, originating in any organ of ſenſe, is tranſmitted to the origin of the nerve affected. For this perception is not an actual repreſentation of the object, by which the ſentient nerve is affected. The idea of redneſs has nothing in common with rays little refrangible, and ſeparated from the ſeven portions of the total ray; and much leſs is it conſiſtent with optical principles, for an image painted by rays upon a ſoft white nerve, to be conveyed for a long way, in perfect darkneſs, through a completely opaque body, to the origin of the thalami optici. There is nothing in the pain of burning that can repreſent to the mind the violent motion of a ſwift and ſubtile matter, by which the particles of the nerves are removed from mutual contact. There is nothing in the idea of a ſharp ſound from a cord of a certain length, that can inform the mind that the ſaid cord vibrates 5000 times in the ſpace of a ſecond. Neither does the taſte teach us that the cryſtals of ſea ſalt are of a cubical figure. Laſtly, motion imparted by a body perceived by the ſenſes, is indeed propagated to the brain, but the mind neither perceives this motion, nor the tremors of ſound, nor the percuſſion of the rays of light, but ſomething perfectly diſtinct from motion. It is eſtabliſhed as a reciprocal law by the Creator, that with certain changes, produced firſt in the nerve, and then in the ſenſorium commune, new and definite thoughts ſhall ariſe in the mind, invariably connected; and that our perceptions of external objects are arbitrary, yet that they are not falſe, appears plainly from the perpetual agreement of ſimilar ideas with ſimilar affections of the ſentient nerves, in all perſons at the ſame time, and in one perſon at different times.

DLVII. Therefore, when we feel, five very different exiſtences are conjoined: the thing which we perceive; the affection of the organ of ſenſe by that body;

body; the affection of the brain, arifing from the percuffion of that fenfory; the change produced in the mind; and, laftly, the confcioufnefs of the mind, and perception of the fenfation.

DLVIII. It appears from certain experiments, that the firft origin of every fentient nerve is always diftinct from all the others; and that the change which is firft excited by external objects in that nerve (DLVI.) continues long in its origin; and that thofe changes are generally fo arranged in the faid part of the brain, that, being difpofed according to the order of time, thofe are neareft together, which were either cotemporary, or occurred in immediate fucceffion; or, laftly, thofe which have a relation to the fame fubject, or were excited by fimilar objects; infomuch, that it is certain, that new ideas are conveyed to the fame part of the brain where others of the like kind are referved: for otherwife, neither would the arbitrary figns of words and letters recall to the memory paft ideas; or difagreeable ideas, returning into the mind, without the affiftance of external objects, reproduce the fame effects, as objects themfelves; nor, otherwife, could there be fo conftant and manifeft a connection of analogous ideas, which fupervene moft remarkably in dreaming, to the corporeal impreffions, acting at that time moft powerfully. Imagination and memory depend on this confervation of ideas. Thofe changes conferved in the fenforium, which many term ideas, are, for the fake of diftinction, by us called the impreffions of things, as they do not exift in the mind, but are impreffed in the body itfelf, and indeed in the medulla of the brain, in an incomprehenfible manner, by certain characters, incredible in their minutenefs, and infinite in their number. Amongft thefe the impreffions received by the fight are the moft remarkable, and moft diftinctly preferved, and next, thofe of hearing; thofe of the other organs are more confufed, and lefs revocable

vocable by the will. Both the impreſſions and their ſigns are preſerved; the latter more eaſily; the former, however, ſo far, that a painter can expreſs with his pencil upon canvas, a face ſimilar to the image of a familiar face, impreſſed upon his mind.

DLIX. We are ſaid to imagine, when, by means of any image preſerved in the ſenſorial part of the brain, the ſame ideas are excited in the mind which would ariſe if the ſentient nerve that firſt produced the ſaid image itſelf ſuffered that change. This we term recalling an image. This definition is confirmed by the example of the great ſtrength of fancy in certain perſons, and in thoſe who are delirious, and in every perſon, in the inſtance of dreams, in which thoughts ariſe in the mind, occaſioned by the images preſerved in the brain, not at all weaker than thoſe which are primarily produced by the change in the ſentient nerve, from the external objects, and in which the perfect reſemblances of perſons and things with which we are occupied, are repreſented to the mind. Attention, quiet, and the abſence of other objects, even obtain a ſtronger aſſent of the mind to theſe traces impreſſed on the brain, than to thoſe perceptions which are excited in the mind by external objects: for the will is much more powerfully determined in thoſe who dream, than in thoſe who are awake; and ſome voluntary muſcles perform, during ſleep, functions, which, while awake, they never could perform, even when their nerves were moſt ſtrongly affected by the ſame object. From hence we may underſtand, how it is poſſible, that a very vivid internal impreſſion in delirium, may ſo impoſe upon the mind, as to be miſtaken for the perception of an external object; which is evident in the ſparks which are excited by rubbing the optic nerve; in the redneſs ſeen by the eye when ſhut; in the vertigo that ariſes from a motion of the retina, which we aſcribe to the external objects themſelves; in double viſion, &c.

DLX.

dlx. Memory is ſaid to be exerciſed, when any thought of the mind, or image of an external object preſerved in the ſentient part of the brain, (ccclxxii.) excites any perception in the mind. This is commonly weaker than in imagination, and almoſt confined to certain arbitrary ſigns, which the mind conjoined with that idea at its firſt perception. For memory hardly repreſents the images and pictures of things to the mind, but almoſt only words, and certain attributes, and abſtract ideas; for which reaſon, it excites volition leſs powerfully. But it appears from the obſervation of the phenomena of memory, that thoſe changes which ariſe from the external ſenſes, remain long in the brain; and ſometimes, if they made a ſtrong impreſſion, are repreſented to the mind for a long period, almoſt forever; but that they are gradually weakened and impaired; unleſs they be renewed, either by the object being repreſented again to the mind, or by the mind itſelf recalling the ſame change again into memory; and that at laſt the change will be in a manner eraſed, and entirely loſt, and the idea which was connected with that change by the law of nature, will never again recur to the mind. This annihilation is gradually effected by new and different impreſſions made on the ſenſorium, and not from time only, or the circulation of the blood, as in cataleptic patients, who ſometimes, after a conſiderable interval of time, return to the ſame train of thought which the diſeaſe had interrupted. But ſometimes all of them will be ſuddenly deſtroyed by ſome diſeaſe, in which the brain is in ſome way compreſſed, either by the blood or any other cauſe. Such a cauſe, acting on part of the common ſenſory, blots out a part of the impreſſions from the memory, ſuch as certain words, or all of them, the characters by which we expreſs words, or our friends, and even the neceſſaries of life: yet all theſe impreſſions may often be renewed by removing the

compreffing caufe. But the ftrength and duration of an idea depend upon its being unufual, exceffive, or greatly conducing either to increafe or leffen our felicity; and, laftly, upon our attention to it, and repetition; which laft renders the impreffions fo vivid, that their perception is at length miftaken by the mind for the perception of external objects, as in the cafe of maniacs.

DLXI. Moreover, if we review the hiftory of human life, it appears, that in early infancy, we have hardly any memory; only fimple perceptions, that foon vanifh: which, neverthelefs, excite ftrong ideas in the mind, as we fee from the crying of infants. The memory is perfected by degrees; and the ideas received from favorite objects, and familiar perfons, remain impreffed in the mind of the infant; while, at the fame time, the imagination likewife increafes, which is often very powerful in young children; as, for example, in terror, which in no age produces more violent or deplorable effects. Afterwards, as the number of our ideas increafes, the facility of preferving paft ideas is impaired, and, at the fame time, the power of the imagination becomes torpid: till at laft the former almoft perifhes, and the ideas which are received efcape from the brain in a fhort time; while, at the fame time, the imagination, which is a kind of memory, languifhes.

DLXII. But fince thefe perceptions produce various changes in the mind itfelf, which are perfectly diftinct from any corporeal faculty, we fhall briefly add fomething concerning them, fo far as may fuffice for the purpofes of medicine. Thought refides in the foul, it attends to the fenfations which are either brought by the fenfes, or recalled by the imagination; frequently alfo to the mere figns which recur into the mind. Attention is when one idea occupies the mind principally or folely for any length of time. The comparifon of two ideas, inftituted by the mind, is called judgment or genius, when

when the mind, by comparing them, difcovers them to be alike or diffimilar. Genius confifts in a vivid fenfation conjoined with rapidity of thought, fo as inftantly to abftract from notions their points of fimilitude and diffimilitude. The principal fource of judgment, invention, and wifdom, confifts in the flow examination of ideas, by which they are confidered by the mind in every point of view, and in the attention of the mind being confined to one object, to the exclufion of all other ideas. Hence the efficacy of darknefs in making difficult calculations; the exquifite attention of blind people to the nature of founds; and of thofe who are deaf, to colours. The fources of error, are negligence in contemplating the whole idea, the eftimating it from a partial view, and the connection of ideas with others that are diftinct, and only related by accident, or external caufes.

DLXIII. The integrity of the judgment depends upon a healthy conftitution of the brain. For when that is compreffed, irritated, exhaufted of blood, or changed in its fabric, the ufe of reafon is totally difturbed; the ftrong internal impreffions on the brain are reprefented to the mind as external or real objects; the chain of ideas is broken, fo that the mind does not compare them, or perceive their refemblance or diverfity, but paffes abruptly from one idea to another totally different; or, laftly, the actions of the fenfes being impaired or interrupted, and all impreffions being in a manner erafed from the brain, man is reduced to a ftate of imbecility or vegetation. But external caufes alfo have confiderable influence in changing the relation of the mind to the impreffions of the fenfes; the air, way of life, food, and habit, either affift or diminifh the foundnefs of the judgment, the force of the imagination, and the ftrength of the memory.

DLXIV. Finally, as these ideas are either indifferent, or have some relation to our happiness, they produce different determinations in the will. Some of the causes by which the felicity of our mind is either increased or diminished, proceed entirely from the body, and are purely mechanical; amongst these are pain, disagreeable sensations, which seem to be produced by every sensation in a nerve that is too strong, and pleasure, in which the nerve is irritated beyond what is usual, but in a moderate degree. Itching is akin to pleasure, and in both the flow of blood is increased into the part in which either pleasure or titillation is perceived; but, when farther increased, it degenerates into pain, or excessive sensation in the nerve. Anxiety is from the blood being retarded in its passage through the lungs. Other ideas which affect the mind, are either entirely unconnected with the properties of matter, or certainly less simple, understood, or mechanical, than the foregoing. The presence of good constitutes joy; the desire of good, love; the expectation of good, hope: the presence of evil, sorrow, terror, or despair; the dislike of evil, hatred; and the expectation of evil, fear. Hope, curiosity, and glory, seem to be affections of the human mind, which neither belong to the body, nor exist in beasts.

DLXV. From these affections of the mind, not only the pure will appears to direct the actions of the body to a foreseen purpose, in order to attain good, and avoid evil, but also in the body itself, neither willing them nor capable of opposing them, various changes happen in the pulse, respiration, appetite, strength, and other functions of the heart, nerves, stomach, and other parts, which both immediately follow and indicate the passions of the mind. Thus anger violently excites the motion of the spirits, increases the motion of the heart, the frequency of the pulse, and the strength of the muscles;

muſcles; forces the blood into the ultimate and pellucid veſſels, and even out of the veſſels; accelerates the excretion of bile, terminates chronic diſeaſes, and removes obſtructions. Grief weakens the ſtrength of the nerves, and action of the heart; retards the pulſe; deſtroys the appetite; and produces paleneſs, cachexy, diarrhœa, jaundice, ſcirrhoſities, and diſeaſes ariſing from a ſtagnation of the humours. Fear diminiſhes the force of the heart, ſo as to occaſion polypuſes, and paleneſs weakens the muſcular motions, relaxes the ſphincters, increaſes inhalation, and diminiſhes exhalation. Exceſſive terror increaſes the ſtrength even to convulſion; excites the pulſe; removes obſtructions, palſies; interrupts the courſe of the blood, and produces ſudden death. Love, hope, and joy, promote perſpiration, quicken the pulſe, promote the circulation, increaſe the appetite, and facilitate the cure of diſeaſes. Exceſſive and ſudden joy often kills, by increaſing the motion of the blood, and exciting a true apoplexy. Shame, in a peculiar manner, retains the blood in the face, as if the veins were tied; and alſo ſuppreſſes the menſes, and has been even known to kill.

DLXVI. In what manner are theſe changes produced by the reſpective paſſions of the mind? Do nervous ſphincters regulate the veſſels, and at one time compreſs them ſubſultorily, and increaſe the motion of the blood, and at another relax them and deſtroy their tone? That ſomething like this obtains in the ſmaller veſſels, appears evidently from the very ſimilar effects produced by fear and cold upon the nerves of the ſkin. In the genital parts, we manifeſtly ſee the veins, under particular circumſtances, conſtricted, and a conſequent accumulation of blood: and it ſeemed probable, that in the larger veſſels, the nervous nooſes ſurrounding many of them produced the ſame effects: for, in various

various parts, they ſurround and include the meningeal, temporal, vertebral, carrotid, ſubclavian, cœliac, meſenteric, renal, and other arteries. But after it was ſhewn by our experiments, that the nerves are at reſt during the action of the muſcles, and cannot be rendered ſhorter by any irritation, we were obliged to deſert this elegant theory. Nor would 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 that thus the motion of the blood is either quickened or retarded, if it were at all certain that the ſmaller arteries have the ſame irritable nature with the large ones. Thus the appetite and periſtaltic motion of the ſtomach and inteſtines, are manifeſtly deſtroyed by the affections of the mind.

DLXVII. It cannot be denied that the Creator has affixed characteriſtic marks to the paſſions of the mind, that in ſocial life man might not eaſily impoſe on man. For the reſpective muſcles, more eſpecially of the voice, face, and eyes, expreſs the ſeveral paſſions of the mind ſo faithfully, that they may be even repreſented in painting. To inveſtigate each of them, would indeed be an elegant taſk, but too long for this compendium. From the action of theſe muſcles being often repeated, phyſiognomy ariſes, ſo that the conſtant expreſſion of the face retains ſomething of the action of the prevailing muſcles; and ſome character of frequent anger often remains in the countenance, after the paſſion itſelf is gone off.

DLXVIII. Whence proceeds the ſympathy of parts, ſo famous in the practice of phyſic? In ſome of them it appears to depend upon the connection of the blood-veſſels; by which the blood, being repelled from one part, preſſes more heavily upon another, which has its veſſels from the ſame common trunk.

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This comprehends revulſions made by blood letting; headach, from cold feet, &c. In other parts, the ſympathy ariſes from a ſimilitude in their fabric, by which they ſuffer like effects from the ſame cauſes ariſing in the body, ſuch as the ſympathy betwixt the womb and the breaſts. Another cauſe is, the continuity of membranes, from hence the itching in the glans of the penis from calculus, the cure of deafneſs by diarrhœa. Another cauſe exiſts in the nerves themſelves, and their anaſtomoſes, as ſatisfactorily appears from the teeth being ſet on edge by certain ſounds, a diſagreeable ſenſation being produced in the maxillary nerve, on account of its various communications with the portio dura. Thus the ſympathy of the eyes, which is not obſervable in like manner in the ears, proceeds from the decuſſation of the optic nerves; and vomiting is excited by nephritis. Laſtly, another cauſe is referred to the common ſenſory, and beginnings of the nerves, which is demonſtrated from general convulſions being produced by the irritation of a ſingle nerve, and univerſal epilepſy by a local diſorder, &c. Some ſympathies in diſeaſes ariſe from a tranſlation of the matter to other parts through the cellular ſubſtance, or by the action of the muſcles, arteries, or gravity.

DLXIX. But that important ſympathy remains to be explained, which ſubſiſts betwixt the body and the mind. For that the nature of the mind is different from that of the body, is proved by an infinity of circumſtances, eſpecially by ideas and affections of the mind, to which nothing in ſenſation is analogous. For what is the colour of pride? or what the magnitude of envy or curioſity? to which there is nothing ſimilar in animals; neither can that good which is deſired by it, glory and the acquiſition as it were of new ideas, be referred to any corporeal pleaſure. Is it poſſible that the body can poſſeſs two kinds of forces, ſo that its infinite particles

particles ſhould unite into one maſs, which do not preſerve their own affections only, and repreſent them to themſelves, but alſo join together into one common thinking whole, differing from the attributes of all, and yet capable both of receiving and comparing theſe attributes? Is there any inſtance of a body, which, without an external cauſe, paſſes from reſt to motion, changes or reverſes the direction of motion, without the action of ſome other cauſe, as is very eaſily obſerved with regard to the mind?

DLXX. Yet this mind, ſo different from the body, is connected with it by the moſt intimate ties, being both obliged to think upon thoſe impreſſions which the body preſents to it, and not ſeeming to poſſeſs memory or judgment, independent of the corporeal impreſſions on the brain; and, laſtly, by means of volition being the cauſe or occaſion of the greateſt and ſwiteſt motions of the body.

DLXXI. Thoſe have acted circumſpectly who, confeſſing themſelves ignorant of the manner in which the body and mind are united, have contented themſelves with the laws eſtabliſhed by the Creator, which they have aſcertained, and not conjectured. They are manifeſtly excuſed by the obſervation, (DLVI.) that even in optics, it is very certain that the affections of the body are connected with the thoughts of the mind, by an arbitrary relation, and that other ideas would have been ſuggeſted, if the Creator had altered the figure, the refracting power, or colours of the parts of the eye. As there is a law, which eſtabliſhes a perpetual connection between the leaſt refrangible rays and the idea of a red colour; there is alſo a law which conſtitutes the connection betwixt the impreſſion of thoſe rays upon the retina, and the correſponding idea. Nor need we be more aſhamed of our ignorance of the mechaniſm of the latter law, than of our ignorance of the nature of the former.

DLXXII. Does the mind govern the body? Do all the motions and actions in the body arife from the mind, as the immediate fource and origin of motion? Do the motions of the heart, arteries, and refpiration, arife from the mind, willing them and folicitous for the common good of the whole fyftem? Is this power of the mind demonftrated by the ftructure of polypi formed in wounds, by the paffions of the mind, and by the nævi materni? Is the abfence of confcioufnefs accounted for by the well known example of the obfcure perceptions we have in refpiration, winking, and mufcular motion, all of which are effected by the will, although we do not know the organs, or attend, that we will, when we breathe, wink, or walk, when occupied in thought? Is it therefore certain, that all motions arife from the mind, becaufe there is no other evident caufe perpetually connected with the body, to which they can be referred?

DLXXIII. There are many reafons which do not yet permit us to adopt this opinion. And, firft, the conftruction and government of the body itfelf appear greatly to exceed the wifdom of the mind. Our mind fees one point diftinctly, (DLV.) and thinks one thought diftinctly; but if it endeavours to fee two objects at the fame time, to contemplate two ideas at the fame time, or to read two letters at once, it always becomes confufed, commits miftakes, and comprehends neither rightly; and confcious of its own powers, whenever it applies ferioufly and diligently to any object, it withdraws itfelf as it were from the impreffions of fenfe, and neither fees, nor hears, nor fmells, nor performs mufcular actions. But the mind ought to be capable of infinite and diftinct thoughts, in order to be able to govern fuch an infinite variety of mufcles, veffels, and fibres, in a manner accommodated to the moft exact geometry; and to refolve and conftruct occafional problems in the direction of the muf-

cles,

cles, ſcarcely ſoluble by the higheſt geometry: and yet we muſt conclude the mind ignorant of this immenſe taſk, and at the ſame time, over and above all thoſe works, capable of contemplating the moſt difficult and abſtract ideas; ſo that neither the care of the body diſturbs its meditations, nor its meditations interfere with the neceſſary motions of the body.

DLXXIV. Moreover, if, without being conſcious of volition, we can will to reſpire, or wink, and with effect; we nevertheleſs retain our control, and can ſuſpend reſpiration, and keep the eyelids firm, and alternately excite their actions, and therefore we never loſe either the conſciouſneſs of our control, or the uſe of it. But we are not able to perform any thing of this kind in the heart or inteſtines; we cannot reſtrain their motion, when too quick, or excite them when languid. Amongſt all mankind, why does every one govern his reſpiraton? why in all ages no one his heart? If cuſtom only is the cauſe of our inconſciouſneſs of this power, why is not the mind ſenſible of its action, in moving the heart, or in exerciſing the periſtaltic motion, after being ſuſpended for hours, or even whole days, in ſwoons, in hyſteric fits, and in aſphyxia?

DLXXV. But it is evidently falſe, that all motions ariſe from the mind, and that without it matter would be an immoveable inert maſs: for the contractility excitable by every ſtimulus, to which the motion of the heart, inteſtines, and perhaps all the other motions in the human body, belong, (CCCCXCI.) does not require the preſence of the mind; it continues in the dead body; it is excited by mechanical cauſes, heat, and inflation; and it does not deſert the fibres, until they become ſtiff and cold, although the mind, which perceives and wills, may have been a long time expelled by the deſtruction of the brain and heart, and even although

although the muſcle, by being taken out of the body, has been ſeparated from every imaginable connection with the mind.

DLXXVI. Little, if any, reliance is to be put in the nævi materni, as is noticed in another place. That the direction of the vital motions, in diſeaſes, is not regulated by prudence, but almoſt entirely by the power of ſtimulus; we are explicitly taught by the moſt ancient and only certain practice, which reſtrains the exceſſive motions in acute and intermitting febrile diſeaſes, by the uſe of blood letting, opium, nitre, Peruvian bark, &c. The ſage has no prerogative in the government of his body, over the mereſt ideot; and that the fœtus, which even at birth is ignorant of the motions of its muſcles, and learns by experience to walk, to ſwallow and to ſee, conſtructs its body, fabricated with ſuch incredible art, is an affirmation ſo repugnant to probability, and ſo abſurd, that of itſelf alone it is ſufficient to refute the hypotheſis.

DLXXVII. The ſtate of aptitude for exerciſing the ſenſes and voluntary motion, in healthy organs, is called wakefulneſs. Indiſpoſition to ſuch exerciſe, and their perfect reſt, with healthy organs, is called ſleep.

DLXXVIII. In ſleep, the mind either thinks not at all of what ſhe knows or retains in memory; or only attends to the traces of paſt objects repoſited in the common ſenſory, (DLVIII.) the vivid repreſentations of which excite altogether the ſame perceptions in the mind as are made by the impreſſion of external objects upon the organs of ſenſe. Theſe repreſentations are called dreams; and have the effect, that while the reſt of the emporium of the ſenſes and muſcular motion is at reſt, ſome part remains open, is pervaded by the ſpirits and watches. Sometimes certain voluntary motions are conjoined with theſe perceptions of the mind, ſo that the organs of ſpeech, many, or all of the limbs,

limbs, are directed by these perceptions, as in somnambulists.

DLXXIX. But, during sleep, the motion of the heart proceeds, and also the distribution and circulation of all the humours in the body, the peristaltic motion of the stomach and intestines, and the action of the sphincters. Lastly, the respiration itself continues to be performed in like manner. This conjunction of the quiescence of certain organs with the motion of others, renders a knowledge of the mechanical cause of sleep difficult.

DLXXX. Therefore, in order to investigate it, we shall consider all the causes, and all the phenomena, both of sleep and vigilance, and trace them in all kinds of animals. For that condition, which is produced alike by all those causes, will be the true cause of sleep. Sleep naturally follows vigilance and the labours of human life. For when awake, there is almost a continual motion of the voluntary muscles, and of the organs of the senses, and the affections of the mind continually impart new stimuli to the nerves, blood-vessels, and heart. Thus the blood, by continual motion and trituration, is altered from a bland nature to an alkaline putridity; while the more subtile spirits are dissipated faster than they are replaced, and gradually not only debility and lassitude of the body are induced; and, if the want of sleep be protracted too long, also feverish heat, acrimony of the humours, and loss of strength. On the return of night, torpor is perceived in all the long muscles; the mind becomes unfit for deep thought, and the desire of rest pervades both mind and body. At this time, the powers which hold the body erect, suffer particularly; the eyelids close involuntarily, the lower jaw falls down, the necessity of yawning increases, the head nods forwards, the circumstances of external objects affect us less; and lastly, the ideas and thoughts become disturbed, and a delirium

rium enſues; from which the tranſition to ſleep is not perfectly known; but which invariably 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 in ſome manner conſumed by muſcular motion, and the exerciſe of the ſenſes, and of which probably a great quantity is exhaled.

DLXXXI. The abſence of every irritation of the head, and other parts of the body, the perfect reſt of the mind and external ſenſes, and darkneſs, have great influence in promoting ſleep.

DLXXXII. Again, a variety of cauſes which debilitate, induce, and increaſe ſleep; ſuch as great loſſes of blood, veneſection, cooling medicines, opiates, and coldneſs of the atmoſphere, and alſo applications which derive the blood from the head, as warm bathing of the feet, and a plentiful meal, which always produces ſleep in all kinds of animals.

DLXXXIII. On the contrary, again, various hot medicines induce ſleep, by accelerating the flow of blood to the brain; ſuch as wine, ſpirits of all ſorts, but more eſpecially when reſolved into vapour, opium, hyoſcyamus, the indigeſtible particles of our aliments, acute and malignant fevers of various kinds; or by retarding 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 and intercepts the courſe of the ſpirits into the nerves.

DLXXXIV. But likewiſe mechanical cauſes produce ſleep; for example, every compreſſure of the dura mater and brain, whether from extravaſated blood, a depreſſed bone, or a collection of water in the ventricles.

DLXXXV. Sleep, therefore, ariſes either from a ſimple abſence, deficiency and immobility of the ſpirits, or from compreſſion of the nerves; and always

ways from the motion of the ſpirits through the brain being impeded.

DLXXXVI. This theory is confirmed by the cauſes of vigilance: for all thoſe things prevent ſleep which produce plenty of ſpirits; more eſpecially warm aromatic drinks, which ſend minute ſtimulating particles to the head; by which the motion of the blood is moderately quickened through the brain, and, being at the ſame time more diluted, it ſecretes more ſpirits in a given time.

DLXXXVII. Sleep, again, is prevented by cares of the mind, attentive and intereſting meditation, and pain of body and mind; all of which prevent the ſpirits in the ſenſorium commune from reſting, and the nerves from collapſing. Therefore, the former cauſes increaſe the quantity of the ſpirits, theſe increaſe their motion. And, therefore, we return to our former concluſion (DLXXXV.) namely, that the nature of ſleep conſiſts in the collapſe of the nerves, proceeding from the ſenſorium commune.

DLXXXVIII. Is the region of ſleep, therefore, in the ventricles of the brain? It is inconſiſtent with the univerſality of ſleep, which extends to animals which have no ventricles in their brain. Do the vital actions continue during ſleep, becauſe it is an affection peculiar to the brain, and independent of the cerebellum? And what is the cauſe of this diverſity, which occaſions the animal functions to reſt during ſleep, and the vital functions to continue? It is that already mentioned, that vital motions are prevented from reſting by perpetual ſtimuli, and perpetually exciting cauſes, (CCCXCII.)

DLXXXIX. The effect of ſleep is the abatement of all the motions in the human body. For now the action of the heart alone remains to propel all the humours, while all the motions of the muſcles and ſentient nerves, and thoſe originating from the paſſions of the mind and volition, are removed; by which, while awake, the courſe of the blood and ſpirits

ſpirits was promoted, as well as by the heart (DLXV. CCCCXVII.) The heart gradually returns from its quick and almoſt feveriſh pulſation, to its morning ſlowneſs; the breathing becomes leſs and ſlower, the periſtaltic motion of the ſtomach and inteſtines, hunger, digeſtion, and the progreſſion of the feces, are all diminiſhed; the thinner juices move more ſlowly, while the more ſluggiſh are collected together, and the effuſed fat is accumulated; the nouriſhing jelly adheres more plentifully to its fibres and cavities; the conſumption of the ſpirits, the attrition of the blood, and the quantity of perſpiration, are all diminiſhed. Thus, while the nervous fluid continues to be ſecreted, and its conſumption to be diminiſhed, it is by degrees accumulated in the brain, ſo as to diſtend and fill the collapſed nerves, and from the acceſſion of the ſlighteſt ſtimulus, both the internal and external ſenſes are excited to action, and the ſyſtem is awakened. Sleep, continued for too great a length of time, diſpoſes to all the diſorders that attend ſlowneſs of circulation, to fatneſs, drowſineſs, and cachexies; and is highly detrimental to the memory.

DXC. Whence the yawning of thoſe about to ſleep? To promote the paſſage of the blood through the lungs, which is now ſlower. Whence the ſtretching of the limbs? To overbalance, by the influx of the ſpirits, the natural contraction of the muſcles, by which all the limbs are put in a moderate degree of flexion, and ſo to reſtore ſtrength to the extenſor muſcles. Whence the opinion, that, during ſleep, the motion of the heart becomes ſtronger, and the perſpiration more plentiful? From the heat of the bedclothes, by which the perſpirable matter being confined, ſoftens and relaxes the ſkin. But any one that ſleeps in his uſual garments, grows colder; and animals which ſleep through the winter, become exceſſively cold, as dormice and hedge-hogs. Why do all animals grow ſleepy after taking food?

Not

Not from preffure upon the aorta, or congeftion of blood in the brain; for even animals which have fcarcely any brain, fleep after food. Do the indigeftible particles of our aliments, by paffing lefs eafily through the brain, and compreffing its medulla, render the fleep lefs refrefhing? Is dreaming perpetual and infeparable from fleep? Is it fo far natural, and a kind of fubftitute for fenfation to the mind, that it may never be without thought? This does not feem probable. We rather afcribe dreams to fome morbid ftate, or to fome ftimulating caufe, interrupting the perfect reft of the fenforium. Hence that fleep refrefhes moft which is without dreams, or at leaft without the remembrance of them. Hence they are generally wanting in the firft fleep, at which time the fpirits are moft exhaufted, and return in the morning when thefe are in fome meafure repaired. Hence care, the ftrong impreffion of fome idea upon the memory, indigeftible food, excefs, or any uneafy pofture of the body, occafion dreams; for they are ufually generated by fome fenfation, with which, according to the laws of the affociation of ideas, the whole collection of fimilar impreffions connect themfelves.

CHAP. XVIII.

OF MASTICATION, SALIVA, AND DEGLUTITION.

DXCI. HARD and tough articles of food, confifting of long parallel fibres, or covered with a bony fhell or cartilaginous integuments, and friable fubftances, generally require maftication, to divide them into fmaller and lefs cohering parts, that they may the more eafily yield to the diffolving powers of the ftomach. The more completely they are fubdivided in the mouth, they become

come the more ſapid, approach the nearer to the nature of a fluid, and are digeſted the more eaſily.

DXCII. Therefore moſt animals are provided with extremely hard teeth, each having a bony, hollow root receiving, through a ſmall hole in the apex of its cone, little blood-veſſels, and a nerve, which go to its internal perioſteum; fixed by the whole root into the alveolus adapted to it, and, in the upper part of its crown, ſtrongly tied down by the adhering gum. But the upper part of the teeth placed above the gums, is not bony, but of a peculiar ſtructure, much harder and denſer, reſiſting putrefaction in the dead body, and almoſt vitreous, compoſed of ſtraight fibres vertical towards the root, and running together in the middle. This portion has neither perioſteum nor veſſels, and being perpetually waſted, ſeems to be as often repaired by ſome fluid which aſcends from the follicle of the root. The teeth are therefore well adapted for overcoming the hardneſs of other bodies, and for comminuting the food.

DXCIII. As the materials of our food are various in their texture and firmneſs, nature has accordingly diverſified the ſtructure of the teeth. In man, the anterior teeth, four in each jaw, are weaker than the reſt, have a ſingle root, and a crown inwardly concave, outwardly convex, extenuated like a wedge, and terminated by a rectilineal edge. They are deſtined for dividing, into ſmaller portions, the ſofter foods, which are merely tough, and for comminuting the fibres and membranes of animals and vegetables, and the kernels of fruits.

DXCIV. The ſecond ſpecies is the canine teeth, of which there are two in each jaw, fixed by a longer and ſtronger, but ſingle root, with a crown of a conical ſhape. Theſe lacerate tough aliments, and hold faſt thoſe which require much trituration.

dxcv. The third order is the grinders, which in general have ſeveral roots, and a quadrangular crown, with a flat ſurface, but divided by chequered aſperities. The two anterior ones are weaker, have one or two roots, with the ſurface of their crown parted into two; the three poſterior grinders are larger, fixed by three, four, and ſometimes five roots, but generally by one leſs in the lower jaw, with a flat ſurface, quadrangular, and commonly divided into as many eminences as there are roots. Betwixt theſe teeth, the bony articles of food are interpoſed and broken, the hard are bruiſed, while the lower teeth, being moved obliquely and laterally, are rubbed againſt the immoveable upper ones: by theſe the functions of the teeth are principally performed.

dxcvi. That the teeth might poſſeſs mobility combined with ſtrength and firmneſs, the upper ones are fixed into the ſockets of the immoveable upper jaw, the lower ones into the lower moveable jaw, which is a ſingle bone, and articulated with the temporals, in ſuch a manner that it may be drawn down from the upper jaw, and raiſed up againſt them with great force; and may be moved laterally to the right and left, and forwards beyond the upper jaw, and backwards to its firſt ſituation. Theſe motions depend upon the articulation of its condyles, (in which the lateral parts of the lower jaw terminate, and which are broadeſt tranſverſely, and convex in the middle,) with the oblique tubercles of the temporal bones, which are hollowed at the root of the jugal proceſs, deeper in the middle, and increaſed by a little flat ſurface of the ſame kind, before the auditory paſſage, from which it is ſeparated by a peculiar fiſſure. This joint has greater liberty in moving, and a durable cartilaginous cruſt, from a cartilage interpoſed between the condyle of the lower jaw and the tubercle of the temporal bone, on both ſides

concave

concave in its middle, with raiſed edges, correſponding by the former to the tubercle of the temporal bone, and by the latter to the adjacent depreſſions.

DXCVII. The muſcles moving the lower jaw, which in man are weaker, but very ſtrong in brutes, are the temporalis, an elevator, ariſing from a large part of the ſide of the ſkull, and from its aponeuroſis, collecting its tendinous fibres, intermixed with muſcular fibres, in a ſtellated manner, into the ſharp proceſs of the jaw; the maſſeter, an elevator, deſcending double or triple from the jugum and margin of the cheek bone backwards into the coronoid proceſs. Theſe act in concert; but the temporal muſcle carries the jaw more backwards, the maſſeter more forwards. The pterygoideus internus deſcends from the pterygoid foſſa, and from the palate bone and root of the little pterygoid proceſs, and its internal wing, into the angle of the lower jaw, which it elevates when depreſſed by its antagoniſts, or draws to one ſide. The pterygoideus externus has a double origin; the one tranſverſe from the inner wing and adjacent bone of the palate, and 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 backwards and downwards into the outer part of the condyle of the lower jaw, which it draws forwards before the upper jaw, and to one ſide.

DXCVIII. The lower jaw is depreſſed, and the mouth opened by the digaſtric muſcle, ariſing from a hollow of the mamillary proceſs, tied by its middle tendon with much firm cellular ſubſtance, of a tendinous nature, to the os hyoides; likewiſe connected to the mylohyoideus, and paſſing through the deſcending fibres of the ſtylohyoideus, increaſed by another fleſhy belly, and inſerted at the ſymphyſis of the two halves of the lower jaw. Moreover,

over, the mouth may be opened by all the other mufcles, inferted into the inferior maxilla, os hyoides and larynx, as the geniohyoideus, mylohyoideus, geniogloffus, fternohyoideus, fternothyroideus, coracohyoideus, and latiffimus colli; although the latter rather draws the fkin of the neck and face downwards. The geniohyoideus and digaftric mufcles draw the jaw backwards.

DXCIX. The lower jaw is elevated with great force, and the lower teeth being carried up againft the upper teeth, divide the food, by the action of the temporal, maffeter, and internal pterygoid mufcles; which appears by undoubted experiments to be very powerful, and fufficient to raife feveral hundred weight. The lateral motions of the jaw, and its circular motion around one condyle as a fixed point, are performed by the external and internal pterygoidei, and by the former mufcles acting fingly and alternately. Thus the food is cut, broken and bruifed; and if the maftication be rightly performed, it is reduced into a kind of pulp.

DC. Before the teeth there is placed a cutaneous and flefhy fack, which is every where produced from the integuments of the face; and inclofes a hollow fpace with both rows of teeth when fhut. The lateral parts are called the cheeks, the middle the lips. From this cavity there is a paffage, betwixt the teeth, into the mouth, which on the upper part is bounded by the bony and foft palate, underneath by the mufcles lying under the tongue, and on the forepart by the teeth. On the back part it opens between the foft palate and tongue into the fauces. The tongue divides the cavity of the mouth in the middle, and is eafily moveable to every part of it.

DCI. During the trituration of the food in the mouth, there is continually poured to it a large quantity of a watery clear liquor, evaporable, infipid,

pid, or very little faline, containing a very fmall quantity of earth, and neither acid nor alkaline, although from it a very fmall portion of lixivial falt may be obtained; of which all around are numerous fources. A large quantity of this faliva is fecreted by innumerable oval glands in the lips and cheeks, and by fome larger ones which are placed round the mouth of the parotid duct; and laftly, by the pores of the hard palate, pouring out the liquor, which they fecrete, through a little fhort duct and hole. The fluid effufed by the exhaling veffels of the cheeks, and back of the tongue, is fimilar, or more watery. It is now afcertained, that the ductus incifivus is impervious, and tranfmits nothing but the artery, which goes from the palate to the noftrils.

DCII. The faliva is a watery liquor, with a fmall quantity of falt, partly lixivial, and partly culinary; with fome oil and earth, evaporable by the fire; with fcarcely any tafte, unlefs when fharpened by difeafe or hunger. The quantity produced is confiderable, as twelve ounces have been known to flow out from wounds in the fpace of an hour. By well bred people, it is for the moft part fwallowed; and ufefully, as it cannot be thrown away without hurting the digeftion.

DCIII. The falivary glands efpecially fupply the faliva. Of thefe, the principal is the parotid, extenfively filling up the interval between the auditory paffage and the lower jaw, and covering the jawbone where naked, and part of the mafleter. It is a conglomerate gland, with round acini, connected by cellular fubftance; which more denfely compacted, forms a kind of involucrum, almoft tendinous, to the whole gland. Its duct is white, vafcular, and capacious, afcending from the bottom of the gland to the jugum, from whence it is tranfverfely inclined, and receives the duct of a gland, feated on the top of the mafleter, which is either continuous

continuous with the parotid, or diſtinct from it, and rarely double; after this, bending round the tumid edge of the maſſeter, it opens with an abrupt termination, without a papilla, through the ſeparating fibres of the buccinator, ſurrounded by many little glands of the cheek. The bulk of this gland, and the number of its arteries, render it the chief ſource of the ſaliva.

DCIV. Another ſmall gland, adjacent to the parotid, but twice as ſmall, compoſed of ſofter and larger acini, connected by a ſimilar membrane, is contiguous to the corner of the lower jaw-bone, and being in part ſubcutaneous, terminates upon it, and in part ſends off an appendix over the mylohyoideus muſcle, which running along the long concave ſide of the lower jaw, of a granular fabric, and ſpread under the membrane of the mouth, is called the ſublingual gland. From the larger maxillary gland, a duct paſſes out along with this appendix, covered by the middle part of the ſublingualis, from which it receives one, two, or three branches; by whoſe inſertion being increaſed, it opens into a projecting membranous cylinder, ſeated on the bridle of the tongue. But other ſmall and ſhort ducts from the ſublingual gland, three, four, or more, even to the number of twenty, perforate the edge of the tongue in the line continued backwards from the frenum, with ſhort little ducts and points, and ſecrete ſaliva. There are inſtances where the larger anterior branch of this gland, which uſually joins itſelf to the duct of the maxillary gland, goes on ſingle, and parallel to it, and opens by itſelf. Some other glands alſo, ſimilar to thoſe of the cheeks, which however may be reckoned among the ſublinguals, by their proper ducts perforate the membrane of the mouth where it departs from the tongue. Various other ſalival ducts have been intimated by different perſons, but they are not confirmed by anatomy.

