SECTION II.

MASTICATION—DEGLUTITION—DIGESTION.

16. The details which follow, refer, for the most part, to the sciences of Anatomy and Physiology, the former of which treats of the structure of animals, the latter of their functions, or of those phenomena which are peculiar to life. It is chiefly of the Physiology of the higher Vertebrate Orders, and particularly of Man, that we design at present to give some account; and in doing this we shall keep in view the important division of Bichat, into the organic or vegetative, and the animal or relative functions, although a slight departure from it will occasionally be necessary, to give connection, and to prevent repetition.

17. The first, because the most essential, processes which engage our attention, are those which relate to the introduction of food into the body, its digestion, and its assimilation.

18. It has hitherto been supposed that many of the lower and more minute creatures possess no cavity for the reception of nutriment, but are supported by the absorption of aliment through the outer surface. Of late, however, so many animals of this obscure kind, formerly thought stomachless, have been discovered to possess alimentary cavities, that it is now probable that no creature whatever is altogether deficient in a stomach. In the Infusoria, such an opening has been discovered, in some instances surrounded on the outside by *cilia*, or a series of hairs, the office of which seems to be to draw food towards the mouth. In the Polypes we find the orifice of the alimentary cavity surrounded in like manner by *tentacula*, or long string-like arms, with which they seize their prey, and convey it to its proper receptacle. In the star-fish the opening of the stomach is surrounded with teeth, and the cuttle-fish, of the division Mollusca, possesses, in addition

30. Define Anatomy;—and Physiology.
31. What processes seem most essential to life?
32. What is now probable in regard to the animal creation?
33. Name some of the varieties of structure.

to its numerous tentacula, a strong beak, like the parrot's, for crushing the shell-fish on which it lives. In Insects we find mandibles and a proboscis or trunk, with a thousand other modifications leading us up to the regular masticating apparatus of the vertebrate division.

19. This *masticating apparatus* consists of several parts. We have, 1st, the teeth for seizing or dividing the food; 2d, the glands which secrete the fluid for moistening the food and mouth; and, 3d, the tongue and other muscles which move the food from side to side, or carry it backwards to be swallowed.

20. From what was formerly said, it must be evident that the *Teeth* are parts of great importance to the zoologist. They at once give him decisive indications of an animal's habits, conformation, and other qualities. In the adult man they are thirty-two in number, and consist of four different kinds, namely, 1st, of eight incisors, or cutting teeth, in front; 2d, of four cuspidati (pointed), or canine teeth; 3d, of eight bicuspidati, or small grinders; and, 4th, of twelve molares, or proper grinders. The molares are flat-crowned in the horse, and in the other Herbivora, while the canine are either wanting, or, as in the horse, are rudimentary; that is, imperfectly developed. The canine are largely developed in the lion (Fig. 8), and in the Carnivora, or flesh-eating tribes, generally, which have also the molares pointed instead of flat. In insectivorous animals, such as the mole and hedgehog, the molares are formed as in Fig. 9; while in the shark (Fig. 10), and other fishes, which swallow their prey entire, the teeth are all of the same pointed form, and are numerously set, even on the lips, sides of the mouth, and throat.

Fig. 8. Bones of Lion's Head.

Fig. 9.

Even the degree in which an animal is carnivorous, or otherwise, is marked very accurately by the more or less

34. What are included in the masticating apparatus?
35. What of the teeth?
36. Enumerate and classify the human teeth in an adult.
37. How in herbivorous and carnivorous animals?
38. How in the mole, and shark?

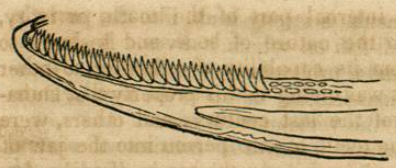

Fig. 10. Shark's Jaw and Teeth.

pointed form of the teeth. Thus, among the Carnivora, the lion and others of the cat tribe are found to have all the molares pointed except two, which are rounded; while ferrets and polecats have four, and dogs eight, rounded. The teeth of man seem to approximate him, in this respect, to families such as we find among the Quadrumana, or monkey tribes, which, in their natural state, live principally upon fruits, but do not refuse also various kinds of animal food.

