born white, or nearly so; and that the black pigment which colours them is not fully secreted till several months after birth. It sometimes happens, though rarely, that from a morbid state of the secretory organs there is no pigment secreted at all, or a white pigment is secerned instead of a black; whence we have white negroes, or persons exhibiting all the common characters of the negro-breed in the form of the head and features of the face, with the anomaly of a white skin. And it sometimes happens, though still more rarely, that from a similar kind of morbid action affecting the secretory organs, the black pigment is secreted in alternate or interrupted divisions; and in this case we have negro children with brindled, marbled, or spotted skins: an instance of which was brought to me by a gentleman about two years ago, who had purchased the child in America, and who, I believe, afterward exhibited it in this metropolis as a public show.

The CUTICLE is the thinnest of the layers that form the general integument of the skin. It often, however, becomes thicker, and sometimes even horny, by use. Thus it is always thicker in the sole of the foot and palm of the hand; and horny in the palms of blacksmiths and dyers; and still more so in the soles of those who walk barefooted on burning sands. It is annually thrown off whole by many tribes of animals—as grasshoppers, serpents, and spiders—and as regularly renewed; and by some animals it is renewed still more frequently: it is shed not less than seven times by the caterpillar of the moth and butterfly before either becomes a chrysalis. There are a few plants that exfoliate their cuticle in the same manner, and as regularly renew it. The West India plane-tree throws it off annually.

From the cuticle shoots forth a variety of substances, which either protect or adorn it, the roots of which are not unfrequently imbedded in the true skin itself. Of the harder kind, and which serve chiefly as a defence, are the nails, scales, claws, and horns; of the softer and more ornamental kinds, are hair, wool, silk, and feathers.

HAIR is the most common production, for we meet with it not only in all mammals, but occasionally in birds, fishes, and insects, varying in consistency and fineness, from a down invisible to the naked eye, to a bristle strong enough to support, when a foot long, ten or twelve pounds weight without breaking.

WOOL is not essentially different in its chemical properties from hair, and it varies equally in the fineness and coarseness of its texture. It is generally supposed by the growers, that the fineness of its texture depends upon the nature of the soil; yet of the two finest sorts we are at present acquainted with, that of Spain and that of New South Wales, which last is an offset from the Cape of Good Hope, and has yielded specimens of broad cloth, manufactured in this country, as soft and silky as that of unmixed Merino wool—that of Spain is grown on a pure limestone soil, covered with small leguminous plants instead of with grass; and that of New South Wales on a soil totally destitute of lime, and covered with a long, rich, succulent grass alone.

Food, however, or climate, or both, must be allowed, under certain circumstances, to possess a considerable degree of influence; for it is a curious fact, that the hair of the goat and rabbit tribes, and the wool of the sheep tribe, are equally converted into silk by a residence of these animals in that district of Asia Minor which is called Angora, though we do not know that a similar change is produced by a residence in any other region; while, on the contrary, the wool of sheep is transformed into hair on the coast of Guinea.

The fine glossy SILK of the Angora goat is well known in this country, as being often employed for muffs and other articles of dress. How far these animals might be made to perpetuate this peculiar habit by a removal from Angora to other countries has never yet been tried. Upon the whole, the soil and climate of New-Holland offer the fairest prospect of success to such an attempt; and under this impression I have for some time been engaged in an endeavour to export a few of each genus of these animals from Angora to Port Jackson.

Silk, however, is chiefly secreted by insects, as some species of spider, whose threads, like the hair of the Angora goat, assume a silky gloss and lubricity, and the phalæna *mori*, or silk-worm, which yields it in great abundance. Yet there are a few shell-fishes which generate the same, and especially the genus pinna, or nacre, in all its species; whence Reaumur calls this kind the sea silk-worm. It is produced in the form of an ornamental byssus or beard: the animal is found gregariously in the Mediterranean and Indian seas; and the weavers of Palermo manufacture its soft threads into glossy stuffs or other silky textures. And I may here observe, that there are various trees that possess a like material in the fibres of their bark, as the morus *papyrifera*, and several other species of the mulberry: in consequence of which it has been doubted by some naturalists whether the silk-worm actually generates its cocoon, or merely eliminates it from the supply received as its food; but as the silk-worm forms it from whatever plants it feeds on, it is obviously an original secretion.