DCV.

DCV. The Creator has wifely provided, that maftication cannot be performed, without the falival glands being compreffed by mechanical neceffity, fo as to difcharge their fluids in an increafed quantity. For, when the mouth is opened, the maxillary gland, being preffed by the digaftric and mylohyoideus, throws forth a fountain of faliva ; the parotid gland is compreffed by the mafleter, when fwelled, and by the cutaneous mufcle of the neck which lies over it : hunger has the fame effects with mufcular preffure, and caufes a flow of faliva into the mouth.

DCVI. The food, therefore, being ground between the teeth, with the watery faliva and air, is broken down into a foft fucculent, figurable pulp, replete with elaftic air, which being heated by its fituation, on account of its elafticity, perpetually tends to the diffolution of the particles of the food between which it is included. By this procefs, the oily and aqueous parts of the food are intermixed ; the fmell and tafte of different ingredients are blended together ; and, at the fame time that the faliva dilutes the faline parts, the food becomes fapid. Such particles as are volatile, are directly abforbed by the bibulous veffels of the tongue and cheeks, and recruit the ftrength, by being reftored to the blood-veffels and nerves.

DCVII. But the motions which are neceffary for turning round the food in the cavity of the mouth that it may be introduced between the teeth, are effected by the tongue, cheeks, and lips. And efpecially, the tongue being at one time expanded, receives the food into the fmall concavity in its furface ; and being moved by its proper powers, (CCCCL.) conveys its load to the part defigned. At another time, the tongue contracted, and narrow, fearches every part of the mouth with its tip, and collects together the food into one heap. At another time, by applying itfelf to the teeth, it draws from

from the cavity of the cheeks the fluids or chewed aliments, and conveys them to the poſterior cavity of the mouth, ſituated behind the teeth.

DCVIII. But theſe motions of the tongue are likewiſe governed by the os hyoides, which is extenſively connected with it by muſcles and membranes, and is compoſed of a baſis, concave inwardly, of horns extending outwardly, and terminated by a thicker knob, and of oval cornicles. When drawn down by its reſpective muſcles, it carries back the tongue at the ſame time, and alſo depreſſes the lower jaw, if the muſcles of that be relaxed. Theſe powers are the ſternohyoideus, but ariſing alſo in part from the clavicle, which is extenuated upwards, and ſtriped with tendinous lines: the ſternothyroideus, which is broader, and ariſes from the ſame place, and alſo from the upper rib; on depreſſing the cartilage, into which it is inſerted, it neceſſarily forces the os hyoides connected with it, to deſcend: it is intermixed with the hyothyroideus and thyreo-pharyngeus, and every where intermixed with the ſternohyoideus: the coracohyoideus, but which ariſes obliquely from the upper and ſhorter ſide of the ſcapula, near its notch; where croſſed by the jugular vein, it becomes tendinous; with its upper belly, it is ſtraight, and pulls the os hyoides directly downwards; it is every where blended with the ſternohyoideus, and the hyothyroideus, which is governed by the former muſcles.

DCIX. Other powers elevate the os hyoides, together with the tongue. The ſtyloglоſſus muſcle, ſuſtained by a peculiar ligament from the upper jaw, which is ſometimes fleſhy. The ſtylohyoideus, a weak muſcle, often ſplit for the paſſage of the biventer, and again collected into two portions, adhering to the tendinous expanſion of the biventer, and inſerted by the one portion into the baſis of the os hyoides, and by the other portion into the horn, and mixed with the tendinous expanſion of the

the mylohyoideus. The ſtylohyoideus alter, when it is preſent, reſembles the former, behind which it is placed; ariſing from the tip of the ſtyloid proceſs, and inſerted into the oſſa triticea, it anſwers the purpoſe of a ligament to ſuſtain the os hyoides. All theſe muſcles draw the tongue back, and elevate its ſides. The mylohyoideus, ariſing from the whole length of the jaw, combining into one with its companion, elevates the tongue, and gives it firmneſs for various motions, or elſe it depreſſes the jaw. The geniohyoideus, accompanying the genioglosſus, pulls the tongue forwards out of the mouth.

dcx. But, moreover, the muſcles of the cheeks variouſly move and compreſs the food in the mouth. Some carry it from the cavity of the cheeks into the cavity of the mouth behind the teeth, as 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 communis in part, the naſalis labii ſuperioris, both zygomatici, the riſorius, tariangularis menti, and the depreſſor proprius anguli oris, which, ariſing on each ſide from an excavation near the ſocket of the canine tooth, is inſerted into the orbicularis. Others, again, ſhut the mouth, that the food received may not fall out; ſuch as the orbicularis of each lip, the proper depreſſor of the upper lip, and the proper elevator of the lower lip, and the elevator communis in part. Of theſe, more particular deſcriptions may be had from profeſſed ſyſtems of anatomy.

dcxi. By theſe means the food, mixed with and ſoftened by the ſaliva, is collected from all ſides, behind the teeth, and is committed to the tongue, expanded by the ceratogloſſi and geniogloſſi, and rendered a little concave by the ſtylogloſſus, from thence it is next conveyed to the fauces.

dcxii. The tongue being raiſed by the ſtylogloſſi, and extenſively applied to the palate, firſt with

with its apex, then gradually with its poſterior extremity, preſſes the food towards the fauces, at that time the only open paſſage. After this, the thick root of the tongue itſelf reſiſts the larynx, which is drawn upwards, and preſſes down the approaching epiglottis, which ſtands up behind the tongue, and is connected with it by numerous membranes, and perhaps by ſome muſcular fibres. At the ſame time, all the muſcles elevating the pharynx act together; the biventer, geniohyoideus, genioglоſſus, ſtylohyoideus, ſtyloglоſſus, ſtylopharyngeus, and others, and draw the larynx upwards and forwards, ſo that the epiglottis preſents itſelf oppoſite to the tongue, and is more eaſily inclined. Hence it is neceſſary for deglutition, that the jaws be cloſed, or at leaſt that the lower one be raiſed, and fixed in that poſition, that the biventer, and the other muſcles already mentioned, may derive ſtability, from it, and elevate the os hyoides. Thus the epiglottis, being turned down, ſhuts up the paſſage to the larynx ſufficiently and largely, and over it, as over a bridge, the food paſſes into the fauces.

DCXIII. By the pharynx we underſtand an ample ſhapeleſs cavity, bounded behind by all the vertebræ of the neck, and the occipital bone before the foramen magnum, in the middle by the cuneiform bone, and before by the opening of the nares, the moveable velum of the palate, the mouth, the tongue, and the larynx: below it is continued into the œſophagus. Its ſides are formed by the lower jaw, the cheeks, 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. Its internal membrane is continuous with the cuticle, and renewable, but more moiſt. Outwardly the pharynx is covered by a good deal of cellular ſubſtance, more eſpecially in its poſterior and lateral parts. Therefore it is lax

and

and dilatable, and fitted for receiving all bodies that are preſſed by the tongue over the larynx.

DCXIV. It is dilated in the action (DCXII.) by the powers elevating it, by the ſtylopharyngeus, which deſcends ſometimes double into the membrane of the larynx, under the os hyoides, and into the margin of the thyroid cartilage, and is largely diſtributed over the internal ſurface of the pharynx, together with the following muſcle; the thyreopalatinus, ſpread in the form of an arch round the moveable palate, and forming two columns, which deſcend along the ſides of the pharynx, and form a conſiderable part of that bag, being alſo connected by broad ſibres to the thyroid cartilage. That the ſalpingopharyngeus is a true muſcle, I am ready to believe, rather from the obſervations of eminent anatomiſts than from my own. Of the cephalopharyngeus, I am doubtful, unleſs you reckon the ſtrong white cellular ſubſtance, which occupies the upper part of the pharynx, as a muſcle. Drink paſſes round the larynx on each ſide of the epiglottis, and falls into the œſophagus.

DCXV. The aliments are prevented from regurgitating into the noſtrils when they arrive at the dilated pharynx (DCXIV.) by the palatum mobile, which is interpoſed. Anteriorly from the bony palate, and laterally from the pterygoid wings, is continued a moveable velum, compoſed of the membranes of the mouth and noſtrils, with intervening muſcles and glands, almoſt of a ſquare figure, and hanging betwixt the cavity of the nares and mouth, into the hollow fauces, in ſuch a manner that it naturally leaves the former open, and is concave towards the mouth: the middle lower portion of this, extended into a conical ſhape, pendulous, before the epiglottis, and replete with many glands, from its appearance in a diſeaſed ſtate, is called the uvula. At each ſide of the velum, two arches deſcend from the velum palati, of which the ſmaller and thinner goes

to

to the tongue, the larger to the pharynx. The elevator of this velum, which is ſtrong, ariſes from the aſperities and plane ſurface of the os petroſum, behind the ſpinal foramen, and alſo from the cartilage of the Euſtachian tube, deſcends inwards with its companion, forms an arch in the velum mobile, between the two plates of the thyreopalatinus muſcle. It may therefore draw that velum to the nares and tubes, that the food may not enter either of them. But, during deglutition, it does not ſeem to have any conſiderable action. At this time regurgitation into the noſtrils is prevented by the conſtriction of the muſcles of the pharynx, together with the depreſſion of the thyreopalatinus, which manifeſtly draws the moveable velum downwards, and applies it to the tongue and pharynx, and of the circumflexus palati mollis, which ariſing a little more forwards from the ſame petrous bone, and from the ſharp proceſs of the cuneiform wing, and from the interval between the wings and innermoſt wing, and from the cartilage of the Euſtachian tube, deſcends broader; and, paſſing through the notch of the pterygoid hook, it changes its direction, and aſcends with a radiated tendon, diſperſed through the upper membrane of the velum palati, and, joining with its fellow, forms the baſis of the other muſcles, and adheres to the ſmooth edge of the palate bone. This is able both to open the tube, and depreſs the velum mobile. Thus the pharynx being contracted like a ſphincter, forces down the food, without permitting any part to regurgitate into the nares. Hence, when the velum of the palate is injured, the aliments regurgitate into the noſtrils, and deafneſs enſues.

dcxvi. During the effort to depreſs the food (dcxvii.) the velum being placed upon it, and depreſſed, is drawn down towards the tongue by the palatopharyngei, and by the circumflexus palati mollis. Theſe muſcles, together with the gloſ-

ſopalatinus,

ſopalatinus, (which laſt is indeed weak, is received into the leſſer arch of the fauces, and on the one ſide is united with its companion into an arch in the velum of the palate, and on the other is inſerted into the tongue,) preſs the velum againſt the protuberant root of the tongue, and intercept any return to the mouth. After the danger of any part falling into the windpipe is over, the epiglottis is raiſed up again, both by its own elaſticity, and by the tongue itſelf being again drawn forwards. Laſtly, the depreſſed uvula is raiſed by the azygos, which ariſes from the tendons of the circumflexus, and by the levator of the ſoft palate.

DCXVII. A little after this, follows an effort to urge the food downwards, which is exerted by the conſtrictors of the pharynx, which draw the back part forwards; theſe muſcles are partly tranſverſe, and partly aſcend into the poſterior ſurface of the pharynx. The principal is the pterygopharyngeus, ariſing from the whole hook, and from the edge of the internal wing, and from the tendon of the circumflex muſcle; from whence forming an arch, it is extended upwards and backwards, and, largely ſurrounding the upper part of the pharynx, it unites with its cognominal companion. The mylopharyngeus is partly continuous with the fibres of the buccinator, in the middle betwixt its two adheſions to the bones, and partly ariſes from an origin of its own, above the laſt of the grinders in the lower jaw. Theſe being almoſt tranſverſe, and ſurrounding the pharynx, draw its back part forwards. Next follow the aſcending muſcles in two ſtrata, the geniopharyngei, of which the obſcure and confuſed fibres originate from the tongue; the chondropharyngei, of a triangular figure, ariſing from the oſſicula triticea; the ceratopharyngei, which aſcend radiated from half of the horn; the ſyndeſmopharyngei, ariſing from the horn of the thyroid cartilage, and diſtinct from the following; the double

double thyreopharyngei, increafed by fibres of the fternothyroideus and cricothyroideus, and the tranf-verfe, the afcending, and the defcending crycopharyngei. Thefe mufcles act fucceffively, the uppermoft firft, and then according to their fituation, and force the food into the œfophagus. At the fame time, the depreffing mufcles of the larynx, the coracohyoideus, fternohyoideus, and fternothyroideus, draw down the larynx backwards, comprefs the pharynx and urge the food downwards. The arytenoidæi contract the perpendicular chink of the larynx as the food paffes near it.

DCXVIII. As various dry and rough bodies are fometimes fwallowed, and as it was neceffary for the pharynx to be dilatable and indolent, the great quantity of mucus, which is collected in all parts of the fauces, is of great importance. Therefore, in general, betwixt the nervous and innermoft coat of the pharynx, are placed a very great number of fimple oval follicles, which pour out through fhort mouths a bland, aqueous, but vifcid and ropy mucus, having a greater quantity of oil, volatile falt and earth, than the faliva. They are moft plentiful in that part of the pharynx which is extended under the occipital bone, where they are difpofed in a fort of radiated right lines; and about the tonfil towards the Euftachian tube, where commonly the fecond tonfil lies on each fide adjacent to the large one, and in that portion of mufcle which is called falpingopharyngeus. But likewife many flat and circular follicles of this kind are feated on the back part of the tongue, as far as the foramen cæcum (CCCCXLVIII.) Other pores from the pulpy flefh of the palate, and from the numerous glands fituated there, difcharge a fimilar mucus. Moreover, the whole moveable palate is of a glandular nature like the pharynx; only compofed of more numerous and thickly diftributed follicles. Nor, laftly,

laftly, are lacunæ wanting, into each of which many fimple glands unite.

dcxix. Where the pharynx defcends from the pterygoidal hook betwixt the two arches of the fauces, that is between the gloffopalatinus and pharingopalatinus, are feated the tonfils, one on each fide, of an oval figure, convex behind, and thicker on the upper part, perforated inwardly with ten or more large finufes, which open through the membranous velum, and by the preffure of the adjacent mufcles difcharge a great quantity of a very vifcid mucus from their finufes. In like manner, the adjacent parts of the nares, and tumid ring of the tubes, and the furface of the epiglottis next to the larynx, and the back of the arytenoid cartilages, are replenifhed with mucous organs. Laftly, the œfophagus itfelf, on all fides, abounds with fimple follicles, from which a mucus more fluid is poured. The glandulæ œfophageæ are of the conglobate kind, and contribute nothing to this mucus. The blood-veffels of the tonfils come from thofe of the tongue and lips; thofe of the pharynx from thefe and from the pharyngea; thofe of the œfophagus from the pharyngeals, upper and lower thyreoidals, the bronchials and aorta. The numerous veins of the palate and tonfils, after forming plexufes, meet in the fuperficial branch of the internal jugular.

dcxix. The œfophagus is a double tube, of which the interior is feparated from the exterior, by much inflatable cellular fubftance. The interior is nervous and ftrong, continuous with the membranes of the mouth and nares, and feparated from the innermoft, (which is the epidermis, plaited and porous, but not villous, exhaling a thin fluid and pulpy,) by peculiar fhort cellular fubftance, in which veffels are reticulated, and glands are interfperfed, which are continuous, and fimilar to thofe of the pharynx. The exterior tube, the mufcular, is alfo ftrong,

ſtrong, with fibres continued backwards and downwards from the cricoid cartilage, changing from annular into external longitudinal fibres, raiſing the œſophagus againſt the food, and dilating it that the mouthful may be received. But other internal circular fibres, which are alſo ſtrong, ariſe in like manner from the cricoid cartilage, and by their ſucceſſive contraction, force the food down through the long tube of the œſophagus, which deſcends firſt in a direct courſe, a little to the left ſide of the windpipe; in the breaſt, it paſſes behind the heart, through the poſterior interval between the two bags of the pleura (LXXVII.) from whence it inclines by degrees a little to the right, and then forwards, that it may paſs through the appointed opening in the diaphragm (CCLXII.) in the interval between exſpiration and inſpiration. The whole œſophagus is ſurrounded externally by cellular ſubſtance, by which it is looſely tied to the neighbouring parts.

DCXX. The aliments are moved through the œſophagus as through an inteſtine. The longitudinal fibres, aſcending to the cartilages of the larynx, dilate the gullet, to receive the deſcending morſel. But when it is received into the gullet, the longitudinal fibres in like manner dilate and elevate the gullet to that place which has received it. Then that part of the œſophagus, where the morſel is ſeated, being irritated, contracts, and propels the food downwards. Its muſcularity is ſtrong, and very irritable.

DCXXI. This upper opening of the ſtomach is contracted, by the action of both the lower muſcles of the diaphragm, in inſpiration, and the food is confined within the ſtomach, ſo that every preſſure of the diaphragm ſends it naturally towards the pylorus. By this means, the ſtomach is ſo cloſely ſhut, that in perfect health, even vapours are confined

fined within the ſtomach; and do not aſcend but from a morbid affection.

CHAP. XIX.

ACTION OF THE STOMACH ON THE FOOD.

DCXXII. THE ſtomach is a membranous bag, deſtined for the reception of the food; placed within the abdomen, behind the liver, diaphragm and left falſe ribs; of a figure ſomewhat oval, or like a caſk; longeſt tranſverſely, and the more ſo the more aged the perſon is. In the fœtus, it is altogether round and ſhort. But if we conſider its figure more accurately, every ſection of it is circular; but ſo, that, in its left extremity, there is an an impervious cavity obtuſely conical, from whence the ſtomach gradually grows wider, and its ſections increaſe towards the œſophagus, at whoſe inſertion is its largeſt ſection; from thence it diminiſhes ſlowly, till being reflected towards itſelf, it ends in the pylorus. Its bulk depends in a great meaſure on the quantity of food, by which the cavity of the ſtomach is augmented; and, on the contrary, it is diminiſhed by faſting. Its ſituation in general is tranſverſe; yet ſo that the entrance of the œſophagus is poſterior, and its right termination anterior. The middle of the human body, or enſiform cartilage, correſponds nearly to the centre of the ſtomach; but alſo to its right ſide, and laſtly to the pylorus: to the latter the umbilical fiſſure correſponds. Since its figure is round, but incurvated; when empty, its larger convex arch is pendulous; but when full, it appears prominent forwards within the peritonæum. At that time, the leſſer arch, interpoſed between the two orifices, is directed perfectly backwards, and includes the

ſmall lobe of the liver. The inſertion of the œſophagus in the full ſtomach is more horizontal; but in the empty ſtomach, more perpendicular: the right extremity of the ſtomach, when empty, is bent upwards to the pylorus; in the full ſtomach, it is bent backwards, and therefore deſcends in perſons lying on their back. In man, when alive, the ſituation of the ſtomach, approaches nearer to that which we have attributed to the full one.

DCXXIII. The viſcera, contiguous to the ſtomach, are the ſpleen, contiguous to its left imperforated extremity, and connected with it by much omentum; the lobule of Spigelius, filling up its leſſer curvature; the left lobe of the liver, largely interpoſing itſelf betwixt the ſtomach and the diaphragm, and compreſſing the anterior part of the ſtomach; after which, below the liver, a moderate portion of the ſtomach is immediately contiguous to the diaphragm, which there lies under the falſe ribs, or it is entirely covered: behind, the pancreas lies under it; below it when empty, the tranſverſe portion of the colon is contiguous for a conſiderable way; laſtly, from the leſſer curvature, ariſes the little omentum, from which a continuous, but ſtronger membrane, connects the œſophagus with the diaphragm: and the larger omentum is not connected to the whole length of the ſtomach, but is wanting on the right ſide near the pylorus; and on the left, it is continued, into a ligament, which connects the ſpleen and alſo the diaphragm with the ſtomach. The ligaments are productions of the peritonæum, receding from the diaphragm, thrown over the ſtomach, and forming is outermoſt coat. Of the orifices, the pylorus lies farther forwards, more to the right ſide, and a little lower.

DCXXIV. The fabric of the ſtomach, in general, is the ſame with that of the œſophagus; of which, it is a kind of expanſion; and, in ſome animals, perfectly ſimilar. The outermoſt coat is from the peritonæum;

peritonæum; is ſtrong, limits the reſt, and affords ſupport to the ſubjacent muſcular fibres: it is expanded into both omentums; and in that place, the ſtomach is without its outermoſt coat. Then follows the firſt cellular coat, more abundant at the origin of the little omentum, where it contains conglobate and lymphatic glands, and alſo in the region of the great omentum; it is thinner and ſhorter in the intermediate planes, ſo that the outer and muſcular tunic in them cohere together: in this ſubſtance, the large branches of the veſſels are diſtributed.

dcxxv. The muſcular coat is next in order, which is complex and difficult to deſcribe or prepare. The longitudinal fibres of the œſophagus, when they arrive at the ſtomach, diſtribute themſelves along all the ſides of the ſtomach. Some of them, of conſiderable ſtrength, run on to the pylorus, along the ſmaller curvature; part of which, by degrees declining, and following the length of the ſtomach, deſcend into the planes of each ſide, and part of them proceed along the pylorus into the duodenum itſelf, and gradually diſappear. Other ſimilar fibres, which are leſs ſtrong, deſcend to the blind ſack on the left ſide of the ſtomach. Beſides, other fibres ſurround that blind ſack, which being gradually increaſed, are continued with the circular fibres of the reſt of the ſtomach. This ſecond ſtratum of fibres is the moſt conſiderable. Laſtly, the ſphincter of the œſophagus, is the moſt internal, and is a continuation of the annular fibres of the œſophagus. It is compoſed of fibres, ariſing from the left of the œſophagus, and running to the right, on each ſide of the gullet, which they nearly ſurround; and gradually becoming longitudinal, they terminate, covered by the ſecond ſtratum, near the pylorus. The ligaments of the pylorus are two bands, lying betwixt the two curvatures, which contract the pylorus. They are formed of longitudinal

tudinal fibres, and run from the ſtomach to the pylorus, intimately connected with the external membrane.

DCXXVI. Next to the muſcular fibres, there is the ſecond cellular coat, larger than the firſt, eaſily inflatable, ſofter, and conſiſting of larger cells than is common in the inteſtines. Into it, the veſſels, which perforate the muſcular coat, enter with large trunks, and are divided into an angular network. Under this, lies the nervous coat, which is thick, white, and firm ; and, like other nervous coats, properly conſtitutes the true ſubſtance of the ſtomach. Then the third cellular ſtratum, which is ſufficiently evident, and whoſe vaſcular network is compoſed of ſmaller veſſels than the former reticulation. Then the villous coat, continuous with the external cuticle, reparable ; mucous and ſoft, with very ſhort villi, but folded into large wrinkles, ſtellated under the œſophagus, and in the middle of the ſtomach almoſt parallel with the ſtomach itſelf. But, at the extremity of the pylorus, there is a more conſiderable fold, commonly called its valve, formed of tranſverſe fibres, and of a reduplication of the nervous coat thickened, and of the villous, ſo that a kind of tumid ring is produced, ſlippery and fleſhy, which is ſurrounded by the duodenum for a conſiderable length. The large wrinkles of the villous membrane are finally ſubdivided into ſmaller ones, reſembling a reticulation, of a quadrangular figure, ſhallow, eaſily diſappearing, and more obſcure than thoſe in the biliary ducts. Throughout the whole of this villous coat, but more eſpecially towards the pylorus, I have certainly obſerved ſome pores, not always to be perceived, which terminate in ſimple follicles, ſeated in the third cellular ſtratum.

DCXXVII. The veſſels of the ſtomach are numerous, and derived from many trunks, that the afflux of the blood might not be intercepted by any preſſure,

ſure, which might eaſily have happened if there had been a ſingle trunk. The common ſource of all theſe is the cœliaca; from its tripod, or above the ſaid diviſion, ariſes its firſt and largeſt artery, the upper coronary, with one branch ſurrounding the œſophagus; to which, and to the diaphragm, and alſo to the liver, it gives branches; with another following the ſmaller curvature, it inoſculates, by an anterior and poſterior trunk, with the leſſer coronary on the right ſide, which ariſes from the right branch of the cœliac in the vena portarum itſelf, and returns along the ſmaller curvature. But the ſame right branch of the cœliac, after deſcending behind the origin of the duodenum, gives off a conſiderable artery to the great arch of the ſtomach, the right gaſtro-epiploica, which being ſuſpended in the omentum, ſupplies both ſurfaces of the ſtomach, and ſurrounding the greater part of it, it is inſerted into the left gaſtro-epiploica. Namely, the left trunk of the cœliac, as it paſſes along the duct of the pancreas and ſinuoſity of the ſpleen, ſucceſſively ſends off many branches to the ſtomach: of which the firſt are commonly nameleſs; and of the following, one branch, called the left gaſtro-epiploica, ſends off one conſiderable branch, and other ſmaller branches, to the omentum, and returns round the ſtomach to the right ſide, to inoſculate with its companion of the right ſide. Other ſmaller twigs, coming from thoſe of the ſpleen, are ſpread upon the remaining part of the greater curve of the ſtomach, as far as the diaphragm, and are called the vaſa brevia. Frequently, alſo, one or two arteries come from the ſplenic one, to the poſterior ſurface of the ſtomach under the œſophagus, in a different direction from the gaſtro-epiploics. The other arteries are ſmaller, the upper pylorics from the hepatics, and the lower from the gaſtro-epiploics, and thoſe of the loweſt part of the œſophagus from the phrenic arteries.

DCXXVIII.

DCXXVIII. Thofe arteries are diftributed in the following manner: the external and mufcular membranes receive fhort branches; the trunks are arranged in the firft cellular ftratum, and with little diminution penetrate the mufcular coat; and between that and the nervous membrane, they compofe a larger and true network; in which all the fmall arteries of the different trunks are united, by an infinity of inofculations. From this reticulation, again, other fhort, but numerous and fmall ramifications, go to the third cellular and villous coat of the ftomach.

DCXXIX. The branches of the veins accompany the arteries. The greater coronary generally goes to the left trunk of the porta, together with the brevia and left gaftro-epiploic; while the right vein of the fame denomination joins with the middle vena colica, and is inferted along with it into the mefenteric branch of the vena portarum. Finally, the right coronary vein belongs to the trunk of the vena portarum itfelf. All thefe veins are without valves; and the upper coronary veins inofculate with the branches of the vena fine pari, in like manner as the arteries inofculate with the thoracic œfophagei.

DCXXX. The nerves of the ftomach are large and numerous, produced from the eighth pair, which forms two plexufes on the œfophagus, of which the anterior and fmaller goes from the œfophagus to the greater curvature and anterior furface; and the pofterior and larger to the fmaller curvature, and along with the arteries to the liver, and to the pancreas and diaphragm itfelf. Thefe nerves may be traced into the fecond cellular ftratum. Beyond this, efpecially the papillæ, are more obfcure. From their very great number, the ftomach is extremely fenfible, efpecially about the entrance of the gullet, infomuch, that acrimonies, which are not perceived by the tongue, turn the ftomach; the inteftines are

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alſo known, by certain morbid obſervations, to be much more indolent; even the naked ſkin itſelf is leſs ſenſible than the ſtomach. By making a ligature upon the nerves of the eighth pair, the action of the ſtomach and the digeſtion of food are deſtroyed.

DCXXXI. I have ſeen conſiderable lymphatic veſſels in the ſmaller curvature of the ſtomach, ariſing from its glands, and inſerted by a very large trunk into the thoracic duct. Others, without doubt, ariſe from the glands of the ſame kind in the greater curve; and eminent anatomiſts have obſerved lymphatic glands over the whole ſtomach. Other lacteal veſſels, I have not ſeen, and will not readily admit thoſe lately deſcribed, which are ſaid to paſs from the ſtomach through the omentum to the liver, filled with true chyle.

DCXXXII. All bags in man are perforated by inorganic pores: through theſe, water poured into the ſtomach exudes through it when ſhut, and, on the contrary, penetrates into the cavity of the ſtomach when put under water. But we cannot for this reaſon conclude, that during life this paſſage is pervious to moiſture.

DCXXXIII. Within the human ſtomach, we firſt meet with a great quantity of mucus, anointing its villous coat, derived from the pores before deſcribed (DCXXVI.) which mucus is not unfrequently tinged by regurgitated bile. Beſides, from the ſtomach, after faſting, upon bending the body, a limpid humour will frequently flow, poſſeſſing all the properties of the ſaliva, but more mucous, which it is very difficult to obtain pure in the ſtomach. It is entirely without any acidity, when it can be had unmixed with food. When ſeparated from the acid impregnations of the food, and left to itſelf, it changes, both in man and brutes, rather to an alkaline nature, more eſpecially in a faſting animal. This liquor diſtils from the arteries of the ſtomach, through

through its villous coat, as is proved by anatomical injections; by which water, glue, and oil, may be thrown into the ſtomach, through numberleſs pores.

DCXXXIV. Then it muſt be remembered, that the ſtomach is compreſſed as in a preſs in the abdomen, which is perfectly full, between the diaphragm, of which the concave left wing lies before and above the liver, and therefore over the ſtomach, and the reſiſting muſcles of the abdomen, the rectus and obliqui, but chiefly the tranſverſe. The more the ſtomach is filled, the more it experiences this preſſure of the abdominal muſcles; becauſe, at that time, it is in contact with the peritonæum at a right angle.

DCXXXV. Now we muſt explain what is received into the ſtomach, and why it is received. The Creator has given to man pain (DLXIV.) and pleaſure, for his preſervation; the one to incite him to avoid evil, the other to invite him to uſeful actions. But the taking of aliment is of the greateſt neceſſity to man. For ſince every day there is much perſpired, much waſted of his real ſubſtance, he alſo ſtands in need of reparation; as the body is manifeſtly waſted by faſting. But the neceſſity of taking food is promoted by the natural tendency of the blood to an alkaline diſpoſition, making it always approach more nearly to a putrid acrimony, by the natural and neceſſary motions of the heart and arteries, and by the heat which very much promotes the putrefaction of animal humours. Moreover, the coagulable diſpoſition of the blood, continually loſing a great part of its water by inſenſible perſpiration, requires a ſupply of its aqueous element to ſeparate the globules and prevent it from coagulation.

DCXXXVI. Theſe truths are proved not only from their cauſes, but likewiſe by the appearances exhibited in men and other animals killed by hunger. For it is common for theſe to have an acrid fetid breath,

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for their teeth to become loofe from the faline acrimony corroding them, and to fuffer violent pains in the ftomach, acute fever, and actual madnefs. Thefe diforders are the more rapid in their progrefs, the more violently the body is exercifed, and the more robuft and younger it is. They enfue very flowly in people who are phlegmatic and unactive, who perfpire little, and whofe blood circulates feebly. Finally, thofe who have lived without food, have alfo lived without bodily exercife, and for the moft part laboured under a difeafe of the nerves.

DCXXXVII. The frefh chyle, compofed, for the moft part, of the acefcent clafs of vegetables, and always thinner than the blood, being received into the circulation, temperates its putrefcent acrimony, dilutes its impending coagulation, and reduces the whole mafs to that moderate degree of faltnefs which is natural to man: and finally, the chyle, but more efpecially that derived from the flefh of animals, and from the farinaceous grains, furnifhes a new gelatinous lymph, which being applied by proper caufes (DCCCCLIX.) to the vacuities of the wafted folids, repairs that wafte. The drink dilutes the coagulable blood, and hinders its putrefaction, by feparating its putrefcent particles. Hence a perfon may live for a long time without food, if fupplied with drink; but without drink, life fubfifts but a few days.

DCXXXVIII. We are induced to take food, both from the fenfe of pain which we call hunger, and from that of the pleafure imparted by the fenfe of tafte (CCCCLV.) The firft of thefe proceeds undoubtedly from the folds of the ftomach, which poffefs great fenfibility, being rubbed againft each other, by the periftaltic motion, and by the preffure of the diaphragm and abdominal mufcles, fo that naked nerves being rubbed againft naked nerves excite an intolerable degree of pain. Thus man

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is both effectually admonifhed of the dangers of abftinence, and excited to procure food by his labours. It is perhaps increafed by the gaftric juice having become more acrid, unlefs it putrefies.

dcxxxix. Thirft is feated in the tongue, fauces, œfophagus, and ftomach. For whenever thefe parts, which are very fenfible, and naturally are moiftened by their mucous and falival juices, grow dry from a deficiency in the fecretion of thofe humours, or from muriatic or alkalefcent falts adhering to them, a much more intolerable fenfation is produced, as thirft is attended by much greater danger, and does not abate until the abundance of water, being reftored to the blood, and the obftruction removed from the fecreting veffels in the parts mentioned, they are again moiftened. From hence we learn, why thirft attends labour, which exhales the water by perfpiration; and why it is a fymptom of fevers, where the exhaling veffels belonging to the tongue and fauces are obftructed; why fimple water is lefs efficacious in allaying thirft; why fubacid liquors are more efficacious, which not only moiften by their fluidity, but alfo, by a mild irritation of the tongue and mouth, excite a flow of the retained humours, and at the fame time correct putrefcency.

dcxl. From thefe caufes, mankind being compelled to take food, has in all ages felected thefe fupports of life from the vegetable and animal kingdoms, fo that of the third, water and falt alone are added. It is probable, that the original choice of our foods was made by experiments, as fuggefted by the fmell and flavour of certain vegetables, and as their utility was confirmed by the renewal of ftrength. By degrees, as animals became incommodious to hufbandmen, and vegetables alone were not fufficient for fupporting them under their labours, the flefh of animals was afterwards added. At prefent, the number of fubftances is almoft infinite,

infinite, which we take either as food or seasoning.

DCXLI. Although there are instances of particular persons, and even of nations, who have lived entirely upon food taken from one class, as upon vegetables alone, or animals alone, and sometimes upon a few individuals of one class; and lastly, upon milk alone or its whey; yet it seems to be necessary, both from the nature of the human body, and to be indispensable according to certain experiments, that we ought to support life especially by two kinds of food, so intermixed, that neither may exceed; which mediocrity we are taught from the loathing itself, which is excited by any one kind of food that has been continued too long.

DCXLII. The flesh of animals appears necessary, from the teeth in both jaws, and from the fabric of the human stomach itself resembling that of carnivorous animals; from the smallness and shortness of the intestinum cæcum, and from the strength which we require. For the flesh of animals alone contains the gelatinous lymph ready prepared, which, being extracted from the broken vessels, passes easily and in great abundance into the blood. Abstinence from animal food causes great weakness both in the body and stomach, and is usually attended by a troublesome diarrhœa. Man agrees with the herbivorous animals in the size and length of the large intestines.

DCXLIII. Esculent vegetables are generally of the acescent kind; a few of them only are either alkalescent or aromatic. Few of them have that gluten which is spontaneously changeable into blood, and they only nourish by means of their farina, a small part of which, after repeated circulations, is at last converted into the natural juices. Yet they are necessary to avoid over repletion with blood, and of too putrescent a kind, from the use of animal food alone, such as most certainly occurs in the anthropophagi,

pophagi, and produces ſcurvy, ferocity, fetor, leproſy, and every kind of alkaline corruption, all which evils are cured by change of diet, and the excluſive uſe of acid vegetables. Hence we are furniſhed with few canine teeth; and our appetite in health, but more eſpecially in diſeaſe, is ſtronger for acidulous vegetables, in proportion to the warmth of our temperament, of the ſeaſon of the year, and of the country. Hence, in the hotteſt climates, people live almoſt altogether upon vegetables, and uſe fleſh very rarely, and with danger; while, in the colder countries, it is eaten freely with leſs danger. Hence bread, or a farinaceous aliment ſimilar to it, is eaten in every part of the world.

DCXLIV. The beſt drink is pure water, free from every kind of ſalt, and not impregnated with air, which excites fermentations. That from a mountainous ſpring, which runs through a ſandy bed, and is cold, clear, light, and inſipid, is juſtly preferred. Whenever there is a deficiency of pure water, as is frequently the caſe in flat countries, or when any power ſtimulating the ſtomach to contraction, or any aromatic is required, it is ſupplied by vinous liquors, eſpecially thoſe prepared from grapes, but alſo from apples and pears; which, after fermentation, become clear, and contain alcohol and an acid ſalt diluted with water. Liquors of the ſame kind, not deſtitute of alcohol, but more flatulent, vapid and colder, are prepared by fermentation from grain toaſted, and boiled in water, in thoſe countries where the grape does not ripen.

DCXLV. Men have invented various condiments. They have added ſalt, vinegar, and acids of various kinds, to correct the putreſcence of fleſh; pepper, hot ſpices, and alliaceous ſubſtances, to ſtrengthen the ſtomach, which is weakend by the conſtant uſe of vegetables; and ſugar, ſalt and aromatics, for the ſake of flavouring or preſerving our food.

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But none of theſe nouriſh, being deſtitute of gelatinous lymph, and nouriſhing farina. The ſpirits of wine and of corn may be of ſome uſe as medicines, but are unfit for drinking.

DCXLVI. According to the difference of country, climate, or ſeaſon, the aliments undergo various preparations, by which crudity is removed, ſolid fibres ſoftened, exceſſive air expelled, diſagreeable acrimony diminiſhed, or a pleaſant flavour imparted. But many vegetable foods, and more eſpecially fleſh meats, require ſome trituration, particularly in man, whoſe ſtomach is but little fleſhy, nor ought the articles of food to become putrid by remaining too long in the ſtomach.

DCXLVII. The meaſure of our food is determined by the ceaſing of our hunger, which is different according to the difference of aliments. Animal and farinaceous food nouriſhes moſt: other aliments ought to ſupply by their quantity, what they want in powers of nouriſhment. In general, we are nouriſhed beſt by a ſomewhat ſpare diet, unleſs ſubjected to much labour.

DCXLVIII. Into the ſtomach, therefore, the aliments are let down, often almoſt crude, and little chewed; of various kinds, as alkaleſcent fleſh, ranceſcent fat, or aceſcent vegetables, bread and milk, and glutinous ſubſtances. Here they are digeſted in an heat equal to that of incubation, imparted by the contiguous heart, liver, and ſpleen; and in a cavity ſhut above (DCXXI.) and alſo below by the aſcent of the pylorus, the narrowneſs of the valve placed there, and the action of the fibres, conſtricting the pylorus, ſo that even milk itſelf remains entirely in the ſtomach of healthy animals ſeveral hours after meals, without paſſing into the inteſtines. Beſides, the aliments are macerated in a moiſt place with much air, either ſwallowed during deglutition, or mixed with the aliments. This air, therefore, expanding by the force of heat, putrefaction, or fermentation,

mentation, burſts the cells in which it is included, divides the viſcid liquors, weakens the ſolid fibres; prepares ſpace for the fluid which is to enter into them. But this air alſo, which is the principal cement of animal ſolids, emerges from their ſubſtance, and leaves the other elements without a vinculum; as we ſee from the phenomena in Papin's digeſter, in the ſtomachs of animals, and even in that of man. This air, ſet at liberty, diſtends the ſtomach more than the food itſelf, and is termed flatus. At the ſame time, the aliments begin to corrupt into a nauſeous liquid, often aceſcent; at other times putreſcent, but leſs ſo in man from the influence of bread and ſalt; or ranceſcent, as appears from the flatus and eructations, variouſly fetid, and even inflammable. This is the ſole cauſe of digeſtion in fiſh and ſerpents, and almoſt in carnivorous birds. Hence, in man, metals themſelves, by long ſtay in the ſtomach, grow ſoft, and are eroded. At the ſame time hunger is removed, the nervous folds of the ſtomach being removed from mutual contact by the aliments interpoſed, the acrid gaſtric fluid being neutralized, and perhaps from the very preſence of this nauſeous liquid being diſagreeable to the nerves.

DCXLIX. But they are prevented from degenerating into complete acidity, by the heat inducing putrefaction, by the action of the gaſtric juice, and of the ſaliva, which is ſwallowed to the amount of half an ounce in an hour, both inclined to alkaleſcency, and by the bile which certainly regurgitates frequently into the ſtomach. Theſe fluids, being incorporated with the aliment, macerate and ſoften it, divide the membranes, reſolve the cellular bands, liquefy the pulps, as warm water and time do in other ſituations, extract their juice, and mingle it with themſelves. There is, therefore, no kind of fermentation in the ſtomach, from which the nature of the fluid, and the deſign of nature, are

are diftinct. And yet the juice of the ftomach alone, by a continuance of its action, in fifhes, diffolves the bones which they devour.