21. Nothing can be more plain than nature's intention in thus varying the forms of the teeth. Without any exception, these variations have the most precise relation to the instincts of each tribe. It is quite impossible that the sharp teeth of the tiger or shark could ever be used for grinding food, like that of the cow or the horse, or that the teeth of the latter could be intended for seizing or tearing flesh; and this becomes still more striking, when we observe how the jaws in which the teeth are set have been articulated. In the Carnivora, as the teeth merely cut, the jaws are jointed like the blades of a pair of scissors; but the jaws of the Herbivora, and of Man, allow of a grinding motion. This motion, in the cow and horse, is from side to side, or nearly circular; in the Rodentia, as the rat, &c., the grinding motion is rapidly performed in a longitudinal direction.

22. The human teeth are composed principally of two substances, the *enamel*, and the *ivory*, or *bone*. The enamel is placed externally and on the body of the tooth, and forms only a thin layer. It has ninety-eight per cent. of earthy matter in its composition, and is so hard as to strike fire with steel, and is viewed by physiologists as void of vitality, so that when once formed, the teeth never increase in size, and when any part of the enamel is destroyed it is never

39. What indications may be drawn from the teeth?
40. What peculiarity in the form and motion of the jaws?
41. Composition of human teeth and the difference.

regenerated. The internal part of the tooth, or ivory, approaches more to the nature of bone, and is shown to possess vitality, from its capability of adhering to other vital structures. It was owing to this property that Duhamel, a physiologist of the last century, and others, were able to transplant the teeth of one person into the jaw of another, to make them grow upon the combs of cocks, &c. Transplanting sound for decayed teeth, threatened, indeed, at one time, to become but too common among the better ranks, until, happily for the interests of humanity, it was discovered that this practice produced disorders more serious than the deficiencies intended to be supplied.

23. Other animals have the enamel differently distributed. The horse, elephant, and other Herbivora, have layers of it which penetrate interiorly. These, from being harder than the surrounding ivory, are longer of wearing down, and hence form projecting ridges, of great importance in triturating their food. The incisors of the beaver, and other Rodentia, want the enamel posteriorly, and, for the same reason, wear soonest in that direction. As a consequence, they always preserve a sharp edge in front, which is of the greatest importance to this gnawing order.

24. The teeth furnish a beautiful example of what has been justly denominated a prospective contrivance. Their presence above the gums at birth would have been only an annoyance. Accordingly, they are then wanting; but nature, which anticipates our needs, places them deep in the jaw, even before birth, to appear in due season. If a section of the jaw of a young animal be made, some of the teeth may be seen just beginning to be formed—others cutting through the bone—while others are passing through their last covering, the gum.* In the child, the teeth generally begin to appear from the sixth to the twelfth month,

* [There is a slight inaccuracy here, for the teeth are not in the jawbone as here intimated. There is placed along the edge of each of the jawbones, a bony process which is covered by the gums, but which is distinct from the jaw. This bony structure contains the rudiments of the teeth, and seems to sprout out along with the teeth in

42. How is the vitality of the bony part proved? illustrations?
43. Peculiarities in certain animals.
44. What of the rudimental teeth in young animals?

and the first or milk teeth, twenty in number, are usually completed about the third year. These again begin to shed about the seventh year; and the second, or permanent set, is not complete until about the sixteenth or eighteenth year.

25. In the process of shedding, the crown, or that part of the tooth which is coming forward, presses upon the fang of the one already occupying the jaw, and causes its absorption. It is the impossibility of growth, in consequence of the non-vital nature of the enamel, which renders the renewal of the teeth necessary. In consequence, also, of the jaw, during youth, increasing its dimensions, mostly posteriorly, it is necessary that the number of the teeth should be increased, in that situation, in order that no part of the jaw may be unfurnished. For this reason, about the time when the human being reaches maturity, a new tooth rises at each extremity of the range, being four new ones in all, which, from the time of their appearance, are called the *wisdom teeth*. There are some teeth which animals of other species do not shed. The incisors of the Rodentia, and the grinders of the elephant, &c., continue to grow during the whole life of the animals.