From the integument of the skin originates also that beautiful PLUMAGE which peculiarly characterizes the class of birds, and the colours of which are probably a result of the same delicate pigment that produces, as we have already remarked, the varying colours of the skin itself; though, from the minuteness with which it is employed, the hand of chemistry has not been able to separate it from the exquisitely fine membrane in which it is involved. But it is impossible to follow up this ornamental attire through all its wonderful features of graceful curve and irridescent colouring,—of downy delicacy and majestic strength,—from the tiny rainbow that plays on the neck of the humming-bird, to the beds of azure, emerald, and hyacinth, that tesselate the wings of the parrot tribe, or the ever-shifting eyes that dazzle in the tail of the peacock;—from the splendour and taper elegance of the feathers of the bird of paradise, to the giant quills of the crested eagle or the condur—that crested eagle, which in size is as large as a sheep, and is said to be able to cleave a man's scull at a stroke; and that condur which, extending its enormous wings to a range of sixteen feet in length, has been known to fly off with children of ten or twelve years of age.

Why have not these monsters of the sky been appropriated to the use of man? How comes it that he who has subdued the ocean and cultivated the earth; who has harnessed elephants, and even lions, to his chariot wheels, should never have availed himself of the wings of the eagle, the vulture, or the frigate pelican? That, having conquered the difficulty of ascending into the atmosphere, and ascertained the possibility of travelling at the rate of eighty miles an hour through its void regions, he should yet allow himself to be the mere sport of the whirlwind, and not tame to his use, and harness to his car, the winged strength of these aerial racers, and thus stamp with reality some of the boldest fictions of the heathen poets? The hint has, indeed, long been thrown out; and the perfection to which the art of falconry was carried in former times sufficiently secures it against the charge of absurdity or extravagance.

LECTURE XII.

ON THE DIGESTIVE FUNCTION AND THE ORGANS CONTRIBUTORY TO IT: THE DIFFERENT KINDS OF FOOD EMPLOYED BY DIFFERENT ANIMALS: CONTINUANCE OF LIFE THROUGH LONG PERIODS OF FASTING.

UNDER every visible form and modification matter is perpetually changing: not necessarily so, or from its intrinsic nature; for the best schools of ancient times concur with the best schools of modern times, in holding its elementary principles, as I have already observed, to be solid and unchangeable; and we have still farther seen, that even in some of its compound, but

gaseous, etherealized, and invisible forms, it is probably alike exempted from the law of change; while the Christian looks forward with holy hope to a period when this exemption will be general, and extend to every part and to every compound; to a period in which there will be new heavens and a new earth, and what is now corruptible will put on incorruption.

At present, however, we can only contemplate matter, under every visible form and modification, as perpetually changing; as living, dying, and reviving; decomposing into its primordial elements, and recombining into new forms, and energies, and modes of existence. The germ becomes a seed, the seed a sapling, the sapling a tree: the embryo becomes an infant, the infant a youth, the youth a man; and, having thus ascended the scale of maturity, both instantly begin the downward path to decay; and, so far as relates to the visible materials of which they consist, both at length moulder into one common elementary mass, and furnish fresh fuel for fresh generations of animal or vegetable existence. So that all is in motion, all is striving to burst the bonds of its present state; not an atom is idle; and the frugal economy of nature makes one set of materials answer the purpose of many, and moulds it into every diversified figure of being, and beauty, and happiness.

But till the allotted term of existence has arrived, animals and vegetables are rendered equally capable of counteracting the waste they are perpetually sustaining in their individual frames; and are wisely and benevolently endowed with organs, whose immediate function it is to prepare a supply of reformative and vital matter adequate to the general demand.

Of this class of organs in plants we took a brief survey in our eighth lecture; and shall now proceed to notice the same class as it exists in animals, and which is generally distinguished by the name of the DIGESTIVE SYSTEM.

There is, perhaps, no animal function that displays a larger diversity of means by which it is performed than the present: and, perhaps, the only point in which all animals agree, is in the possession of an internal canal or cavity of some kind or other in which the food is digested; an agreement which may be regarded as one of the leading features by which the animal structure is distinguished from the vegetable.