DCL. For, the flefhy fibres in the ftomach being now irritated by the flatus, weight, and acrimony of the food, begin to contract themfelves more powerfully than when the ftomach is empty, and with greater force in proportion as it is more full, its round fwelling ftretching the fibres. And, firft, the plane of the fmaller curvature draws the pylorus to the œfophagus; and, being inferted only into its left furface, it draws that to the right. The principal ftratum of the circular fibres, diminifhes the cavity of the ftomach, incorporates the aliments with the juices, (DCXXXIII.) and compreffes them flightly as if between the hands on oppofite fides and gradually determines them towards the pylorus: but it is not immediately permitted to efcape, both on account of the reafon before affigned, (DCXXVI.) and alfo becaufe this motion begins from the part that is moft irritated; and, therefore, impels the aliment upwards, as at other times it forces it downwards. The contracted portion of the ftomach propels the food into the neighbouring dilated part, and is in its turn relaxed when that other is contracted. Thefe alternate contractions at laft terminate in complete evacuation. In this action, there is nothing which refembles the trituration made by the ftrong gizzards of granivorous fowls, which fome anatomifts have afcribed to the human ftomach; yet it has a confiderable degree of ftrength, and affords an example of fibres contracted to more than a third part of their length; for the ftomach is frequently reduced to much lefs than a third of its diameter, even to the breadth of an inch; and, laftly, is capable of difcharging needles. Yet it neither bruifes berries, nor the fofteft worms.

DCLI. The action exerted by the diaphragm and mufcles of the abdomen, is ftronger than the periftaltic force of the ftomach; for, by this, it is capable

pable of perfectly evacuating the ſtomach, and of bringing its anterior and poſterior ſides into actual contact. For this force, principally, expels the fluids immediately, but the ſolids only when they are ſoftened, and rendered ſmall enough for the valve of the pylorus, through that pylorus into the duodenum, which is inclined when the ſtomach is full; for the aliments do not ſeem to leave the ſtomach, before they have loſt their fibrous or other texture, and are reſolved into a mucous, yellowiſh, cineritious, ſomewhat fetid, pultaceous liquid. That which is firſt prepared and liquefied, goes firſt, and, therefore, water and milk, firſt of all; then pot herbs; and, laſtly, fleſh. The harder, tougher, and longer ſkins or fibres, paſs at the ſame time unchanged: and ſuch things as are hard and too large to paſs the pylorus, are retained in the ſtomach for a long time.

DCLII. But the moſt conſiderable portion of the drink is abſorbed by the pendulous patulent veins of the ſtomach itſelf, correſponding to the exhaling arteries (DCXXXIII.) and is carried by a ſhorter way to the blood, as plainly appears from injections. Does any thing enter the lymphatic veſſels (DCXXXI.)?

DCLIII. The ſtomach, being irritated by too great a quantity or acrimony of the food, or elſe by nauſea from regurgitation of the bile, or other cauſe, with an antiperiſtaltic motion repels its contents upwards, and diſcharges them through the open and relaxed œſophagus, by vomiting. But this is aſſiſted by the action of the abdominal muſcles, which compreſs the belly, draw in the ribs, and, as the deſcending diaphragm acts againſt them, they evacuate the ſtomach with very great force, ſqueezed as if in a preſs.

DCLIV. But the aliments tranſmitted in their natural courſe to the duodenum, meet there with the bile which frequently regurgitates into the ſtomach itſelf, and with the pancreatic juice. The nature of

of the former of theſe, the principal fluid of digeſtion, requires a previous hiſtory of the viſcera, which tranſmit their blood to the vena portarum.

CHAP. XX.

THE OMENTUM.

DCLV. THE peritonæum is a ſtrong ſimple membrane, by which all the viſcera of the abdomen are ſurrounded. It has an exceedingly ſmooth, exhaling, and moiſt internal ſurface; outwardly, it is every where ſurrounded by cellular ſubſtance; which, towards the kidneys, is very looſe and very fat; but is extremely ſhort at the lower tendon of the tranſverſe muſcles. It begins from the diaphragm, which it completely lines; and at the laſt fleſhy fibres of the ribs, and the external lumbar fibres, it completes the ſeptum, in conjunction with the pleura, with which it is continuous through the various intervals of the diaphragm. It deſcends behind, before the kidneys; before, behind the abdominal muſcles; it dips into the pelvis; from the bones of the pubes, paſſes over the bladder, and deſcends behind it; and being again carried backwards at the entrance of the ureters in two lunar folds, it rejoins upon the inteſtinum rectum, that part of itſelf which inveſts the loins, and in this ſituation lies before the rectum.

DCLVI. 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, the large veſſels of the pelvis, the obturatoria, penis, bladder, and aorta, and aſcending into the breaſt, accompany the gullet and vertebræ; by means of which, there is a commu-

nication between the whole body and the peritonæum, well known in dropſical people.

DCLVII. It has various prolongations for covering the viſcera. The ſhorter productions of this membrane are called ligaments; and are formed by a continuous reduplication of the peritonæum, receding from its inner ſurface, incloſing cellular ſubſtance, and extending to ſome viſcus, where its plates ſeparate; and having diverged, embrace the viſcus; but the intermediate cellular ſubſtance always accompanies this membranous coat, and joins it with the true ſubſtance of the viſcus. Of this ſhort kind of production, three belong to the liver, one or two to the ſpleen, and others to the kidneys and to the ſides 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, and from injuring themſelves, being ſecurely connected with the firm ſides of the peritonæum.

DCLVIII. But the moſt important of all theſe productions of the peritonæum, are thoſe called the meſentery and meſocolon; and the deſcription of which, although very difficult, ought not to be ſeparated. We ſhall, therefore, begin firſt with the meſocolon, as being the moſt ſimple. In the pelvis, the peritonæum ſpreads itſelf ſhortly before the rectum. But where that inteſtine becomes looſe, and forms the ſemilunar curve, the peritonæum there riſes conſiderably from the middle iliac veſſels and region of the pſoas muſcle, double (DCLVII.) and with a figure adapted for receiving the hollow colon. But above, on the left ſide, the colon is connected with almoſt no intermediate looſe production to the peritonæum, ſpread upon the pſoas muſcle, as high as the ſpleen, where this part of the peritonæum, which gave a coat to the colon, being extended under the ſpleen, receives

and

and ſuſtains that viſcus, in a hollow ſuperior receſs:

dclix. Afterwards the peritonæum, from the left kidney, from the interval between the kidneys, from the large veſſels, and from the right kidney, emerges forwards, under the pancreas; and forms the broad and ſufficiently long continuous production, called the tranſverſe meſocolon, which, like a partition, divides the upper part of the abdomen, containing the ſtomach, liver, ſpleen, and pancreas, from the lower part. The lower plate of this tranſverſe production, is continued ſingly from the right meſocolon to the left, and ſerves as an external coat to a pretty large portion of the lower and deſcending part of the duodenum. But the upper plate, leſs ſimple in its courſe, departs from the lumbar peritonæum at the kidney and region 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 beyond the colon, it is joined with the lower plate, ſo that a large part of the duodenum lies within the cavity of the meſocolon. Afterwards, in the region of the liver, the meſocolon is inflected, and deſcending over the kidney of the ſame ſide, much ſhorter, it includes the right of the colon; as far as the inteſtinum cæcum, which reſts upon the iliac muſcle; and the appendix, which is provided with a peculiar, long, curved meſentery. There the meſocolon terminates, almoſt at the bifurcation of the aorta.

dclx. The whole of the meſocolon, and of the 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 it ſuſtains the colon, and alſo from part of the inteſtinum rectum, the meſocolon, continuous with the outer membrane of the inteſtine, forms itſelf into ſmall ſlender bags, reſembling the omentum, for the moſt

part in pairs, with their loofe extremities thicker and bifid, and capable of admitting air, blown in between the plates of the mefocolon.

DCLXI. In the next place, we come to the mefentery, a very large, folded production of the peritonæum, continuous with the tranfverfe and right mefocolon, at the right fide of the emerging duodenum; and then proceeding for a long way with both mefocolons, even as low as the pelvis. The mefentery, under the right portion of the tranfverfe mefocolon, defcending from that part of the peritonæum, which lies upon the aorta, under the pancreas, and having numberlefs folds in its edge, contains the very long feries of the fmall inteftines.

DCLXII. Every part of the mefentery and mefocolon contains fat, collected in the neceffary interval of the plates; generally in greater quantity, where they are longer; and interpofed veffels diftributed around the fat, which the arteries fecrete, and the veins, as already mentioned, abford; and alfo very numerous glands, which are moft confpicuous in a young fubject.

DCLXIII. The nature of the omentum is very analogous to that of the mefentery. But there are many membranes that come under this general denomination, of the fame ftructure and utility, all compofed of a tender membrane, very eafily lacerated, through which reticulated veffels are diftributed, with fat depofited in ftreaks along their courfe. This membrane is always double; and between its lamellæ, clofely connected by very tender cellular fubftance, the veffels are diftributed, and the fat collected. And, firft, where the top of the right kidney, and the lobulus caudatus of the liver, with the fubjacent large veffels, form an angle with the duodenum, there the external membrane of the colon which comes from the peritonæum, joining with the membrane of the duodenum, which alfo arifes immediately from the peritonæum,

tonæum lying upon the kidney, enters backwards into the tranſverſe fiſſure of the liver for a conſiderable ſpace, is continuous with its external coat, contains the gall bladder, ſupports the hepatic veſſels, and is very yellow and ſlippery. Behind this membranous production, betwixt the right lobe of the liver, hepatic veſſels, vena portarum, biliary ducts, aorta, and adjacent duodenum, there is a natural opening, by which air may be blown extenſively into all that cavity of the omentum, which we ſhall preſently deſcribe; and, laſtly, into the bags of the reſt of the omentum.

dclxiv. From thence, in a courſe continuous with this membrane (dclxiii.) from the pylorus and the ſmaller curvature of the ſtomach, the external 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, acroſs the little lobe, into the ſtomach, ſtretched before the lobe and before the pancreas. This is the little omentum or hepatico gaſtricum; which, when inflated, reſembles a cone; and gradually becoming harder, and emaciated, it changes into a true ligament, by which the œſophagus is connected to the diaphragm (dcxxiii.)

dclxv. But the larger omentum, the gaſtrocolicum, is of a much greater extent. It begins at the firſt acceſſion of the right gaſtro-epiploic artery to the ſtomach, being continued there from the upper plate of the tranſverſe meſocolon (dclix.); and then from the whole great curve of the ſtomach, as far as the ſpleen, and alſo from the right convex end of the ſtomach towards the ſpleen, until it alſo terminates in a ligament that ties the upper and back part of the ſpleen to the ſtomach. This is the anterior lamina.

dclxvi. Being continued downwards, ſometimes to the navel, ſometimes to the pelvis, it hangs before the inteſtines, and behind the muſcles of the abdomen,

abdomen, until, from its lower edge being reflected upon itſelf, it aſcends, leaving an intermediate vacuity between it and the anterior lamina, and is continued for a very great extent into the external membrane of the tranſverſe colon, and laſtly into the ſinus of the ſpleen, by which the large blood-veſſels are received, and it ends finally on the œſophagus, under the diaphragm. Behind the ſtomach, and before the pancreas, its cavity is continuous with that of the ſmaller omentum.

DCLXVII. To this the omentum colicum is connected, which ariſes farther to the right than the firſt origin of the omentum gaſtrocolicum from the meſocolon, with the cavity of which it is continuous, but produced ſolely from the colon and its external membrane, which departs double from the inteſtine; it is prolonged, and terminates by a conical extremity, ſometimes of longer, ſometimes of ſhorter extent, above the inteſtinum cæcum.

DCLXVIII. The uſes of the omentum are many. In common with the meſentery, it forms looſe ſpaces, into which the fat may be poured, and preſerved during ſleep and inactivity, that it may be afterwards diſſolved by increaſe of motion, reſtored by the abſorbent veins, and conſtitute a principal ingredient of the bile. Hence it is ſometimes found very thick, even an inch thick, and at others thin, and more tranſparent than paper. For that the fat returns again into the veins, is demonſtrated from human omenta being found of very different bulks and fatneſs, according as they belonged to indolent, laborious, or diſeaſed ſubjects; from the phenomena in animals; from the analogy of all the reſt of the fat of the human body (xx.); from experiments in frogs, where this reabſorption of the fat may be made evident to the eye; and, laſtly, from the evidently inflammable nature of the bile. Hither I alſo refer the diſorders of digeſtion, the crudities

and

and coldneſs of the ſtomach, obſerved from cutting out the omentum.

DCLXIX. For all the blood which returns from the omentum and meſocolon, goes into the vena portarum, and by that into the liver itſelf. The omentum gaſtrocolicum is furniſhed with blood from each of the gaſtro-epiploic arteries, by many deſcending reticulated branches: of which the moſt lateral are the longeſt, and the loweſt anaſtomoſe by minute twigs with thoſe of the colon. It alſo has branches from the ſplenic, duodenal, and adipoſe arteries. The omentum colicum has its arteries from the colon, as alſo the ſmaller appendices, (DCLX.) and from the duodenal and right epiploic. The arteries of the ſmaller omentum come from the hepatics, and from the right and left coronaries.

DCLXX. The omentum, being fat and indolent, has very ſmall nerves. They ariſe from the nerves of the eighth pair, both in the greater and in the leſſer curvatures of the ſtomach.

DCLXXI. The arteries of the meſentery are, in general, the ſame with thoſe which go to the inteſtines, and of which the ſmaller branches remain in the glands and fat of the meſentery. Various ſmall acceſſory arteries go to both meſocolons, from the intercoſtals, ſpermatics, lumbars and capſulary, to the tranſverſe portion, from the ſplenic artery and pancreatico duodenalis, and to the left meſocolon, from the branches of the aorta going to the lumbar glands.

DCLXXII. The veins of the omentum, in general, accompany the arteries, and unite into ſimilar trunks: thoſe of the left part of the gaſtrocolic omentum into the ſplenic, and alſo thoſe of the hepaticogaſtric, which likewiſe ſends its blood to the trunk of the vena portarum: thoſe from the larger and right part of the gaſtrocolic omentum, from the omentum colicum, and from the appendices epiploides, into the meſenteric trunk. All the veins of the meſentery

mesentery meet together in one, which is the true trunk of the vena portarum: being collected first into two large branches; of which the one, the mesenteric, receives the gastro-epiploic vein, the colicæ mediæ, the iliocolica, and all those of the small intestines as far as the duodenum; the other, which going transversely inserts itself into the former, above the origin of the duodenum, carries back the blood of the left colic veins, and 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 called hæmorrhoidalis interna, is sometimes inserted rather into the splenic than into the mesenteric vein. Has the omentum also lymphatic vessels? Certainly there are conglobate glands, both in the little omentum and in the gastrocolicum; and ancient anatomists have observed pellucid vessels in the omentum; and a modern has described them for lacteals of the stomach.

DCLXXIII. The other uses of the omentum are, to interpose itself betwixt the intestines and peritonæum, which are very apt to adhere; to preserve the mobility of the former entire, both among themselves and upon the peritonæum; to lessen friction; and to lubricate the muscular fibres with a very bland oil. Therefore, even in insects, there is a great deal of fat around the intestines. In the large intestines, there are a great many appendices, because they have larger lacerti, and cannot be altogether covered by the omentum. The omentum also arranges the vessels, conducts and supports them, connects the contiguous viscera, and exhales a soft vapour, which, mixing with watery abdominal exhalations, anoints and lubricates all the viscera.

DCLXXIV. The mesentery sustains the intestines in such a manner, that they possess both mobility and firmness: it supports and conducts with safety the blood-vessels, lacteals and nerves; it fixes the glands,

glands, as ſhall be noticed hereafter, gives an external coat to the inteſtines, and forms moſt of the omenta.

DCLXXV. But beſides, the blood, returning through the meſenteric and meſocolic veins, brings with it to the liver a ſecond principal conſtituent of the bile; namely, a copious ſubalkaline humour, which is abſorbed from all the ſmall inteſtines, as will be demonſtrated in its proper place. Moreover, from the large inteſtines, it conveys to the liver another fluid, but more putrid, fetid, and nearly approaching to the nature of volatile alkali, abſorbed from the alvine fæces, that now begin to ſmell ſtrong; which is eaſily proved, both from proper experiments, and from the induration of the fæces when too long retained in the bowels. For this water is naturally fluid, and rendered more ſo by incipient putrefaction; it moderates the tenacity of the oil from the omentum and meſentery, and keeps it from coagulation. But it eſpecially imparts to the bile that alkaline rancidity with which it abounds, and on which the great tenuity, and dyeing and ſaponaceous powers of the bile almoſt ſolely depend.

CHAP. XXI.

SPLEEN.

DCLXXVI. THE ſpleen is alſo one of thoſe viſcera, which ſend their blood to the liver. It is pulpy, bloody, livid, and ſomewhat thick; of an oval circumference, often notched on the margin, or even divided into lobes; on one ſide, towards the ribs, convex, on the other concave; with two ſurfaces, one anterior towards the ſtomach, and another poſterior towards the diaphragm; divided by the entrance of its veſſels; and with two extremities, of which the inferior and anterior is the ſharpeſt.

ſharpeſt. It is connected to the ſtomach by the little omentum and upper ligament, ſupported from the adjacent colon by the ligament (dclviii.) behind, it is contiguous to the renal capſule; and it is connected to the kidney by the peritonæum. It alſo receives the peritonæum from the diaphragm, under the denomination of a ligament, in the back part of its hollow ſinus, behind its veſſels. Its ſituation is variable, and depends on the ſtomach. When that is empty, the ſpleen is placed more perpendicularly, and its extremities become ſuperior and inferior: but when the ſtomach is full, and its middle curvature ariſes forwards (dcxxii.) then the ſpleen at the ſame time changes its ſituation, and its extremities become anterior and poſterior, ſo as to lie almoſt tranſverſely. Alſo, being of a very ſoft texture, it is more ſpongy and larger when the ſtomach is empty; and when the ſtomach is full, being preſſed by it againſt the ribs, it is emptied. Hence, in weak ſubjects, it is large; but in thoſe who die ſuddenly, and in full health, it is ſmall. It alſo deſcends with the diaphragm in inſpiration, and aſcends with it in exſpiration; and beſides, it frequently varies its ſituation with the colon. Frequently there is a ſecond acceſſory ſpleen, or even ſeveral.

dclxxvii. The blood-veſſels of the ſpleen are large, in proportion to its weight. The arterial trunk comes from the cœliac; the left branch of which proceeds in a ſerpentine courſe, above and behind the pancreas, to which it gives branches, and to the meſocolon, ſtomach, and omentum, incurvated along the ſulcus of the ſpleen, and being ſupported by the right end of the gaſtrocolic omentum, it in a manner perforates the ſpleen by many branches. The thickneſs of this artery is greater than that of the aorta. The ſplenic vein is remarkably ſoft, almoſt more ſo than any other vein of the body; it forms the principal left branch of the vena portarum,

portarum, and, befides the branches accompanying the arteries, it receives the great coronary, defcending behind the pancreas, and fometimes the internal hæmorrhoidal. The vafa brevia, arifing from thofe of the fpleen, we have mentioned elfewhere; and laftly, fmall twigs from the lumbars, phrenics, intercoftals, and thofe of the renal capfules, go to the ligaments and membranes. In like manner, the fplenic and fhort veins communicate with the renal capfulary, renal and phrenics.

DCLXXVIII. The lymphatic veffels which are defcribed in the duplicature of the membrane of the fpleen, which, however, does not exift, and are faid to proceed on to the receptacle of the chyle, are very evident in the calf; and in mankind are rendered confpicuous by blowing air under the membrane, or by maceration, or by injecting water into the artery.

DCLXXIX. The nerves of the fpleen are fmall; fo that it is little fufceptible of pain, and is very rarely inflamed. They arife from a particular plexus of the pofterior branches of the eighth pair, (DCXXX.) and of peculiar branches from the large gangliform plexus, which the fplenic trunk of the intercoftal nerve produces; and they furround the fplenic artery with branches.

DCLXXX. The fabric of the fpleen appears to be much more fimple than is commonly believed. For it is compofed, both in man and in calves, entirely of arteries and of veins; the former of which are remarkably branchy, and fubdivided into fewer large branches, but into very numerous minute ones, terminating finally in very tender twigs, very difficult of injection, and arifing very crowded together; from which there is a ready paffage into the correfponding veins. Various authors have confidered thefe pencils, with their parallel branches, being fomewhat round, as glands. Injection, rightly managed, never efcapes into any intervals; nor

nor have hollow glands ever been demonſtrated with certainty. Each little arterial trunk, with the ſmaller twigs that proceed from it, is ſurrounded by a very fine cellular web, in the ſame manner as in all the viſcera, but here rather ſofter. The whole body of the ſpleen is externally ſurrounded by a ſingle membrane, ſimple and not very firm, continued from the peritonæum, and joined to the ſubſtance of the ſpleen by thicker cellular ſubſtance.

DCLXXXI. Obſervation alſo teaches us, that the ſpleen contains more blood, in proportion, than any other viſcus; ſince it has no muſcles, fat, air veſſels, or excretory ducts, interpoſed between its blood-veſſels. Its blood is ſcarcely ever coagulated, has a ſomewhat dark colour, and from its dilution, colour, and greater proportion of water, may be almoſt compared to the fœtal blood. It abounds with water and volatile ſalt, but has leſs oil.

DCLXXXII. The want of an excretory duct to the ſpleen, has occaſioned, in all ages, inquiries, doubts, and controverſies, about its uſe. The following ſeems to us to correſpond with its fabric; although, perhaps, all the uſes of the ſpleen are not comprehended by it. A great quantity of blood is carried to the ſpleen, (DCLXXVII.) and, from the denſity and ſerpentine courſe of the artery, its motion is ſlow; but, when the ſtomach is empty, at which time it arrives in greater quantity, and being leſs compreſſed, is retained in the ſpleen, it in ſome meaſure ſtagnates, from the very great proportion of branches to the trunks in this part; and the difficult circulation of the blood of the ſpleen through the ſtraits of the liver. Hence the very frequent ſchirroſities of the ſpleen; hence that immenſe quantity of blood with which the whole ſpleen is diſtended, and which is not found in any other viſcus in ſuch quantity. Therefore the blood, in this warm ſituation, and fomented by the putrid fæces of

of the adjacent colon, is refolved, and afterwards advances, in a certain degree, towards putrefaction, as appears from its colour and fluidity. But it is the more fluid, becaufe the fpleen has no fecretory veffels, and therefore the whole quantity of water enters the vein, which was brought by the artery.

DCLXXXIII. Then, when the ftomach is filled with food or flatus, the fpleen is compreffed into a narrower compafs, againft the refifting ribs and fuperincumbent diaphragm, and the blood which was returning through the fplenic vein, flowly and in fmall quantity, is fuddenly preffed out of the fpleen, returns with celerity to the liver; mixes with the fluggifh blood loaded with the fat of the omentum and mefentery, (DCLXIX.) dilutes it, preferves it from coagulation and ftagnation; and, at the fame time, it conduces to increafe the fecretion of bile, at the time when it is moft wanted, for the procefs of digeftion which is then going on. The fpleen, therefore, feems to fupply to the bile fome aqueous principle, but probably of a fubalkaline nature, and acrid from its ftagnation.

DCLXXXIV. Is the fabric of the fpleen cellular? Does the blood poured out into thofe cells ftagnate? Is it diluted with fome juice fecreted by peculiar glands? Nothing of this is demonftrated by anatomy; nor do liquids or wax ever efcape from the arteries, unlefs injected with two great violence. Is an acid juice prepared in the fpleen for the ftomach? That opinion is difcarded, as repugnant to the nature of all the animal juices, and inadmiffible, from the want of a paffage. Is the fpleen ufelefs? Is this proved, by the little injury animals fuftain from its extirpation? The lofs even of a confiderable part does not injure a robuft animal; and yet there are examples, where, from its extirpation, the liver became fwelled and difeafed, the bile more fcanty and darker, and troublefome flatulencies fucceeded, which are referable

ferable to the vitiated nature of the bile, the obstruction of the liver, and diminished powers of digestion; if they were confirmed by repeated experiments.

CHAP. XXII.

PANCREAS.

DCLXXXV. THE pancreatic juice, which is watery, insipid, thin, neither acrid nor alkaline, is excreted at the same place into which the bile is discharged.

DCLXXXVI. The pancreas, the largest of the salivary glands, is of great length, is situated before the left renal capsule and the aorta, above the inferior lamina of the transverse mesocolon; (which beyond the pancreas, behind its superior lamina, behind the stomach, before the spleen, under and behind the liver, joins with the inferior lamina;) is of a flattish triangular shape, with a light depression on the upper part, and is covered with the peritonæum. Upon it, being posterior and inferior, the posterior side of the empty stomach rests. The pancreas begins at the spleen itself; extends almost transversely towards the right side, across the vertebræ, at the right of which it grows broader, being received betwixt the superior and inferior plates of the transverse mesocolon (DCLIX.) and is, finally, so connected by its round head to the duodenum, as to serve it for a mesentery. It is like the salivary glands, composed of round, hardish acini, connected by a good deal of cellular substance. Its vessels are rather numerous than large, and are derived chiefly from the splenics: but on the right side it is supplied by the first artery of the duodenum, and from another which is inferior, and is common to the

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 also supplies considerable twigs to this gland; and minute branches come from the phrenic and capsular arteries. The nerves are not considerable, whence it is little sensible; they are derived from the posterior gastric, the hepatic and splenic plexuses, &c.

DCLXXXVII. The duct runs through the middle of this gland, white and tender, arising every where from an infinite number of roots, by which, being gradually increased, it emerges before the vena portarum and mesenteric artery, having received a larger branch from the larger part of the pancreas; following the course of the duodenum, it arrives at the same part of the duodenum into which the biliary duct proceeds; where, changing its course, it descends, and being extended into a sinus, betwixt the coats of the intestine, internally smooth; and, being continued, after having received the ductus choledochus, it opens in a particular fold in the bottom of the descending part of the duodenum. But it not unfrequently happens, that it opens by an orifice distinct from that of the biliary duct; and sometimes by two, of which the one, the lower, is distinct and less; but in man, and in most other animals, it always opens near the biliary duct. In its orifice there is no valve.

DCLXXXVIII. The quantity of fluid secreted is uncertain: but it must be very considerable, if we compare it with the weight of the saliva, the pancreas being three times larger, and seated in a warmer place. It is expelled by the force of the circulating blood, and of the incumbent viscera in the full abdomen; as the liver, stomach, spleen, mesenteric and splenic arteries, and the aorta. Its great utility appears from its constancy, being found in almost all animals: nor is it refuted by the

the few experiments, in which a part of it was cut out from a robuſt animal without occaſioning death ; becauſe the whole pancreas cannot be removed without the duodenum : for even a part of the lungs may be cut out, without producing death, but they are not therefore uſeleſs. Its effervеſcence with the bile ariſes from the effect of the ligature, and of air mixed with the inteſtinal humour.

DCLXXXVIII. It ſeems principally to dilute the viſcid cyſtic bile, to mitigate its acrimony, and to mix it with the food. Hence it is poured into a place remote from the cyſtic duct as often as there is no gall bladder. Like the reſt of the inteſtinal humour, it dilutes and reſolves the maſs of aliments, and performs every other office of the ſaliva.

CHAP. XXIII.

LIVER, GALL BLADDER, AND BILE.

DCLXXXIX. THE liver, the largeſt of all the viſcera, occupies a large part of the abdomen, above the meſocolon ; and in the fœtus one ſtill larger. Both above, and behind, and before, and to the right, it is covered by the diaphragm, from which it receives the peritonæum, 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 anteriorly, under the name of ligamentum ſuſpenſorium, which divides the greater right lobe from the ſmaller left lobe ; and diverging, it expands into a membrane of the liver, (DCXXIII.) white, ſimple, thin, like the external coat of the ſtomach, having cellular ſubſtance under it, by which it is joined to the ſub-

ſtance of the liver. To the lower margin of this, the umbilical vein is united; which, in the adult, having almoſt diſappeared, leaves a fibrous appearance, with much fat. In the extremity of the left lobe, and on the convex part, and not unfrequently at its edge, a membrane goes to the liver from the diaphragm; which in children, and in other inſtances, is frequently to the left ſide of the œſophagus, but in adults to the right ſide; and always conjoined both to the gullet and to the ſpleen, when the liver is large. This is the left ligament. The right ligament ties the diaphragm very far back to the very thick right lobe. Beſides, but without any apparent length, the membrane of the right lobe of the liver is often conjoined with the diaphragm by cellular ſubſtance in the right lobe, behind and to the right of the oval lobule, more eſpecially in old ſubjects, for in the fœtus it is eaſily ſeparated; and betwixt the ſuſpenſory and left ligament, there intervenes a production of peritonæum, in like manner continuous, reſembling a ligament. But alſo from the kidney, the peritonæum going to the liver makes a reduplication like a ligament; and the ſmaller omentum, and the continuous looſe productions of the meſocolon (dclxiii.) unite the liver with the ſtomach, duodenum and colon; and the meſocolon alſo unites it to the pancreas. Thus the liver is ſuſpended in the body with firmneſs, and yet with conſiderable mobility, ſo that it may be variouſly agitated and depreſſed by the diaphragm. The ſame ligaments form the common membrane, which covers the liver as well as other viſcera.

dcxc. Moreover, the inner concave ſurface of the right lobe of the liver, correſponds with its forepart to the colon; and with its back part to the right kidney and renal capſule, to which it is connected by cellular ſubſtance. The middle ſinus is contiguous to the duodenum, which touches the

gall bladder, and that part which conducts the great blood-veſſels. The left lobe extends largely over the ſtomach; and frequently, eſpecially in younger ſubjects, is extended beyond the œſophagus into the left hypochondrium. The lobule adapts itſelf to the ſmaller curvature of the ſtomach. But, moreover, the pancreas lies under the liver, and the right venal capſule is tied to the part of the liver fartheſt to the right by much cellular texture.

dcxci. The figure of the liver is difficult to deſcribe. It begins in the cavity of the right hypochondrium, by a very thick ſolid protuberance, convex towards the diaphragm, and hollow towards the colon and kidney; having a protuberant line dividing theſe concave ſurfaces, which is continued into the longer appendix of the lobule. After this, the liver grows gradually ſlenderer and thinner, and is extenuated, with an almoſt triangular ſhape, into a tip, which paſſes into the left hypochondrium, acroſs 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 anterior and lower part. The whole obtuſe margin lies backwards. The upper and back part of the liver is every where convex; ſuſtains the diaphragm; and with a large portion, which is ſomewhat flatter towards the left ſide, it lies under the heart: but the lower ſurface, variouſly ſigured, reſts upon the duodenum, colon, ſtomach, pancreas, and right renal capſule. For there are ſeveral fiſſures which divide the ſurface into different regions, which did not eſcape the notice of the ancients.

dcxcii. The principal of theſe, the tranſverſe, extends from right to left, and divides a third part of the liver, beginning ſlender in the right lobe, and growing broader towards the left. Before this tranſverſe fiſſure, there is an excavation in the right lobe

lobe for the gall bladder; then there is the convex anonymous lobe; and then the foſſa of the umbilical vein, extending tranſverſely backwards, often covered with the bridge that joins the anonymous to the left lobe. Behind the great ſulcus in the right ſide, there is a tranſverſe eminence, ſlender at its commencement, growing broader towards the right and moderately hollow, by which the great blood-veſſels are conducted into the liver: the hollow was by the ancients denominated the portæ. This joins the lobe, which I ſhall next deſcribe, with the right lobe. Then the poſterior lobule, papillary, obtuſely conical, projects into the little curvature of the ſtomach. The thick root of this and of the former excavated eminence, begins from the convex part of the liver, at the diaphragm; and in the right ſide, is impreſſed with an oblique furrow, inclined to the right ſide, for the trunk of the vena cava, deſcending from the heart to the lumbar vertebræ, and frequently covered by a conſiderable portion of the ſubſtance of the liver, as by a bridge, ſo as to form a tube. The left end of the lobule is terminated by another foſſa almoſt ſtraight backwards, but alſo inclined to the left; which beginning at the extremity of the tranſverſe one, terminates at the paſſage of the vena cava through the diaphragm. In this was lodged the ductus venoſus in the fœtus, of which there are ſtill ſome remains to be perceived in the adult. All that lies beyond this is the left lobe, which is ſimple, uniformly concave below, ſo as to lie upon the ſtomach, and extenuated to an edge.

DCXCIII. This very large viſcus is proportionably ſupplied with veſſels, and of various kinds. The artery, which is indeed conſiderable, being the greater and right portion of the cæliac, emerging forwards and to the right, goes tranſverſely before the vena portarum; and after giving off the ſmall coronary and the pancreatico duodenalis, the latter of

of which is pretty large, the reſt enters the liver, commonly by two branches; of which the left ſupplies the umbilical foſſa, the venal duct, poſterior lobule, with the left and the anonymous lobes, and the ſuſpenſory ligament; this branch inoſculates with the phrenic and epigaſtric arteries. The right lies deeper, covered by the biliary ducts; goes to the right and anonymous lobes, and ſends off, in one ſmall trunk, the cyſtic artery, which immediately dividing into two, is ſpread both under and over the gall bladder, covered by its external coat, and ſupplies branches to the gall bladder and biliary ducts, and likewiſe many to the liver. From the left branch, or ſometimes from the trunk, a ſuperficial artery goes to the biliary ducts, anonymous lobe, and glands of the portæ. Beſides the cæliac artery, not very rarely, a large right branch is produced from the meſenterica major, creeping behind the pancreas; this ſerves inſtead of the right hepatic branch of 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 is often very conſiderable. Thoſe ſent to the liver from the phrenic, mammaries, renal and capſulary arteries are ſmaller. They communicate alſo with the epigaſtrics.

DCXCIV. In the fœtus, the umbilical vein brings a great deal of blood to the liver, at which time the vein going to the portæ is but ſmall. It ſends forth, while it ſtretches backwards through its foſſa, numerous and very large branches, each of them equalling the vena portarum in bigneſs; at this place it is dilated into a tumor, which unites with the left branch of the vena portarum. But it ſends a ſingle branch through the poſterior part of the horizontal foſſa into the vena cava, or into ſome of its hepatic branches: this is called the ductus venoſus. In the adult, indeed, this duct is obliterated, and

and the vena portarum, which has now grown larger, ſupplies the hepatic branches.

DCXCV. The vena portarum receives all the blood of the ſtomach (DCXXIX.) of the inteſtines and meſentery (DCXXXI.) of the ſpleen (DCLXXVII.) omentum (DCLXIX.) and, laſtly, of the pancreas, at firſt into two trunks, the tranſverſe ſplenic and aſcending meſenteric, and then into one, which is continued with the meſenterics. It is large, compoſed of ſtrong membranes, ſtronger than thoſe of the vena cava, aſcends behind the firſt flexure of the duodenum, receives the veins from the right ſide of the duodenum, and the ſmaller coronary, aſcends to the right in the ſinus of the lobule of the liver (DCXCII.) and is afterwards again divided into two large trunks. The right, which is ſhorter, larger, and bifurcated, having received the cyſtic vein, goes to its own lobe. The left proceeds through the remaining part of the tranſverſe furrow of the liver, and ſupplies the lobule, the anonymous and left lobe, and being reflected, enters the umbilical foſſa, about the middle of which, it penetrates branchy into the liver. There are inſtances in which the branch of the poſterior lobule rather proceeds from the trunk of the vena portarum.

DCXCVI. The vena portarum is ſurrounded on every ſide with a good deal of cellular ſubſtance, which it brings with it from the meſentery and ſpleen; and which being denſe and ſhort, ſtrengthens the membranes, which are firmer than thoſe of the aorta itſelf. Intermixed with this cellular ſubſtance, are alſo many ſmall veſſels and the hepatic nerves, which are all comprehended under the denomination of capſule, which is nothing more than the cellular ſubſtance, and never has a ſingle truly fleſhy fibre. The vena portarum carries this along with it, through the liver, and is ſuſtained by it; inſomuch, that the branches, when cut, being ſupported, preſerve the roundneſs of their ſection.

Each

Each branch of the vena portarum is divided into many others, again divided and ſubdivided, even to the ſmalleſt capillaries, as arteries commonly are, Every branch of the vena portarum is accompanied by a branch of the hepatic artery, creeping upon its ſurface, and upon the hepatic ducts, almoſt in the ſame manner as the bronchial arteries uſually creep along the bronchia; and by a branch of the biliary duct, which are both connected by thin cellular ſubſtance. Some go out of the liver, being divided on the ligaments, and inoſculating with the ſurrounding veins. The ſum of the branches in the vena portarum is always greater than the trunk; hence the calibers of all the branches together, greatly exceed that of the trunk (XXXVII.) Hence there is a great degree of friction, (CLXXX. and CLXII.) exactly as in the arteries.

DCXCVII. But as the blood is conveyed to the liver by the vena portarum, as well as by the hepatic artery, it muſt of courſe be conveyed away by ſome other vein. Therefore, the extreme branches of the vena portarum and hepatic artery inoſculate ultimately with other veins, which are branches of the cava; ariſing from the whole circumference of the liver, they run towards the poſterior gibbous part of the liver, unite into branches and trunks, which at laſt terminate in ten or more large veſſels. The ſmaller and more numerous of theſe, ariſe from the poſterior lobule and liver, and go to the cava, where it aſcends towards the left, to the diaphragm, through the ſulcus, that lies on the right ſide of the lobule, and is often included by a bridge thrown over it. The remaining two or three, which are much larger, are inſerted into the ſame cava, cloſe to the diaphragm, whoſe veins they often receive. The branches of the vena cava are, in the adult, on the whole, fewer than thoſe of the vena portarum; which is an argument that the blood moves more quickly through theſe branches, on account of the diminution

diminution of the friction, (CLXX.) and of the very collection of the blood into a lefs caliber, which always accelerates its courfe, when there is a fufficient compreffing force (CLXX.) I know not of any valves in the mouth of thefe veins, which deferve to be remembered. The trunk of the vena cava afcends through a foramen of the diaphragm, obtufely quadrangular, included by mere tendons furrounding it; and therefore (CCLXII.) not eafily variable: and immediately expands into the right auricle. The fmaller veins of the liver, creeping upon its furface, are fent from the phrenica, renalis and azygos; or at leaft there is a communication betwixt thefe and the hepatic veins coming from the portæ.

DCXCVIII. That the blood comes from all parts (DCXCV.) by the vena portarum to the portæ, is proved by ligatures, by which the veins fwell betwixt thefe parts and the ligatures; while the vena portarum itfelf grows flaccid and empty. But that it afterwards goes through the liver to the cava, is proved by anatomical injections, which fhow the anaftomofes, and open communication betwixt the vena portarum and the cava, and by the common nature of the veins going to the cava. Again, the difficulty of the arterial diftribution of the vena portarum, as being remote from the heart, and the oily nature of its blood, occafion it to ftagnate, accumulate and form fcirrhous fwellings in the liver oftener than in any other part. But this danger is diminifhed by mufcular action, and refpiration; and is increafed by reft, indolence, and four and vifcid aliments. Hitherto, we have been fpeaking of the adult liver, in which both the umbilical vein and the ductus venofus are empty, although they cohere with the left branch of the vena portarum.

DCXCIX. The nerves of the liver are rather numerous than large; hence, when wounded or inflamed,

flamed, it caufes a moderate degree of pain. They have a twofold origin. Moft of them arife from the large gangliform plexus of the fplenic branch of the intercoftal nerve, with the addition of a branch from the pofterior plexus of the eighth pair; they accompany the hepatic artery, and, playing around its trunk, go to the liver, with that and the branches of the vena portarum. Another fafciculus of nerves ufually enters with the ductus venofus, and arifes from the pofterior plexus of the eighth pair, but fometimes, from the great plexus.