26. The second part of the masticating apparatus, is that which moistens the food and mouth. The fluid employed for this purpose is tasteless, and is called *saliva*. It is produced by six bodies called glands, two of which are placed near the angles of the lower jaw (submaxillary), two under the tongue (sublingual), and one on each side, immediately before the ears (parotid). All these open into the mouth by means of small tubes or ducts—the four first under the tongue, the two latter on the inside of the cheeks, opposite the second or third molar teeth of the upper jaw. The fluid trickling from the latter may be seen at any time by turning out the cheeks, and watching their small openings. Its flow is seen to be increased by pressing with the finger from the ear forwards. The camel is supplied with additional salivary glands in its throat, which are of great service in its long journeys over burning deserts. Fishes, again, from living in water, and masticating but little, do not require, and are therefore destitute of, salivary organs.

their growth to maturity, and is found to be absorbed after the teeth have been removed, as in advanced age, leaving the jawbone only covered by the lining membrane of the gums. This bony process is called the alveola, or alveolar process, into which the teeth are inserted, and being an appendage both to the teeth and the jawbone, it serves to impart great solidity to their attachment, and render their extraction difficult. The pieces of bone which sometimes come out with the teeth when awkwardly extracted, are not parts of the jawbone, but pieces of this alveolar process, or bony socket of the teeth The gum is the soft part covering this bony process.]

45. Describe the progress of teething in infancy.
46. Wherein is the wisdom of this arrangement seen?
47. How is the posterior part of the jaw supplied at mature years?

27. The muscles of the tongue, cheeks, &c., which bring the food under the influence of the teeth, and pass it backwards into the gullet, form the third and most curious part of the masticating apparatus. Indeed, this, which we shall examine in connection with *deglutition*, or swallowing, is undoubtedly among the most admirable and wonderful of the bodily processes. During the comminution of the food the mouth forms a shut cavity, bounded by the closed lips anteriorly, the cheeks laterally, and the root of the tongue and the curtain of the palate brought together posteriorly. In Fig. 11, which represents the throat or pharynx cut open behind, *d* is the curtain (*velum palati*), with its central dependent part called

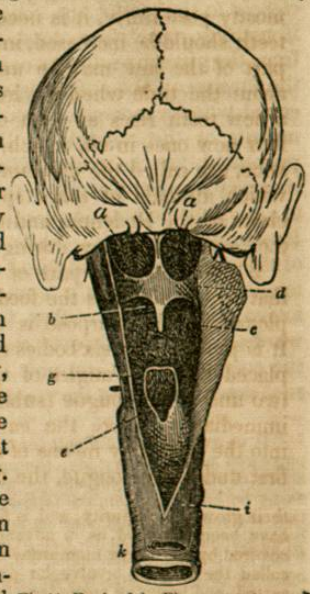

Fig. 11. Back of the Pharynx cut open.*

* *a a*, the nostrils. *b*, the mouth. *c*, the tongue. *d*, the curtain of the soft palate. *e*, the glottis, opening into the windpipe. *g*, the epiglottis. *i*, the gullet. *k*, the windpipe.

48. What difference in other animals?
49. Describe the salivary apparatus, and illustrations.
50. How is the food passed into the stomach?

the *uvula*, and *c*, the tongue. When the food has been properly moistened, and broken down, it is rolled into the form of a ball, and is passed backwards by the tongue and other muscles into the *pharynx*, which may be conceived of as a kind of bag, having the nostrils (*aa*) opening into it from above; the *mouth* (*b*) opening below these; the *glottis* (*e*), and the *gullet*, or *œsophagus* (*i*), still lower; besides two other openings called *Eustachian tubes*, which open on its sides, and lead to the internal ear.

28. Before the food can get into the pharynx, the curtain (*d*), which we have said is, during mastication, applied closely to the root of the tongue, must be lifted up. But if nothing more were done, the food or drink might pass from the pharynx into any or all of the openings mentioned, the inconvenience attending which, every one has experienced when a morsel of food or a little fluid gets into the nostrils or the windpipe. This, however, is effectually prevented, for the curtain is not only lifted up, but is also instantly applied closely to the back of the pharynx, so as to cut off the communication with the nostrils, and close the Eustachian openings; while, at the same instant, the sides of the glottis, or opening into the windpipe (*e*), are drawn together, and a gristly substance, the epiglottis (*g*), is folded back over it. The food, being still forced backwards, passes rapidly over the epiglottis into the gullet (*i*), the only opening it can now escape by, and from it is carried downwards into the stomach.*