Let us then, in the first place, trace this cavity as it exists in man and the more perfect animals; the organs which are supposed to be auxiliary to it, and the powers by which it accomplishes its important trust. Let us next observe the more curious deviations and substitutes that occur in classes that are differently formed: and, lastly, let us attend to a few of the more singular anomalies that are occasionally met with, and especially in animals that are capable of subsisting on air or water alone, or of enduring very long abstinences or privations of food.

The alimentary cavity in man extends from the mouth through the whole range of the intestinal canal:* and hence its different parts are of very different diameters. In the mouth, where it commences, it is wider; it contracts in the esophagus or gullet; then again widens to form the stomach, and afterward again contracts into the tube of the intestines. This tube itself is also of different diameters in different parts of its extent; and it is chiefly on this diversity of magnitude that anatomists have established its divisions. Its general length is five or six times that of the man himself; and in children not less than ten or twelve times, in consequence of their diminutive stature. In some animals it is imperforate; it is so occasionally in birds, and fishes, and almost uniformly so in zoophytes.

Generally speaking, the extent of the digestive cavity bears a relation to the nature of the aliments by which the individual is designed to be nourished. The less analogous these aliments are to the substance of the animal they are to sustain, the longer they must remain in the body to undergo the changes that are necessary to assimilate them. Hence the intestinal tube of herbivorous animals is very long, and their stomach is extremely large, and often double or triple; while the carnivorous have a short and straight

* Study of Med. ii. 2.

digestive canal, the food on which they feed being already of their own nature, and containing a larger quantity of nourishment in a less bulk; and hence demanding a smaller proportion both of time and space to become fit for use. In this respect man holds a medium between the two: his digestive canal is less complex than that of most animals that feed on grass alone, and more extensive than that of most animals that are confined to a diet of their own kind. Man is hence omnivorous, and is capable of subsisting on an aliment of either sort; and from his digestive organs, as well as from various others, is better qualified for every variety of soil and climate than any other animal.

Man, however, is by no means the only omnivorous animal in the world; for the great Author of nature is perpetually showing us that, though he operates by general laws, he is in every instance the lord and not the slave of them. Hence, among quadrupeds, the swine, and among insects the ant, possesses as omnivorous a power as man himself, and feeds equally on the fleshy parts of animals, and on grain, and the sweet juices of vegetables. In consequence of this omnivorous power in the ant, we may often make use of him as a skilful anatomist; for, by putting a dead frog, mouse, or other small animal in a box perforated with holes, and placing it near an ant-hill, we shall find it in a few days reduced to a perfect and exquisite skeleton, every atom of the soft parts being separated and devoured.

The solid materials of the food are first masticated and moistened in the mouth, excepting in a few cases, in which it is swallowed whole. It is then introduced into the stomach, and converted into an homogeneous pulp or paste, which is called chyme; and shortly afterward, by an additional process, into a fluid for the most part of a milky appearance, denominated chyle; in which state it is absorbed or drunk up voraciously by thousands and tens of thousands of little mouths of very minute vessels, which are not often found in the stomach, but line the whole of the interior coating of that part of the intestinal tube into which the stomach immediately empties itself, and which are perpetually waiting to imbibe its liquid contents. These vessels constitute a distinct part of the lymphatic system; they are called lacteals from the usual milky appearance of the liquid they absorb and contain. They progressively anastomose or unite together, and at length terminate in one common trunk, named the thoracic duct, which conveys the different streams thus collected and aggregated to the sanguineous system, to be still farther operated upon, and elaborated by the action of the heart and the lungs.

The means by which the food is broken down and rendered pultaceous after being received into the stomach are various and complicated. In the first place, the muscular tunic of the stomach acts upon it by a slight contraction of its fibres, and so far produces a mechanical resolution: secondly, the high temperature maintained in the stomach by the quantity of blood contained in the neighbouring viscera and sanguiferous vessels, gives it the benefit of accumulated heat, and so far produces a concoctive resolution: and, thirdly, the stomach itself secretes and pours forth from the mouths of its minute arteries a very powerful solvent, which is by far the chief agent in the process, and thus produces a chemical resolution. In this manner the moistened and manducated food becomes converted into the pasty mass we have already called chyme: and, fourthly, there are a variety of juices separated from the mass of the blood by distinct glands situated for this purpose in its vicinity, which are thrown into the duodenum, or that part of the canal into which the stomach immediately opens, by particular conduits, and in some way or other appear to contribute to the common result, and to transform the chyme into chyle, but concerning the immediate powers or modes of action of which we are in a considerable degree of darkness. Of these glands the most remarkable and the most general are the liver and the pancreas or sweet-bread; the first of which secretes the bile, and is always of a considerable size, and appears to produce a very striking effect on the blood itself, by a removal of several of its principles independently of its office as a digestive organ.