DCC. The lymphatic veffels of the liver are numerous, and may be conftantly and eafily feen about the portæ. They arife from the whole concave furface of the liver, and from the furface of the gall bladder, run together into a plexus, furrounding the vena portarum, and go to the conglobate glands, feated before and behind the faid 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, are defcribed other lymphatics, whofe infertion is not well known; for it is hardly probable that they enter the cava, nor have they been fufficiently often traced to the receptacle of the chyle.

DCCI. The interior fabric of the liver is more obfcure. Through the whole liver, bundles of biliary veffels, of branches of the vena portarum, and of the hepatic artery, are diftributed. Each veffel has both its proper cellular texture furrounding it, and ligaments of the fame fubftance, by which it is tied to its fellow veffels; and, laftly, the whole bundle is furrounded by cellular texture. The branches of the vena cava lie on the outfide of the others, being lefs accurately received into the fame bundle. Laftly, the ultimate branches of the vena portarum, cava, and hepatic artery, and of the biliary ducts, which we fhall foon defcribe, are united

ted together by means of cellular fubftance (DCXCVI.) into a fort of acini of a fomewhat hexagonal fhape, furrounded with lax cellular fubftance. In thefe bunches, likewife, there are mutual anaftomofes of the branches of the vena portarum, and of the hepatic artery, with the roots of the vena cava, and of the branches of the vena portarum, with the firft origins of the pori biliarii; which laft connection is demonftrated by anatomical injections; for liquors injected into the vena portarum, at laft return through the porus choledochus.

DCCII. Many eminent anatomifts have taught, that thefe acini are hollow, having arteries and veins fpread upon their external furface, and that the bile, fecreted from the branches of the vena portarum, is depofited into their cavities. They derive their arguments from the anatomy of brutes, in whofe liver the acini are round, and more defined than in man; and from difeafes, which exhibit cells and round tubercles, filled with lymph, chalk, and various kinds of concreted matter. To this, they might have added the lentor of the bile, by which it refembles mucus, and the analogy of the follicles of the gall bladder.

DCCIII. But greater accuracy in anatomy does not admit thefe follicles into which the fmall fecretory veffels are faid to open; for fuch would intercept the courfe of wax injections, and would occafion intermediate knots betwixt thefe veffels and the biliary pores, which have never yet been feen: for the wax flows in one continued thread, without any retardation, effufion into a cavity, or diminution of its impetus, from the vena portarum into the biliary ducts. Nor could the great length of the biliary ducts admit of a glandular fabric. For all follicles depofite, at no great diftance, their fluid, which is not fitted for a long courfe, as they deftroy fo great a part of the velocity received from the arteries. Laftly,

Laftly, the very common preffure, would fo crufh thefe bundles of acini, which we muft fuppofe, that the motion of the excretory duct could derive no affiftance from thence. The concretions and hydatids are formed in the cellular fubftance; and, laftly, the bile, when firft fecreted, is fufficiently fluid.

DCCIV. Again, we are convinced, that no bile is feparated from the hepatic artery, by the peculiar ftructure of the vena portarum, which would be ufelefs if it fecreted nothing; by the continuity of its branches with the biliary ducts, which is much more evident than in the arteries; by the experiment, in which it appears that the biliary fecretion continues after the hepatic artery is tied; by the great fize of the biliary ducts, in proportion to fo fmall an artery, and by the peculiar nature of the blood collected in the vena portarum, which is perfectly adapted for the fecretion of bile. For it contains both oil, which abounds more in the bile than in any other humour of the body; and a faponaceous fluid, abforbed from the ftomach, and the alkalefcent fubfetid vapour of the abdomen, brought back from the whole furface of the inteftines, ftomach, omentum, liver, fpleen, and mefentery, as we know by evident anatomical experiments; and, finally, the alkalefcent femiputrid, acrimonious humidity, abforbed from the alvine fæces themfelves, while they are indurated in the large inteftines, and brought thither by the internal hæmorrhoidal veins, from whence that bitternefs, alkalefcent and putrefcent difpofition of the bile is derived. But in the blood of the hepatic artery, there is nothing which renders it peculiarly fitted for the fecretion of bile, or analogous to it.

DCCV. Since, therefore, the vena portarum conveys the blood, in its fitteft ftate, for the fecretion of bile, to the ultimate acini of the liver, (DCCIV.) as there the paffage, from each branch of the vena

vena portarum, into the beginning of the biliary ducts, is direct without any intermediate follicle, and as fluids injected into the vena portarum readily take this courfe, the bile will be propelled that way by the force of the blood furrounding it, and urging it from behind, and alfo by the acceffory force of the diaphragm preffing the liver againft the reft of the vifcera in the very full abdomen, (dclxxxix.) and again of the thorax, contracted in exfpiration, it will be forced into the larger branches, and laftly into the two trunks of the hepatic biliary duct; which trunks meet together in one on the vena portarum, and in the tranfverfe foffa of the liver, near the anonymous lobe.

dccvi. This duct is compofed of a ftrong nervous membrane, like that of the inteftines, and of an external and internal cellular coat, and of a villous coat, loofe, elegantly reticulated, but afperated with many fmall pores and finufes, and continuous with that of the inteftine. There is no certainty of any mufcularity. From experiments, it appears to have a moderate degree of irritability. That it is vaftly dilatable, is fhown from difeafes. They feem alfo to fhow that this duct is poffeffed of great fenfibility.

dccvii. The hepatic duct, thus formed, goes along the vena portarum, more to the right than the artety, towards the pancreas; and then defcending obliquely, covered by fome part of that gland, it comes in contact with the back and lower part of the fecond flexure of the duodenum, about fix inches from the pylorus; paffes through an interval in its flefhy fibres; meets with an oblique oblong finus, made by the pancreatic duct, and opens into it by a narrow orifice. This finus defcends obliquely a long way through the fecond cellular coat, of the duodenum, perforates the nervous coat, and again runs obliquely between it and the villous tunic; and, laftly, opens into a protuberant long tailed

ed wrinkle of the duodenum. Between the firſt arrival of this duct at the duodenum and its orifice, a ſinus, almoſt an inch long, which receives the ductus choledochus, is incloſed between the membranes of the inteſtines, ſo that when this inteſtine is filled, or diſtended by flatus, or cloſely contracted by a violent periſtaltic motion, it muſt be conſequently compreſſed and ſhut; but when the duodenum is relaxed, and moderately empty, it diſcharges itſelf. Any regurgitation from the duodenum is hindered by this obliquity, and by the wrinkle, which is eaſily preſſed together, or cloſed, and by the very eaſy deſcent of freſh bile through the duct. Even air does not find its way from the inteſtine into the duct.

DCCVIII. But in the very portæ, this duct receives the addition of another leſs canal of the ſame kind, for a good way parallel, and adhering to it, and inſerted into it in a very acute angle. This is called the cyſtic duct, from its origin, and is ſometimes firſt increaſed by another duct from the liver. It ariſes from the gall bladder, which is found in moſt animals; but is abſent in ſome, eſpecially the ſwift footed, and perhaps only the herbivorous. It is contained in an excavation of the right lobe of the liver, (DCCXCII.) to the right of the anonymous lobule, in ſuch a manner, that in young people, it lies entirely within the edge of the liver, but in adults projects conſiderably beyond it, lying upon the colon. Its ſituation is tranſverſe, from before backwards; its neck aſcends a little.

DCCIX. The figure of the gall bladder is variable, but in general like that of a pear; it is terminated before by an obtuſe, hemiſpherical, impervious end; and gradually diminiſhes backwards; the neck or tip of this truncated cone being reflected againſt itſelf once or twice, and tied together by proper cellular ſubſtance; and having made another flexure upwards, ends in the cyſtic duct; which from thence

thence goes towards the left ſide of the hepatic duct. But this duct, being alſo contracted by many cellular bands, is internally marked with many protuberant wrinkles, which, conjunctly in the dried gall bladder, repreſent a kind of ſpiral valve; but being ſoft and alternate in the living body, they retard, but do not entirely obſtruct, the courſe of the bile either way, as is proved by experiments, made with air and preſſure. Beſides, it is reticulated like the gall bladder itſelf.

dccx. 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 retaining it in its ſituation. The ſecond is a looſe cellular coat. The third coat has ſometimes ſplendent longitudinal fibres, in different directions, ſo as obliquely to interſect each other. At other times, it has none; ſo that we may doubt of its muſcular nature, eſpecially as the irritability of the gall bladder is ſlow and obſcure. The nervous, ſecond cellular, and villous coats, are found as in the inteſtines, except that the laſt, as in the biliary ducts, is reticulated and full of cells. In the gall bladder, eſpecially about its neck, but even as far as its middle, we obſerve muciferous pores, capable of receiving a briſtle; and arteries, as in other places, diſcharge ſome watery humour into the cavity of the gall bladder, and bile eaſily tranſudes through inorganic pores to the ſurface of the gall bladder, and neighbouring membranes.

dccxi. All animals, between their gall bladder and liver, or between their ducts, have alſo ſome peculiar openings into the gall bladder; into which ſome ducts, originating from the liver, or from the hepatic biliary duct, open. In man, ſimilar ducts have not been ſhown by any certain experiment, and the gall bladder, when full of bile, is eaſily ſeparated from the liver, without a drop of bile eſcaping either from it or from the liver. There is alſo a thin

thin water in the bladder as often as the cyſtic duct is obſtructed.

DCCXI. The bile naturally flows both out of the bladder and liver, whenever there is no impediment in its courſe; ſo that both ducts ſwell when the paſſage is obſtructed, and the cyſtic lies in a ſtraight line with the choledochus. Nor is it probable that the whole of the bile is ſent into the gall bladder before it flows into the duodenum. There is not a perpetual obſtacle which hinders its efflux, and peculiarly obſtructs 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, and therefore not formed for receiving all the bile; the choledochus, much larger than the cyſtic, and therefore not appointed for the reception of its bile only. There are many animals in which the hepatic duct enters the inteſtine without any communication with the cyſtic. In living animals, even when the cyſtic duct is free, the bile 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 of the excretory duct, which is ſo many times larger than the ſalivary ones; from diſeaſes, in which four ounces of cyſtic bile only have flowed out daily through an ulcer of the ſide. But the hepatic bile goes into the gall bladder, as often as there is any obſtruction in the duodenal ſinus, from flatus, or any other cauſe compreſſing the orifice of the ductus choledochus. Accordingly, it is found extremely full, whenever the common biliary duct is compreſſed by any ſcirrhoſity or tumour, and it is ſometimes enlarged beyond all belief; if the cyſtic duct be tied, it ſwells betwixt the ligature and its union with the hepatic duct; and in living animals, the hepatic bile has been ſeen to diſtil into the wounded gall bladder. This is not inconſiſtent with the retrograde angle, for

for a very ſlight preſſure urges the bile from the liver into the gall bladder; and air eaſily takes the ſame way, more eſpecially if the duodenum be firſt inflated. Nor does there ſeem to be any other bile ſecreted by the gall bladder. Whenever the cyſtic duct is obſtructed by a calculus, or by a ligature made upon it, we find nothing in the gall bladder, except a ſmall quantity of inſipid mucus, ſecreted from the follicles, (DCCX.) or ſome watery exhalation. In many animals, we meet with no appearance of a gall bladder, when, nevertheleſs, plenty of acrid and ſalutary bile is diſcharged into the inteſtines. It does not ſeem probable, that any bile is ſecreted in the gall bladder from the cyſtic branch of the vena portarum, for that is a mere returning veſſel; nor from the hepatic artery, for it is ſcarcely probable, that the very acrid cyſtic bile ſhould be ſeparated from a milder blood than milder hepatic bile prepared from appropriated blood (DCCIV.)

DCCXII. 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 latent cauſe exiſting in the nerves. This courſe is morbid, and produces the jaundice; which, therefore, is cured by the paſſage of the calculi, and by reſtoring its free courſe.

DCCXIII. Therefore, a portion of the hepatic bile being received into the gall bladder, ſtagnates, being only gently agitated by reſpiration, and there exhales its thinner parts, which we ſee extenſively diffuſed over the adjacent membranes. The remainder, being oily and ſubalkaline, from its warm ſituation, grows acrid and rancid, and its thickneſs, bitterneſs, and colour are increaſed; nor is there any other difference betwixt the cyſtic and hepatic bile, which laſt we find in the ducts, leſs bitter, leſs dark coloured, and leſs viſcid. That this difference proceeds only from ſtagnation, appears from ſuch animals

animals as have only a larger porus hepaticus, inſtead of a gall bladder; for the bile which ſtagnates there, is remarkably more bitter than that in 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, it is of no uſe, and ſupplies it more quickly when we principally want it for the digeſtion of the aliments, now flowing in great quantity into the duodenum. This quickneſs is greater in proportion as the cyſtic duct is ſmaller than the gall bladder.

DCCXIV. The gall bladder, indeed, does not touch the ſtomach, but the beginning of the deſcending duodenum. But when the ſtomach is diſtended, and occupies a conſiderable ſpace in the very full abdomen, it both preſſes the liver and duodenum, and compreſſes the gall bladder, and empties it. Thus the bile flows through a free paſſage, from the gall bladder into the biliary duct, and into the duodenum; moſt eaſily in perſons lying on their back, for then the bottom of the gall bladder is uppermoſt. Hence the gall bladder becomes turgid after faſting. There is ſcarcely any other evacuating power than the ſtomach and diaphragm; for that reſiding in the proper muſcular and contractile membrane of the gall bladder, is very inconſiderable.

DCCXV. The hepatic bile is always bitter, but the cyſtic more ſo; always viſcid; of a full yellow colour, with a tincture of green; miſcible, by trituration, with water and oil, and with vinous ſpirits; coagulable by the mineral acids; ſoluble in the alkalies, eſpecially the volatile alkali; well adapted for diſſolving oily, reſinous, or gummy ſubſtances; of a lixivial and ſaponaceous nature; quickly putrefying, and by putrefaction ſpontaneouſly acquiring the odour of muſk. Its chemical analyſis, and experiments of mixture with various ſubſtances, demonſtrate, that it contains a large portion of water, and

and a conſiderable quantity of the inflammable oil, which is ſo evident in cyſtic calculi. It therefore, is a ſoap; but of that ſort which is compoſed of a volatile alkaline ſalt, mixed with oil, and retains its water. Therefore, being intermixed with the aliment, reduced to a pulp and expreſſed from the ſtomach by the periſtaltic motion of the duodenum, and preſſure of the abdominal muſcles, it in a great meaſure overcomes the aceſcent qualities of the food; it diſſolves the coagulum of milk, and diſpoſes the aliment more to putreſcency; it diſſolves the oily matters, ſo that, by freely incorporating with the watery parts, they may form chyle, and enter the lacteals; it abſterges and attenuates the mucus; and, laſtly, excites the periſtaltic motion by its acrimony; all which offices are confirmed, by obſerving the oppoſite diſeaſes to ariſe from a want of bile. Nor is the hepatic bile ſufficient to evacuate the inteſtines, if the cyſtic is wanting. So great is its utility, that perfectly robuſt animals have been found to die in a few days, by preventing the afflux of bile to the inteſtines, or deſtroying the gall bladder.

DCCXVI. The bile gradually deſcends along with the food, and is evacuated along with the fæces, ſomewhat changed, its bitterneſs being deſtroyed by putridity. Perhaps ſome of the watery, leaſt bitter, and thinneſt parts, are again taken up by the vena portarum. Its regurgitation into the ſtomach is impeded by the aſcent of the duodenum, at the bottom of which it enters, by the valve of the pylorus, and by the acceſs of new chyle which the ſtomach adds to the former: in man, however, it frequently happens, and in birds always. The bile in the fœtus is bland and ſweet; for in them no fetid fæces ſupply acrid alkaline vapours, nor is there any oil abſorbed. As the bile is viſcid in ſluggiſh and fat animals, and in man from the ſame cauſes, and from grief, it readily forms hard coagulums,

 either

either calcareous or refinous, and much more frequently than the urine, according to our experiments. Its ufe is manifeft, as, by trituration with the aliments, it diffolves oil, refifts acidity, and ftimulates the inteftines to contraction.

DCCXVII. In the fœtus, befides fecreting the bile, the ufe of the liver is evidently to tranfmit the blood returning from the placenta, and, as it feems, to moderate its impetus. Even in the adult, it has the fame ufe, though lefs manifeftly, in retarding the return of the blood coming back from the chylopoëtic vifcera.

CHAP. XXIV.

SMALL INTESTINES.

DCCXVIII. BY the fmall inteftines, anatomifts underftand one continued, and almoft cylindrical tube, whofe tranfverfe fection is nearly oval, the obtufe end being towards the unconnected fide of the inteftine. This tube being continued for a long way from the end of the ftomach, the right orifice of which it embraces, (DCXXV.) terminates by expanding into a larger inteftine. Anatomifts have ufually reckoned three fmall inteftines, though nature has formed but one. However, the duodenum has a tolerable fixed limit, at the bottom of that part of the abdomen which is above the tranfverfe mefecolon (DCLIX.) But that fmall inteftine which lies below this mefocolon, has no certain mark of diftinction, by which the jejunum, commonly fo called, is feparated from the ileum : for although the former abounds more with valves and blood-veffels, and is furnifhed with longer villi, and therefore appears fomewhat redder ; and the ileum again rather contains glands, and has fewer vafcular ramifications ; thefe differences infenfibly occur, without

out any certain limits, being great in their extreme, and obſcure in their contiguous terminations.

DCCXIX. The duodenum is denominated from its length. It is lax and large, eſpecially in its firſt flexures, becauſe in part it has no external membrane, and in part is not completely ſurrounded by it. It is florid and tender, and has fleſhy fibres of conſiderable thickneſs. It begins by adhering round the annular orifice of the pylorus; then it proceeds undulating, but on the whole tranſverſe, to the right and backwards in the empty ſtomach, to the gall bladder, to the neck of which it becomes contiguous (DCCXIV.) From thence it deſcends obliquely to the right, and backwards as far as the lower plate of the meſocolon, and the entrance of the biliary duct, and in that courſe is received betwixt the upper and lower plates of the meſocolon. From thence it again returns, tranſverſely, but at the ſame time aſcending, behind the pancreas and large meſenteric veſſels, to the left, along with the left renal vein; it goes out from the duplicature of the plates of the meſocolon; and making a turn, it deſcends on the right of the ſaid veſſels, through a peculiar foramen, in which the meſentery, left and tranſverſe meſocolon, adhere to it, to the lower part of the abdomen, which it enters, and becomes the jejunum. The largeneſs of this inteſtine, its aſcent from the inſertion of the biliary duct, its ſucceeding flexure around the root of the meſentery, cauſe ſome delay, by which the bile and pancreatic juice are here eſpecially mixed with the alimentary maſs.

DCCXX. In the reſt of the ſmall inteſtine there is no certain point; but with uncertain and infinite convolutions, not to be deſcribed, it fills the lower part of the abdomen and the pelvis, ſurrounded by the colon, and alſo lies between the bladder and uterus.

DCCXXI. The fabric of the ſmall inteſtine is almoſt the ſame with that of the ſtomach and œſophagus.

phagus. Excepting part of the duodenum, it receives an external coat from the peritonæum, or meſentery, applied to the acute vertex of the inteſtine, double, and ſeparated there by ſome cellular ſubſtance, often by fat, but cloſely embracing the reſt of the inteſtine, ſo that its muſcular fibres adhere to the external membrane, which does not at all differ from that of the ſtomach. By this external membrane, and by the meſentery (DCLXI.) the inteſtines are ſupported as firmly as is neceſſary, and with very great mobility.

DCCXXII. But the muſcular coat is different, from the difference of figure. The moſt conſiderable ſtratum of fibres in the inteſtines is circular; they ſurround the tube on every ſide, and are uniform, parallel, formed of imperfect arches, cemented into circles, pale, and yet remarkably contractile. The longitudinal fibres are, in the ſmall inteſtines, few in number, and ſcattered round their whole extent, but eſpecially laid over the others on the obtuſe vertex of the inteſtine.

DCCXXIII. Within the muſcular coat, is ſeated the ſecond cellular, larger, as in the ſtomach, ſpread on all ſides round the nervous coat, and in man rarely fat. But the nervous coat, as in the ſtomach, ſerves as the foundation for the whole inteſtinal tube; it is compoſed of compacted fibres, which, by inflation, may be ſeparated and diſunited, ſo as to aſſume a cellular appearance. Next follows the third cellular coat, which is almoſt like the ſecond. The innermoſt, the villous, differs from that which we deſcribed in the ſtomach: for, firſt, it is every where folded into wrinkles, generally ſemicircular, but alſo into others joining the ſemicircular ones obliquely, and into others variouſly irregular, into which the nervous coat ſlightly enters, but the third cellular enters deeply, lying between the doubled villous coat, and filling up the duplicature. Theſe folds begin within one inch of the pylorus, and are

moſt

moſt numerous in the firſt half of the inteſtines, dut gradually diminiſh in number. In each of theſe a ſmall artery and vein lie upon the convex ſurface of its ſecond cellular coat. The firſt plicæ in the duodenum are confuſed, and lie nearly in the direction of the inteſtine. They are changed into acute circles and valves by anatomical preparation. They are indeed ſoft, and eaſily inverted, and yield to the paſſage of the alimentary pulp either way, but by their number they retard it, and enlarge the ſurface of the villous membrane.

DCCXXIV. Laſtly, the membrane is here truly villous, which in other parts is ſo named from analogy. Namely, the whole internal ſurface of the inteſtine, both the valves, and the intervening hollows, ſend out every where innumerable pendulous flocculi, reſembling ſilk velvet, which are conical, but ſomewhat obtuſe, productions of the inner coat of the inteſtine, containing cellular ſubſtance between the duplicature, and veſſels and nerves wrapped up in that ſubſtance, and likewiſe a lacteal veſſel, ſuch as we ſhall afterwards deſcribe, ſo as very much to reſemble the papillæ of the tongue, except in being ſofter.

DCCXXV. The chief veſſel of each of the villi is an oval veſſel, opening by a ſlender duct in the ſurface of the villous coat, often filled with a milky fluid, and ſurrounded by neighbouring veſſels.

DCCXXVI. In the internal ſurface of this villous coat, open an infinite number of pores; ſome larger, others ſmaller. The former lead to conſpicuous ſimple mucous glands, ſeated in the third cellular ſtratum, ſimilar to thoſe ſeated in the mouth and pharynx, having a very vaſcular follicle, and an orifice opening into the inteſtine. In the duodenum there are ſeveral of them which are contiguous, but do not run together, and cannot always be demonſtrated; in the ileum they are very numerous, both ſolitary, a few joined together, and in conſiderable numbers

numbers collected into an elliptical figure. They are ſurrounded by villous membrane.

DCCXXVII. The ſmaller pores are found throughout the whole inteſtines, and ſurround the baſis of the villi; they are moſt conſpicuous in the large inteſtines, where they have been long known, but have been lately diſcovered in the ſmall inteſtines likewiſe. Theſe alſo ſeem to depoſite a liquor of the mucous kind.

DCCXXVIII. The veſſels of the ſmall inteſtines are very numerous. The common larger trunk belonging to that part of the inteſtine that lies below the meſocolon, is called the meſenteric artery, which is the largeſt of thoſe produced by the aorta, and ſituated above the renal arteries. Deſcending behind the pancreas, to the right of the beginning of the jejunum, and beſides the colic branches, being eſpecially produced in a long trunk towards the right, to the bottom of the meſentery and termination of the ileum, it ſends numerous branches from its left ſide, the firſt and laſt being ſhorter, the middle ones longer. Theſe, ſubdividing into ſmaller, join with thoſe adjacent into convex arches; which again ſend out other branches, united in like manner, forming almoſt five ſeries of arches, until the laſt ſend, from their convexities, ſtraight and very numerous branches to the inteſtine.

DCCXXIX. The diviſion of theſe branches on the inteſtine, is very uniform; ſo that from the meſentery, through the firſt cellular coat, there is ſent one anterior, and another poſterior, which, having given ſmall branches to the outermoſt and fleſhy coats, penetrate to the ſecond cellular one: there the anterior trunk, running out towards the obtuſe vertex of the inteſtinal ellipſis, is continued ſtraight into the correſponding poſterior branch; and, according to its ſize, gradually ſends off ſmaller arbuſcular branches, inoſculating with the contiguous and oppoſite branches, by innumerable twigs. From this

this reticulation, branches penetrate through the nervous tunic into the third cellular ſtratum, and laſtly into the cavities of the villi, which finally, with open orifices, exhale their contents into the inteſtine. This courſe is eaſily imitated, by injections of water, ſize, or mercury. From recent obſervations, it has been added, that the arterial extremities open into an hollow veſicle, and there depoſite their liquor, which exudes through the common orifice of the veſicle. Beſides, the reticular diſpoſition of the arteries, and their numerous anaſtomoſes, have the effect, that the inteſtines are as little ſubject to obſtructions as poſſible, and that any obſtructing matter may eaſily return, by means of ſo many inoſculations, into the larger arterial trunks.

DCCXXX. The laſt trunk of the meſenteric artery inoſculates with the ileo-colic. The duodenum has various arteries. The firſt, the uppermoſt from the hepatic, on the right, goes round the convexity of the curvature of this inteſtine, in the pancreas, and ſupplies this inteſtine, and inoſculates with another on the left, and inferior, the pancreatico duodenalis which makes a ſimilar arch in the pancreas, in the hollow of the curvature of the duodenum, and is at laſt inſerted into the lower duodenal arteries, produced by the meſenteric in its paſſage before this inteſtine. I willingly paſs over the ſmall arteries, which go from the ſpermatics to the duodenum, and from thoſe of the renal capſule.

DCCXXXI. The veins, exactly correſponding with the arteries, meet all together, into the meſenteric trunk of the vena portarum; except the right duodenal vein, which goes immediately into the trunk of the vena portarum itſelf; and thoſe ſmall veins which accompany the ſmall arteries, (DCCXXX.) and are inſerted into the ſpermatics and lumbals. Nor have I hitherto been able to diſcover any other veins of the meſentery, ariſing from the cava. It is a property

perty common to all theſe veins to be without valves, and to communicate freely with the arteries. In the villous coat, which is for the moſt part compoſed of veins, as the venous trunks are fewer and larger, they abſorb from the inteſtines a thin humour; as appears from the injection of watery liquors, which readily take that courſe; and, from analogy, in aged perſons, in whom the meſenteric glands, and conſequently the paſſage of the lacteals, are frequently obliterated, and from the analogy of birds, which have no lacteals, and from the celerity with which watery liquors paſs to the blood and through the kidneys, compared with the ſmallneſs of the thoracic duct, and chiefly from thoſe experiments which have confirmed by ocular demonſtration the paſſage of water from the cavity of the inteſtine into the vena portarum.

DCCXXXII. The nerves, numerous and ſmall, impart to the inteſtines a conſiderable degree of ſenſibility; they ariſe from the middle plexus of the ſplenic nerves, which embraces the meſenteric artery, and play round it in great numbers, wrapped up in a very denſe cellular ſubſtance. The duodenum has likewiſe nerves from the poſterior hepatic plexus of the eighth pair. From the acute ſenſibility of the inteſtines, it is probable, that the ultimate branches of the nerves penetrate into the third cellular coat.

DCCXXXIII. From the exhaling arteries, a thin aqueous liquor diſtils into the cavity of the inteſtines, reſembling the gaſtric juice, not acrid, but ſaltiſh. The very great quantity of this liquor is computed from the great ſize of the excretory orifices, and of the ſecreting arteries, which are not larger in any part of the body; and from the laxity of parts perpetually kept warm and moiſt, and from the copious diarrhœas or watery diſcharges that often follow the uſe of purgative medicines.

But

But the mucus arifing from the fources, DCCXXVI. DCCXXVII. lubricates the internal furface of the villous membrane, and defends the fenfible nerves from acrid or fpirituous alimentary matters. Hence, it is more abundant at the beginning of the large inteftines, becaufe there the mafs of aliment begins to be feculent, acrid, and tenacious.

DCCXXXIV. This liquor is mixed with the pulpy mafs of the aliment, with the bile, and with the pancreatic juice, by the external motion of the mufcles furrounding the abdomen; but this force is quite fmall, and unfit for moving forwards the aliments. And in the firft place, the periftaltic motion is not any where ftronger, or more evident, than in the fmall inteftines. For any part of the inteftine, irritated by flatus, or any fharp or rough body, contracts itfelf, even after death, very violently in that part where the ftimulus is applied, frees itfelf from the offending or diftending body, and expels it into the contiguous part of the lax inteftine; which alfo contracting from the fame ftimulus, repels what it received, either way. This motion occurs in various parts of the inteftines, without any certain order, wherever flatus or alimentary matter act as ftimuli. So great, however, is the aptitude of the inteftines, for motion, that they emulate, and even exceed, the irritability of the heart, or at leaft are fcarcely exceeded by it. When not irritated, they remain at reft, as I have often obferved; and we may fuppofe this to be the caufe why fat retards the belly. The air is the principal ftimulus of the inteftines, next the aliment, and laftly the bile. This motion is performed by a wonderful fort of alternate creeping and revolution of the inteftines, which diffection eafily demonftrates in living animals, and unfortunate cafes of wounds in the abdomen, and ruptures, have fhown in the human fpecies. And fince, here, among fo many inflexions, gravity can have no effect, the inteftine

teſtine when irritated, evacuates itſelf equally upwards and downwards. From this, the antiperiſtaltic motion is underſtood, by which the pulp of the alimentary maſs is longer expoſed to the gentle trituration of the inteſtine, and to the action of the diluent liquor, and of the abſorbing veins. All the contents of the inteſtines are at laſt determined to the large inteſtines, becauſe every ſtimulus begins in the left orifice of the ſtomach; and the conſtant ſucceſſion of food excites a new contraction in the parts above, by irritating them, while no contraction of the colon propagates a ſtimulus backwards to the lower part of the ileum; hence the looſe colon receives what deſcends into it, and unloads itſelf into the large unactive cæcum more eaſily, than it can repel upwards the aliments it has received, and which are reſiſted by the preſſure of the inteſtine propelling freſh matter. Anatomiſts obſerve, that this motion acts more ſtrongly downwards than upwards, and that the ſuperior parts of the inteſtines are more irritable. But as often as any inſuperable obſtacle reſiſts the paſſage of the aliment, the ſeat of the principal contraction will be there, and the aliment will be repelled upwards, even from the valve of the colon, through the whole length of the inteſtines, into the ſtomach, and laſtly into the mouth itſelf.

DCCXXXV. This periſtaltic motion, in which the inteſtine is conſtricted, is performed by the circular fibres, which are capable of moſt exactly emptying the tube, ſo as to propel downwards the moſt minute bodies, ſuch as needles or powders. But the revolutions of the inteſtines, drawn upwards or downwards, and the bending of the ſtraight, and the ſtraightening of the crooked portions, which are ſo conſpicuous in animals, are performed by the long fibres, and which, moreover, when they contract themſelves towards the ſeat of the preſent, ſtimulating

ting food, we fee dilate the fucceeding portion of inteftine, and fit it for receiving. The fame contraction, forces the villous membrane into the cavity of the inteftines, and renders the folds longer; and expreffes the mucus, fo that fuch a quantity is applied to the alimentary mafs, as is required by the irritation and degree of the ftimulus. They alfo produce frequent, and generally harmlefs, introfufceptions, by drawing up the fucceeding portion of inteftine, againft that which is contracted, in fuch a manner, that the former is received within the latter, which is relaxed.

DCCXXXVI. The alimentary pulp, therefore, diluted with the pancreatic juice and that of the inteftines, intimately mixed with the faponaceous bile, and covered with mucus, is accurately triturated, and more efficacioufly than in the ftomach, in proportion as the fides of the fmall inteftines approach nearer together, and to the length of the feries of the periftaltic motion acting, and to the quantity of animal juices affufed. The vifcid pulp, intermixed with air, becomes frothy, without fermentation, and the air continues to have the fame effects as in the ftomach, but fo that every acid tendency within the inteftines is counteracted. But the oily or fat parts of the food, diffolved by the bile, (DCCXV.) and mixed with the watery juices, acquire ufually a bright white colour, like an emulfion, firft vifible in the duodenum, below the entrance of the biliary duct; and afterwards adhering clofely to the villous coat, throughout the whole length of the fmall inteftines. But the gelatinous juices of flefh meats, diluted by copious affufion of water, and being of themfelves of a fubvifcid nature, adhere to the villous coat, and are prepared for abforption. The water and watery liquors are all very greedily abforbed by the veins: and yet the fæces never grow thick in the fmall inteftines, as far as I have obferved, becaufe the water abforbed is repaired

repaired by the arterial vapour and the mucus; nor do they become fetid in any confiderable degree, both on account of the great quantity of diluting juices, and becaufe their quick progreffion does not allow them time for putrefaction. In the beginning of the jejunum, the white mafs is coloured with bile; in the end of the ileum, it is entirely mucous. Thofe remains, which are more earthy, grofs, coarfe, and acrid, and were excluded by the abforbing orifices, either by their own weight, or by fome power acting as a fphincter, defcend into the large inteftines, being gradually, forced down, fo as to complete their whole courfe in the fpace of about twenty-four hours. But within three or four hours, or a little more, almoft all the chyle is extracted.

DCCXXXVII. The confiderable length of the fmall inteftine, which is five times longer than the body, or more, the great furface of the villous membrane increafed by folds, the incredible number of exhaling and abforbing veffels, the flow progrefs of the food through the large inteftines, and the great quantity of the inteftinal juice, poured to the alimentary mafs, have the effect of providing abundantly, in the fmall inteftines, every requifite for diluting the food with our juices; for their abforption into the lacteals and the mefenteric veins; for the abfterfion of vifcidities from the inteftine; for preventing adhefions and coagulations; for the fuppreffion of any acidity, not yet fubdued; and for the deftruction of the deleterious qualities in many juices, which, being directly mixed with the blood, inftantly kill, but are without injury received by the mouth. Hence the inteftines are long in animals that feed upon any hard food, but fhorter in carnivorous ones, and fhorteft in thofe that live upon juices alone; and, in man, an uncommon fhortnefs of the inteftines has been attended with hunger, and fetid and fluid fæces.

DCCXXXVIII. The heat, by which the aliment is fomented, and which is well fitted for the ſolution of the gelatinous matter, and for exciting the beginning of putrefaction, is therefore the principal cauſe of the fetor, which is gradually produced in the aliment; and alſo 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, as in the ſtomach, by breaking the coheſion of the aliments, if any yet remain entire. The inteſtinal water dilutes the maſſes of aliment; and if any hard part remains, ſoftens it by maceration. The bile being intimately mixed with oil, diſſolves it, and renders it miſcible with water.

CHAP. XXV.

LARGE INTESTINES.

DCCXXXIX. WHAT remains, after the chyle has been abſtracted, conſiſts of ſome portion of the bile, but mucous and degenerate; ſome part of the human mucilage; moſt of the earthy parts that were in the food; all thoſe parts, which by their acrimony were rejected by the abſorbing mouths, changed, however, by putrefaction, (DCCXXXVI.) with all the ſolid fibres and membranes, which reſiſted the powers of maceration and the periſtaltic motion.

DCCXL. All theſe remains paſs from the extremity of the ileum into the cæcum, in which they ſtagnate; namely, the extremity of the ſmall inteſtine applies itſelf obliquely to the right ſide of the colon, reſting upon the right ileum and iliac muſcle, ſo that, upon the whole, it aſcends, but more with its lower ſide, and leſs with its upper, which is almoſt tranſverſe. But the extremity of the

the nervous and villous coats, and tranſverſe fleſhy fibres of the ileum, are ſo extended betwixt the departing fleſhy fibres and nervous coat of the colon, that there hangs within the cavity of this large inteſtine, a moveable, ſoft, double projecting fold, compoſed of the villous and nervous coats of the large inteſtine, and of the villous and nervous coats of the ſmall inteſtine, and of the interpoſed fleſhy fibres of the ileum and colon, connected by much cellular ſubſtance. The upper fold is tranſverſe and ſhorter, the lower is larger, longer, and aſcending. They are conjoined by a ſmall production of the ſame kind, more eſpecially where they approach in the right ſide. Betwixt theſe two folds, the mouth of the ileum opens, like a tranſverſe ſlit. By inflation, this ſtructure is much altered, aſſuming the appearance of membranes and hard valves. After the cellular ſubſtance is entirely removed, and the interpoſed fleſhy fibres are cut, the ileum, comes out from the colon, and the valvular appearance diſappears; but if a large part of it only be removed, ſo that it ſtill remoins inſerted by ſome, it reſembles a ſphincter.

DCCXLI. Below the entrance of the ileum, at the diſtance of ſome inches, the great inteſtine deſcends and reſts with an impervious extremity, upon the ileum. From the lower part of this, towards the right ſide, a very acutely conical ſmall inteſtine extends, in adults ſlender, in the fœtus proportionally larger, variouſly incurvated upwards, ſometimes downwards, and full of ſmall mucous glands, which pour out a glutinous matter to the fæces; in the fœtus, the colon itſelf is continued with a conical termination into the appendix. But the weight of the ſuperincumbent ſcybalæ, 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; the ſtrength of the fleſhy fibres uniting both inteſtines; the very contractile

contractile force of the ligaments; the fitnefs of the anterior fac of the cæcum, for eafily receiving the fæces from the ileum; all contribute to remove the appendix from the middle, fo that it arifes from the left fide of the extremity of the colon: and to form the thick and pendulous bag of the colon lying fartheft to the right fide, and which is peculiar to adults. When, therefore, the remains of the alimentary mafs come from the ileum into the colon, they fall by their weight into this impervious bag, and ftagnate there, and become putrid, both from the warmth of the place and their own nature; and here, efpecially, the fetor of the excrements begins.

DCCXLII. The inteftine which is continuous with the cæcum, and indeed the fame, is named the colon. This thick and very large inteftine, which is much ftronger than the fmall inteftines, begins in the right ileum, (DCCXL.) afcends along the kidney, lies in the angle of the right hypochondrium under the liver, and is connected to both vifcera by the peritonæum. Then it paffes under the liver and ftomach, for the moft part tranfverfely, to the fpleen, under which it lies, (DCLXXVI.) and in a deep recefs under the left ribs, it is often reflected upon itfelf. Then it defcends again, and having made a large flexure to the left ileum, (DCLVIII.) it is continued with the lower part of this flexure into the pelvis, and becomes the rectum.

DCCXLIII. The ftructure is, on the whole, the fame with that of the fmall inteftines, but it differs in feveral particulars. And firft, all the longitudinal fibres are collected into three bundles, which run through the whole extent of the inteftine; and of thefe one, and that the largeft, lies naked; another, at its origin, is concealed by the omentum, and the third by the mefocolon. Thefe are fhorter than the inteftine, and contract it fo that the nervous and villous membranes (DCXLIV.) project inwardly.

wardly. Thefe fibres are connected moft accurately with the external coat of the inteftine; but in the intermediate places, and chiefly at the mefocolon, is feated the firft cellular coat replenifhed with fat. Being dilated at their origin, they adhere to the vermiform appendix. In the extremity of the colon, there are often only two ligaments, the two fmaller joining into one. They diffufe themfelves upon the rectum fo as to cover it entirely.

DCCXLIV. Again, the flefhy and nervous coat, third cellular and villous tunics of the colon, are extended into much larger wrinkles in the parts betwixt the ligaments, often projecting in a threefold rank, which being fuftained by the ligaments, are able to fupport a little the fcybalæ, and refift their relapfe. In the beginning of the colon, they are very exactly threefold; but in its progrefs, they vary more and more, being lefs, and double, and folitary, and fmall and large intermixed, and entirely abfent. Where the ligaments which contract the colon, difappear, thefe valves difappear almoft entirely. Laftly, the villous coat is thinner, and without villi, but wrinkled and porous, furnifhed both with large pores leading to proper, large, round, folitary follicles, and with innumerable fmall pores leading to fmaller follicles. Both kinds fupply a great quantity of mucus.