* It is exceedingly difficult for a person who has not made these parts and actions his study, thoroughly to comprehend them. The action of the curtain, perhaps the most interesting of the whole, may easily be exemplified in the following manner:—We have said first, that the mouth, during mastication, forms a shut cavity, the curtain being applied closely to the root of the tongue. The same takes place when the cheeks are distended with air. If the communication were not then cut off posteriorly, the air would escape by the nostrils. We may even feel the curtain forced back when the lips are kept firm and the distended cheeks are pressed with the fingers. Secondly, we have said that the curtain is lifted up and applied to the back of the pharynx during deglutition, in order to cut off the communication with the nostrils. To show that this is the case, attempt to swallow some fluid or saliva from the mouth, and at the same time keep the cheeks distended. This will be found impossible, because, the moment the curtain is lifted up, the compressed air escapes by the nostrils. As an example of the curtain being applied to the back of the pharynx, blow smartly through the mouth, when it will be found that not a particle of air escapes by the nose. The communication with the nose must therefore be cut off. Again, when we blow through the nose, though the mouth be kept open, no air will escape by it. The curtain must therefore be applied to the tongue; nay, while blowing through the nose, we may even see this in the mouth of another, or feel it with our finger in our own. Children born without curtain and palate never can suck, because they cannot make the mouth a shut cavity; and, in this case, or where these parts have been destroyed by disease, deglutition is always difficult.

To form a proper conception of the other parts concerned in deglutition, a preparation, like the one described at the close of this section, must be seen.

51. Describe the structure of the mouth and throat.
52. How is the food kept out of the nostrils posteriorly?
53. How is the windpipe protected?
54. Describe the act of deglutition.

29. Complicated as these different actions may appear, we know how accurately they are all performed many hundred times daily, in swallowing our saliva, and in taking food and drink. They may be divided into three kinds; first, those of the cheeks, tongue, and sometimes the curtain, which give us sensations, and are voluntary; secondly, those of the pharynx, which still produce a sensation, but which can be called into operation only when the food or drink comes into contact with the pharynx;* and, thirdly, those of the gullet, which are performed almost entirely without our consciousness.

30. In the examples hitherto adduced, we have found mastication to precede deglutition. Other animals, however, swallow their food first, and comminute it afterwards. This is the case with the lobster, the grasshopper, &c., which have their teeth immediately connected with

* The simple experiment of swallowing our saliva several times in rapid succession, illustrates this well. As long as there is saliva to come into contact with the pharynx, deglutition can be performed; when the saliva is exhausted, our power over these parts is gone. Mr. Mayo thinks the muscles in this case are fatigued and cannot act. This is evidently incorrect, for they instantly act again with ease when saliva is furnished.

55. How many and what organs are employed?
56. Are all voluntary actions?
57. Illustrate those that are involuntary.

their stomachs. One species of the latter has no fewer than two hundred and seventy teeth. The same purpose is served by the gizzards of granivorous birds, only that the grain is ground between two hard horny surfaces, which act like millstones, their effect being increased by numerous small stones swallowed instinctively by the animal. As many as two thousand of these stones have been counted in the gizzard of a goose.

31. The processes which have been described are all preparatory to the *digestion of the food*, and this takes place in the stomach and intestines. Substances received into the stomach as food must necessarily undergo many changes in their composition before they are fitted to form part of the animal body, but the extent of the change required is proportionate to the difference between the qualities of the nutritive materials in their original and in their assimilated states. Thus, the conversion of vegetable into animal matter necessarily implies a more lengthened process, and a more complicated apparatus, than the assimilation of what has already been animalized. The cow eats grass, and converts it into flesh, by passing it through a series of very complicated organs; and we, in our turn, eat the flesh of the cow, and convert it into the substance of our bodies, but we employ for this purpose a much less complex machinery. As a substitute for such assistance as the cow lends in this case, man has invented the art of cooking, by which he is enabled to extract nourishment from substances that to him in their natural state are quite indigestible. Hence he has much greater variety in his food than any other animal.

32. The agent which nature employs to bring about the decomposition of the food when it arrives at the stomach, is called the *gastric juice*. When milk is taken into the stomach, the active principle of the gastric juice immediately separates the fluid from the solid parts, and this is

58. What animals swallow before mastication? and why?
59. What instinct of certain birds is remarkable?
60. What is said of digesting vegetable and animal food?
61. What of the cow.
62. What of the gastric juice.

the reason why milk is always curdled when it is vomited. This principle in the calf's stomach, called the runnet, when infused, is used for the same purpose in dairies.