From this brief survey of the process of digestion it is obvious that the stomach itself performs by far the principal part; in some animals, indeed, it appears to perform the whole; and it is hence necessary that we examine the general structure and powers of this organ with a little more minuteness.

In man the stomach is situated on the left side of the midriff; in its figure it resembles the pouch of a bag-pipe; its left end is most capacious; its upper side is concave, its lower convex; and the two orifices for receiving and discharging the food are both situated in the upper part. In its substance it consists of three distinct coats or layers, the external and internal of which are membranous, and the middle muscular. The internal coat, moreover, is lined with a villous or downy apparatus, and is extremely convoluted or wrinkled; the wrinkles increasing in size as the diameter of the stomach contracts.

From what I have already observed, it must appear that the process of digestion in man consists of three distinct acts: mastication, which is the office of the mouth, and by which the food is first broken down; chymification, or its reduction into pulp, which is the office of the stomach; and chylification, or its dilution into a fluid state, which is the office of that part of the intestinal canal which immediately communicates with the stomach. The whole of this process is completed in about three hours, and under certain states of the stomach, to which I shall advert presently, almost as quickly as the food is swallowed. The most important of these three actions is that of chymification; and, while it takes place, both orifices of the stomach are closed, and a degree of chilliness is often produced in the system generally, from the demand which the stomach makes upon it for an auxiliary supply of heat, without an augmentation of which it appears incapable of performing this important function.

Considering the comparatively slender texture of the chief digesting organ, and the toughness and the solidity of the substances it digests, it cannot appear surprising that mankind should have run into a variety of mistaken theories in accounting for its mode of action. Empedocles and Hippocrates supposed the food to be softened by a kind of putrefaction. Galen, whose doctrine descended to recent times, and was zealously supported by Grew and Santarelli, ascribed the effect to concoction, produced, like the ripening and softening of fruits beneath a summer sun, by the high temperature of the stomach from causes just pointed out. Pringle and Macbride advocated the doctrine of fermentation, thus uniting the two causes of heat and putrefaction assigned by the Greek writers; while Borelli, Keil, and Pitcairn resolved the entire process into mechanical action, or trituration; thus making the muscular coating of the stomach an enormous mill-stone, which Dr. Pitcairn was extravagant enough to conceive ground down the food with a pressure equal to a weight of not less than a hundred and seventeen thousand and eighty pounds, assisted, at the same time, in its gigantic labour, by an equal pressure derived from the surrounding muscles.*

Each of these hypotheses, however, was encumbered with insuperable objections; and it is difficult to say which of them was most incompetent to explain the fact for which they were invented.

Boerhaave endeavoured to give them force by interunion, and hence combined the mechanical theory of pressure with the chemical theory of concoction; while Haller contended for the process of maceration. But still a something else was found wanting, and continued to be so till Cheselden in lucky hour threw out the hint, for at first it was nothing more than a hint, of a menstruum secreted into some part of the digestive system; a hint which was soon eagerly laid hold of, and successfully followed up by Haller, Reaumur, Spallanzani, and other celebrated physiologists. And though Cheselden was mistaken in the peculiar fluid to which he ascribed the solvent energy, namely, the saliva, still he led forward to the important fact, and the GASTRIC JUICE was soon afterward clearly detected, and its power incontrovertibly established.

* See Series I. Lecture X.