DCCXLV. The blood-veffels of the large inteftines are partly from the greater and left mefenterics, and partly from the hypogaftrics. The middle colic artery arifes from the large mefenteric trunk, as that defcends behind the tranfverfe mefocolon. It rifes upwards with one, two, and fometimes three branches to the tranfverfe mefocolon, and unites on the right fide with the ileo-colic; and on the left, with the lower mefenteric, in a very large arch, which is the largeft of all the arterial inofculations in the human body. Again, under the mefocolon, from the fame large mefenteric artery, a larger

larger branch goes directly to the valve of the ileum with the colon, and inosculates upwards at the right of the colon with the middle colic; and to the left with the mesenteric; but from the middle of the mesentery it gives a branch that runs along the mesocolon of the appendix vermiformis, and terminates with two branches in the two folds of the ileum and colon, both the anterior and posterior. Lastly, the lower mesenteric, arises by its proper trunk from the aorta, betwixt its bifurcation and the renal arteries, and goes to the left part of the colon: upwards it forms a large arch, with the middle colic; downwards in three or four trunks, it spreads over the iliac flexure of the colon, and descends even into the rectum. There 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 arise without the pelvis. I pass over the smaller colics, arising from the spermatics, intercostal, omental, capsulary, and lumbar arteries. The veins, like the arteries, run together into the gastrocolic, and the internal hemorrhoidal, and thence into the vena portarum; and into the middle and external hemorrhoidals, and the trunks of the iliacs.

DCCXLVI. The division of the vessels to the large intestines, differs much from that of the small intestines. Their arches are less frequent and less often subdivided; the trunks follow the course of the intestines a long way; the glands seated on them are fewer; the branches on the intestines less arbuscular, divided at less angles, and more tortuous; and the reticulation in the cellular substance is looser. An exhaling moisture distils into the cavity of the intestines, and the veins likewise absorb a thin fetid vapour from the fæces. The external, and perhaps also the internal veins, swelling into varices, pour out the hemorrhoidal blood; which

is always unnatural, although ſometimes infractions of the veſſels of the porta are relieved by that evacuation.

dccxlvii. But there are alſo lymphatic veſſels, ariſing from the whole tract of the colon, and from the rectum, which unite with thoſe of the loins. We are not without examples of chyle having been found inſtead of lymph, in theſe lymphatics, ariſing from the colon; a proof, that even in this place ſomething ſtill remains, which may be added to the blood with advantage.

dccxlviii. The nerves proceed from the left colic plexus compoſed by the deſcending branches of each renal plexus, and others ariſing from the intercoſtal trunk in the thorax and loins, and others from the large meſenteric plexus. Theſe accompany the lower meſenteric artery, and go to the colon. The lowermoſt nerves ariſe from the plexus juſt mentioned, and go to the rectum, within the pelvis; others go to the ſame inteſtine from the lower intercoſtals, and from the nerves of the ſacrum. Theſe nerves are not numerous, and the inteſtine is not very ſenſible, that it may endure the hard and acrid fæces.

dccxlix. The inteſtinal fæces, therefore, retained in the blind beginning of the large inteſtines, (dccxl.) become dry by the abſorption of their fluid parts, ſhaped by the round and contracted colon, aſcend from the bottom of the cæcum, being elevated by the long ligaments, which unite 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 ſmall inteſtines. The longitudinal fibres being drawn towards the contracted portion of the inteſtine, as to a fixed point, draw the lower part of the inteſtine upwards, and dilate it; then the next part of the inteſtine, to which the fæces are brought, being irritated in like manner, contracts the long fibres

towards it; by a ſucceſſive repetition of which action, the fæces finiſh their courſe through the whole large inteſtine; for the moſt part within twenty-four hours in a healthy perſon. For this periſtaltic motion of the large inteſtines may be ſeen in living animals, and in the human body from wounds; it is alſo confirmed by the antiperiſtaltic motion, and by the phenomenon of glyſters being diſcharged through the mouth. The ſame fibres reſiſt the air contained in the inteſtines; and flatulence is ſaid to be generated as often as they are overcome and yield, and the inteſtine is dilated.

DCCL. While the groſs fæces aſcend from the cæcum along the folds (DCCXL.) or valves, at the entrance of the ileum, they incline the lower fold to the left, and backwards, and draw down the ligament common to both valves, and thus depreſs the upper fold downwards: thus the paſſage is accurately ſhut, ſo that nothing may return into the ileum; which, however, cannot be done ſo accurately in a fluid ſtate of the fæces. The fæces, when falling down from the upper parts, depreſs the upper valve, and thus accurately exclude themſelves. This happens very exactly with hardened fæces, but not ſo accurately with fluid fæces. From thence, becoming more and more dry and figured, they continue to move ſlowly forwards by the ſame cauſes (DCCXLIX.) through the whole colon, which is repeatedly bent, and of five or ſeven feet in length, in ſuch a ſpace of time as is ſufficient to give no interruption to the affairs of human life; and which is leſs than twenty-four hours, by the time the alimentary maſs remained in the ſmall inteſtines.

DCCLI. At length the hardened excrement falls into the rectum, which is at firſt inclined downwards, and then alſo forwards, of a broad and flat figure, at firſt contiguous to, and afterwards ſpread under the bladder, or vagina, but connected more with the latter than with the former. Here the fæces are

are collected for a great while, and often to a great quantity, being a part which is loofe, or furrounded with foft vifcera and mufcles, and much fat.

DCCLII. The ftructure of the rectum differs very much from that of the other inteftines. The external membrane or peritonæum covers it only before, while behind it is connected to the region of the os facrum, by a very broad ftratum of cellular fubftance, replenifhed with fat, and many conglobate glands. The mufcular fibres are much ftronger than in the other inteftines, efpecially the longitudinal ones, which being compofed of the three ligaments, expanded and feparated, firft occupy the anterior face, and then the whole inteftine: they dilate it againft the advancing fæces, and draw it back after they are excluded. But the tranfverfe fibres are alfo ftrong, and their laft oval, tumid ring, is the internal fphincter by which the opening of the anus is accurately clofed.

DCCLIII. Moreover, the villous tunic, which is extremely full of pores, and rough with polygonous and tender wrinkles, has likewife fome finufes peculiar to itfelf. Namely, the part of the inteftine next to the fkin and inferior orifice, forms a white firm valvular circle, into which defcend longitudinal folds, but incurvated and approaching to each other on the circle itfelf. Betwixt thofe folds, therefore, finufes are interpofed, hollow upwards, and of a greater depth towards the bottom. Into their cavities open mouths from large mucous glands; while the margin of the anus itfelf is defended by febaceous glands, that it may not be excoriated by the hard and acrid fæces.

DCCLIV. There are alfo proper mufcles which govern the anus. The external fphincter is broad and flefhy, and confifts of two plates of femi-elliptic fibres, which crofs each other towards the coccyx, and towards the genital parts. And, in the former place, they are inferted by flefhy bundles into a

callous

callous cellular fabric defcending from the coccyx. In the latter, in like manner, they are attached by fimilar bundles to the fkin of the perinæum; but by three ftronger than the others, one middle, and two lateral into the accelerator and bulb of the urethra, the lateral ones partaking both of the nature of a fphincter and levator. The fibres, therefore, of the fphincter, approaching to a ftraight line between their anterior and pofterior fixed extremities, clofe the opening of the anus, which lies between them. With the internal fphincter, the external one is conjoined by a flefhy portion, that they may operate together. Their action is voluntary and not perpetual; for the anus feems to be clofed naturally, by the narrownefs of its orifice, compared with the largenefs of the inteftine, by the wrinkles correfponding to the other (DCCLIII.) by the ftrength of the tranfverfe fibres of the internal fphincter, and by the incumbent bladder.

DCCLV. But the office of the levators is different. They are large and complicated mufcles. They defcend betwixt the oppofite offa ifchia, are placed under the rectum and bladder, and fuftain both, and prevent the rectum from defcending and gaping difguftingly. Moreover, by their fibres fpreading extenfively in the manner of a fphincter, and being joined to that mufcle, they can dilate its fibres, and open the anus; but, at the fame time, they elevate and fuftain the inteftine from prolapfing while the fæces are paffing. They arife, as is well known, from the fpine of the ifchium, os ileum, and fynchondrofis of the offa pubis, terminating the margin of the great foramen of the pubes, and from that part of the ifchium, which is above the tubercle. Finally, they meet together under the coccyx, into which they are inferted by numerous fibres.

DCCLVI. Therefore, whenever the fæces are collected within the rectum in any great quantity, and

and become troublefome by the irritation of their weight, or acrimony, even to the adjacent vifcera; they are forced by the power of the will through the ftraits of the collapfed inteftine (DCCLIV.) by the force of the incumbent diaphragm, exerting an effort; which being drawn downwards with great force, preffes downwards the vifcera of the abdomen, which are alfo refifted by the contraction of the abdominal mufcles, and forces the contents of the bladder or rectum through the inferior opening between the bones of the pelvis, where the refiftance is leaft. When the refiftance of the anus is thus overcome, the force of the diaphragm abates, and the fæces are difcharged from the body, by the periftaltic motion of the inteftine itfelf. After the fæces are expelled, the inteftine is drawn back by its longitudinal fibres; and the anus being contracted by both its fphincters, fhuts its orifice as before.

DCCLVII. Thefe fæces in man, and carnivorous animals, are very fetid, almoft putrid, fubalkaline, foft, and contain much oil mixed with faline matter, which are the remains both of the aliments and of the bile and other humours of the human body. An acrid and fetid water returns from the fæces into the blood; hence, coftivenefs in fevers is hurtful, as by its addition it promotes putrefcency.

CHAP. XXV.*

CHYLIFEROUS VESSELS.

DCCLVIII. THE chyle is a white juice (DCCXXXVI.) extracted from the aliments, which is poured into the blood. It feems to be compofed of water and oil, as appears from its tafte, being fweet with fome mixture of faltnefs, from its acef-

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cent nature, from the whitenefs of its colour, from its fpontaneous feparation and coagulability, and from its lightnefs, by which it fwims on the blood: in all which properties it very much refembles an emulfion. It is compofed of vegetable farina, with lymph and animal oil. It every where retains the properties of the volatile and oily aliments. It changes into milk with very little alteration. But then, the glutinous pellucid ferum which it contains, becomes more manifeft, being coagulable into a kind of a jelly, by expofure to a high temperature, or by evaporating its water.

DCCLIX. That the chyle is abforbed into the lacteal veffels from the villous coat of the inteftines, to which it adheres, has been long known, by experiments with coloured liquids, which defcribed the fame courfe; from the fimilitude of the white liquor, as feen in the lacteals, and out of them and from the venous nature of lacteal veffels. But late experiments have given us better information on many particulars. The chyle is abforbed by the patulent orifice in the extremity of each of the villi, by a force fimilar to that of capillary tubes; is received into the hollow villi, which are relaxed when the inteftine itfelf is relaxed; but the veficle, being compreffed by the fucceeding conftriction of the mufcular fibres of the inteftine, the chyle is preffed on into the duct, which begins to appear in the fecond cellular ftratum. But there is a double feries of thefe trunks, one anterior, the other pofterior, as we obferved of the blood-veffels, (DCCXXIX.) From thence the lacteal veffel, already united into a larger canal, paffes into the firft cellular ftratum, and, in general, follows the courfe of the arteries, and likewife accompanies their arches, being conjoined with others of the fame kind into a very obliquely angled network. This kind of veffels hitherto has been obferved only in quadrupeds. In the large inteftine they arife without the

veficle.

vesicle. Very many arise from the first part of the small intestines under the mesocolon; some from the duodenum, and a few from the large intestines themselves.

DCCLX. The lacteal vessels are valvular in the very first cellular texture of the intestine, being provided, like the lymphatics, with very frequent, double, lunated valves, (LVII.) which admit the chyle passing from the intestines but prevent its return. Through this whole course, the chyle is propelled by the peristaltic motion of the intestines; by the peristaltic action of the vessels themselves, which are certainly irritable, even after death propelling the chyle; and by the considerable pressure of the abdominal muscles, directed by the valves.

DCCLXI. But betwixt the plates of the mesentery, at the divisions of the vessels, are found an infinite number of glands, of the conglobate kind, but softer and spongy, consisting of cellular texture full of juices, covered with an external membrane, less hard than in other parts, and variegated with numberless small blood-vessels. Some lacteal vessels seem to pass by these glands: the greatest number enter them; and, being divided and subdivided through their cellular fabric, compose the greatest part of the gland. On the other hand, other lacteal vessels originate in every gland; and, being mutually joined, compose trunks, of which the ultimate and largest go out from the gland. In the same manner the chyle enters two, three, or four glands, in succession; nor does any lacteal vessel arrive at the thoracic duct without entering some of these glands, although it may occasionally pass by some without entering them. That this is the true course of the chyle, and that it passes from the intestines to the mesenteric glands, appears from tying them, by the vessels growing turgid betwixt the ligature and the intestine; from schirrosities in the glands, by which they are rendered conspicuous; and from the nature

ture of the valves preventing any return to the inteſtines.

DCCLXII. What happens to the chyle in theſe cellular ſpaces is not ſufficiently known; but it appears that ſome thin liquor is ſecreted from the arteries in theſe glands, by the affuſion of which the chyle is diluted. For it is obſerved, that after the chyle has paſſed all the glands, it appears more watery; and thin liquors, injected through the arteries, exude into the cells of the glands, and mix with the chyle, ſince the lacteal veſſels may be filled through the arteries. Laſtly, this milky fluid appears manifeſtly in the glands of infants.

DCCLXIII. From the laſt glands, which are collected together in the centre of the meſentery, a few very large lacteal veſſels go out, to the number of four, five, or more, which aſcend with the meſenteric artery, and intermix with the lymphatic plexus, which ariſing from the lower parts of the body, creeps over the renal vein, and afterwards with that which comes behind the aorta from the lumbar glands, and with the hepatic. A duct is thus produced, ſubject to great varieties, but which moſt frequently expands into a veſicle of conſiderable breadth at the ſide of the aorta, lying between that and the right appendix of the diaphragm, two or more inches long; and moſt commonly continued above the diaphragm into the thorax, conical both ways: it is called the receptacle of the chyle. In this the gelatinous lymph of the limbs, and of the abdomen, mixes with the chyle, and dilutes its white colour; ſo that 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 two or three ſmall and narrow ducts, inſtead of this receptacle. This, however, is moſt frequent, and being compreſſed by the diaphragm and aorta, propels the chyle with greater velocity, in proportion

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as its caliber is larger than that of the duct into which it empties itſelf. This receptacle is rarely 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.

DCCLXIV. That the chyle comes from the inteſtines into this duct, is ſhewn from injections, by which quickſilver has ſometimes been puſhed from the firſt lacteal veſſels into the thoracic duct; from ligatures made on the duct itſelf, or the red veins which receive it, 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.

DCCLXV. The thoracic duct, as it is called from its courſe, is generally ſingle; or, if double for ſome part of its courſe, it ſoon unites into one, which aſcends in a waving courſe behind the pleura, betwixt the vena azygos and the aorta; and receives in its way the lymphatic veſſels of the ſtomach, œſophagus, and lungs, paſſing through the conglobate glands, of which there are many incumbent on it, and collected into large bunches. It is, on the whole, cylindrical; and often forms iſlands, by ſplitting and uniting again, more eſpecially in its upper part. It has few valves, and thoſe leſs conſpicuous. About the fifth vertebra of the back, it generally goes to the left, behind the œſophagus, and then aſcends along the left ſide of the thorax, behind the ſubclavian veſſels, till it arrives near the ſixth vertebra of the neck.

DCCLXVI. Then, being reflected and often divided, it deſcends with each branch dilated into a ſort of veſicle, and enters, either with diſtinct or united openings, into the junction of the ſubclavian and internal jugular vein, by an oblique courſe from the upper, poſterior, and right ſide, downwards, to the left, and forwards; or going on with one or other branch, it enters the ſubclavian, on the outſide of that

that junction. It is guarded by a true, moveable, and almoſt circular valve; alſo by its deſcent the blood is prevented from entering it. It is rarely otherwiſe diſpoſed; and very rarely ſplit into two, with one branch entering each ſubclavian; and yet more rarely does it ſend a branch into the vena azygos. Near its inſertion it receives a large lymphatic veſſel, coming tranſverſely from the arm; and another deſcending from the head, in one or more trunks.

DCCLXVII. 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.

DCCLXVIII. I have attributed the firſt cauſe of motion in the chyle, and of its abſorption, to the attraction of the capillary veſſels, alternated with the periſtaltic contraction of the inteſtines. The attraction fills the villi; the periſtaltic force empties them, and moves the chyle farther forwards. The reſt of its motion ſeems to depend on the force of the membrane of the lacteal veſſel itſelf, which, even after death, expels the chyle, ſo that the veſſels become pellucid, which before were milky. The alternate compreſſing force of the diaphragm alſo has ſome effect; and the motion of the chyle through the thorax is ſomewhat accelerated by the receptacle, which, being compreſſed, propels the chyle ſo much the more quickly, as it is larger than the thoracic duct.

DCCLXIX. The chyle, mixed with the blood, does not immediately change its nature; as is proved from the milk produced from it. But five hours or more after a meal, almoſt to twelve, during all which time a woman can afford milk; having circulated near 80,000 times through the body, fomented with the heat of the body, and mixed with the animal juices, it is changed, ſo that its fat ſeems to be partly depoſited in the cellular ſubſtance, partly

partly figured into the red globules, (cxlvii.) the gelatinous part changes into the ſerum of the blood; and the watery parts go off, partly by urine and perſpiration, and in part dilute the blood. Nor is it uncommon for a pellucid liquor to be in place of the chyle in the lacteals in a dying animal, or for a white liquor to be in one part of the meſentery, and limpid liquor in another, in veſſels which perfectly agree in their fabric. There are not, therefore, two kinds of veſſels from the inteſtines; of which the one carries chyle only, and the other lymph.

dcclxx. When digeſtion is not going on, the lacteal veſſels abſorb water from the inteſtines, and are tranſparent, and the thoracic duct conveys the lymph of the abdomen, and of moſt parts of the body, to the blood (liii.)

CHAP. XXVI.

KIDNEYS, BLADDER, AND URINE.

dcclxxi. THE chyle, when taken into the blood, contains a great deal of water; the proportion of which in the blood would be too great, and its ſeparation into the cellular ſubſtance too eaſy, if it were not excreted. A part of it exhales through the ſkin, (ccccxxxvi.) and another part, as large, or often larger, is ſtrained through the kidneys, and ejected from the body.

dcclxxii. The kidneys are two viſcera, placed behind the peritonæum, one on each ſide of the ſpine, incumbent upon the diaphragm, and upon the pſoas and quadratus muſcles of the loins, but ſo that the right kidney is commonly placed lower and more backwards. Before the right kidney are placed the liver upon its upper part, (dcxc.) and then the colon and inteſtines; before the left kidney are the ſpleen, ſtomach, pancreas, and alſo the colon. They are

are tied by reduplications of the peritonæum to the colon, duodenum, liver, and ſpleen. Their figure externally is convex, and ſemi-elliptical; laterally they are flat, and inwardly concave; they are unequally divided into an upper, longer and thicker extremity, and into a lower, flat, ſlender extremity. They are firmly inveſted by a ſtrong external denſe membrane, which does not come from the peritonæum. Betwixt that membrane and the peritonæum of the loins, there is always interpoſed a great quantity of fat, by which the whole ſurface of the kidney is ſurrounded on all ſides, and the nidus is completed, which, though prepared for it, the kidneys would not totally fill. From the kidney the peritonæum aſcends to the liver, ſpleen, colon, and diaphragm, and forms as it were ligaments for the kidney.

DCCLXXIII. The veſſels of the kidneys are very large, both the arteries, which together exceed the meſenterica, and the veins. The arteries ariſe 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 trunks. From theſe ariſe the lower capſular arteries, and the adipoſe ones belonging to the fat cortex of the kidney (DCCLXXII.) and not unfrequently the ſpermatics. The fat, rather than the kidneys, receives ſmaller branches from the ſpermatic and lumbar arteries. The arteries are thick, ſo that the proportion of their coats to their caliber is great; that they are among the ſtrongeſt of the body; and that they exceed the ſtrength of the aorta by one third.

DCCLXXIV. The veins are large, eſpecially the left, and leſs inconſtant than the arteries: the right, which is often without a branch, is ſhort and concealed; the left always receives one of the ſpermatics, and the capſular, and the laſt branch on that ſide of the vena ſine pari. It is a very large vein, and

and accompanies the duodenum, being extended tranfverfely a confiderable way to the left, before the aorta. Both the arteries and veins of the kidneys arife from the great trunks in an angle, acute downwards, and both divide themfelves into feveral branches before they enter the kidney. That the paffage of the blood from the renal arteries into the veins is very quick, appears from the facility with which water, wax, or air pafs that way. The uppermoft veins of the fat of the kidneys come from the capfular veffels, the middle from the renal ones, and the lowermoft from the fpermatics.

DCCLXXV. There are lymphatic veins, of confiderable fize, found near the renal veins, where they form the beginning of the receptacle of the chyle (DCCLXIII.) and which are faid to receive the branches that are divided under the external coat of the kidney, and are rendered manifeft by putrefaction, or by the injection of a fluid into the renal arteries, or even into the ureter.

DCCLXXVI. The nerves of the kidneys are fmall, but numerous; arifing from a confiderable plexus, mixed on each fide with ganglions, which is generated by branches of the great femilunar ganglion, joined with others coming from the intercoftal trunk, from within the thorax itfelf. They enter the kidney, along with the artery, and fend off the middle mefenteric, (DCCXLVIII.) and the fpermatic nerves. As thefe nerves are fmall, they give but a fmall degree of fenfibility to the kidney.

DCCLXXVII. Upon the top of each kidney is feated the renal capfule; which in the fœtus is large, even larger than the kidney itfelf, but does not afterwards increafe in the adult: it is glandular, of the conglomerate kind, divided into lobes, of an oval fhape in the fœtus, and triangular in the adult; that on the right fide is connected to the liver; the left to the fpleen and pancreas; and both to the diaphragm and kidney, by as many fides. From careful

ful obſervation, it ſeems to be hollow within, ſeparable like a ventricle, with the internal ſurfaces ſmooth, as if cut, full of a liquor of a yellowiſh red colour, and fluid, almoſt like blood. The arteries of theſe capſules are many, and of three kinds; the uppermoſt from the phrenics, the middle ones from the aorta, and the lower ones from the renals; the veins are one on each ſide, the right one going to the cava, and the left to the renal vein. The ſaid vein creeps almoſt naked through the very ſmooth ventricle, in the ſulcus dividing the capſule, and ſends branches through its internal ſurfaces. Its uſes are as yet unknown; although we are led to believe, that it is ſubſervient to the kidney, eſpecially in the fœtus, from their conſtant vicinity in ſo many animals. It has no excretory duct, nor does it diſcharge any juice, by viſible pores, into the vein.

DCCLXXVIII. The internal fabric of the kidney is ſimple, and known. The veſſels enter the interval between the upper and lower portions of the kidney, and penetrate into its ſubſtance, ſurrounded with a cellular ſheath, and divide into branches, which run between the branches of what is called the pelvis, along the columns interpoſed betwixt the papillæ. From thence, having formed arches both in the papillæ and between them, they ſurround the origin of the papillæ, nearer to the periphery, ſometimes joined, but by ſmall branches: from whence proceed innumerable little twigs, of which ſome return by the intervals between the papillæ into the columns, and into the papillæ; and others tend towards the external ſurface of the kidney, and ſometimes paſs through the coat of the kidney, enter into its adipoſe covering, and are there changed into minute ſerpentine twigs, which being reflected towards the ſame portion of the kidney from whence their trunk aroſe, they are gradually extended, and intermixed with the uriniferous

ous tubes. But from the cortex, bundles of uriniferous tubuli arise in several rays, collected in great numbers into threads, of which each contains many tubuli. 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 itself takes the same course. Between these papillæ, and about their origin, are situated some roundish knots, which the latest anatomists consider as arterial glands, producing the proper and more narrow urinary ducts. Between these ducts many arteries run parallel. It is probable, that the cortex consists of curved vessels, which eminent anatomists have supposed to be smaller than the red ones.

DCCLXXIX. Those uriniferous vessels gradually converge, being joined together like rays, and inserted in great numbers into one blind duct, which ducts complete the rest of the papilla, and terminate singly in its convex extremity by conspicuous pores. The number of these papillæ is not altogether certain ; but thirteen or more of them, simple, triple, and even quadruple, have been seen. These were in the fœtus so distinct, that the kidney then appeared to consist of as many distinct smaller kidneys, connected together by loose cellular membrane, each of which was furnished with its proper cortex of serpentine vessels, and its compages of straight uriniferous ducts ; the basis of all of them lay in the circumference of the kidney, and their vertices converged towards the centre. The opposite cortices of two of these little kidneys make a column, which separates the two papillæ. In the adult, the cellular substance being condensed, draws the papillæ closer, and unites them into one kidney ; however, it again almost recovers the condition which it had in the fœtus, if the cellular plates be

are relaxed by injecting water into the veſſels. The kidney is alſo larger in the fœtus than in the adult.

DCCLXXX. Around the protuberant ſurface of each papilla, a looſe membranous diſtinct covering, of larger ſize, adheres; ſo that the papilla, or ſometimes two contiguous ones, project into the hollow tube of this cylindrical funnel. Two or three of the tubes unite together, and form by that union three hollow trunks, an upper, middle, and lower, which again unite, but on the outſide of the kidney, into one conical canal, called the pelvis.

DCCLXXXI. The blood of the renal artery being leſs moveable, as is generally believed, than that of the brain, and probably containing more water, and being brought by the ſerpentine arteries of the kidneys, depoſites into the rectilineal tubes of the papillæ a great portion of its water, and the oil incorporated with it, and the ſalts, and any thin fluid it may contain. But the ſmall diameter of each uriniferous duct at its origin, and its firm reſiſtance ſeem to exclude the groſs oil, and the chyle, and the coagulable lymph. Hence, the increaſed celerity of the blood ſo eaſily forces the red globules through theſe tubes, and, by morbid relaxation, they tranſmit the true fat and the chyle, and the 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 the urine, which was of a yellow colour, ſuddenly becomes watery from violent affections of the mind. A vaſt quantity is prepared; equal to that of perſpiration, or ſomewhat greater.

DCCLXXXII. The urine, by heat or putrefaction, ſometimes by diſeaſe, and in ſome animals more eaſily, changes into a volatile alkaline ſubſtance, intimately mixed with oil; partly empyreumatic, yellow, and volatile; and partly very fixed, ſeparable only by the laſt degrees of fire, called phoſphorus, a congealing

a congealing ſubſtance, ſpontaneouſly emitting light, and taking fire in the air : and with earth in greater quantity than any other human fluid, both cretaceous and ſparry ; 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 ſea-ſalt in freſh urine, and even after long putrefaction it is found in the phoſphorus, although a great part of it is changed into volatile alkali. Nor is the urine wholly deſtitute of an acid, ſimilar to the vitriolic, both in man and in animals. There is alſo a ſalt obtained from urine, which is fuſible by heat, cooling and analogous to nitre. In fevers, the oily and ſaline parts of the urine are augmented in quantity and acrimony.

DCCLXXXIII. The ureter, continuous with the pelvis, carries on the urine received from the kidney, by the preſſure of the incumbent viſcera, and of the abdominal and lumbar muſcles, and by the blood circulating and giving impulſe from behind ; and, laſtly, by the weight of the urine. The ureter, covered by the peritonæum, is compoſed of cellular membrane ; then of a weak and obſcure muſcular coat, if any : then a ſecond cellular coat ; a firm, white, nervous one ; a third cellular coat, and an innermoſt very ſmooth membrane, porous and glandular internally ; and it is in general moderately irritable. It is of different diameters in different places, and every where ſwells into veſicles. It deſcends along the pſoas muſcle, acroſs the great iliac veſſels, arrives into the pelvis behind the urinary bladder ; and, at the union of the deſcending and tranſverſe portions of the bladder, enters obliquely betwixt the muſcular fibres and nervous coat ; and deſcends betwixt the nervous and villous coats, for a conſiderable way inwardly, ſo that the mouths of the two ureters are near each other, and open by a truncated orifice. They have no valves, either at their

their orifice, or in any part of their courſe. From their inſertion, a protuberant line of the thickened nervous coat deſcends towards the caput gallinaginis.

DCCLXXXIV. That the urine is ſeparated in the kidneys, is a matter of fact, as it can be emulged from its canals by preſſure. That it deſcends by the ureter, is ſhewn by the ſurpriſing ſwelling of the kidney, and of that part of the ureter which is above a ligature, and by the emptineſs of that part which is below it. That it paſſes into the bladder, is alſo proved, by the immenſe ſwelling of the ureters and kidneys, as often as the bladder cannot receive the urine, or cannot emit it; in conſequence of an obſtacle in either place.

DCCLXXXV. Nor does the urine ſeem to come in any other way. For although it be certain, that the ſtomach, like all other membranes, exhales; although it be not improbable, from experiments, that the bladder alſo abſorbs; and although the paſſage of acidulous waters be extremely quick; it does not follow, that there is a way, different from 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 aſcertained that vapours, either exuding from the bladder, or tending towards it, can here find open pores in the peritonæum; and membranes which are already wetted and ſaturated with moiſture, do not imbibe much. But the urine alſo which is contained in the bladder, diſtends it even ſo as to occaſion death; and does not find any paſſage through which it can eſcape into the pelvis; and on the other hand, when the ureters are obſtructed with ſtones, ſo that the bladder receives nothing from them, it is either quite empty, or contains a very acrid and thick urine, manifeſtly indicating that the water can find no way from the pelvis into the bladder. And a careful attention to the manner in which

which mineral waters are difcharged by urine, demonftrates, that there is no fuch rapidity therein as is commonly imagined; but that the cold of the water drunk, like external cold applied to the fkin, ftimulates the bladder, fo as to make it difcharge immediately the urine it contains already fecreted, and not that derived from the drink juft taken. Again, the largenefs of the renal veffels demonftrates, that not much lefs than an eighth part of the blood of the whole body is fent to the kidneys; and, confequently, above 1000 ounces of blood in an hour; fo that it is not furprifing that 20, or even 50 ounces of water, are feparated from the blood in that fpace of time. Finally, it is certain, that both man and animals perifh if the ureters be tied or obftructed; nor, in thefe circumftances, is any urine found in the bladder.

DCCLXXXVI. The urinary bladder is feated in the cavity of the pelvis, which is an appendix to the abdomen, furrounded almoft on all fides by bones; but laterally, and at the bottom, only inclofed by mufcles; and in every dimenfion, larger in women than in men. It is fo fituated in it, as to cohere with the offa pubis by much cellular fubftance; then it receives from them the peritonæum, which is applied to a fmall part of it before; but behind the bladder, it defcends for a great way, almoft as far as the infertions of the ureters; from whence it proceeds to the rectum, or to the uterus in women. Behind the bladder, the feminal veficles, proftate gland, rectum, and levatores ani, lie under it. In the fœtus, the bladder being very long, and conical, extends above the offa pubis; but in adults, it hardly arifes above thofe bones, even when inflated, becaufe, in them, the pelvis is much larger and deeper in proportion to the body.

DCCLXXXVII. The figure of the bladder is, in general, oval, but its anterior furface is flatter, its pofterior more convex, and its inferior obtufe vertex, which

which refts upon the rectum, is very flat and broad. Such is the figure of it in the male adult: in the fœtus it is almoft cylindrical; and, in women, who have had many children, it is fo much flattened laterally, that it refembles a roundifh tetrahedral figure, of which the fections are triangular. This change feems to arife from the weight of the urine, which depreffes the lower parts of the bladder, and extends it in breadth, fo as to render it fhorter and broader. It is of different magnitudes; fo that, in fome difeafes, from irritation, and habitual contraction, it becomes very fmall.

DCCLXXXVIII. The fabric of the bladder is much like that of all large membranous receptacles. The firft membrane is cellular; in its forepart lax, and replenifhed with fat; behind, it is lefs fo, where it alfo unites with the rectum. In this, there is a network of veffels, chiefly of veins. Next to this follows the mufcular coat, which is very difficult to defcribe, confifting of pale contractile fibres, difpofed in various reticulated bundles, not continuous, but with intervening fpaces, in which the nervous coat lies uncovered. The principal ftratum of thefe is longitudinal; which, arifing before from the proftate gland, and frequently, though not always, fo connected to the fynchondrofis of the offa pubis, or the membranes covering it, as feemingly to arife from thence, afcend towards the conical fuperior extremity of the bladder; defcend over it, along the pofterior furface, become at that place very broad, and again terminate at the proftate; but at the fides they diverge, varioufly palmated, and are blended from the anterior and pofterior planes. Thefe fibres muft deprefs the bladder, and confequently propel the urine towards its lower part.

DCCLXXXIX. The remaining fibres are very difficultly reduced to any order. They fill the intervals of the former; arifing from the proftate, then inflected, they afcend, and form a ftratum, partly oblique,

oblique, and partly tranfverfe, the interior ones more fo than the others, both in the forepart and back part of the bladder.

DCCXC. The contractile force of the bladder is gentle, but perpetual; fo that it contracts from its greateft dilatation to its fmalleft diameter, without any alternate relaxation, and remains long in its ftate of greateft contraction. The urine is its leaft uneafy ftimulus; water injected is more fo; and calculus, and every kind of irritation, the moft infufferable. When immoderately diftended, it lofes its powers; fo that either it cannot expel, or it cannot retain the urine.

DCCXCI. Within the mufcular coat is fpread the fecond cellular ftratum, of an elegant fabric, inflatable, more tender, and fofter than in the inteftines. Next follows the nervous coat, continuous with the fkin, and acutely fenfible; the innermoft, refembling that of the ftomach, is laft; more obfcure; difficultly feparable from the nervous one; continuous with the epidermis; and, like it, eafily reparable, extremely mucous, and folded into various wrinkles, without any certain order. In it, the pores of the cryptæ fometimes appear, but not always eafily, pouring out a vifcid and bland gluten. The mucus itfelf is very manifeft, and is prepared in greater quantity in proportion to the irritation of the bladder. It is of the greateft importance for diminifhing the irritation of the acrid urine.

DCCXCII. The veffels and nerves of the bladder coincide with thofe which go to the genital parts, where we fhall defcribe them. Thofe which come from the epigaftrics are fmall. Their principal reticulation is in the firft cellular ftratum, and there is another in the fecond. Through the villous coat the exhaling arteries exhale, as we learn by experiment, from anatomical injections; and the abforbing veins open, to which are owing the greater confiftence and higher colour of the urine, when retained.

retained. The lymphatic veſſels in the outer cellular ſtratum, are eaſily demonſtrated; but their origin is probably foreign from the adjacent inteſtine.

DCCXCIII. The urinary bladder is of the ſame nature with other membranous ſacs, ſo that it both tranſmits water from its cavity through the inorganic pores of its membranes, and abſorbs water when immerſed in it.

DCCXCIV. Into this bladder, the urine flows, in one uniform ſtream, as has been proved, in morbid and uncommon caſes, in which the extremities of the ureters were viſible to the eye, and there remains, and becomes more acrid and higher coloured, from the abſorption of its water. We are not fully acquainted with the cauſe, which retains the urine in the bladder. The ſphincter is obſcure; the depreſſion of the bladder ſeems to aſſiſt, which being convex, deſcends upon the rectum, behind the ſphincter, below its orifice, ſo that the urine does not reach the orifice of the urethra till collected in ſome quantity. It is certain, that the urine does not eſcape ſpontaneouſly even from the dead body.

DCCXCV. At length, the urine, by its bulk and acrimony, irritating the ſenſible fabric of the bladder, is expelled, firſt by the motion of the diaphragm and abdominal muſcles, by the preſſure of which, impelling the inteſtines againſt the bladder in the erect poſture, the urine makes itſelf a way through the narrow and impeded paſſage; and ſecondly, by the periſtaltic motion of the bladder itſelf, ariſing from the contraction of its muſcular fabric (DCCLXXXVIII. et ſeq.)

DCCXCVI. By the urine, beſides the water, and part of our food, much matter, that is noxious to the human body, ſeems to paſs off; eſpecially calcareous earth reſorbed from the bones and ſolid parts, and which would produce bony cruſts and calculi wherever it was retained; the ſparry earth of waters; an acrid oil mixed with ſalt, ſo as to aſ-

ſume a volatile nature. The urine, by its retention, diſpoſes to the generation of calculi, and to gout: when ſuppreſſed, it produces acute fevers; and laſtly, flows back to the brain, and is depoſited on it, and deſtroys it.

DCCXCVII. From the obtuſe vertex of the bladder, not exactly from its bottom, but further forwards, a canal with a ſmall orifice, continuous with the bladder, ariſes. It is denominated the urethra, and is compoſed of an internal membrane, which is evidently continuous with the epidermis, of ſurrounding cellular ſubſtance, and of a firm nervous coat. It is variable in its diameter and direction; in women, it is ſtraight, tranſverſe, and ſhort. I do not find a valve in its orifice.

DCCXCVIII. The urethra is at firſt ſurrounded on all ſides, by the proſtate gland; it then proceeds naked, for a ſmall ſpace; it is then embraced by the bulb immediately attached to it, firſt below, and then above; it is then received in the interval between the corpora cavernoſa of the penis, contiguous to it above, and laterally, and acquires ſtrength and the ſtate of an open tube from them. The urethra is wideſt where it ariſes from the bladder; it contracts itſelf conically in the proſtate; in its naked part it is cylindrical; it enlarges at the firſt acceſſion of the bulb; in the penis it is alſo cylindrical, and again dilates itſelf a little before its termination.

DCCXCIX. This canal is governed by various muſcles, either proper or contiguous. And firſt, in women, there are manifeſtly fibres placed round the egreſs of the incipient urethra, which are, on the whole, tranſverſe, but variouſly decuſſating each other; of which the fixed point is in the vagina, and the office is evidently that of a ſphincter, to depreſs the canal, about the opening of which they are diſpoſed, and to cloſe it againſt the reſiſting contracted vagina, and ſphincter of the anus. In man,

man, ſimilar tranſverſe fibres, but forming an arch upwards, run into the conjunction of the bladder with the proſtate; both covering a longitudinal bundle of fibres and the proſtate, and covered by theſe fibres, they are to a certain degree fitted for contracting the orifice of the bladder.

DCCC. The firſt tranſverſe muſcle proceeding tranſverſely from that branch of the iſchium which ſends forth the erector muſcle of the penis, towards the other os iſchium, partly paſſes into it, partly is inſerted into the middle of the bulb of the urethra, and partly degenerates into the accelerator. It preſſes upon, ſhakes, and draws backwards the bulb of the urethra. The other, produced from the branch of the os iſchium, is inſerted into the iſthmus of the urethra before the bulb, and dilates it.

DCCCI. But likewiſe the levator of the anus ſeems to raiſe the urethra againſt the os pubis, and to ſhut the exit from the bladder; and the conſtriction of the accelerator, together with the ſphincter, is eaſily perceived in the living body, as it perfectly cloſes the mouth of the bladder, and checks the urine even while it is flowing; whence there is no doubt, that the moderate tenſion of this muſcle contributes towards retaining the urine.

DCCCII. An effort being now made, (DCCXCV.) by the preſſure of the diaphragm, the urine is ejected with greater celerity, as it comes from a large receptacle, through a narrow canal; and, being diſcharged, the body is freed from the uneaſy ſenſation. The laſt drops, which remain in the loweſt part of the bulb, and are retained there by their weight, are expelled by the accelerator muſcle, which is a ſtrong muſcular expanſion, placed round the bulb of the urethra, with pennated fibres, meeting in the bottom middle part of the bulb, faſtened before by two tendons to the cavernous bodies of the penis behind, and connected by three muſcular portions to the ſphincter of the anus, of which two are lateral, and

and one central, with ſome acceſſion from the tranſverſe muſcles. This muſcle, when the ſphincter is ſteady and ſhut, draws the bulb upwards; and, acting upon the urethra alternately, with conſiderable force, expels the laſt drops of the urine.

DCCCIII. We cannot admit, that the pyramidal muſcle of the abdomen, draws the bladder downwards from the bundle of umbilical veſſels, and relaxes it, and fits it for the action of the long muſcular fibres, as the muſcle itſelf is often wanting; as it cannot depreſs the bladder, and very rarely reaches the navel.