33. A good many years ago, Dr. Stevens of Edinburgh showed very satisfactorily the action of the gastric juice on various substances, by enclosing these in silver balls, perforated with holes, which were swallowed by an itinerant German, who went about exhibiting the singular power he had acquired of swallowing stones, &c. In one of these balls, divided by a partition, were enclosed four and a half scruples of raw beef, and five scruples of raw fish. In twenty-one hours the beef had lost one and a half scruples, and the fish two scruples. In another ball was placed some beef which had been previously chewed; and in thirty-eight hours after it had been swallowed, it was found quite empty. The balls, in other experiments, contained pieces of roasted turkey, boiled salt herring, raw potatoes and parsnips, and apples and turnips, both raw and boiled, which disappeared in thirty-six hours. He also enclosed in the balls live leeches and worms, which were found, upon examination, not only dead, but completely dissolved. Most probably they were first killed by the high temperature of the body, and were then acted on by the gastric juice, for we observe that this fluid has no action on a body as long as it retains its vitality. Different kinds of worms which naturally inhabit the stomach and intestines, remain free from its influence so long as they are alive, but whenever they die, they are either digested or evacuated. In accordance with the same law, there is the curious observation made by Mr. John Hunter, the truth of which has since received repeated confirmations, that the gastric fluid actually, in some cases after death, dissolves and perforates the stomach itself and surrounding structures. Dr. Stevens, in another series of experiments, found that the gastric juice of dogs produced no effect upon vegetables, but easily dissolved flesh, bones

63. Describe Dr. Stevens's experiments, in the stomach of a German.
64. Mr. Hunter's observation.
65. Dr. Stevens's experiments.

and even ivory, while the same fluid in the sheep or the ox made no impression on beef, mutton, or other animal bodies, but acted energetically on vegetable substances.

34. Dr. Beaumont, of America, enjoyed a rare opportunity of observing the qualities of the gastric juice, and the process of digestion in the human body. A young Canadian, called Alexis St. Martin, who had received the contents of a musket in his left side, after recovering from the effects of his wound, had an opening left into the stomach, through which its operations and contents could be seen and examined. At first this opening was attended with inconvenience, but afterwards a fold of the stomach became fitted to it and filled it up, acting like a valve, so that it could be pushed inwards at pleasure. Dr. Beaumont having hired this young man as his servant, made a most elaborate and careful series of observations on different parts of the digestive process, which he has published, and which are well worthy of a perusal. To show the properties and action of the gastric juice, we shall here state a few of these. It had been noticed by previous observers that the fluid obtained from the stomachs of animals is sometimes not in the least acid; but Dr. Beaumont has shown, that though this fluid may show no acidity at other times, during digestion, or even when the stomach is mechanically irritated by an India rubber tube, the bulb of a thermometer, &c., it is always acid; and the acidity which is caused principally by a small quantity of muriatic acid (spirit of salt), appears to be essential to the proper performance of digestion. Dr. Beaumont frequently obtained at one time as much as an ounce of the gastric juice, which appeared to him to be poured out into the stomach of his patient by numerous minute clear points. He says it is a clear transparent fluid, without smell, slightly saltish, and very perceptibly acid. Its taste resembles that of thin mucilage, slightly acidulated with muriatic acid. It undergoes putrefaction with difficulty, and checks its progress in other animal substances. In

66. Dr. Beaumont's patient, and experiments.
67. Describe the gastric juice, and its effects upon food.

one of the experiments, St. Martin dined at one o'clock on roast beef, bread, and potatoes. In half an hour the contents of the stomach were found to be reduced to a mass resembling thick porridge, and by six o'clock the whole had been dissolved and carried out of the stomach. In other experiments, Dr. Beaumont shows that vegetables are much more rapidly dissolved than animal substances, and some of the latter more quickly than others of the same kind. Thus, fried tripe was digested in one hour; boiled cod, and likewise bread and milk, in two hours; roasted beef, and also soft-boiled eggs, in three hours; salted pork in four and a half hours; hard-boiled eggs in five and a half hours; and an unusually full meal of salted pork required six hours for digestion. Other experiments, similar to those of Dr. Stevens, were also made, in which St. Martin breakfasted on fried sausages with coffee and bread, while portions of the sausage, enclosed in a muslin bag, were placed in the stomach. In three hours the stomach was half empty, and the contents of the bag about half diminished; and in five and a half hours the stomach was empty, and the bag contained only a few small pieces of gristle, and the spices of the sausage.*