This wonderful menstruum, the most active we are acquainted with in nature, is secreted by a distinct set of vessels that exist in the texture of the stomach, and empty themselves into its cavity by innumerable orifices invisible to the naked eye; and it is hence called gastric juice, from γαστὴρ, which is Greek for stomach. Mr. Cruickshank supposes about a pound of it to be poured forth every twenty-four hours. "The drink," says he, "taken into the stomach may be two pounds in twenty-four hours; the saliva swallowed may be one pound in the same period, the gastric juice another, the pancreatic juice another. The bile poured into the intestines Haller supposes about twenty ounces, besides the fluid secreted through the whole of the internal surfaces of the intestines;"* which Haller calculates at not less than eight pounds in twenty-four hours,—a calculation, nevertheless, that Blumenbach regards as extravagant.†

The quantity of the gastric juice, however, seems to vary very considerably, according to the demand of the system generally, or the state of the stomach itself. In carnivorous birds, whose stomachs are membranous alone, and, consequently, whose food is chymified by the sole action of the gastric juice, without any collateral assistance or previous mastication, this fluid is secreted in much larger abundance; as it is also in those who labour under that morbid state of the stomach which is called canine appetite; or when, on recovery from fevers, or in consequence of long abstinence, the system is reduced to a state of great exhaustion, and a keen sense of hunger induces a desire to devour food voraciously and almost perpetually.

Such was the situation of Admiral Byron and his two friends, Captains Cheap and Hamilton, after they had been shipwrecked on the western coast of South America, and had been emaciated, as he tells us, to skin and bone, by having suffered with hunger and fatigue for some months. "The governor," says Admiral Byron, "ordered a table to be spread for us with cold ham and fowls, which only we three sat down to, and in a short time despatched more than ten men with common appetites would have done. It is amazing that our eating to that excess we had done from the time we first got among these kind Indians had not killed us; we were never satisfied, and used to take all opportunities, for some months after, of filling our pockets when we were not seen, that we might get up two or three times in the night to cram ourselves."‡

When pure and in a healthy state, the gastric juice is a thin, transparent, and uninflammable fluid, of a weak saline taste, and destitute of smell. Generally speaking, it is neither acid nor alkaline; but it appears to vary more or less in these properties, not only in animals whose organs of digestion are of a different structure, but even in the very same animal under different circumstances. It may, however, be laid down as an established rule, that in *carnivorous* and *graminivorous* animals possessing only a single stomach, this fluid is acid, and colours blue vegetable juices red; in *omnivorous* animals, as man, whose food is composed both of vegetable and animal diet, it is neutral; and in graminivorous *ruminating* animals with four stomachs, and particularly in the adults of these tribes, it has an alkaline tendency, and colours blue vegetable juices green.

There are two grand characteristics by which this fluid is pre-eminently distinguished; a most astonishing faculty of counteracting and even correcting putrefaction; and a faculty, equally astonishing, of dissolving the toughest and most rigid substances in nature.

Of its ANTISEPTIC POWER abundant proofs may be adduced from every class of animals. Among mankind, and especially in civilized life, the food is usually eaten in a state of sweetness and freshness; but fashion, and the luxurious desire of having it softened and mellowed to our hands, tempt us to keep several kinds as long as we can endure the smell. The wandering hordes of gypsies, however, and the inhabitants of various savage countries, and espe-

* Anat. of the Absorbing Vessels, p. 106. † Physiol. Institut. xxvii. § 410
‡ Voyage, p. 181. See also Hunter's Animal Economy, p. 196.

cially those about the mouth of the Orange river in Africa, carry this sort of luxury to a much higher pitch, for they have no objection to an offensive smell, and appear to value their food in proportion to its approach towards putrefaction. Now all these foods, whatever be the degree of their putridity, are equally restored to a state of sweetness by the action of this juice, a short time after they have been introduced into the stomach.

Dr. Fordyce made a variety of experiments in reference to this subject upon the dog, and found uniformly that the most putrid meat he could be made to swallow, was in a very short time deprived of its putrescency. We cannot, therefore, be surprised that crows, vultures, and hyenas, who find a pleasure in tainted flesh, should fatten upon so impure a diet; nor that the dunghill should have its courtiers among insects as well as the flower-garden.

The gastric juice has hence been employed as an antiseptic in a variety of cases out of the body.

Spallanzani has ascertained that the gastric juice of the crow and the dog will preserve veal and mutton perfectly sweet, and without consumption, thirty-seven days in winter; while the same meats immersed in water emit a fetid smell as early as the seventh day, and by the thirtieth are resolved into a state of most offensive liquidity.