DCCCIV. But as the urine is acrid, and the membrane of the urethra very ſenſible, and as the air can be admitted into it, nature has ſupplied this canal with a large quantity of mucus. Beſides its ſources in the bladder, this mucus is generated, in the firſt place, by two conglomerate glands; one of which is ſeated on each ſide, in the angle betwixt the bulb of the urethra and the cavernous body of the penis, and ſends out a duct, running for a conſiderable way obliquely along the urethra, and inſerted before its bulb. I am ignorant of any gland of the iſthmus different from the cellular texture. Moreover, the whole urethra is full of cylindrical mucous ſinuſes, moſt of which deſcend towards the glans, though ſome run in a contrary direction, into whoſe ſides minute cryptæ depoſite a fluid and bland mucus. The largeſt of theſe ſinuſes are diſpoſed in a ſeries along the upper ſide of the urethra, beginning before the bulb, and extending to the origin of the glans. The ſmall ones are both mixed with theſe large ones, and diſpoſed on the ſides. In women, they are numerous and large in their ſhort urethra, eſpecially at its opening.

DCCCV. The neceſſary propriety of human life requires the detention of the urine. But this very utility is attended with the danger of diſeaſe, ſince the

the urine when at reſt, immediately depoſites its earthy particles, which by the acceſſion of new ſtrata, form calculi. But the great number of people free from calculi, ſhow, that the very lubricous mucus of the bladder is a ſufficient protection, unleſs the uſe of ſabulous and tophaceous water, of wine, or of viſcid aliments, exceſſive inactivity, preternatural retention of the urine, the preſence of ſome viſcid body to attract the calculous earth, and, finally, nephritic diſeaſes, afford a ſuperabundance of calculous earth, or a nucleus for its adheſion,

C H A P. XXVII.

MALE ORGANS OF GENERATION.

DCCCVI. THE veſſels belonging to the genitals ariſe near the kidneys, almoſt in every kind of animals. This is occaſioned by the opportunity of deriving a double uſe from one organ, which might diſcharge both the urine and the ſemen, and by the relation of the genital parts to the interval between the tops of the thighs, which is ſubſervient to cleanlineſs, modeſty, the facility of parturition, of making water, and to the effect of the efforts employed in theſe.

DCCCVII. The male ſemen is formed in the teſticle; is depoſited in the ſeminal veſicles; is ejected from the penis; is injected into the uterus, and fecundates the ovum. Such is the arrangement we ſhall follow. The human teſticles, ſmall in proportion to the body, in the fœtus, when very young, are lodged within the peritonæum, and gradually deſcend under it into the groins, and when it has arrived at maturity, they lie below the groins; their ſituation being changed, perhaps by the ſimple force of their weight, and of the influx of blood; yet ſometimes they remain in the groin, even in adults.

adults. They defcend by a cellular paffage, which in the fœtus is open, and called the procefs leading from the cavity of the peritonæum into the fcrotum; and the fame paffage, after the tefticle is tranfmitted, is contracted and obliterated by a law of nature.

DCCCVIII. The tefticles are defended by various integuments. In the firft place, they are furrounded by the fcrotum, which is formed of a denfe cellular coat, vafcular and compacted into a folid membrane, clofely adhering to the fkin, which poffeffes fome elaftic motion from cold and during venery, but without any mufcular fabric, although when it acts it becomes corrugated, and draws up the tefticles. This cellular coat, commonly called the dartos, is placed round each of the tefticles feparately; therefore, at their union, they form a kind of feptum, in a dry preparation; this feptum is often imperfect in its upper part, near the penis.

DCCCIX. The dartos is interiorly relaxed into cellular fubftance, which is inflatable as in other places, but without fat, except in the lower part of the fcrotum. Next follows a mufcle, from its office called cremafter; which arifes from the degenerating fibres of the lefs oblique mufcle of the abdomen, and from the tendon of the obliquus externus, which has got the name of a ligament, and fometimes from other fibres defcending from the os pubis, and being expanded into a vagina, and furrounding the tefticle behind, and then on all fides, it compreffes, elevates, and emulges it.

DCCCX. Next to this follows the fecond cellular ftratum, which is continuous with the exterior fpongy web, which furrounds the peritonæum; this is called the tunica vaginalis. It is compofed of longer cells than elfewhere, which may be inflated one after another. At the beginning of the tefticle, above the epididymis, part of the vaginal coat, which furrounds the tefticle, is fo fepa-

rated

rated from the reft, which lies higher than the tefticle towards the ring of the abdominal mufcles, as almoft to prevent the tranfmiffion of air. Betwixt this membrane and the following, there is a fpace, into which vapour is exhaled, and fometimes a little water is collected. The innermoft coat of the tefticle, called the albuginea, is a ftrong, white, compact membrane, which immediately invefts the fubftance of the tefticle.

DCCCXI. The tefticle properly fo called, is of an oval figure, with an acute vertex, directed upwards and a little outwards. The epididymis is a kind of addition to the tefticle; a flat thick tape, which goes round the pofterior margin of the tefticle, to which it is connected by cellular texture, and by veffels. Below it is flatter; on the upper part it adheres to the tefticle by a thick and convex head, as it alfo does at the very bottom. In the middle, it is partly attached, and being partly loofe, forms a fhut cavity.

DCCCXII. To the tefticle the fpermatic arteries defcend, one on each fide, arifing from the aorta below the renal arteries; but not unfrequently from the renals themfelves, or from one of the capfulary, or from the aorta itfelf above the renal. This artery, the fmalleft in the body in proportion to its length, defcends outwards before the pfoas mufcle, and gives fmall branches to the liver, the fat of the kidney, the ureter, lumbar glands, mefocolon, peritonæum, and efpecially a remarkable adipofe branch, bent around the bottom of the kidney: and, without becoming lefs, it proceeds 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 by a long aperture, growing wider downwards; a great many of which, flender and interior, are partly inferted extenfively into the middle of the os pubis, and partly decuffate

and

and unite with the fibres of the mufcle of the oppofite fide; thefe are called the inner column. Other external ftronger fibres, feparated from the former by the aperture, are inferted in a thick bundle into the outer fide of the os pubis, under the denomination of the external column: from it 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, inflected and afcending along the inner and weaker column. Below thefe fibres, through the fmall opening left, which is often divided by tendinous fibres, the fpermatic artery defcends, along with the vein, and vas deferens, formed into a cylindrical cord, with a good deal of cellular fubftance, before the external column, but does not perforate the peritonæum, which lies before it through its whole extent. At this ring, the ductus deferens is joined with the rope of veffels, and the whole bundle proceeds into the groin, and afterwards into the fcrotum. The fpermatic artery gives many branches to the cremafter, to the cellular coat, and to the feptum of the fcrotum; and defcends in two plexufes to the tefticle; of which the principal paffes betwixt the epididymis and origin of the vas deferens, to the middle and lower part of the tefticle, and is diftributed in tranfverfe branches, through the albuginea: the other plexus goes to the tefticle in company with the vas deferens, has a like termination, and is varioufly inofculated with the former. Other fmall arteries go to the coverings of the tefticle from the epigaftrics, and others from thofe of the bladder, accompanying the vas deferens; both of which communicate with the fpermatic veffels.

DCCCXIII. Thefe very numerous arteries play about the epididymis; but the larger of them fpread tranfverfely through the albuginea, which they perforate in feveral places, and enter into the innermoft fubftance of the tefticle, through which they

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are every where diſtributed upon the numerous membranous ſeptula. There is no larger anaſtomoſis or communication betwixt the ſpermatic artery and vein here, than in other parts, nor are the branches within the albuginea, received into the teſticle, without blood. But the long courſe of this artery, the ſmallneſs of its diameter, the ſerpentine flexures, the great proportion of the branches to the trunk, and their cold ſituation, demonſtrate, that the blood arrives at the teſticle ſlowly, and in ſmall quantity.

DCCCXIV. The right ſpermatic vein carries its blood to the cava; the left to the emulgent vein, or to both: it is enormouſly larger than the artery, both in its trunk and branches; and accompanies it, but more plentifully, having ſeveral trunks interwoven into a very long reticulated web within the abdomen, which ſurrounds the artery, and is continued into the teſticle, by degrees dividing into two like the artery. There are ſome valves in this vein, though few.

DCCCXV. The external coverings of the teſticle have their arteries from the epigaſtrics; the ſcrotum from the crural arteries, and from the internal branch of them, which is called the external pudenda; the correſpondent veins go to the ſaphæna, and to the crural veins.

DCCCXVI. The nerves of the teſticle are many, whence its ſenſibility is peculiarly acute, ſo that injuries of the teſticle are immediately followed by faintings and convulſions, and particularly by locked jaw. Some of them ariſe deep from the renal plexus, from the great meſenteric plexus, from the trunk of the intercoſtal nerve, and laſtly from the meſocolic plexus, and follow the courſe of the ſpermatic veſſels. Others, more ſuperficial, deſcend to the coverings of the teſticle, from the ſecond, third, and fourth pair of the lumbar nerves.

DCCCXVII. I have frequently obſerved lymphatic veſſels in the ſpermatic cord, which are believed to ariſe from the teſticle itſelf, and which unite with thoſe that accompany the inguinal blood-veſſels. The induſtry of late anatomiſts has traced ſome of them even to the network of the teſticle itſelf.

DCCCXVIII. The blood, moved ſlowly and in a ſmall quantity, brought by its arteries into the inner fabric of the teſticle, (DCCCXIII.) is diſtributed into minute veſſels, which carry their fluids to the ſeminal veſſels, although we are ignorant of the manner by which the arteries communicate with theſe tubes, bundles of which form the whole ſubſtance of the teſticle. Theſe are ſmall, ſerpentine, ſomewhat firm, and have a very ſmall caliber in proportion to their membranes; they are not, however, ſo impervious as to prevent them from being filled through the vas deferens. They are collected together into bundles, above twenty in number, ſeparated by cellular partitions, which deſcend from the albuginea into the teſticle, and conduct the arteries and veins. In each cell there is a duct which receives the ſemen from the ſeminiferous veſſels. Theſe ducts, twenty or more in number, form a network of longitudinal veſſels adhering to the albuginea, and inoſculate with each other; and readily permit quickſilver to eſcape into the ſurrounding cellular ſubſtance. From this net twenty or thirty ducts aſcend to the upper part of the epididymis, which being wonderfully convoluted, form as many vaſcular cones. Theſe, joined together by intermediate cellular ſubſtance, and lying upon each other, form the head of the epididymis, and in that head ſoon meet together into one duct on the outſide of the teſticle.

DCCCXIX. This ſingle duct being convoluted into an infinite number of folds and ſerpentine flexures, in a manner not found in any other part of the body,

body, and connected together by much loose cellular substance, and being collected by one continuous membrane produced from the albuginea, constitutes the epididymis. But the duct of which the epididymis is composed, grows larger as it descends; from whence being reflected, it again ascends along the posterior surface of the testicle, and by degrees unfolding its spiral convolutions, which are now much larger, it gets the name of ductus deferens. Almost always, however, a small vessel separates somewhere from the ductus deferens, and ascends along with the chord, having an uncertain termination.

DCCCXX. This is the course described by the semen, moved forwards by the fluid successively coming from the testicle, and perhaps by the cremaster; but very slowly, as we may conclude from the numberless convolutions of the epididymis, obstructing almost every kind of injection; and from the length of time that is required to repair the semen, after the seminal vesicles have been exhausted.

DCCCXXI. The cylindric ductus deferens being composed of very thick spongy substance, included betwixt two firm membranes, perforated by a very small tube, begins at the bottom of the epididymis, ascends in the chord of the spermatic vessels, passes through the ring of the abdomen (DCCCXII.) descends into the pelvis, applies itself to the bladder between the ureters, and there meets with its subjacent receptacle, which is called the vesicula seminalis, of which there are two, one right and one left. Here the vas deferens lies on the inner side of the vesicle, as far as the prostate gland; and being dilated in its course, and bent in a serpentine direction, it appears cellular. But very near the prostate, the duct, being continued from these cellular windings, unites with a conical duct coming from the vesicle, in a very acute angle, into one

 duct,

duct, alfo conical, which is continued rather from the vas deferens, and penetrates through the proftate gland, there forms a great flexure, diverges outwardly at right angles from its companion of the other fide, and, becoming contracted, opens into the urethra in one of the two very fmall lateral orifices of the tumid, long beaked, hollow protuberance. By injecting a liquor into the ductus deferens of a dead fubject, we perceive that it flows both into the urethra and into the feminal veficle, but more readily into the former: but in a living perfon the femen never flows out but in the act of venery; and confequently the ductus deferens conveys all its femen, notwithftanding the retrograde angle, to the feminal veficle.

DCCCXXII. By this laft denomination we underftand a membranaceous, firm inteftine lying under the bladder, connected with it by much cellular fubftance: from which ten or more impervious cells proceed, fome of which are alfo ramified and divided, but which end in impervious conical extremities. This inteftine, with a great deal of firm cellular fubftance and intervening veffels, and peritonæum lying under it, is fo contracted, as to be collected into a fhort ferpentine mafs. Befides, its external fabric is pulpy and thick, and is fomething analogous to the ductus deferens. Its external fabric is wrinkled like the villous and reticulated coats of the biliary veffels, villous with minute flocculi; and is faid to have fmall pores and glands, with which I am unacquainted, though it certainly has various and hollow cells.

DCCCXXIII. The liquor depofited in it, in the tefticle is yellowifh, thin, and watery; and retains the fame nature in the veficle, though it becomes there more vifcid and yellow; and laftly, in man it becomes white, when it is mixed with the liquor of the proftate. It has a peculiar heavy fmell, in every kind of animal; and it is the heavieft fluid in

in the body. In water, part of it forms a thin, ſwimming pellicle, but the greater part, which is ſeemingly of a pulpy nature, ſinks to the bottom; and in the ſemen which has been long retained by continent people, ſhining globules mixed with a whiter liquor are eaſily ſeen with the naked eye. It agrees in many particulars with mucus.

DCCCXXIV. Without the conveyance of this into the womb, no animal which is of two ſexes can be fecundated. The reaſon of this was unknown, till the microſcope ſhewed, that in man, and in every other animal, the ſeminal liquor is full of living animalcules, reſembling eels, having in man a thick head, and a long and ſlender but conſpicuous tail; which are always found in healthy ſemen, from the period of puberty; but, before that time, and in thoſe who are ſterile from ſickneſs, they are abſent, and they are not found in any other animal fluid. That they are animalcules, appears evidently from their various motions, avoiding obſtacles, retrogreſſion, and change of velocity.

DCCCXXV. The real uſe of theſe animalcules has been much doubted; and we ſhall have another opportunity of conſidering the received 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 other infuſory animals.

DCCCXXVI. That the ſemen is produced from the lymph of the blood, and that the chyle is added to the lymph appears probable from the diſpoſition to venery quickly ſupervening after eating, and being leſſened by faſting. It is compounded of the liquor of the teſticles, and of the ſeminal veſicles, which in ſome animals is more evident, and of the coagulable milky fluid of the proſtate gland. That liquor, however, only fecundates which is generated in the teſticles; as we ſee from caſtrated ani-

 mals,

mals, which, though they have the feminal veficles and proftate, are yet unprolific.

DCCCXXVII. The feminal fluid is retained in the veficles, excepting in the venereal act and in the illufions of dreams. Being prefent during that whole time, according to its quantity, it ftimulates the animal to venery. But a confiderable part of the femen, and that the moft volatile and odorous, is abforbed into the blood, and by its addition to it produces wonderful changes, impregnating the whole animal with its fmell, caufing the beard, and hair upon the pubes, and horns to grow, changing the voice and difpofitions. For thefe do not happen in confequence of the age of the animal, but of the femen, and never occur in eunichs. The growth and ftrength of caftrated animals are diminifhed; but in uncut animals, the ferocity and ftrong fmell, diffufed through the whole flefh, increafes. And from fome examples of animals, and even of men, it has evinced a fatal irritating power, by exciting convulfions. Retention of the femen feems to proceed from the narrownefs of the feminal duct, excretory duct, a fcirrhofity of the proftate, and other caufes not fufficiently known.

DCCCXXVIII. The quantity of femen expelled at one time from the veficles in man is but fmall, efpecially if the abftinence from venery has been fhort; and it is natural that it fhould be but flowly produced from fo fmall, and that a fubcutaneous artery. Its generation is accelerated by love, by the prefence of the beloved object; fo that it diftends its veffels with a fenfe of pain. Nature herfelf, therefore, enjoins venery for the prefervation of the human race, and likewife of the health of every found man. That it paffes from the tefticle into the veficles, is fhewn by difeafes, in which the ductus deferens being obftructed, a fwelling of the tefticle has enfued. From the veficle it does not efcape, except during the venereal act.

DCCCXXIX.

DCCCXXIX. As the femen is fmall in quantity, that it might be projected with greater force, and to a further diftance, another humour, which is generated by the proftate, is added to it. This gland, fhaped like a heart, with the fmall end foremoft, furrounds the origin of the urethra, and contains it, though moft contiguous to the upper furface of the gland. It is a very hard and compact gland, of a peculiar fabric, not evidently conglomerate; it prepares a thick, white, bland, copious fluid, which is projected at the fame time and from the fame caufes (DCCCXL.) with the femen itfelf, into the excavations at each fide of the openings of the feminal veficles, through numerous ducts, and in the femen its white colour and vifcidity are predominant.

The urethra, although cylindrical upon the whole, has three confiderable dilatations. The firft in the proftate at the caput gallinaginis, the fecond in the bulb, and the third in the beginning of the glans. Its courfe at firft is generally horizontal, afterwards it afcends along the offa pubis, and in the male it is finally pendulous, except in the time of venery. It is a continuation of the nervous coat of the bladder, and is internally lined with a very fmooth epidermis; between which and the nervous coat there is cellular fubftance.

DCCCXXX. But is was neceffary for this urethra to be firm and ftraight, that the femen might be thrown with fome force into the diftant womb; therefore it is furrounded by a triple cavernous body. The firft, the proper cavernous body of the urethra, begins, as foon as that canal has paffed the proftate, with a thick origin, almoft like a heart; at firft it lies under the urethra, but afterwards furrounds it alfo above, but is there thinner, and accompanies it 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

of the urethra, and, being dilated, returns in a contrary direction along the penis, and, being terminated by a broad, thinner, and round extremity, it refts upon the corpora cavernofa penis, and for the moft part communicates with them by an imperfect feptum. The fabric of this body is cellular, but lax, and compofed rather of plates, interwoven like a net, than of fibres, and inclofed between two firm membranes.

DCCCXXXI. Into this cavernous body of the urethra, the blood is poured out from the deep feated arteries, which come from the external hemorrhoidals (DCCCXXXVI.) This is demonftrated by the injection of any kind of fluid, which eafily flows from thefe arteries into the cellular fpaces furrounding the urethra. But they are not fpontaneoufly turgid with blood, becaufe there are veins equally open, fufficient to carry away the effufed blood. But when thefe veins are compreffed by the powers mentioned in DCCCXXXIX. the blood is then retained within the cellular fpaces, while the arteries, being ftronger, continue to pour it in. Thus the blood ftagnating, diftends the bulb of the urethra, together with its cavernous body, and the glans itfelf. But this is performed generally when the other cavernous bodies of the penis, with which this of the urethra has no communication, are previoufly diftended.

DCCCXXXII. The cavernous bodies of the penis arife from the offa ifchii, almoft from their bottom, with which they are joined by a white, cellular, but very denfe and firm fubftance; from whence inclining inwards and towards each other, they inclofe the urethra, a little before its bulb, where, changing their direction, they go on parallel, and conjoined together, with the urethra lying below and between them, and terminate in the glans with an acute end, laterally furrounded by the cavernous body of the urethra. They confift of a very firm integument,

integument, and ſpongy internal fleſh, as in the urethra, (DCCCXXX.) like it alſo capable of being diſtended with blood. Between theſe cavernous bodies, there is a middle ſeptum, compoſed of firm parallel tendinous fibres, growing narrower downwards, and not continuous; ſo that the intermediate ſpaces are larger and more numerous, as they are more forward; and a free communication is left between the right and left ſpongy body. Other fibres of this kind run through the cavernous bodies, as well as the ſeptum, and are inſerted into the very firm involucrum: they prevent over-diſtention and aneuriſms of the penis.

DCCCXXXIII. Theſe cavernous bodies are ſurrounded by much very fine cellular ſubſtance; of which the part lying next the cavernous bodies is tenſe and firm, like a membrane; without it the cellular ſubſtance is very tender, continuous with that of the ſcrotum, and included within a thin ſkin without any fat, and always the more tender the nearer the ſkin it is. By inflation, it aſſumes a beautiful ſilky texture. But the glans (DCCCXXX.) is covered in the following manner by the ſkin: being continued from the penis, and reflected againſt itſelf, as in the eyelids; covered on both ſides with its proper cuticle, and filled with intermediate cellular ſubſtance, it is called the preputium, and may be drawn back, and laſtly, it is continued forwards again to the glans penis, and is there changed into a tender, ſoft, ſpongy, flocculent body, acutely ſenſible, covered with its proper cuticle, and with a depreſſed pulpy reticulum, ſpread over the reflected cavernous body of the urethra, (DCCCXXX.) and, finally, continuous with the membrane of the urethra itſelf. The prepuce is tied by a double triangular frænulum, by which the ſkin is joined to the cellular involucrum of the penis, as far as the mouth of the urethra. In the hollow which lies under the crown of the glans, and in that circle itſelf, are ſeated

feated fimple febaceous follicles, which feparate a liniment, which, from the nature of the place, is fetid, as in other parts of the body expofed to friction. The whole penis is fuftained by a firm cellular fubftance, compacted into a kind of triangular ligament, which defcends from the fynchondrofis of the offa pubis, and is continuous with the denfe and hard cellular ftratum that furrounds the cavernous bodies.

DCCCXXXIV. 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 the prolific femen.

DCCCXXXV. Thefe cavernous bodies of the penis, during coition, by the blood impelled through the arteries, and retained in the veins, become turgid, diftended and ftiff, and fuftain the flaccid, or if it alone were filled, the weak urethra, in fuch a manner that the femen may arrive at the diftant womb. This is demonftrated from the diffection of animals killed in the act of venery, from artificial erection, from the injection of liquid fubftances into the veffels of the penis. It is produced by love, the defire of enjoyment, the friction of the glans, and various irritations of the bladder, tefticles, feminal veffels, and urethra, from urine, from abundance of good femen, from the venereal poifon, from cantharides, whipping with rods, or nervous convulfion. But the caufe of this diftention is not yet evident. The defcription of the diftribution of the blood-veffels into the genital parts is therefore now neceffary, to fhow how little it is adapted for promoting the caufe which compreffes the veins.

DCCCXXXVI. The aorta at the fourth vertebra of the loins, and the vena cava at the fifth, are divided; of thefe the latter is pofterior, the former anterior. The common iliac branches, before they arrive at the middle interval at the beginning of the

the thighs, ſend off inwards and downwards a conſiderable artery, called the hypogaſtric, which in the fœtus is larger than the femoral artery, and in the adult is equal to it. This deſcends into the pelvis, and divides into four, five, or ſix principal branches; of which the firſt is the iliaca anterior, which alſo ſends branches to the dura mater and cauda equina, upwards to the loins, and downwards to the os ſacrum. The next, the ſacra lateralis, goes to the ſame os ſacrum and cauda equina, when it does not ariſe from the former. The third, the iliaca poſterior, is almoſt confined to the glutei muſcles. The fourth, the iſchiadica deſcendens, ſupplies ſeveral muſcles, the nerves, and the levator ani. The fifth, or the trunk, is the hæmorrhoidea infima or pudenda communis, which, within the pelvis itſelf, ſends conſiderable branches to the bladder, and to the rectum the middle hæmorrhoidal, which anaſtomoſes with the meſenterics; after which, going out of the pelvis, it creeps by the ſide of the obturator, and gives off the external hæmorrhoidals to the ſphincter and ſkin of the anus: then dividing, its internal branch ſupplies the bulb of the urethra and the proſtate; the external is again divided, and with one branch enters deeply into the cavernous body of the penis, and runs through its whole length; while, the other branch often joined with the veſſels of the bladder, runs along the back of the penis, and terminates in branches ſent to its corpora, and to the ſkin. The ſixth is the obturatrix, ſpent upon the joint of the femur and adjacent muſcles. The laſt, the umbilical artery, will be deſcribed in treating of the fœtus; in the adult it ſends ſome branches to the bladder, from its thick callous vagina. Sometimes ſeveral of theſe arteries ariſe from one common trunk. The ſkin of the penis and ſcrotum have their arteries from the epigaſtric, from the crural, and from its internal branch. Theſe external arteries

teries communicate in many places with the internal.

DCCCXXXVII. The veins, in general, correfpond with the arteries. They often come off from the iliacs in two trunks, forming a plexus with each other; then the hæmorrhoidal vein, returning around the os pubis, forms a very large plexus upon the proftate gland, with the veins of the bladder arifing in the pelvis: from which the vena penis arifes, which is often fingle, and is furnifhed with valves, determining the return of the blood to the cava. The external veins of the penis and fcrotum go to the faphæna and crural, and communicate in feveral places with the internal veins, more efpecially at the bafis of the prepuce.

DCCCXXXVIII. The lymphatic veffels of the penis, feen by very eminent anatomifts, are faid to run under the fkin of the penis. The nerves, which are very numerous, and very large, and accompany the arteries of the penis, arife from the great trunk of the fciatic nerve. But the bladder, rectum, and uterus, are fupplied by the lower mefenteric plexus, which arifes from the middle one, and defcends into the pelvis.

DCCCXXXIX. To diftend the penis, it is neceffary that the veins (DCCCXXXVII.) carrying back the blood from the cavernous bodies of the penis or urethra, be compreffed, or, at leaft, that a power be applied to the ultimate veins, which open every where into the cavernous bodies, hindering them from abforbing the blood brought there by the arteries. The firft may be in fome degree effected by the levator, drawing up the proftate and bladder; but, from the analogy of the nipples of the female breaft, of the gills of the peacock, of the blufhing of the face produced by the paffions of the mind, and of animals, all of which copulate in the fame manner, without any erector mufcle; of the erection in animals totally different in their ftructure from man, and

and especially of the very sudden erections in birds; from the very inaction of the erector muscles themselves during libidinous erection, and from their unfitness for compressing the veins; it is probable, that, independently of the muscles, the absorption of the blood by the veins may be retarded, and that it is affected by the multitude of deep seated nervous nooses, which being constricted by the force of pleasure, compress the veins, so that, being rendered narrower, they return less blood to the trunks than what is imported by the arteries, which are not only free from any stricture, but at the same time, by the increase of the pulse, are bringing the blood more quickly, which is an accessory cause. But the cause of this convulsion seems to exist in the nervous sphincters, since the penis becomes erected, both from mechanical irritation of the nerves, and that more subtile irritation caused by the imagination.

DCCCXL. To a continued and violent erection, an expulsion of semen at last succeeds, which requires much greater force than simple erection. For the semen is emitted when the irritation of the nerves is arrived at its greatest height: and in natural venery, when the cellular spaces of the urethra, which are later of being filled, and the continuous glands at last become turgid with blood, so that being distended with a large quantity of warm blood, they become stiff, and therefore the nervous papillæ, being erected, are violently affected by the cause of pleasure. The seminal vesicles are evacuated by the levator muscles of the anus, which press them against the resisting bladder, being excited either by voluptuous imagination alone, or by the excessive pruritus of the nerves of the glans, especially of its lower part, in the neighbourhood of the frenum. The semen is never discharged along with the urine, in a healthy man; because the expulsion of it requires the bladder to be shut; for, while

lax,

lax, it affords 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.

DCCCXLI. Soon afterwards, the ſenſible urethra being irritated by the ſemen, the powers conſtricting it are called into action. This is principally effected by the accelerator, (DCCCII.) which ſtrongly compreſſing the bulb and adjacent part of the urethra, propels the contents more ſwiftly, in proportion as the bulb exceeds in diameter the urethra. That this may act firmly, the ſphincter of the anus, and therefore alſo that of the bladder, muſt be contracted. The accelerator ſeems alſo to be the principal muſcle of erection, by compreſſing the veins of the corpus cavernoſum of the urethra. At the ſame time, the erectores penis, as they are commonly called, ariſing from the above tubercles of the iſchium, being ſtrong, and inſerted into the cavernous bodies, ſupport the penis, in a direction intermediate betwixt the tranſverſe and perpendicular. Thus the ſemen is projected into the vagina, and into the uterus itſelf, in prolific coition. This action is very violent, and comes near to a convulſion; whence it is wonderfully debilitating, and very much injures the nervous ſyſtem principally, as the maladies ariſing from thence ſeem to indicate, from the affection of the nerves, without which the ſemen cannot be expelled.

CHAP. XXVIII.

VIRGIN UTERUS.

DCCCXLII. THE uterus in woman 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 with its mouth inclining

clining a little forwards. In the female adult, it is contained within the pelvis; but in the infant, it rifes above it. In women, the peritonæum defcends from the os pubis into the pelvis, and proceeds for a confiderable way behind the bladder, to the bottom of the uterus. Then it afcends along the uterus; and a fecond time defcends on its oppofite fide, applied to it as far as the vagina, and the tranfverfe portion of the uterus, from whence, including the rectum with lunated folds, it ceafes to differ from the ftructure in man. But this fame peritonæum, coming into the pelvis from the iliac veffels, and being broader than the uterus, and adhering to its fides, and to the vagina; and being reflected along itfelf, divides the pelvis into two regions, the anterior and pofterior, like a partition, and is called the ligamentum latum. It is accurately connected with the uterus, without any intermediate fat, fo as to ferve it on all fides as an external coat. It does not hinder the uterus from being totally moveable.

DCCCXLIII. The body of the uterus is ufually diftinguifhed from its neck. The figure of the body is convex before and behind, with a degree of flatnefs, with acute edges, where its furfaces meet, converging at the fides, and moderately convex at the top. It has a peculiar fabric, of a clofe compact, firm, but fomewhat fucculent, cellular fubftance, in which we perceive mufcular fibres, efpecially in puerperal women. They are flat, and reticularly interwoven with each other, fome longitudinally difpofed along the uterus from the fundus to the os uteri, others arranged in various circles, and particularly in the fundus, and betwixt the tubes, and likewife in the neck near the mouth. In beafts, the uterus is manifeftly mufcular; and in women, likewife, it gives evident figns of a contractile nature. Its outer coat is received from the peritonæum. After repeated examinations, I have not found any mucous finufes, branching and varioufly dividing within

within the ſubſtance of the uterus, but veins ſurrounded with cellular ſubſtance, which do not collapſe. The internal membrane of the uterus is continuous with the cuticle; within the cavity, it is pulpy, and covered with ſhort flocculi; in the cervix, it is callous and valvular. The cavity of the uterus is ſmall, almoſt triangular, but bounded by lines convex inwardly; in the remaining part, it is a compreſſed cylinder. This part, which is called the cervix uteri, is cylindrical, compreſſed, and thick, and has alſo a cylindric cavity within. It is entirely rough, with callous wrinkles, extenuated to an edge, and inclined towards the vagina. Theſe recede from an anterior and poſterior line towards the ſides, and are joined by ſmaller wrinkles, in the intervals of which are mucous ſinuſes, as round globules are every where found in the upper part of the neck of the womb, filled with a very pellucid liquor, differing both in number and magnitude. It is not uncommon for the uterus to be divided by a middle projecting line. The cervix is terminated by the os internum uteri, having a tranſverſe ſlit, ſurrounded with tumid lips, drawn out into the vagina, and received within its blind extremity, projecting into it obliquely and forwards. It is full of mucus, and has mucous ſinuſes in its tumid edges.

DCCCXLIV. The triangular part of the uterus ſends out, from its lateral angles, canals, folded together by means of cellular ſubſtance, growing gradually broader, and, again a little contracted towards the extremity: their direction is at firſt tranſverſe towards the ovarium, and afterwards deſcending, but with ſome variation: they are termed the Fallopian tubes. Their external membrane is from the peritonæum; for they are included within the duplicature of the broad ligament: their internal membrane is wrinkled almoſt reticularly, mucous, and is extended to a greater length, in the form of ſpread fringes, folded longitudinally, which crown the orifice

fice of the ovarium, and are connected to the ovary. Betwixt the two membranes, is fome fpongy cellular fubftance, of a more flender texture than in the vas deferens. They ufually contain mucus, the origin of which is not known. There are alfo a great number of veffels interpofed, and perhaps fome mufcular fibres, but the latter are more obfcure. They are fupported by a proper fold of the peritonæum, which proceeds from the broad ligament.

DCCCXLV. The ovaries are tranfverfely fituated in the fame broad ligament, included in its duplicature behind the tubes, and conjoined to thefe tubes by a peculiar expanfion of the broad ligament, which is long enough to allow them a free motion. They are of an oblong figure, compreffed on each fide; their unconnected edge is convex, and femi-elliptical; but that which is connected with the ligament is ftraight. Their peritonæal membrane is thick, and almoft cartilaginous. Their fabric very much refembles that of the uterus itfelf; being clofe, white, and cellular, and without fat. The margin of the broad ligament, where it recedes from the uterus, becoming thicker, to fuftain the ovary, has fomething of a folid fubftance, refembling a ligament, but is not hollow, or a true canal.

DCCCXLVI. In the ovary even of a young girl, there are round veficles, confifting of a pretty ftrong pulpy membrane, and connected every where to the ovarium by cellular threads, which are filled with coagulable lymph; uncertain in their number, fifteen or more being found in one ovary; nor uniform in their fize. They are remarkable bodies, being found very widely diffufed through all animals, even in thofe which have but one fex.

DCCCXLVII. Laftly, the uterus fends forwards, from the fame lateral angles of its triangular body, a fafciculus, compofed of long cellular fibres and veffels,

veſſels, which, becoming ſmaller in its progreſs, goes out of the pelvis through the ring of the abdomen (DCCCXII.) into the groin, where it ſplits into branches, and ſeparates into ſmall veſſels, which communicate with the epigaſtrics. Has it alſo long fibres propagated from the uterus itſelf? I have not ſeen them ſufficiently diſtinctly.

DCCCXLVIII. The arteries of the uterus are from the hypogaſtrics; a conſiderable branch of which the uterine, like the loweſt to the bladder in men, ariſes from the umbilical trunk, or immediately below that trunk. It goes to the lower part of the uterus, almoſt at the termination of its neck, giving branches to the uterus, bladder, and rectum, and aſcending upwards, it ſends tranſverſe inflected branches to the uterus, makes numerous anoſtamoſes with the ſpermatics, and often gives arteries to the tube itſelf. Another plexus of branches tends downwards to the vagina, running along it a conſiderable way, although there is alſo a proper vaginal artery originating likewiſe in the pelvis, and ſometimes acceſſory branches from the meſocolic. There are alſo ſeminal veſſels which have the ſame origin as in men, and deſcend with a pampiniform plexus over the pſoas muſcle into the pelvis, and divide into two plexuſes. The poſterior goes to the ovary itſelf, with many twiſted ſurculi diſtributed through its ſubſtance and among the ova. The anterior both ſupplies the tube, and deſcends to the uterus, in which it is divided into winding branches upwards and downwards, ſome going to the bladder. Another artery, the middle hæmorrhoidal, from the trunk of the pudenda communis, accompanies the vagina a conſiderable way forwards, to which, and to the bladder and rectum, it is diſtributed. Moreover, the beginning of the vagina and the clitoris, have arteries from the external hæmorrhoidal, and the clitoris, like the penis, has both deep ſeated

and

and ſuperficial arteries, alſo inoſculating with a branch from the bladder.

DCCCXLIX. The uterine veins on the whole correſpond with the arteries, originating from the trunks of the hypogaſtrics; they are both internal as the uterine, the vaginal, and middle hemorrhoidal, and external as the circumflex, and thoſe of the clitoris. But they form 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 veſical veſſels, goes to the clitoris, as in men to the penis. They have no valves, except a few in the ſpermatics, which alſo, in a very large bundle, go to the ovarium, and the alæ veſpertilionis.

DCCCL. Within the uterus itſelf the arteries terminate in exhaling branches on its internal ſurface. In the puerperal ſtate they are elongated into pendulous tubes. Thus the veins of the uterus become at that time very large ſinuſes; for they are enormouſly enlarged, and open with very large mouths into the cavity of the uterus.

DCCCLI. Lymphatic veſſels are found in the uterus of brutes, and in women more rarely, though by very eminent anatomiſts.

DCCCLII. The nerves are ſupplied from the loweſt meſocolic plexus, united with thoſe of the ſacrum, and ſending large branches to the bladder, womb, and rectum; beſides which, ſome paſs through the broad ligament to the ovarium, and others from the nerve that goes with the veſſels to the clitoris, ariſing from the ſciatic trunk. But the ovary has alſo its proper nerves from the renal plexus, ſimilar to thoſe which go to the teſticles of the male. Thus all theſe organs, from the great number of their nerves, are extremely ſenſible.

DCCCLIII. What we have hitherto defcribed is common to all ages of the female; but about the 13th year, or fomewhat later, nearly at the fame time when femen begins to be formed in the male, a confiderable change alfo takes place in the female. For, at this time, the whole mafs of blood in the female begins to circulate with an increafed force, the breafts fwell, the pubes becomes covered; and at the fame time the menfes begin to flow, by a common law of nature; although in different countries, the time and quantity of blood difcharged is different.

DCCCLIV. This difcharge is preceded by various fymptoms in the loins, heavy pains, fometimes like colic pains, with an increafed pulfe, headachs and cutaneous puftules, and a white fluid commonly flows from the uterus. For now the fleecy veffels of the uterus, which have hitherto depofited into the uterus a milky fluid, of a very white colour in the fœtus, and in young girls ferous, now begin to be turgid with blood; and at laft to pour out the red cruor itfelf into the cavity of the uterus. This continues fome days, while, in the mean time, the firft troublefome fymptoms abate, and the orifices of the uterine veffels again gradually contracting, diftil only a little ferous moifture as before. But at uncertain intervals in young girls, gradually, however, fhortening to the end of the fourth week, the fame pains return, the fame flow of blood takes place, and this period is obferved to about the 50th year; though the diet, country, and conftitution, have much influence in this refpect. Pregnancy commmonly produces a ceffation of the menftrual difcharge.

DCCCLV. That this blood is difcharged from the veffels of the uterus itfelf, is demonftrated by actual infpection of women who have died during their courfes; of living women, in whom the uterus being inverted, has diftilled the blood from the os internum:

internum: and of others, in whom, from obstruction of the menses, the uterus has been filled with concreted blood; and by comparing the nature of the uterus itself, replete with soft vessels, and spongy with the thin, by no means villous, and callous vagina. Observation also shews, that this is good blood in an healthy and clean woman. However, there is nothing to prevent the blood from being discharged through the vagina, when the uterus is obstructed, as in other instances it is through the intestinum rectum, and lastly through the remotest parts of the body.

DCCCLVI. Since no animal certainly menstruates in the same manner as the human species, (although some animals distil blood from their genitals, in the season of their annual venery) and since the body of the male is free from this periodical discharge, the cause of this hemorrhagy, peculiar to the female sex of the human species, has been an object of inquiry in all ages. From the remotest periods, it has been ascribed to the attraction of the moon, which is known to raise the tides; by others, to a sharp stimulating fluid secreted in the female parts, also the cause of the venereal appetite. But its being caused by the moon is disproved, since there is not a day in which there are not many women subjected to this evacuation, and there are not fewer in the decrease than the increase of the moon. There is no such thing as any ferment near the uterus, but every thing is bland and mucous; and 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, many of them at that time being rather affected by pain and languor; and the seat of venereal pleasure is rather in the entrance of the pudendum than in the uterus, from which last the menses flow. Lastly, that the menstrual blood is forced out by some cause exciting the motion of the blood

againſt the veſſels, appears from hence, that, when retained, it has been known to break through all the other organs of the body, where no ferments were acting, the veins being even ruptured; nor is the effect of the retained blood confined to thoſe parts which pour out the venereal humour.