35. We have occasionally examples of the power of the gastric juice over still more solid bodies. Cuvier opened the stomach of an ostrich, which contained nearly a pound of bits of iron, copper, pieces of money, &c., corroded and worn down by attrition. Even the human stomach has a similar power, though less frequently called upon to exercise it. An American sailor, who died in one of the London hospitals in 1809, had swallowed during the ten previous years no fewer than thirty-five clasp-knives.

* The gastric fluid has been found equally to produce its specific effects when substances are submitted to its action out of the body. It has lately been ascertained that a fluid very similar in its properties, may be produced by mixing the dissolved mucus of the stomach with a little muriatic acid. The mixture possesses different properties from either fluid singly. A brief account of the case of Alexis St. Martin is given in Dr. Combe's work on Digestion, and in Mayo's Physiology, and a larger account in a separate volume is published by Dr. Beaumont in America, and republished in this country by Dr. Combe

68. Illustrate the power of the gastric juice by examples.

Corroded fragments of upwards of thirty of these were found in the stomach after death. Other cases of the same description have since been recorded.

36. The intestinal canal is divided into the *stomach* (Fig. 12, *b*), *small intestines* (*d d*), and *large intestines* (*e e e*); all of which are contained in the abdomen or belly,

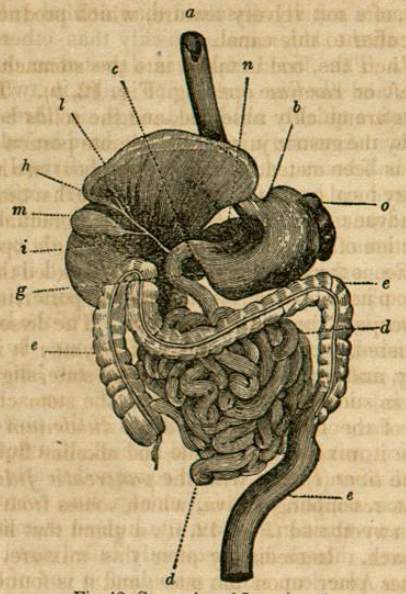

Fig. 12. Stomach and Intestines.*

and are seen in their natural situation in Fig. 21. They are all composed of three coats. The outer or serous coat is the smooth surface we see on opening the belly of an

* *a*, the gullet. *b*, the left or cardiac extremity of the stomach. *c*, the right or pyloric extremity of the stomach. *d d*, the small intestines. *e e e*, the large intestines. *g*, the duodenum or commencement of the small intestines. *l*, the liver. *h*, the duct from the liver. *m*, the gall bladder. *i*, the common duct. *n*, the pancreas or sweetbread. *o*, the spleen.

69. What division is made of the intestinal canal?
70. Describe the mesentery.

animal, the two layers of which unite behind the bowels to form the mesentery (Fig. 13, *c c*), which attaches the intestines to the back-bone; the middle is the muscular coat, which produces what are called the peristaltic or vermicular (worm-like) motions, which take place in the propulsion of the food downwards; the inner is the mucous coat, of a soft velvety texture, which produces all the fluids peculiar to this canal.

37. When the food is taken into the stomach, it enters by the left or *cardiac* opening (Fig. 12, *b*). The more fluid parts are quickly absorbed, and the solids begin to be acted on by the gastric juice. A moderate portion of animal food, as has been stated, is dissolved in about two hours, and an ordinary meal generally in about double that time. As the solution advances, the dissolved parts are gradually moved by the action of the stomach towards the right opening (*c*). This portion is thicker than the rest, and is called the *pyloric orifice*, from its supposed resemblance to a porter, in preventing the escape of the undissolved food. The dissolved food, here gathered, receives the name of *chyme;* it is a grayish, pulpy matter; always, in a healthy state, slightly acid. It passes in successive portions, from the stomach into the first part of the intestines, called the *duodenum* (Fig. 12, *g*), where it mixes with the bile and alkaline fluid poured out by the *liver* (*l*), and with the *pancreatic juice*, a fluid somewhat resembling saliva, which comes from the *pancreas*, or sweetbread (Fig. 12, *n*), a gland that lies behind the stomach. Immediately after this mixture, an alteration takes place upon the mass, and it is found to separate into two parts, one of which is carried out of the system by the bowels,* while the other, called the *chyle*,