Physicians and surgeons have equally availed themselves of this corrective quality, and have occasionally employed the gastric juice, internally in cases of indigestion from a debilitated stomach, and externally as a check to gangrenes, and a stimulus to impotent and indolent ulcers. I do not know that this practice has hitherto taken place very largely in our own country, but it has been extensively resorted to on the Continent, and especially in Switzerland and Italy; and in many cases with great success.

But the gastric juice is as remarkable for its solvent as for its antiputrescent property. Of this any indústrious observer may satisfy himself by attending to the process of digestion in many of our most common animals; but it has been most strikingly exemplified in the experiments of Reaumur and Spallanzani. Pieces of the toughest meats, and of the most solid bones, enclosed in small perforated tin cases to guard against all muscular action, have been repeatedly thrust into the stomach of a buzzard: the meats were uniformly found diminished to three-fourths of their bulk in the space of twenty-four hours, and reduced to slender threads; and the bones were wholly digested, either upon the first trial or a few repetitions of it. Dr. Stevens repeated the experiment on the human stomach by means of a perforated ivory ball, which he hired a person at Edinburgh alternately to swallow and disgorge, when a like effect was observed.

The gastric juice of the dog dissolves ivory itself and the enamel of the teeth; that of the hen has dissolved an onyx and diminished a louis-d'or;* even among insects we find some tribes that fatten upon the fibrous parts of the roots of trees, and others upon metallic oxides. And it is not long since that, upon examining the stomach and intestinal tube of a man who died in one of the public hospitals of this metropolis, and who had some years before swallowed a number of clasp-knives out of hardihood, their handles were found digested, and their blades blunted, though he had not been able to discharge them from his body.

It is in consequence of this wonderful power that the stomach is sometimes found in the extraordinary condition of digesting itself; and of exhibiting, when examined on dissection, various erosions in different parts of it, and especially towards the upper half, into which the gastric juice is supposed to flow most freely. It is the opinion of Mr. John Hunter,† however, whose opinions are always entitled to respect, that such a fact can never take place except in cases of sudden death, when the stomach is in full health, and the gastric juice, now just poured forth, is surrounded by a dead organ. For he plausibly argues, that the moment the stomach begins to be diseased, it

* Swammerdam, Biblia Naturæ, p. 168.

† Phil. Trans. 1772.

ceases to secrete this fluid, at least in a state of perfect activity; and that so long as it is itself alive, it is capable, by its living principle, of counteracting the effect of this solvent power. Yet a case has lately been published by Mr. Burns of Glasgow, in which the stomach appears to have been eroded, although the death, instead of being sudden, did not take place till after a long illness and great emaciation of the body. It is possible, however, that even here the stomach did not participate in the disease. That the living principle of the stomach is capable, so long as it continues in the stomach, of resisting the action of the gastric juice, can hardly be questioned. And it is to the superior power of this principle of life, that worms and the ova of insects are so often capable of existing in the stomach uninjured, and even of thriving in the midst of so destructible an agency.

But though the solvent juice of the stomach is the chief agent in the process of digestion, its muscular power contributes always something, and in many animals a considerable proportion, towards the general result; and hence, the shape and structure of this organ, instead of being uniformly alike, is varied with the most skilful attention to the nature of the mechanism by which it is to operate.

In its general construction the stomach of different animals may be divided into three kinds; membranous, muscular, and bony. The first is common to graminivorous quadrupeds, and to carnivorous animals of most kinds; to sheep, oxen, horses, dogs, and cats; eagles, falcons, snakes, frogs, newts, and the greater number of fishes, as well as to man himself. The second is common to graminivorous birds; and to granivorous animals of most kinds; to fowls, ducks, turkeys, geese, and pigeons. The third, to a few apterous insects, a few soft-bodied worms, and a few zoophytes; to the cancer-genus, the cuttle-fish, the sea-hedgehog; tubipores and madrepores.

Of the membranous stomach we have already taken notice in describing that of man; and at the bony stomach we took a glance in a late lecture on the teeth and other masticatory organs. It only remains, therefore, that we make a few remarks on that singular variety of the membranous stomach which belongs to ruminant animals, and on the muscular stomach of granivorous and graminivorous birds.