DCCCLVII. Nature has, in general, given women a ſofter body, leſs elaſtic ſolids, ſmaller muſcles, with a greater quantity of fat interpoſed betwixt their fibres, and ſlenderer bones, with ſmaller proceſſes. Moreover, the pelvis of the female is, in all its dimenſions, larger; the oſſa ilia more diſtant from each other; and the os ſacrum turned more backwards from the bones of the pubes, while the oſſa iſchii are ſeparated by a longer line; but above all, the angles in which the bones of the pubes meet is much larger: which differences are confirmed by the obſervations of the greateſt anatomiſts; and from neceſſity itſelf, which requires a greater ſpace for the greater number of viſcera in the pelvis. Moreover, the arteries ſupplying the uterus are very large, more ſo than in men; and their caliber is larger in proportion to their coats, and they are more lax in proportion to the veins: but the veins are, in proportion, leſs ample in the men, and of a more firm texture than in other parts of the body. From hence it follows, in the firſt place, that, in women, the blood is brought to the womb in greater quantity, and more quickly, through lax and ample arteries; and, in the ſecond place, that, on account of the rigidity and narrowneſs of the veins, it returns with difficulty from the uterus, and diſtends its veſſels.

DCCCLIX. The female infant, when firſt born, has ſmall lower extremities; and the greater part of the blood of the iliac arteries goes to the umbilicals, a ſmall portion only enters the pelvis. Hence the pelvis is ſmall, and little concave; and the bladder and uterus itſelf, with the ovaries, riſe above the pelvis.

pelvis. But, when the fœtus is born, and the umbilical artery is tied, all the blood of the iliac artery deſcends into the lower limbs and pelvis, which grow larger, and the pelvis becomes deeper and wider; ſo that by degrees, the womb and bladder ſink into its cavity, and are not ſo much compreſſed by the inteſtines and peritonæum, when the abdominal muſcles contract the lower parts of the belly. Then, when the growth is completed, or nearly ſo, the arteries of the uterus, and of the pelvis in general, which in the fœtus were very ſmall, have become very large, and are eaſily injected with wax; and all things are ſo changed, that the hemorrhoidal artery now forms the trunk of the hypogaſtric (DCCCXXXVI.) as formerly the umbilical had done. More blood, therefore, at this time goes into the uterus, vagina, and clitoris, than formerly.

DCCCLX. At the time when the growth of the body has almoſt ceaſed, and a large quantity of blood is prepared in ſound viſcera and in healthy conſtitutions, plethora takes place in both ſexes of the human ſpecies. In the male, it vents itſelf frequently by the noſtrils, from the exhaling veſſels of the pituitary membrane (CCCCLVIII.) being dilated to ſo great a degree, as to pour out the red blood, 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 paſſage, becauſe the very weight of the blood carries it downwards, and becauſe the uterine veſſels, now much enlarged, being placed in a lax ſituation in the ſucculent and ſoft cellular ſubſtance of the uterus, and being therefore very extenſile and exhaling by very ſoft flocculi, open into the empty uterus, and the blood finds almoſt a more eaſy paſſage that way, than into the correſponding veins; while in the ſame females, the arteries of the head are firmer and ſmaller in proportion. The return of the blood is alſo retarded, both becauſe the flexures of the

arteries

arteries, from the increaſed afflux of the blood, become more ſerpentine and fitter for retarding the motion of the blood, and 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, according to diſſections, are turgid; then in the arteries of the loins and in the aorta itſelf; now when the heart ſends a new torrent of blood into the veſſels already diſtended, its force is at laſt propagated to the ſerous veſſels of the uterus, ſo that they diſtil at firſt a copious warm mucus, then red ſerum, and laſtly pure blood. The ſame determination of the blood to the genital parts, forces out the hitherto latent hairs, increaſes the bulk of the clitoris, dilates the cavernous plexuſes of the vagina, and excites the appetite towards venery. Accordingly, the quantity of the menſtrual diſcharge is increaſed, and its firſt appearance haſtened by every thing that either increaſes the quantity of blood in general, or determines it particularly to the uterus; ſuch as joy, deſire, pediluvia, a full diet, warm climate, and lively temperament of body. It is diminiſhed by thoſe things which diminiſh plethora and the motion of the blood, as want, grief, cold atmoſphere, inactivity and preceding diſeaſes.

DCCCLXI. When ſix or eight ounces of blood have been thus evacuated, the unloaded arteries now exert their elaſtic force as all arteries do, and their diameters being contracted, they only tranſmit a thin fluid as at firſt. But the quantity of blood which the uterus diſcharged, being reproduced by the ſame cauſes, it is again excreted through theſe ſame paſſages, rather than through any other. Nor is it neceſſary to inquire, why this period is nearly menſtrual; for this depends upon the proportion which ſubſiſts between the quantity and momentum of the blood collected, and the reſiſtance of the uterus, which will at laſt gradually yield,

yield. Therefore this difcharge of blood returns fooner and does not wait for the interval of a month, whenever a greater quantity of blood is determined to the uterus in plethoric or libidinous women. They ceafe entirely to flow, when the uterus, like all the other folid parts of the body, has acquired fo great a degree of hardnefs, as cannot be overcome by the force of the heart propelling the arterial blood. This hardnefs in the uterus, in the arteries and ovaries, is fhewn by the knife and by injections. Animals in general have no menfes; on account of their uteri being membranous rather than flefhy, and if the firmnefs of their veffels, which is fo great, that in thefe animals no hemorrhage, either from the noftrils, or any other part, ever occurs. In men they do not occur, becaufe in their pelvis there is no fpongy organ fit for retaining the blood; and becaufe the arteries of the pelvis are both harder and fmaller in proportion than the veins, and thus the impetus of the blood is turned afide into the lower extremities, of which in men, the growth is greater, as that of the pelvis is lefs.

DCCCLXII. Why do the breafts fwell at the fame time? Their fabric in many refpects is analogous to that of the uterus; as appears from the fecretion of the milk in the breafts, which fucceeds the birth of the fœtus, and which increafes or diminifhes in proportion as the lochial flux diminifhes or increafes; from the fimilitude of the ferous liquor, found in the uterus, to the thin whitifh milk, in thofe, who are not lactefcent, which is very apparent in animals; and from the erection of the nipples by friction, analogous to the erection of the clitoris. Therefore, the fame caufes which diftend the veffels of the uterus, likewife determine the blood more plentifully to the breafts; the confequence of which is an increafe of the conglomerate gland of the breaft, and of the furrounding fat.

CHAP.

CHAP. XXIX.

CONCEPTION.

DCCCLXIII. WE now enter upon a very difficult ſubject; to inveſtigate what internal changes take place in woman, when the germination of the life of a new being begins within her, whom, in proper time, ſhe is to bring forth. We ſhall relate, in the firſt place, therefore, thoſe things which obſervation has proved; and then ſhall add thoſe hypotheſes by which learned men have endeavoured to ſupply whatever is not learnt from experience. How few things are aſcertained on this ſubject, and how difficult they are to be aſcertained, I have learned too much by experience.

DCCCLXIV. That ſome light may appear amidſt this darkneſs, we ſhall begin with the moſt ſimple animals, and afterwards notice what nature has added in others whoſe fabric is more compounded. The ſmalleſt animals then, which have very few or no limbs, very little diſtinction of parts, very ſhort period of life, the vital functions both few and very ſimilar to each other; theſe animals bring forth young ones like themſelves, with no diſtinction of ſexes, all of them being fruitful, and none fecundating the reſt. Some of them exclude their young whom they have conceived in their bodies, through ſome opening in their bodies; from others, ſome limbs fall off, which are completed into animals of a kind ſimilar to thoſe from which they have fallen. This kind of generation is extended very widely, and comprehends the greater part of animal life.

DCCCLXV. The next, which are a little more compounded, all parturiate; yet in ſuch a manner, that in their bodies is generated a certain particle, diſſimilar

ſimilar to the whole animal, and contained in ſome involucra, within which lies the animalcule that is afterwards to become ſimilar to that within which it is produced; theſe are called eggs. A great part of theſe animals is immoveable.

DCCCLXVI. The animals which follow, which are not indeed numerous, have both eggs and alſo male ſemen; ſo that both ſexes are joined in the ſame individual. By the male ſemen we underſtand that with which it is neceſſary for the eggs to be ſprinkled, in order to become prolific, although alone it never becomes a new animal. In this claſs, therefore, a juice is prepared by its own proper organs, which is poured on the eggs generated in like manner, in proper, but different organs.

DCCCLXVII. Thoſe animals are much more numerous which have both a male juice and female eggs; and yet are not capable of fecundating themſelves, but ſtand in need of real venery. For of this kind two individuals concur in the work of fecundation, in ſuch a manner, that each impregnates the other with its male organs, and reciprocally has its female organs impregnated by the male parts of the other.

DCCCLXVIII. And now the nature of animals approaches nearer and nearer to that of the human race; amongſt the individuals of which, though in other reſpects ſimilar, ſome have only male organs, and theſe males ſprinkle their ſemen on the female eggs of others. Many cold blooded animals affuſe their ſeed upon the eggs after they are excluded from the body of the mother. Warm animals inject their ſemen into the very uterus of the female. But now, whether eggs be generated within the body of the female, and the fœtuſes be produced incloſed in coverings, or whether the female carry the live fœtus ſo long in its uterus, until it produce them without any involucrum; the difference between theſe oviparous and viviparous animals

imals is ſo ſmall, that in the ſame claſs, and in the ſame genus, ſome animals lay eggs, and others live fœtuſes; and, laſtly, the ſame animal ſometimes lays eggs, and ſometimes brings forth live young.

DCCCLXIX. From this review of animals it appears, that all of them are produced from an animal ſimilar to themſelves; many of them 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 locomotive and more lively animals, having a compound ſtructure, only 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 preſervation of a leſs numerous progeny.

DCCCLXX. To this effuſion of the male juice into the female organs, both ſexes are excited by the moſt vehement deſires: the male indeed moſt ſtrongly; the female being always ready to ſuffer the venereal congreſs, it behoves the male to be animated with a deſire of venery, when he has abundance of good and prolific ſemen. Therefore, this circumſtance itſelf is the greateſt cauſe of venereal deſire in him; but in females, of the brute kind eſpecially, it is a certain degree of inflammation in the vagina, which excites an intolerable itching.

DCCCLXXI. But nature has added, for combining the energy of both, in women and in quadrupeds, to the uterus, a vagina or round membranous canal, very dilatable, which, embracing the mouth of the uterus, (DCCCXLIII.) deſcends downwards, and then downwards and forwards, lying under the bladder, add reſting upon the rectum to which it adheres, and, laſtly, opens under the urethra with an orifice a little contracted. This orifice, in the fœtus and in virgins, is protected from the action of the air or water, by a remarkable valvular fold, denominated the hymen, formed of the ſkin and cuticle of the vagina, probably for ſome moral purpoſe, as amongſt

amongſt all the animals I have examined, it exiſts only in the human ſpecies. It would be circular, if it were not incomplete under the urethra and even there it is not always deficient; toward the anus it is broader. Being gradually worn away by copulation, and lacerated, it at laſt diſappears. The caruncles, which are called myrtiformes, are partly the remains of the lacerated hymen, and partly the indurated extremities of the columnæ of the vagina; and, laſtly, the valves of the mucous lacunæ hardened into a kind of fleſh.

DCCCLXXII. The fabric of the vagina in women is cutaneous, and is compoſed of a firm callous cuticle, and a thick, white, nervous ſkin, in which, more eſpecially at its extremity, fleſhy fibres appear. Its internal ſurface is, in a great meaſure, rough with callous verrucæ, which, though hard, are ſenſible, and with inclined laminæ, terminated by a projecting edge, pointing downwards, and arranged ſo that they are collected into two principal columns, ſtudded as it were with theſe verrucæ, of which the uppermoſt and largeſt is extended under the urethra, and the loweſt is incumbent on the anus. From each of theſe, a valvular ſeries of ſmaller papillæ, variouſly inflected into arches, is continued till they mutually meet on both ſides. This fabric ſeems to be deſigned for the purpoſes of enjoyment, and for facilitating its expanſion. It is furniſhed with a peculiar mucus, from ſinuſes ſituated all over it, but more eſpecially in its poſterior and ſmoother ſide.

DCCCLXXIII. At the entrance of the vagina are prefixed two cutaneous appendages, called nymphæ, continued from the cutis of the clitoris, and from its glans itſelf, full of intermediate cellular ſubſtance, of a diſtendible fabric, jagged and furniſhed on both ſides with ſebaceous glands, ſuch as are alſo found in the folds of the prepuce of the clitoris. Their chief uſe, it is ſuppoſed, is to direct the urine, which

which flows betwixt them from the urethra, ſo as to turn it off from the body, which office is attended with a certain erection of the nymphæ. Theſe membranes deſcend from a cutaneous arch ſurrounding the clitoris, which is a part extremely ſenſible, and wonderfully prurient, and, like the penis, is compoſed of two cavernous bodies, ariſing from the ſame bones, and joined together, but without including any urethra. It is furniſhed with blood-veſſels, nerves, and levator muſcles, and a ligament ſent down from the ſynchondroſis of the oſſa pubis, analogous to thoſe in men: and in like manner from venery, the clitoris grows turgid and erect, but leſs in modeſt women; but from friction always.

DCCCLXXIV. The muſcle, termed oſtii vaginæ conſtrictor, ariſes on each ſide from the ſphincter of the anus, and being increaſed by an acceſſion from the os iſchium, covers the vaſcular plexus, and proceeds broadly forwards, along the beginning of the labia externa, and is inſerted into the crura clitoridis; it ſeems to compreſs the lateral plexuſes of the vagina, and to retard the return of the venous blood in both ways. The tranſverſe muſcle of the urethra, and the bundle from the ſphincter inſerted into it, have the ſame ſituation as in men.

DCCCLXXV. The female being invited either by moral love, or the deſire of pleaſure, admits the male, whoſe penis being introduced into the vagina, is rubbed againſt its ſides, until the male ſemen is ejected and thrown into the uterus. Thus, as we have obſerved of the male, (DCCCXL.) the friction of parts ſo tender and exquiſitely ſenſible, excites a convulſive conſtriction of all the parts ſurrounding the vagina. By theſe means, the return of the venous blood being ſuppreſſed, the clitoris, both the nymphæ, and the plexus ſurrounding almoſt all the vagina, become turgid, more eſpecially in

in libidinous women; the pleaſure is raiſed to the higheſt pitch: and, laſtly, though not always, or in all women, there is expelled, by muſcular force, (DCCCLXXIV.) a mucous lubricating liquor of various origin. The principal ſources of this are, in the firſt place, in the entrance of the urethra, where large mucous ſinuſes are placed in the tumid extremity of this uriniferous canal. Then, at the ſides of the urethra, in the bottom of the ſinuſes which are formed by the membranous valves being concave upwards, two or three large mucous ſinuſes penetrate into the ſubſtance of the urethra itſelf. 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 mucus from ſmall follicles.

DCCCLXXVI. But, by the ſame action which increaſes the pleaſure to the higheſt degree, and, therefore, cauſes a conflux of blood to the whole genital ſyſtem of the female, (DLXIII.) a much more important change is produced in the internal parts of the female: for, when the hot ſemen of the male penetrates into the ſenſible cavity of the uterus, which is itſelf turgid and heated with influent blood, the Fallopian tubes at the ſame time ſwell, being very full of diſtended veſſels, creeping betwixt their two coats, and now filled with a very great quantity of blood. In this ſtate, theſe tubes become red and rigid, and the fringed mouth of the tube aſcends, and is applied to the ovarium. All theſe changes are confirmed by diſſections of women, and other animals, and by morbid caſes.

DCCCLXXVII. But, in a female of ripe years, the ovary is extremely turgid, with a lymphatic coagulable fluid, with which the veſicles are diſtended. In a prolific copulation, ſome one of the riper of theſe veſicles burſts, and opens with a manifeſt cleft, and at length effuſes a clot of blood. Within this veſicle,

vesicle, after copulation, a kind of flesh is formed, at first flocculent, then granulous, and like a conglomerate gland, consisting of many acini joined together by cellular substance; which, by degrees, becoming larger and harder, fills the whole cavity of the vesicle, and is indurated till it acquire a scirrhous appearance, in which, for a long time, a cleft, or the vestage of one, remains. This is the corpus luteum, common to all warm blooded quadrupeds, in which some late anatomists have asserted, that there is a fluid before defloration; which, however experience does not admit, since there is no corpus luteum at that age. Nor is the vesicle, which becomes the human ovum, contained in the corpus as in a calyx.

DCCCLXXVIII. Moreover, in a prolific congress, the tube, compressing the ovarium, is supposed to express through a fissure in the outer membrane, a mature ovulum, and to absorb it, and then to transmit it to the uterus by a peristaltic contraction, which begins from the first point of contact, and gradually forces the ovulum towards the uterus, as is very manifest in animals. The truth of this is certainly supported by the fissure produced in the ovarium after conception; by fœtuses being certainly found in quadrupeds and in women, both in the ovarium and in the tube; and by 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, with certainty, in quadrupeds, unless after a long time. It is probable, that at the time of conception, the true ovum being almost fluid, very soft and pellucid, 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 fixed in it, and becomes the covering of the corpus luteum. But the accounts of ova,

said

ſaid to have fallen from women during the firſt days, are not certain, and are contradicted by the ſmallneſs of the fœtus obſerved many days after conception; by the ſhape which it was firſt obſerved to have, which is always oblong, and in brutes even cylindrical; and likewiſe by the ſmallneſs of the tube.

DCCCLXXIX. Theſe things are performed with pleaſure to the future mother, and not without a peculiar ſenſation of internal motion in the tube, and of a tendency to faint. Neither is the place of conception in the uterus, into which accurate experiments ſhow that the male ſemen reaches. For the power of the male ſemen fecundates the ovum in the ovarium itſelf, as is proved by the fœtuſes being found in the ovaries and tubes; by the analogy of birds, in which, by copulation, one egg indeed falls into the uterus, but many are fecundated at once in the ovarium. Nor is this inconſiſtent with the ſmall quantity of the male ſemen, or its ſluggiſh nature, which, by eminent anatomiſts, has been thought unadapted for performing ſuch a journey. For it is certain, that the male ſemen has filled the tubes themſelves after recent impregnation, both in women and other animals.

DCCCLXXX. The uterus indeed, certainly in animals, and in women probably, is cloſed after conception, leſt the very ſmall ovum, together with the hope of the new progeny, ſhould periſh. At that time the new mother ſuffers many diſagreeable affections, which probably ariſe from the abſorption of the ſubputrid and ſubalkaline male ſemen. Conception, almoſt like the ſwallowing ſome rancid egg, cauſes nauſea, eſpecially of fleſh meat, vomiting, the eruption of ſome puſtules, and pains in the teeth. The greater inconveniences I aſcribe to the ſwelling of the uterus, compreſſing the viſcera

of

of the abdomen, and to the retention of the menſes.

DCCCLXXXI. What we have hitherto ſtated, can certainly be confirmed or corrected by the teſtimony of our ſenſes. What follows is more conjectural, and more difficult, on account of the paucity of experiments, and their little agreement with each other. And, in the firſt place, it is a difficult queſtion, from whence do the rudiments of the new animal proceed? Are they derived 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 fœtus to both parents in animals, but eſpecially in plants, as confirmed by numerous experiments, and as the diſeaſes of parents are propagated to their children. But no ſemen has ever been obſerved with certainty in females; and innumerable examples of animals ſhow, that the ſpecies may be propagated without any mixture of ſeeds. Laſtly, the reſemblance to the father ſeems only to ſhow, that in the male ſemen there is ſome power, which can influence the form of the ſoft ſubſtance of the very minute embryo, juſt as the ſame power adds length to the pelvis in the body itſelf, dilates the larynx, and cauſes the horns to grow.

DCCCLXXXII. To the father ſome have attributed every thing; chiefly after the ſeminal worms, now ſo well known, were firſt obſerved in the male ſemen by the help of the microſcope, which are obſerved, with truth, to agree in figure with the form of the firſt embryos of all animals. But theſe animalcules are not proportionate to the number of the fœtuſes, and are not perpetual in the different tribes of animals; and they have too great a reſemblance to thoſe animalcules that are every where produced in other juices, which, though always tenacious of their own genus, are never found to grow

up

up into a totally different kind of animal, poffeffing limbs.

DCCCLXXXIII. Again, other anatomifts, not lefs celebrated or lefs worthy of credit, have taught that the fœtus exifted in the mother and maternal ovary; that the male femen excites it into a more active life, and likewife influences it varioufly, but that it finds it already exifting and prefent. For yolks are manifeftly found in the female ovary, even although they have not been fubjected to any male influence. But the yolk is an appendix to the inteftine of the chick; and derives its arteries from the mefenteric artery, and the membrane of the yolk is continued from the nervous membrane of the inteftine, which is continuous with the fkin of the animal. In the hen, therefore, the fœtus feems to be prefent along with the yolk, which is a part of it, and receives veffels from it. Laftly, the analogy of nature fhows, that many animals generate eggs without any connection with a male of the fame fpecies, but that no male animal is ever prolific without a female. There is a continued progreffion from the female quadruped to the oviparous, and from that to the non-oviparous. But the old animal produces the new one from part of itfelf. It is therefore certain, that the male is an appendage to that fex which produces the fœtus from its own body; which addition is neceffary in fome tribes of animals, but in the greateft number, and moft fruitful, may be wanted. Nor can any kind of ingrafting be admitted with any degree of probability, by which the dilated navel of the maleborn animal fhould cohere with the veffels of the female. For this navel is much too fmall at the time when the yolk is of confiderable fize; nor could the very fmall umbilical arteries be applied to the very large yolk with any hope of a continuance of the circulation.

DCCCLXXXIV. Thus much concerning the materials. But there is as much difficulty concerning the means by which 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 the fortuitous concourſe of atoms, the blind attractions of nutritive particles, and the action of ferments inconſcious of their effects. The ſoul is certainly unequal to the taſk of producing ſuch a beautiful fabric; and internal moulds, of which I never could conceive any clear idea, are to be referred to thoſe hypotheſes which the deſire of explaining thoſe things, of which we are unwillingly ignorant, has produced.

DCCCLXXXV. To me, indeed, the teſt of experiment ſeems to coincide with thoſe things which the mind itſelf foreſees will ariſe from their own cauſes. For hence, indeed, it appears to me certain, that the beautiful ſtructure of animals, ſo various, that it is always perfectly adapted to the proper and diſtinct habits and functions and manner of life of each; calculated by rules more perfect than thoſe of human geometry, and moſt evidently accommodated to foreſeen purpoſes, in the eye, the ear, and the hand, and finally, every where; can be aſcribed to no cauſe below the infinite wiſdom of the Creator. Again, the more frequently, and the more minutely, we obſerve the long ſeries of increaſe through which the ſhapeleſs embryo is brought to the perfection neceſſary for animal life, the more certainly does it appear, that thoſe things, which are obſerved in the more perfect fœtus, exiſted in the tender embryo, although the ſituation, figure, and compoſition, ſeem at firſt exceedingly different from what they appear at laſt; for an unwearied and laborious patience diſcovers the intermediate degrees by which the ſituation, figure, and ſymmetry, are inſenſibly corrected. Even the tranſparency of the primary fœtus alone conceals many things, which the

the colour afterwards added does not generate, but renders manifeſt to the eye. And it ſufficiently appears that thoſe parts, which eminent anatomiſts have ſuppoſed to be generated at a later period, and to be added to the primeval ones, were connate with theſe, though ſmall, ſoft, and colourleſs.

DCCCLXXXVI. It does not ſeem improbable, that the embryo, lying dormant during a long period, neither increaſes, nor is agitated, except by a very gentle motion of the humours, which we may ſuppoſe to oſcillate from the heart into the neighbouring arteries, and from theſe back again into the heart. But it is alſo probable, that the ſtimulus of the male ſemen excites the heart of the fœtus to greater contractions; ſo that it inſenſibly evolves the complicated veſſels of the reſt of the body by the impulſe of the fluid, and propagates vital motion through all the canals of the animal embryo; more quickly into ſome parts, and more ſlowly into 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 animals. In all animals, heat aſſiſts this evolution; in the more ſimple ones, whoſe veſſels are few, and leſs complicated in the variety of their origin, it alone effects it.

DCCCLXXXVII. Of the objections which are uſually brought, ſome are not true, as the difference of ſtructure cauſed by nævi; others ſeem to belong to cauſes depending on ſome accident, ſuch as moſt inſtances of monſters; ſome to the increaſe of ſome particular parts, occaſioned by the powers of the male ſemen; ſome to the cellular texture variouſly relaxed, ſo that it ſeems to form new parts; ſome to indurated juices. Although it is not eaſy to explain every thing mechanically, yet we ought to remember,

ber, that if indeed the new animal actually, and according to obſervation, exiſts in the egg, thoſe difficulties which are made cannot overturn things which have been truly demonſtrated, although perhaps ſome things may remain, to which, in the preſent infancy of human knowledge, we cannot yet give a ſatisfactory anſwer.

DCCCLXXXVIII. Some days after the human ovum is brought down into the uterus, we become more ſenſible of its changes. The ovum itſelf ſends out, from every part of the ſurface of its membrane hitherto ſmooth, ſoft branchy flocculi, which adhere to and inoſculate with the exhaling and abſorbing flocculi of the uterus (DCCCXLIII.) This adheſion takes place in every part of the uterus; but chiefly in that thick part which lies between the tubes, and is commonly 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 fœtus. Before adheſion, it is either nouriſhed by its proper fluid, or by abſorption, if indeed there is a time when it does not adhere.

DCCCLXXXIX. At this time, in the ovum, there are contained a great proportion of a watery fluid, coagulable by heat or alcohol, and limpid, and the fœtus, which is long inviſible, as I have never obſerved it before the 17th day, at firſt a ſhapeleſs maſs, conſiſting of mere mucus, and then cylindrical. When now ſome diſtinction of parts ſucceeds, it has a very great head, a ſmall body, no limbs, and is fixed by a flat ample navel to the obtuſe end of the ovum.

DCCCXC. From this minuteneſs the ovum increaſes in ſize, and alſo the fœtus, but in unequal proportions; for while the arterial ſerum is conveyed by paſſages, gradually more open, into the veſſels of the ovum, the fœtus itſelf grows the faſteſt, to which the greateſt part of the nouriſhment ſeems to paſs through

through the very large umbilical vein. At the ſame time, the ovum itſelf alſo grows, but ſlower, ſo that the proportion of the ovum, and the waters which it includes, to the fœtus, is perpetually diminiſhing. The flocculi of the ovum gradually diminiſh and occupy a ſmaller portion of the ovum, and are inſenſibly ſpread over with a continuous membrane, and only thoſe which ſprout out from the obtuſe end of the ovum increaſe, and are by degrees formed into a round circumſcribed placenta.

DCCCXCI. Such is the appearance of the ovum in the ſecond month; and after that period, it changes only in bulk. That portion of the ovum, in its upper part, next the uterus, making about a third of its whole bulk, conſiſts of a round, flat, ſucculent, fibrous, tuberous and perfectly vaſcular diſc, changed into equal and ſimilar tubercles, accurately, and often inſeparably connected, generally with the uppermoſt part of the uterus remarkable for its large veſſels, by thin cellular ſubſtance without fat collecting the veſſels, both generally, but chiefly in the circumference of the greateſt circle, and alſo by the exhaling arteries of the uterus, anſwering to the veins of the placenta, and by the arteries of the placenta, inoſculating with the large veins of the uterus. There, in the ſurface common to the uterus and placenta, a communication exiſts, by which the uterus tranſmits to the fœtus, both that ſerous liquor not unlike milk, and laſtly, as it ſeems, blood itſelf. This communication of fluids between the uterus and placenta, ſeems to be demonſtrated by the ſuppreſſion of the menſes in pregnant women, whoſe blood muſt be turned into another channel; from the loſs of blood which follows from the ſeparation of the placenta, eſpecially in a miſcarriage; and from the blood of the fœtus being exhauſted by hæmorrhagies from the mother; from hæmorrhagies that enſue from the unſecured navel-ſtring, while the placenta remains in the uterus, killing the

the mother; and, laſtly, from the paſſage of water, quickſilver, tallow, or wax, from the uterine arteries of the mother into the veſſels of the placenta, as obſerved, and lately confirmed by eminent anatomiſts. But that it is blood which is ſent into the fœtus, is evinced by the magnitude of the ſinuſes of the uterus and placenta; the diameter of the ſerpentine arteries of the uterus; the hæmorrhagy that follows the ſeparation, even the moſt gentle, of the placenta, and eſpecially by the motion of the blood, which, in a fœtus deſtitute of a heart, could only be given to the humours of the fœtus by the blood of the mother.

DCCCXCII. The remaining part of the body of the ovum, and likewiſe the convex ſurface of the placenta, are covered by an external membrane, which is villous, flocculent, reticulated, porous, eaſily lacerable, and vaſcular, reſembling a fine placenta, and is called the chorion. This alſo is connected to the flocculent and very ſimilar but ſofter ſurface of the uterus, by veſſels ſmaller than thoſe of the placenta, but manifeſtly inoſculated from the chorion into the veſſels of the uterus.

DCCCXCIII. Under the chorion lies a continuous white, opaque, and firm membrane, not vaſcular, which does not cover the part of the placenta contiguous to the uterus, but its concave ſurface contiguous to the fœtus. It coheres by cellular texture both with the chorion and amnios. The moſt ſimple name we can give it, is the middle membrane.

DCCCXCIV. The innermoſt coat of the fœtus, the amnios, is a watery pellucid membrane, very rarely having any conſpicuous veſſels, which, however, I have obſerved even in the human ſubject; extremely ſmooth, and in all parts alike; alſo extended under the placenta along with the former, and every where in contact with the waters. If there be more fœtuſes than one, either in woman or

in

in any other female, each of them has its proper amnios.

DCCCXCV. The nouriſhment of the fœtus from the beginning to the end of the conception, is without doubt conveyed through the umbilical vein. This gathering its roots from the exhaling veſſels of the uterus, (DCCCLIV.) and from the umbilical artery, with which it is manifeſtly continuous, and forming venous ſinuſes under the ſurface of the placenta, unites into a large trunk, which being twiſted in various folds, but leſs than its correſponding arteries, and being of ſufficient length to allow of a free motion; ſurrounded with cellular ſubſtance full of mucus; ſeparated by three partitions, and by the membrane which is continued from the amnios, but firmer, and known by the name of the umbilical rope; and ſwelling into ſeveral knots, enters the navel between diverging arches of the ſkin and abdominal muſcles, and proceeding to a proper ſinus of the liver, (DCXCII.) ſends the ſmaller portion of its blood through the ductus venoſus, which is ſmall and ſeated in the poſterior foſſa of the liver, to the vena cava; and tranſmits to the heart the greater part through the large hepatic branches which conſtantly ariſe from its ſulcus, and remain even in the adult, (DCXCV.) and through the branches of the cava, (DCXCVII.) continuous with theſe. The ſinus of the vena portarum, or left branch, is alſo a part of the umbilical vein, and its branches bring the blood from the placenta to the cava, while the right branch alone (DCXCV.) carries the meſenteric and ſplenic blood through the liver.

DCCCXCVI. But this is not the only uſe of the placenta: for the fœtus ſends great part of its blood to the placenta, through two very large umbilical arteries, which are the continuation of the aorta; and after giving off ſlender femorals, and very ſmall arteries into the pelvis, they aſcend reflected along the

the bladder, ſurrounded by the cellular plate of the peritonæum, and ſome fibres ſeparated from the bladder and urachus, and on the outſide of the peritonæum enter into the umbilical cord, in which, alternately ſtraight and contorted, with various windings, ſomewhat ſharper than thoſe of the vein around which they play, they arrive at the placenta, whoſe ſubſtance is entirely made up of their branches, and the correſponding veins, and lubricous cellular ſubſtance accompanying both veſſels; ſo that the acini themſelves, conſpicuous in the placenta, are convolutions of veſſels. This blood ſeems to paſs out through the arterial veſſels of the placenta into the bibulous veins of the uterus, ſo that after undergoing the action of the lungs of the mother, it returns ameliorated to the fœtus: For what other reaſon can be aſſigned for ſuch large arteries, which carry off above a third part of the blood of the fœtus?

DCCCXCVII. Is the fœtus alſo nouriſhed by the mouth? Does it drink from the cavity of the amnios, the lymphatic lubricating liquor, which is coagulable, unleſs when putrid, in which the fœtus ſwims, and whoſe origin is not ſufficiently known? Is this opinion confirmed by the analogy of chickens, which are neceſſarily nouriſhed from the contents of the egg only; by the abſence of a navel-ſtring in ſome fœtuſes; by the meconium filling the large, and part of the ſmall inteſtines; by the liquor found in the ſtomach of the fœtuſes of birds, and even of the human ſpecies, ſimilar to that which fills the amnios; by the proportionable decreaſe of the liquor amnii, to the growth of the fœtus; by coagulated fibres, found continued from the amnios, through the mouth and gullet, into the ſtomach of the fœtus; by hairs and true fæces being found in the ſtomach of the fœtuſes of quadrupeds; by the open mouth of the fœtus, which we have certainly obſerved; the gaping of the chicken, ſwimming in this liquor, and its attempts as if to ſwallow it?

What

What are the fources of this lymph of the amnios? Does it tranfude through the invifible veffels of the amnios? Is it tranfmitted to it through certain pores from the fucculent chorion, which is itfelf fupplied from the uterus? On every point, numberlefs difficulties occur; but it feems more probable, that this liquor is nutritious, efpecially in the early ftages of the fœtus, and that it is derived from the uterus.

DCCCXCVIII. The excrements of the fœtus are collected during that whole time in fmall quantity, on account of the great tenuity of the nutritious fluid, percolated through the very fmall veffels of the uterus. I frequently obferve, that the bladder is almoft empty in the fœtus. However, there is generally fome quantity of urine, collected in the large and very long urinary bladder. But in a great portion of the inteftines, there is collected a green pulp, poffibly the remains of the exhaling juices; for I have feen a fimilar fubftance in other cavities, that are filled with exhaling juices, and in the vaginal coat of the tefticle.

DCCCXCIX. Is there, then, no allantois? fince it is certain, that from the top of the bladder the urachus paffes out, which is a tender canal, at firft broad, covered by the longitudinal fibres of the bladder as with a capfule; and afterwards, when thofe fibres have receded from it, it is continued flender, but hollow, for fome way along the umbilical cord; in which, however, it vanifhes. Are not the other parts, though not yet feen in the human fpecies, fupported by the very ftrong analogy of brute animals, which have both an urachus and an allantois? But a proper receptacle, continuous with the hollow urachus, fo large in quadrupeds, has not yet been obferved in man with fufficient certainty, or not fufficiently often; and thofe eminent anatomifts, who have obferved a kind of fourth veffel, continued along the umbilical cord into a proper veficle, do not confider that veffel to be the urachus,

urachus, and very lately have referred it to the omphalomesenteric genus; and in the human fœtus, the urine is separated in a very small quantity: nor perhaps would it be an improbable conjecture, that some portion of the urine is conveyed from the urachus into the funiculus umbilicalis, and its spongy cellular fabric, and there effused; and therefore, that, of all animals, man has the longest umbilical cord, because he alone has no allantois. It is certainly short, and enters into the cord, but does not seem to reach the placenta. Sometimes, in the adult, it has remained open, and has contained urine even as far as the navel.

DCCCC. In the mean time, the fœtus grows; the tubercles of the limbs gradually shoot from the trunk; and the further most beautiful evolution of the child advances to perfection, in a manner which cannot be described here, and not yet sufficiently by anatomists; of which, however, we must premise a short account.

DCCCCI. The embryo which we first saw in the uterus of the mother, was gelatinous, having scarcely a definite form, of which one part could not be distinguished from another. There was, however, in that gluten, a heart, the source of life and motion; there were vessels which generated the liquor of the amnios; there were therefore umbilical vessels, and the trunks of the yolk, which it receives from the fœtus, are largest when they first become visible. There was both a head and spinal column, each of them very large, and larger in proportion than at any other time. There were likewise, without doubt, the rest of the viscera, but in a mucous and pellucid state; for which reason, they may be observed sooner than is to be expected naturally, by rendering them opaque.

DCCCCII. But in every part of the fœtus, a very large proportion of water is mixed with a very little earth, so that the very cellular texture is in an intermediate

intermediate ſtate between fluid and ſolid; from large drops of water being interpoſed between diſtant ſolid elements.

DCCCCIII. In birds, beſides this living gluten, there is the albumen, which is of a lymphatic nature; and the yolk, which is oleaginous: in man, there is a lacteous fluid, not very unlike the yolk, and coagulable lymph. That the blood is prepared from the fat by the proper powers of the fœtus, we are perſuaded from the example of birds. From it, are gradually prepared the other humours, and all of them are at firſt mild, void of taſte, colour and ſmell, and of a glutinous nature. The peculiar nature of each ſupervenes, at a later period, in ſome of them not till many years after birth, for inſtance in the ſemen.

DCCCCIV. The elementary ſolids, even in the adult, conſtitute much the ſmalleſt portion even of the harder parts of the human body; in the fœtus they differ from the fluids, only by a ſomewhat greater degree of coheſion, reſembling, as yet a gluten, at firſt fluid, and afterwards of greater conſiſtence. In this, the fibres, of which none were to be diſtinguiſhed in the primeval embryo, are by degrees produced, by the gluten, as it ſeems, being compreſſed between the neighbouring veſſels, part of the water expreſſed, and the earthy elements attracting each other. Theſe fibres variouſly comprehend one another, and form cellular texture, even morbidly, and intercept little ſpaces, in which a fluid is contained. Of this cellular ſubſtance, are formed the membranes and veſſels, and almoſt the whole body.

DCCCCV. The veſſels are prior, and exiſt, formed in the firſt appearance of the embryo. What firſt appears diſtinct, and formed in an egg during incubation, are venous circles: but theſe veins ſuppoſe arteries, by which they both receive their fluid, and the motion of that fluid. They are not generated mechanically,

mechanically, from any obſtacle to the courſe of the arterial blood. The trunks of the veins are firſt viſible, and afterwards the branches which lead to theſe trunks. If they were produced from reflected arteries, the branches would firſt be ſeen, and the trunks formed in the laſt place. Nor could the arterial blood, if repelled by an obſtacle, form thoſe moſt beautiful circles, and veſſels returning into the heart; but it would rather be irregularly diffuſed through the cellular texture. And the primeval heart would ſoon loſe its vitality, unleſs as much fluid returned to the heart by the veins, as was ſufficient to maintain its pulſations.

DCCCCVI. There are, therefore, in the primeval fœtus, when it firſt becomes viſible, ſome things more perfect and conſpicuous; others involved, inviſible, and very ſmall. The heart is the moſt perfect, and the only moveable and irritable part; although it is in many reſpects different from what it is in the adult. The brain is large and fluid; the veſſels formed, which appear in the back, next to the heart. We cannot yet diſtinguiſh the viſcera, muſcles, nerves, limbs; the bones themſelves, of which the firſt appearance is mucous, or the veſſels of the reſt of the body. The other portion is the abdomen, of which the umbilical capſule is an immenſe hernia.

DCCCCVII. To this embryo is ſuperadded motion, in man almoſt of the heart alone; and alſo in birds, whoſe formation does not take place without a heat rather greater than that of the human body: yet, without the heart, heat deſtroys, inſtead of forming the fœtus. The heart is proportionally largeſt at the very firſt, and afterwards decreaſes more and more in compariſon with the reſt of the body. Its pulſations are alſo at this time very frequent, and in the very ſoft fœtus extremely powerful, in impelling the humours, and diſtending and producing the veſſels.

DCCCCVIII.

DCCCCVIII. To the force of the heart is oppofed, what neverthelefs is of fervice in the formation of the fœtus, the vifcidity of the vital humours which unite the earthy elements. There is therefore in the embryo both an impelling force, which increafes the longitudinal growth ; and a refifting force, which moderates that increafe, and increafes the lateral preffure, and thus the diftention. By the force of the heart all the arteries, or for eafinefs of expreffion the artery, which reprefents all the reft, with all the furrounding cellular texture, is lengthened out ; its folds are fmoothed out. It is alfo dilated. And the blood by its lateral preffure makes an effort againft the almoft impervious branches of the arteries, fills and involves them, and fets them off at more obtufe angles : thus are produced fpaces, having little refiftance, into which the gluten is depofited. In the very fubftance of the artery, while it is every where dilated, between its imaginable folid threads, are prepared little reticulated fpaces like the interftices of a diftended net, which are alfo adapted for receiving humours. Thefe are larger round the heart and in the head, whither the impulfe of the heart is more direct, and in the placenta : they are fmaller in the inferior part of the body, from which the umbilical arteries fubtract the greateft part of the blood.