All animals which ruminate must have more stomachs or ventricles than one; some have two, some three; and the sheep and ox not less than four. The food is carried down directly into the first, which lies upon the left side, and is the largest of all; the vulgar name for this is the *paunch*. There are no wrinkles on its internal surface; but the food is considerably macerated in it by the force of its muscular coat, and the digestive secretions which are poured into it. Yet, in consequence of the vegetable and unanalogous nature of the food, it requires a much farther comminution; and is hence forced up by the esophagus into the mouth, and a second time masticated; and this constitutes the act called rumination, or chewing the cud. After this process, it is sent down into the second ventricle, for the esophagus opens equally into both, and the animal has a power of directing it to whichsoever it pleases. This ventricle is called the *bonnet* or *king's-hood;* its internal surface contains a number of cells, and resembles a honey-comb; it macerates the food still farther; which is then protruded into the third ventricle, that, on account of its very numerous folds or wrinkles, is called *many-plies,* and vulgarly *many-plus*. It is here still farther elaborated, and is then sent into the fourth ventricle, which, on account of its colour, is called *the red*, and by the French *le caillé*, or the curdle, since it is here that the milk sucked by calves first assumes a curdled appearance. It is thus that the process of digestion is completed, and it is this compartment that constitutes the true stomach, to which the others are only vestibules.

There are some animals, however, which do not ruminate, that have more than one stomach; thus the hampster has two, the kangaroo three, and the sloth not less than four.* Nor does the conformation terminate even with

* Wiedemann, Archiv. b. i

quadrupeds; for among birds the ostrich has two ventricles,* and among fishes the stomateus *hiatola*. The horse and ass, on the contrary, though graminivorous quadrupeds like the ox, have only one stomach.

There may seem, perhaps, something playful in this application of different systems of mechanism to the same class of animals, and of the same system to different classes: but it shows us, at least, that the hand of nature is not necessarily fettered by its own general laws, nor compelled, even under the same circumstances, to adopt the same cause to produce the same effect. Yet, if we had time, we might proceed beyond this remark, and point out, if I mistake not, the reasons for such diversities, and the skill with which they are introduced. Thus the horse and ass are formed for activity, and require lightness; and hence the bulk and complexity of three or four stomachs would counteract the object for which they are created; but it does not interfere with the pursuits of the ox, which is heavy and indolent in its nature; and which, though it may perhaps be employed as a beast of burden, can never be made use of for speed. The activity of the horse and ass, moreover, excites, from the stimulus it produces, a larger secretion of gastric juice than is met with in the ox, and thus in a considerable degree supplies a substitute for the three deficient stomachs; but it by no means extracts the nutriment so entirely from the food introduced into it; and we hence see the reason why the dung of horses is richer than that of black cattle, and why they require three or four times as much provender.

We may apply the whole of these remarks to the ostrich, whose peculiar habitation is the sandy and burning deserts of the torrid zone, where not a blade of grass is to be seen for hundreds of miles, and where the little food it lights upon must be made the most of. The double stomach it possesses enables it to accomplish this purpose, and to digest coarse grass, prickly shrubs, and scattered pieces of leather, with equal ease. This animal is supposed to be one of the most stupid in nature, and to have no discernment in the choice of its food; for it swallows stone, glass, iron, and whatever else comes in its way, along with its proper sustenance. But it is easy to redeem the ostrich from such a reproach, at least in the instance before us; for these very articles, by their hard and indestructible property, perform the office of teeth in the animal's stomach; they enable it to triturate its food most minutely, and to extract its last particle of nutriment. It is true that in the class of birds, or that to which the ostrich belongs, a double stomach must necessarily, to a certain extent, oppose the general levity by which this class is usually characterized. But the wings of the ostrich are not designed for flight: they assist him in that rapidity of running for which he is so celebrated, and in which he exceeds all other animals, but are not designed to lift him from the earth. In reality, the ostrich appears to be the connecting link between birds and quadrupeds, and especially ruminant quadrupeds. In its general portrait, as well as in the structure of its stomach, it has a near resemblance to the camel; in its voice, instead of a whistle, it has a grunt, like that of the hog; in its disposition, it is as easily tamed as the horse, and like him may be employed, and often has been, as a racer, though in speed it outstrips the swiftest race-horse in the world. Adanson asserts, indeed, that it will do so when made to carry double; and that, when at the factory of Podore, he had two ostriches carefully broken in, the strongest of which, though young, would run swifter, with two negroes on his back, than a racer of the best breed.