DCCCCIX. The fœtus increafes very quickly, as is moft evident in the example of the chick in ovo, whofe length on 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 its increafe in the egg during the firft day. For the fœtus has a larger and more irritable heart, veffels larger in proportion, and likewife more numerous and relaxed, and its folid parts are mucous and diftenfible. The breaft is later formed, and furrounded

ſurrounded with membranes ſo ſoft, that they cannot be ſeen.

DCCCCX. The embryo does not only increaſe in bulk, but is remarkably altered in every particular, ſo that it is brought forth totally diſſimilar from what it was, when it firſt became viſible. And firſt it is probable, that from the production of the arteries of the limbs, the limbs connected to the ſides by ſome gluten are ſeparately evolved, and that at firſt they ſprout out very ſhort, but afterwards become gradually longer, and divided into diſtinct articulations, as the wings of a butterfly are expanded by the extenſion of a network of veſſels. Thus likewiſe the right ventricle of the heart is expanded by the blood coming to it in greater quantity; and, being increaſed by degrees, becomes equal to the left.

DCCCCXI. On the other hand, the cellular texture, from its glutinous aqueous nature, becoming gradually harder by the addition of earthy particles; by a gentle attraction contracts the parts, which were before ſtraight, into various flexures; and unites the auricles to the heart, from which they were hitherto ſeparate. Thus the muſcles, by their action, draw out the proceſſes from the bones, and dilate the ſmall cavities into large cells: and likewiſe incurvate the bones, and variouſly modify their ſhape.

DCCCCXII. Preſſure has much influence: to it is attributed the deſcent of the teſticles into the ſcrotum, after the abdominal muſcles acquire irritability; to it the repulſion of the heart into the breaſt, when the integuments of the breaſt become larger: to it alſo the lengthening of the breaſt, the ſhortening of the abdomen, and the leſſening of its viſcera, when the air received into the lungs dilates the cavity of the thorax. But even the bones are variouſly depreſſed by the preſſure of the muſcles, blood-veſſels, and even of the very ſoft brain itſelf; and

and by the ſame means fleſh is changed into tendon.

DCCCCXIII. The power of derivation brings the blood into the pelvis and lower extremities, from the cloſed umbilical arteries: when the foramen ovale is contracted by the auricles drawn towards the heart, it evolves the right ventricle of the heart: when the veſſels of the yolk have occupied the whole length of the egg, and can receive no further elongation, it dilates the umbilical arteries of the chick, and produces a new membrane with incredible celerity. On the contrary, but by the ſame power, after the blood has acquired a new facility of admiſſion into any veſſels, the other parts, to which its paſſage is not equally eaſy, increaſe leſs quickly. The growth of the head is ſlower after the lower limbs have begun to increaſe.

DCCCCXIV. By the evaporation of the thinner part of a fluid, a membrane may be formed, as in the example of the epidermis: or cartilage, as happens in the bones: or bone itſelf, or ſomething of a ſtony nature, which happens very frequently in the ſhells of aquatic animals. The bones at firſt are ſoft, and of a mucous nature; then they acquire the conſiſtence of jelly; and this afterwards becomes a cartilage, without any change of parts, as far as can be obſerved.

DCCCCXV. Cartilage, however, is not ſo imperceptibly converted into bone. It never happens, without lines and furrows having previouſly marked the cartilage; without the red blood making a paſſage for itſelf into the veſſels of the bones; without theſe veſſels manifeſtly penetrating from the nutritious trunks into the interior of the bone, and impinging 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 are formed cellular texture and laminæ, which the veſſels themſelves ſeem to compreſs into

into a medullary tube. Laſtly, in the epiphyſis, which both remains cartilaginous, and denies entrance to the blood much longer, the red veſſels penetrate through the extreme cruſt, as alſo others which come from the exterior veſſels of the limbs. Thus alſo in the epiphyſis is produced a red vaſcular nucleus, which, being gradually increaſed by veſſels ſent out from its ſurface, converts the reſt of the cartilage into a bony nature.

DCCCCXVI. In theſe long bones, it ſeems evident, that their growth is owing to the arteries being elongated by the force of the heart, and gradually extended to the extremities of the bones: and that the hardneſs is owing to groſſer particles, depoſited in the cartilage, after its veſſels have admitted the red blood. But even a bony callus never becomes ſound, till newly formed red veſſels have penetrated its ſubſtance.

DCCCCXVII. The flat bones originate from a kind of membrane. Over this, the fibres ſpread themſelves, at firſt in a looſe network, and afterwards more denſely, having a membrane for their baſis; the pores and intervals between theſe fibres being gradually contracted and filled with a bony juice, at laſt convert it into perfect bone. In theſe bones alſo, ſtraight red veſſels, are diſtributed between the fibres.

DCCCCXVIII. The phenomena of the formation of callus, prove, that, between the primeval fibres, an oſſeous fluid, replete with groſſer particles, is depoſited, as it exudes in ſmall drops, not from the perioſteum, but from the inmoſt ſubſtance of the bone, and gradually becomes indurated. But even chemical analyſis extracts that gluten from the bones; and in anchyloſis, it appears poured around in the manner of conſiſtent 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

of madder adhering to it, manifeſtly diſtinguiſhes it by its colour.

dcccxix. The perioſteum covers the bones, as membranes the viſcera; and from it cellular productions follow the interior veſſels of the bones: but the perioſteum has neither ſtraight fibres, nor the habit of alveoli or laminæ, nor red veſſels, while the bone in the egg is indurating; nor does the perioſteum at all adhere to the bone, except in the epiphyſis, when its bony nature is ſpreading from the middle; and it is thinneſt when the bone is in a cartilaginous ſtate, afterwards it becomes every where complete. In the flat bones, it every where affords a baſis for the bony fibres.

dccccxx. Therefore the head is large, every where membranaceous, and, in the firſt days of geſtation, cartilaginous in few places, the mouth deep, and the jaws long; alſo, in the mature fœtus, there are the rudiments of the teeth, to which a great deal of membrane is attached: the brain is at firſt fluid, and always ſoft; it is alſo large; and the nerves are large: the eyes are large, and the pupil is ſhut by a membrane: the breaſt is very ſhort, but expanſile, on account of the great quantity of cartilage: the belly is large, and incloſed with membranes: the liver very large: the bile is inert and mucous: the inteſtines are ſlowly irritable, and, when the fœtus is ripe, are full of green ſoft fæces: the kidneys are divided into lobes, and large, and renal capſules very large: the pelvis is very ſmall, ſo that the ovaries, the bladder, and Fallopian tubes project above it: the genital ſyſtem is denſe, not yet evolved, or ſecreting its fluids: all the glands are large, eſpecially the conglobate glands, and full of ſerous fluid: the ſkin is at firſt pellucid, and afterwards covered with a ſoft cuticle, and ſebaceous ointment: the fat is gelatinous, and afterwards grumous: and the tendons ſoft, ſucculent, and not yet ſhining.

dcccccxxi. There is a great difference betwixt the circulation of the blood in the fœtus and in the adult: that this may be underſtood, it is neceſſary to deſcribe the organs by which it is preformed. The firſt is the thymus, a ſoft looſe gland, conſiſting of many lobes, collected into two larger upper proceſſes, 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 fœtus, and occupies a great part of the breaſt: it is ſeated in the cavity of the mediaſtinum, and in 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. In the adult, being compreſſed by the enlarged lungs, and by the aorta now become larger, it gradually diſappears. Of the uſe of this gland or its liquid, we are altogether ignorant; although all the other glands, eſpecially the conglobate ones, are alſo larger in the fœtus, as we have juſt now obſerved.

dcccccxxii. We have ſaid, that the cavity of the breaſt is ſhort, being compreſſed by the enormous bulk of the liver; the lungs are ſmall in proportion to the heart, and ſolid ſo as to ſink in water, when completely excluded from the air, by being ſurrounded with water. Since, therefore, previous to reſpiration, the lungs cannot tranſmit ſo great a quantity of blood as they do in the adult (ccxcii. ccxcvii.) in the fœtus there are therefore other ways prepared, by which the greateſt part of the blood paſſes from the umbilical vein and lower cava, into the aorta, without entering the lungs. In the primeval fœtus there is no right ventricle of the heart; and the communication between the right auricle and the left is ſo large, that all the blood which comes by the vena cava paſſes immediately into the aorta, a very ſmall quantity excepted, which goes to the very ſmall and inviſible lungs. Afterwards, in the fœtus, now grown bigger, the lungs are indeed

deed larger, and the paſſage from the right part of the auricle into the left is narrower, ſince the auricular canal is now taken entirely within the heart, and the auricles themſelves are become much ſhorter. But yet the ſeptum, which is common to the right and left auricles, is perforated with a large foramen ovale, through which the blood coming from the abdomen, and a little repelled by the valvular margin of the right auricle, (LXXXIII.) flows in a full ſtream into the left ſinus. But by degrees the membrane of each ſinus is elevated backwards, and is connected with the pulmonary ſinus, above the oval foramen, by an upper fibre on each ſide, and then by many lower palmated ones in ſucceſſion, ſo as to cloſe up at firſt a ſmall part, and afterwards the greater part of this foramen; ſo that only a tranſverſely oval oblique paſſage is left, which remains free betwixt the round margin of the ſaid oval foramen, and the increaſing veſſel in the mature fœtus, equal to about a fifteenth part of the mouth of the vena cava.

DCCCCXXIII. That the blood takes this courſe, and that no part of it, on the contrary, flows from the left ſinus into the right, is conſiſtent with every fact. For, the column of blood in the right ſinus is very large; for it is impoſſible there ſhould be a larger, as it brings back the blood from the whole body; and the left auricle contains leſs blood than the right, as part of it flows through the ductus arterioſus, whence it is alſo much leſs than the right: moreover, the valve in the mature fœtus is ſo large, and placed ſo much to the left of the iſthmus or muſcular arch (DCCCCXXII.) that when impelled from the left ſide, the valve, like a ſhutter, cloſes up the foramen; but being impelled from the right ſide, it readily gives way, and tranſmits either blood or flatus, and even retains flatus itſelf, when blown from the right, and does not ſuffer it to return to the right ſide.

 DCCCCXXIV.

DCCCCXXIV. Moreover, but a ſmall portion of that blood which entered the right ventricle paſſes to the lungs: for the pulmonary artery, being in the fœtus much larger than the aorta, is continued in a ſtraight line into the ductus arterioſus; which is larger than the joint caliber of both the pulmonary branches, and greatly larger than the opening of the foramen ovale, and which enters into that part of the aorta which firſt comes in contact with the ſpine, under its ſubclavian branch: by which means it transfers more than half the blood of the pulmonary artery to the deſcending aorta, which muſt otherwiſe have paſſed through the left ventricle into the aſcending branches of the aorta; and this is the reaſon why the aorta in the fœtus is ſo ſmall at its coming out from the heart. By this mechaniſm, therefore, the lungs are relieved from preſſure, and a great part of the blood flows in a more direct courſe to the umbilical arteries, and the powers of both ſides of the heart are united in propelling the blood of the aorta.

DCCCCXXV. Thoſe who have aſſerted that the fœtus reſpires in the uterus, having made very few obſervations, have neglected that moſt eaſy one which is derived from the water, in the middle of which the fœtus ſwims, and likewiſe of the lungs, which in a fœtus are conſtantly heavy, and ſink in water; and, laſtly, the evident ſhortneſs of the breaſt, and ſmallneſs of the lungs. Whether it can take in air during its ſhort paſſage through the vagina, is more difficult to determine; and I ſuſpect, that in a certain ſituation, a healthy fœtus, not too much compreſſed, may ſometimes inſpire, while it is in part ſtill impacted between the parts of the mother.

DCCCCXXVI. The uterus increaſes conſtantly along with the fœtus; the ſerpentine arteries of which it is compoſed being extended, and rendered ſtraight, by the blood impelled into them; the veins being unable

unable to return the blood into their trunks compreſſed by the great bulk of the uterus, and ſwelling out into immenſe ſinuſes; and laſtly, the menſtrual blood, being retained in the uterus, and not entirely ſpent on the ſtill ſmall fœtus. Its thickneſs continues the ſame, becauſe the greater quantity of blood in the arteries and veins compenſates for the extenuation of its ſolid parts. The fundus or upper part, eſpecially, increaſes; ſo the tubes now deſcend from the middle of the gravid uterus. The uterus, therefore, riſes out of the pelvis, even as high as the colon and ſtomach itſelf, and compreſſes the abdominal viſcera, and the bladder and rectum. The os uteri in the firſt months of geſtation is drawn upwards along with the uterus, and recedes from the entrance of the vagina: after the third month, however, it again deſcends and immerges into the vagina. The ſame becoming perpetually ſhorter, projects into the impervious extremity of the vagina: for it is conſtantly becoming more tender; and, from that cartilaginous hardneſs which it has in the virgin womb, it is relaxed into a mucous ſoftneſs. Never perfectly cloſed together, it is covered and defended from the air by the mucus of the ſinuſes, and perhaps by that of the veſicles which are ſeated in the cervix uteri. Finally, the cervix, which remains long unchanged, at length, during the laſt months of geſtation, becomes likewiſe ſhort, and its opening becomes flat and broad, without length; and towards the time of delivery, is always, more open. At the ſame time, the fœtus increaſing, which in the firſt months had no certain ſituation, and about the middle of the time of geſtation, was often rolled together into a globe, ſo that the head lay betwixt the knees, ſinks its ponderous head more and more into the pelvis, and directs it towards the cervix uteri.

DCCCCXXVII. The various complaints in the uterus are now increaſed to the higheſt degree. Being diſtended

diſtended by the blood retained in it, all its nerves are irritated; for nothing is more diſagreeable to man, than exceſſive tenſion, unleſs it occurs very gradually. From the head of the fœtus, ſunk into the pelvis, the rectum, bladder, and that part of the uterus next to the neck, and the moſt ſenſible, are preſſed, and become painful: the fœtus, having acquired its full bulk, diſtends the uterus every way; and with greater uneaſineſs, becauſe, the waters being now taken away, the projecting limbs, and the head, preſs much more ſtrongly on the uterus. It is alſo thought, that the placenta itſelf, now very large, diſtends the naked internal ſurface of the uterus. From theſe cauſes, ariſe at firſt tranſient efforts of the irritated uterus, to free itſelf; and at laſt, when theſe cauſes have got to their utmoſt height, an uneaſy ſenſation is occaſioned by the impacted head of the fœtus, like that which ariſes from a collection of fæces in the rectum; by which pain, therefore, the mother is forced to attempt the birth of the child. The time of delivery arrives at the expiration of nine ſolar months, and is in the ſame manner defined in every ſpecies of animals, although by particular cauſes it may be accelerated or retarded for ſome weeks, provided theſe cauſes be aſcertained, and their power not extended too far.

DCCCCXXVIII. Tormented by teneſmus, now become intolerable, the mother exerts the whole effort of a very deep inſpiration, by which the viſcera of the abdomen being forced downwards, preſs upon the uterus, (DCCLVI.) while, at the ſame time, the womb itſelf, being contracted by its contractile force, urges the fœtus, ſo as ſometimes to exclude it, without any efforts of the mother. The difficulties of the birth, however, are evidently overcome principally by the efforts of the mother, when the mouth of the uterus, now very ſoft, ſuffers itſelf to be diſtended by the head of the fœtus. For the amnios, filled with water, protruded in the form of a cone,

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by the head of the fœtus, dilates the os internum uteri, becomes extenuated, and diſtended, and burſts; the waters eſcape, which lubricate the paſſage of the vagina, and relax all the parts. Then the naked head of the fœtus, with the face turned towards the os ſacrum on account of its weight, and being urged forwards, like a wedge, dilates the os uteri; till, by a very powerful effort of the mother, the bones of the pubes being often ſomewhat looſened with intolerable pain to the mother, and tremor of the whole body, the head is preſſed out, and advances through the dilatable vagina, which is not very much compreſſed by any bone; and the fœtus is brought forth, with difficulty even in quadrupeds, but moſt difficultly in the human race, whoſe fœtus has the largeſt head.

DCCCCXXIX. It is natural for women to have but one child at a birth, which law they have in common with all the larger animals, except the carnivorous. Frequently, however, they have two, more rarely three, and never more than five. It is not to be doubted, that a ſecond fœtus may be conceived, while the firſt remains in the uterus; ſince women have frequently born children, in whoſe uterus a hard and oſſified fœtus had been long retained.

DCCCCXXX. The placenta, connected with the fundus uteri, (DCCCLXXXVIII.) is generally ſeparated without difficulty in a mature birth, by weaker throes of the mother, and by the art of the midwife. Thus the flocculi of the placenta are drawn out from the villi of the womb, a conſiderable flow of blood takes place, and the mother is delivered of the ſecundines. At the ſame time, the umbilical cord is tied; for it cannot be left open in a healthy and lively child without danger; and is cut. Thus the umbilical vein is deprived of its ſupply of blood, and an inſuperable obſtacle is oppoſed to the arteries of the ſame name.

DCCCCXXXI.

DCCCCXXXI. The uterus, which hitherto had been exceſſively diſtended, now contracts itſelf by the power of its elaſtic fibres, (DCCCXLIII.) ſo ſuddenly and powerfully, as often to catch the hand of the deliverer, and the placenta, if it be not ſoon looſened. Thus, the veſſels are compreſſed, alſo contracting to a leſs ſize by their own power; whence the large quantity of blood that was collected in the uterus, is expreſſed and flows out under the denomination of the lochia; at firſt pure blood, but afterwards, as the veſſels contract themſelves more cloſely, it becomes yellow, and afterwards white; and the extenſive wound of the uterus is healed, which ſoon ſhrinks to a bulk not much exceeding that of the virgin uterus.

DCCCCXLIV. But two or three days after delivery, when the firſt violence of the lochial diſcharge has abated, the breaſts ſwell conſiderably; and as in the time of geſtation they yielded a little ſerum, they now become turgid, at firſt with a ſerous, thin fluid, which is ſoon followed by the 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, grows ſour ſpontaneouſly, but is tempered by the addition of oil and lymph, and is compoſed of an odorous volatile halitus, a good deal of fat, water, viſcid cheeſy matter, and an earthy ſubſtance rather alkaleſcent; by faſting ſome time, from the chyle being then converted into ſerum, the milk becomes ſalt, alkaleſcent, and diſpleaſing to the infant. Like the chyle, it frequently retains the nature of ſome kinds of aliments and medicines. The cauſe of this increaſed ſecretion in the breaſts, ſeems to depend on revulſion, and to ſucceed the ſuppreſſion of that plentiful uterine ſecretion by which the fœtus was nouriſhed; as diarrhœa ſucceeds ſuppreſſed perſpiration. For it has been obſerved, that true milk has been diſcharged from other parts, and

and even through wounds. And there is besides 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 pregnancy, manifestly generates it. But the inosculations betwixt the mammary and epigastric arteries, though true, are so small, that in this nothing is to be ascribed to them.

DCCCCXLV. The breasts are composed of a very large quantity of very soft and very white surrounding fat; and of a conglomerate convex gland, consisting of round, hard kernels, of a reddish blue colour, surrounded externally, and connected together, by firm cellular substance, separating into smaller acini; which structure is common to men and women. To these glands many vessels are distributed from the internal mammaries, from the external thoracics, and lastly from the humeral artery, all which mutually inosculate near the nipple. The trunks of the mammary arteries, but not the mammales, inosculate with the epigastric vessels; the veins more evidently. The nerves, both large and numerous, as in cutaneous parts, are derived from the nerves placed between the upper ribs.

DCCCCXLVI. From the middle of this gland of the breast, and likewise from the surrounding fat, from an infinite number of roots, numerous, very slender, soft, white, and dilatable ducts arise, which converge on all sides to the nipple in the centre, both into the circle which subtends its base, and into the area of that circle, and emerge into the root of the nipple. This is a cavernous cellular body, into which the blood may be effused, so as to cause erection, as in the penis. This papilla is perforated by twenty or more excretory ducts from the breast, called lactiferous; between which there is not any inosculation, and which are much narrower in the nipple, than before: and in the flaccid state of the nipple, are compressed, wrinkled, col-

lapsed,

lapsed, and shut; but when the nipple is erected by any kind of titillation, they become straight and have patulent mouths, lying betwixt the cutaneous wrinkles. This papilla is surrounded by a circle furnished with sebaceous glands, which defend the tender skin against attrition and perpetual moisture.

DCCCCXLVII. This is the first food of the infant, and at other times also is exceedingly salutary to man. This the infant knows how to take, before it has attempted to perform any other function of the body. Taking the nipple in its mouth, it causes it to swell by gentle vellications, and presses it with the lips, that no air may enter betwixt them; at the same time, it inspires and forms a space in its mouth, in which the air is rarefied; and thus, the pressure of the air, and the compressing force of the lips of the infant, emulges the milk from the nipple, from which, on account of its quantity, it is moreover disposed to flow spontaneously; and the infant sucks, and is nourished. The first serous milk, termed colostra, loosens the bowels of the young infant, and evacuates the meconium, (DCCCXCVIII.) to the great advantage of the child. Yet, even independent of the fœtus, simple titillation erecting the nipples, and increasing the afflux of blood, has produced a flow of milk, even from virgins, old women, and men. Milk is only generated after puberty; before that time a serous humour flows from the breast; and for the most part it is first generated about the middle of pregnancy. After the menses have ceased, the breasts, as well as the uterus, being grown effete, cease to perform their office.

DCCCCXLVIII. But great changes happen to the infant when born. The first is respiration, which it attempts even within the vagina of the mother; being probably excited, by various pain and anxiety, to those cries with which it salutes the light, and

perhaps

perhaps by the deſire of food which is obtained from the ſtore of the amnios: therefore, it draws air into its lungs, and dilates them, till now, ſmall and full of ſerous humours, and changes them from being of a deep red colour, ſmall, ſolid, and ſinking even in ſalt water, into a ſubſtance, which is light, ſpongy and floating, large, full of air, and almoſt of a white colour: therefore, the blood enters more eaſily into theſe enlarged and looſe lungs, (cclxv.) in conſequence of which, a large portion of the blood of the pulmonary artery, that went through the canalis arterioſus into the aorta, now paſſes into the lungs by the other branches of that artery. And the duct is ſtill more deſerted, as there is a new obſtacle to the deſcent of the blood into the abdomen; for the very large umbilical arteries are now tied, ſo that the blood of the deſcending aorta cannot now find its way, but by an effort with which it dilates all the arteries of the pelvis and lower extremities. Finally, as the lungs receive more blood, the aorta ariſing from the heart alſo receives a greater quantity, and the intermediate ductus arterioſus is compreſſed between the tumid aorta and the pulmonary artery, ſo that in the adult it is found not only empty but ſhortened; in other reſpects it is ſingularly red within, ſoft, and very apt to concrete with ſtagnating blood. This courſe of the blood, therefore, is ſoon aboliſhed, commonly within a year.

dcccxlix. Then the foramen ovale is, by the ſame cauſes, alſo gradually cloſed up. For as ſoon as the paſſage into the lungs is rendered eaſier, the paſſage into the right ſide of the heart alſo becomes eaſier; whence the blood of both cavas flows thither more plentifully, as it is invited by the lax pulmonary artery, and therefore does not need that paſſage excavated in the ſeptum of ſinuſes. Again, the umbilical vein, being now almoſt deſtitute of any ſupply of blood, on account of the umbilicus being

being tied, (dcccccxxx.) lefs blood will flow into the lower cava, and confequently the preffure againft the foramen ovale will be diminifhed; into which, moreover, the blood of the upper cava, on account of the ifthmus, will be fcarcely able to penetrate. Laftly, as more blood is conveyed through the lungs into the left finus, it is dilated, and, along with the whole finus, the cornicles of the oval valve, which are fixed to it, are extended, and elevate the valve; fo that, in the mature fœtus, being drawn over the ifthmus, it entirely fhuts up the paffage, and is clofely applied to the ifthmus, while, at the fame time, the blood, within the left finus, fupports the valve againft the impulfe of the blood within the right finus. Thus, by the acceffion of a little friction of the uppermoft margin of the valve againft the fuperior ifthmus, the foramen ovale clofes up by degrees, and the upper margin of the valve is agglutinated and coheres to the pofterior furface of the ifthmus. But this takes place very flowly; fo that, very frequently, even at an advanced age, a fmall aperture ftill remains between the ifthmus and upper part of the valve; and where there is no aperture, yet there are the remains of the whole foramen, hollow to the left fide, and of a paffage at the upper part, open towards the right fide, and clofed to the left, becaufe the power of the blood in the right fide is always either greater than its refiftance on the left, or certainly not lefs, even in the advance of life.

dcccccl. The umbilical vein, being deprived of blood, foon clofes up. The blood of the vena portarum, being no longer impeded by an oppofite force coming from the umbilicus, occupies the left finus and curve of the umbilical foffa, (dcxcv.) and tranfmits blood through thofe branches by which the umbilical vein formerly fent blood into the cava. The ductus venofus being neglected, clofes by the new compreffion which the diaphragm, defcending in

in inſpiration, makes againſt the liver; 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 next the vena portarum.

DCCCCLI. The umbilical arteries are cloſed up in the ſame way as other arteries uſually are when tied, by part of the blood being coagulated into a polypus, which fills up the impervious extremity, and by the blood, which meets with reſiſting membranes, diverging into the adjacent leſs reſiſting branches. Nor do I overlook the force of the abdominal muſcles, by which thoſe arteries are compreſſed againſt the full abdomen in reſpiration; or the very acute angle in which the umbilicalis, ariſing from the iliac artery, and now incurvated with it along the bladder, makes; or the ſtraight direction in which the thighs, which in the fœtus made an acute fold with the body, are now extended. Thus, theſe arteries are ſoon ſhut up, leaving only a very ſmall tube, that leads to two or three arteries of the bladder. The urachus is very quickly obliterated, from its aſcending directly from the bladder, being a very ſlender tube, having no outlet, and now neglected on account of the deſcent and permeability of the urethra.

DCCCCLII. From ſimilar cauſes the liver is gradually diminiſhed, and contracts itſelf within the ribs; and the inteſtina craſſa, from their ſlender condition in the fœtus, dilate to a conſiderable diameter, and the ſtomach is elongated; and the cæcum is formed by the weight of the fæces preſſing downwards on the right of the appendix; and the lower extremities are remarkably enlarged by the repulſion of the blood, from the umbilical arteries now tied; and the other changes take place, by which the fœtus inſenſibly advances to the nature of a perfect adult.

CHAP.

CHAP. XXX.

NUTRITION, GROWTH, LIFE, AND DEATH.

DCCCCLIII. EVEN after the child is born, it continues to grow, but always more ſlowly in proportion to its age. There are many cauſes for the perpetual diminution of its growth. Many veſſels ſeem to be obliterated, both becauſe they are compreſſed by the neighbouring torrent of ſome large artery, and becauſe the blood, now become more viſcid, coagulates. Beſides, the food being now coarſer, accumulates in the blood more earth, which, being carried through the whole body with the nutritious fluid, renders every part of it harder, bones, teeth, cartilages, tendons, ligaments, veſſels, muſcles, membranes, and cellular ſubſtance; ſo that an increaſe of hardneſs may be perceived, even by the touch. Wherefore, ſince the blood flows from the heart through fewer canals, and ſince all the parts which ſhould be lengthened or diſtended have become harder, it neceſſarily follows, that thoſe which ought to increaſe in bulk, will yield leſs and leſs to the impulſe of the heart.

DCCCCLIV. But the heart likewiſe, which is the part that is firſt conſolidated of 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 heart itſelf grows more ſlowly, and continually bears a leſs, and at laſt an eight times ſmaller, proportion to the reſt of the body in the adult. 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 powers are augmented, the diſtending ones are at the ſame time diminiſhed.

DCCCCLV.

DCCCCLV. There will, therefore, ſooner or later, be an end of increaſe; and this will happen ſooner, in proportion to the quickneſs and frequency of the contractions of the heart, and will approach when the cartilaginous cruſts of all the bones are now become ſo thin that they cannot yield or give way to the increaſe of the bony part. In women, the menſes ſeem to put an earlier ſtop to the growth. In cartilaginous fiſhes the growth is perpetual.

DCCCCLVI. There is no durable ſtate; for, nature from the firſt conception, tends, by a perpetual progreſs, towards decreaſe. It is ſaid, however, to take place, when there is neither any increaſe of bulk, nor yet any very viſible decreaſe.

DCCCCLVII. For we are all perpetually conſuming (CCCCXXXIV.) Nor do we only loſe the fluid parts of our bodies, but even thoſe which are reckoned the moſt ſolid. For even the bones are changed; and the teeth, which are harder than the bones, increaſe in bulk when the attrition of the oppoſite teeth ceaſes to wear them away, and, therefore, their elements are changed: even the fibres of ivory in the elephant's tooth have given way, and ſurrounded on each ſide, in curved lines, a leaden ſhot: the bony juice likewiſe is changed; ſince in ſome caſes the bones grow ſoft: in others, it forms bony tumors: even cicatrices themſelves have a manifeſt growth, for otherwiſe they would not be ſufficient, in an adult, to fill up a wound received in infancy; and a great quantity of the earthy, certainly of the animal part of our bodies, goes off by urine, as is proved by ſome diſeaſes.

DCCCCLVIII. The cauſes of the deſtruction of the ſolids conſiſt in the perpetual extenſion and retraction, which happens at every pulſation of the heart, of which there are an hundred thouſand every day, a degree of motion by which metals themſelves are worn; then in the friction of the fluids againſt the ſolids; the wearing away of all the membranes, which

which terminate with a loofe extremity, either on the furface or in the internal cavities of the body, which are fupported folely by the reft of the canal; in the alternate fwelling and collapfe of the mufcles; and in the attraction and preffure which our mufcles exert. But the parts of our body are the fooner worn away, that they confift of a great deal of gluten combined with a fmall quantity of earth; and that gluten, when it is extended, if the extenfion has been a little fuperior to the force of cohefion, muft of neceffity fall away and be carried off from the earthy parts. Thus, deficiencies are generated, fuch as are vifible in the arteries of old men. The cellular texture, which otherwife would be diffolved in water, into a jelly, is worn away by the friction produced by the impetus of the blood preffing againft the neighbouring blood-veffels and mufcles, and by the perpetual alternation of flexion and extenfion.

DCCCCLIX. This decreafe would be very quick and indeed there would be no great diftance between the end of our life and its beginning, unlefs thefe loffes were repaired. The fluid parts are reftored by the aliments, and that pretty quickly; as appears from the example of a chicken, in which blood is generated from its aliment within two days. The fat, however, and red globules of the blood, are formed out of the fat, as is fhown elfewhere; the lymphatic juice from the jelly; the mucus, from mucus; and the reft of the humours, from thefe and water. The folids are repaired almoft by the fame means which we have defcribed in the hiftory of the fœtus. A gelatinous juice is conveyed from the aliments, through the arteries, to all parts of the body, and exudes into the cellular texture every where. The furrows, which we imagine to be made in the inmoft arterial membrane by the impetus of the blood, are filled up by a vifcid matter, applied to them by the lateral preffure;

fure ; never in too great quantity, becaufe the exuberant parts of the nutritious particles muft neceffarily be abraded by the current of the blood. Nor will it be deficient while there is a fufficient quantity of aliment, fince there is more reft, and lefs refiftance in the bottom of the furrow, which is farther removed from the motion of the blood through the centre of the veffel. There feem to be certain powers in the air, by which the aliment is attached to the folid parts, although we are ignorant of the manner in which they act.

DCCCCLX. The decreafe of the cellular texture arifing from attraction or preffure is repaired by the vifcid vapour exhaling from the artery, and applied to the wafted places by the force of the neighbouring arteries and compreffing mufcles, its aqueous part being expreffed and abforbed. The gluten repairs moft of the organic parts, tendons, and membranes ; being formed into new cellular fubftance, as in the fœtus.

DCCCCLXI. The wafte, which takes place in the unconnected extremities of parts adhering by their other extremity to the reft of the body, can be repaired by protrufion alone, while the lymph fills up the intervals produced.

DCCCCLXII. When the growth of the body can proceed no further, fatnefs fupervenes, which is a kind of imitation of real growth. This proceeds from the fat generated by the aliment ; which, from the impetus of the blood being now leffened as it enters the fmall veffels with more difficulty, is removed to the fides of the veffels ; enters the lateral veffels, and inorganic pores of the arteries ; exudes into the cellular texture ; and there is accumulated, in confequence of the diminution of the compreffing power of the blood, and likewife of the abforption by the veins.

DCCCCLXIII. The beginnings of decay are perceptible even in youth itfelf. Even in that blooming

ſeaſon the ſolid elements of the body are augmented, the apertures through which the humours flow are leſſened, the veſſels are obliterated, and the greater attraction of the cellular ſubſtance has condenſed the whole body. In every part of the body the induration produced by age becomes conſpicuous, in the bones now wholly brittle, in the ſkin, in the tendons, in the conglobate glands, in the arteries, and in the weight of every part, and of the brain itſelf. But thoſe parts grow ſooneſt rigid, which are moſt exerciſed by motion; as thoſe in every workman, which he chiefly employs in his profeſſion.

DCCCCLXIV. Moreover, the arteries continue to become denſer, narrower, and even impervious, both by the internal preſſure of the blood flowing through the large arterial tube, and by the attraction of the cellular texture of which the greateſt part of the artery is compoſed. An infinite number of parts of the cellular texture therefore ceaſe to be nouriſhed; to which the minute arteries hitherto conveyed nouriſhment; but which being now ſtopped up, bring none. The extending force being removed, the cellular flocculi attract each other, leſſen the interſtices between them, degenerate into membranes, or ſubſtances of a hard texture, which incloſe, and, as it were ſtrangulate other veſſels. The gelatinous vapour likewiſe concretes in the interſtices of the cellular texture, and forms a hard ſolid with its ſides. The muſcles, by the expulſion of their blood, and the concretion of their fibres, degenerate into hard denſe tendons, deſtitute of irritability.

DCCCCLXV. At the ſame time, the nerves become more and more callous, and inſenſible to the impreſſions of the ſenſes, and the muſcles to irritation: thus the contractile force of the heart, and the frequency of its pulſations, is diminiſhed, and therefore every force which impels the blood into the ultimate veſſels.

DCCCCLXVI.

DCCCCLXVI. The quantity of humours is diminiſhed in the denſer body, as the perſpiration, ſemen, humours of the eye, and of the conglobate glands; the vapour, which moiſtens the ſolid parts of the body, every where manifeſtly decreaſes. For this reaſon, nutrition now languiſhes, becauſe there is more which requires nouriſhment, and leſs nutritious juice.

DCCCCLXVII. Nor is the quantity of humours only diminiſhed: they themſelves likewiſe become vitiated. They were mild and viſcid in children: but theſe ſame humours are now acrid, ſalt, fetid, loaded with a great quantity of earth, in old men. This is produced by the uſe of ſalt and putreſcent aliments, the bad effects of which increaſe, being collected through a great length of time; alſo, by the diminution of the cutaneous perſpiration, and the coſtiveneſs of the belly, on account of the diminiſhed irritability, and by the reſorption of the putrid liquamen, thus increaſed. Hence the fetor of the urine, of the breath, and the difficult healing of wounds.

DCCCCLXVIII. But the greateſt fault of the humours, is, that they abound with earthy particles, both collected inſenſibly from the aliments after the ſecretions have become leſs eaſy, and partly abſtracted from the ſolids themſelves, and returned into the blood: for this earth is demonſtrated in ſome diſeaſes, and by the nature of the gouty concretions. From this abundance of earth, the proportion of that element through the whole body, is again augmented, becauſe the nutritious liquor brings too much of it along with it; whence the brittleneſs of the bones, and the hardneſs of all the parts increaſes: it is likewiſe every where depoſited in the cellular texture, and produces every where cruſts, at firſt callous, and then bony or ſtony, chiefly in the coats of the arteries.

DCCCCLXIX. The rigidity of the whole body, the decreaſe of the muſcular powers, and the diminution

tion of the ſenſes, conſtitute old age; which, ſooner or later, oppreſſes mortals ſeverely: ſooner, if ſubjected to violent labour, or addicted to pleaſure, or fed upon an unwholſome diet; but more ſlowly, if they have lived quietly and temperately, or if they have removed from a cold to a warm climate.

DCCCCLXX. But as thoſe cauſes inceſſantly continue to operate in rendering the matter of the body more denſe, in diminiſhing its irritability, and in augmenting the quantity of earth, it is not poſſible but decrepit old age muſt ſucceed. In it, the ſenſes are almoſt deſtroyed, and the vis inſita of the muſcles becomes exceedingly weak, ſo that the limbs loſe their ſtrength, and become, eſpecially the legs, unable to direct the body; that the callous inſenſibility of the nerves cannot be excited to perform the office of generation; that the very inteſtines, becoming torpid, do not obey the habitual ſtimuli; that, by the induration of the intervertebral cartilages, the body bends forward; that by the falling out of the teeth, the jaws, now rendered ſhorter, do not ſupport the lips ſufficiently; and laſtly, that the pulſations of the heart become one half leſs frequent than in the infant ſtate.

DCCCCLXXI. Thus at laſt, the neceſſity of natural death approaches, although the greateſt number of mortals are carried off prematurely by diſeaſes. One in a thouſand exceeds the age of 90; and one or two perhaps in a century 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. It is not eaſy to ſay what was the cauſe, in long lived people, of their longevity. England ſeems to exceed all other nations in the number of thoſe who live to an advanced age; and in general, the temperate countries are remarkable in this reſpect. Among the claſſes of men, the commonalty has almoſt ſolely afforded theſe rare examples; although, from its being

being the moſt numerous, we may expect a greater number of examples. Some prerogative ſeems to belong to ſobriety, at leaſt in a moderate degree; temperate diet; peaceable diſpoſition; a mind not endowed with very great vivacity, but cheerful, and little ſubject to care. Among animals, birds are longer lived: and fiſhes, whoſe heart is very ſmall, growth very ſlow, and whoſe bones never harden, are the longeſt lived.

DCCCCLXXII. Death from old age happens ſometimes, but rarely. It may be ſaid to occur, when the powers gradually decay, firſt of the voluntary muſcles, then of the vital muſcles, and laſtly, of the heart itſelf; ſo that, in an advanced age, life ceaſes through mere weakneſs, rather than through the oppreſſion of any diſeaſe. I have often obſerved the ſame kind of death in animals. 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 from the heart into thoſe arteries neareſt to it, and to be carried back from thence: the flame of life is thus ſupported for a little while, which ſoon after we 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 propel the blood through the lungs, that the aorta may receive its due quantity. The laſt efforts of reſpiration are now exerted to open a paſſage for the blood through the lungs, until even the powers given by nature for performing the action of inſpiration, becoming unequal to their taſk, ceaſe. Then, 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 being irritated by it, continue to beat weakly. But at laſt, when the reſt of the body has become perfectly cold, and

and the fat itſelf congealed, even this motion ceaſes, and the death becomes complete.

DCCCCLXXIII. I ſhall call that death, when the heart has become totally deprived of irritability. For the mere quieſcence of the heart is not without hope of reſuſcitation: neither does the putrefaction, or inſenſibility, or coldneſs of any part of the animal body, demonſtrate the death of the whole animal: but all theſe things, when joined together, and perpetually increaſing, with the rigidity produced by the congelation of the fat, in conſequence of reſt and cold, afford the ſigns of death in any doubtful caſe.

DCCCCLXXIV. The body after death is deſtroyed by putrefaction. Thus the fat, and the water, and the gluten, being reſolved, are diſſipated; the earth, deprived of its bonds of union, inſenſibly moulders away, and mixes itſelf with the duſt. The ſoul goes to that place which God hath appointed it: its indeſtructibility by death is proved by a very common phenomenon; for many people, when their bodily powers are waſted and ſpent, give evident proofs of a highly ſerene, vigorous, and even cheerful mind.

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