Yet widely different is the mechanism of the stomach in birds of flight that feed on vegetables: nor could any contrivance be better adapted to unite the two characters of strength and levity. Instead of the bulky and complicated compartments of the membranous stomach of ruminant animals, we here meet with a thick, tough, muscular texture, small in size, but more powerful than the stoutest jaw-bone, and which is usually called GIZZARD.

It consists of four distinct muscles, a large hemispherical pair at the sides, and two smaller muscles at the two ends of the cavity. These muscles are

* Vallisnieri, Anatomia, &c. p. 159, 1713.

distinguished from the rest belonging to the animal, not less by their colour than by their prodigious strength; and the internal cuticle with which they are covered is peculiarly callous, and often becomes quite horny from pressure and friction.

The gizzard of grazing birds, as the goose and turkey, differs in some degree in the formation of its muscles from that of granivorous. They have also "a swell in the lower part of the esophagus, which answers the purpose of a reservoir, in which the grass is retained, macerated, and mixed with the secretions poured out by the glandular surfaces surrounding it, in this respect corresponding to the first and second stomachs of ruminating animals, in which the grass is prepared for mastification,"* though essentially lighter.

In most birds, indeed, we meet with an approach towards this, in a cavity situated above the muscular stomach, and called the crop, or craw. This first receives the food from the mouth, and slightly softens it by a mucous fluid secreted from its interior; and thus prepared, a part of it is given back to the young, where there are young to partake of it, and the rest is sent to the gizzard or proper stomach, whose muscular mechanism, in conjunction with its gastric juice, soon comminutes it into the most impalpable pulp. There are several kinds, however, that, like the ostrich, endeavour to assist the muscular action by swallowing pebbles or gravel; some of which find this additional aid so indispensable, that they are not able to digest their food, and grow lean without it. Spallanzani attempted to prove that these stones are of no use, and are only swallowed by accident; but their real advantage has been completely established by Mr. J. Hunter, who has correctly observed, that the larger the gizzards, the larger are the pebbles found in them. In the gizzard of a turkey he counted two hundred; in that of a goose, a thousand.

Reaumur and Spallanzani have put the prodigious power of this muscular stomach to the test, by compelling geese and other birds to swallow needles, lancets, and other hard and pointed substances; which, in every experiment, were found, a few hours afterward, on killing and examining the animal, or on its regorging them, to be broken off and blunted, without any injury to stomach whatever.

Yet, as all animals are not designed for all kinds of food, neither the force of the strongest muscular fibres, nor the solvent power of the most active gastric juice, will avail in every instance. The wild-boar and the vulture devour the rattlesnake uninjured, and fatten upon it; but there are many kinds of vegetables which neither of these are capable of digesting. The owl digests flesh and bone, but cannot be made to digest grain or bread; and in one instance died, under the experiments of Spallanzani, when confined to vegetable food. The falcon seems as little capable of dissolving vegetables; yet the eagle dissolves bread and bone equally; and wood-pigeons may, in like manner, be brought to live, and even to thrive, on flesh meat. The procellaria *pelagica*, or stormy petrel, lives entirely on oil, as the fat of dead whales and other fishes, whenever he can get it; and if not, converts every thing he swallows into oil. He discharges pure oil from his mouth at objects that offend him; and feeds his young with the same substance. This is the most daring of all birds in a tempest, though not more than six inches long. As soon as the clouds begin to collect, he quits his rocky covert, and enjoys the gathering and magnificent scenery: he rides triumphantly on the whirlwind, and skims with incredible velocity the giddiest peaks and deepest hollows of the most tremendous waves. His appearance is a sure presage of foul weather to the seaman.

There are some tribes of animals that appear capable of subsisting on water alone, and a few on mere air, incapable as these substances seem to be, at first sight, of affording any thing like solid nutriment. Leeches and tadpoles present us with familiar proofs of the former assertion, and there are various kinds of fishes that may be added to the catalogue. Rondelet kept a silver fish in pure water alone for three years; and at the end of that period it had

* Home, On the Gizzards of Grazing Birds, Phil. Trans. 1810, p. 183.