[* This process by which the useless portion of the food is carried off is called excrementitious, and is indispensable to health. The bile secreted by the liver, appears to be the agent specially active in propelling this rejected mass downward, and upon the healthful condition of the bile, both in quantity and quality, depends the regularity by which this function is performed. The peristaltic motion of the bowels seems to be produced by the bile, and when this is absent, a substitute has to be found in some drug of similar properties, to overcome or prevent constipation.]

71. The coats of the intestines.
72. What propels the food downwards, and what is it called?

or the nutritious part of the food, is taken up, principally from the small intestines, by innumerable minute vessels. These have received the name of *lacteals*, from the milk-white appearance they present when extended with chyle, and they are said to terminate on the inner or mucous coat of the intestines by open mouths. Figure 13 shows the lacteal vessels (*b b*) coming from part of the small intestines named the *jejunum* (A). The membrane *c c*, named the mesentery, is that by which the intestine is confined to the spine. The lacteals have a beaded appearance, from the valves with which they are thickly furnished to prevent the return of the chyle. This fluid,

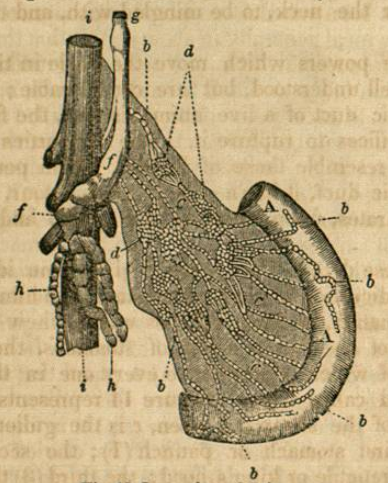

Fig. 13. Lacteals and Jejunum.

A A, a portion of the small intestines (jejunum). *b b b b*, lacteal vessels. *c c c*, the mesentery. *d d*, mesenteric glands. *f f*, the receptacle of the chyle. *g*, thoracic duct. *h h*, lymphatic vessels from other parts of the body. *i*, the aorta.

73. Name the two openings of the stomach, and relations.
74. What becomes of the fluid and then of the solid food?
75. What is chyme?
76. Where does the food pass from the stomach, the chyme?
77. What fluids does it mix with there, and what takes place?
78. What vessels take up this chyle, and in which intestine?

in passing through them, traverses small bodies called mesenteric glands (*d*), in which it probably undergoes some alterations. As it advances, the lacteals unite more and more, until they terminate in a vessel called the *receptacle of the chyle* (*f*), where the chyle mixes with *lymph*, a fluid brought from other parts of the body. In the accompanying engraving, other absorbing vessels (*h h*) are seen coming from other parts of the body, also to unite in the receptacle of the chyle. The compound of lymph and chyle then passes through the terminating branch of this system of vessels, called the *thoracic duct* (*g*), a little larger in man than a crow-quill, and by it is poured into veins near the neck, to be mingled with, and to become, the blood.

38. The powers which move the chyle in this course are not well understood, but are considerable; for when the thoracic duct of a live animal is tied, the force from behind suffices to rupture it. The properties of chyle somewhat resemble those of blood. When poured from the thoracic duct, it has a slightly pink colour, and, like blood, separates, upon standing, into a solid and a watery part.

39. These details may serve to give some idea of the process of digestion in man, and animals like him. Among the Ruminantia, or those animals which chew the cud, there is not one, but a series of stomachs, the curious structure of which is familiar to every one in the article of our food called tripe. Figure 14 represents the four stomachs of the sheep cut open, *e* is the gullet opening into the first stomach or paunch (1); the second (2) is called the reticule or king's hood; the third (3) the many-plies; and the fourth (4) the red, which is the only one having an inner surface like the human stomach. P shows the situation of the pylorus. The Ruminating family possess a voluntary power over their stomachs, which we and most other animals want. They are able, at pleasure, to bring up, into their mouths, the food which

79. Where and how is it then carried, and what mixture takes place?
80. By what vessel does it pass into the veins, and meet the blood?
81. Does the chyle resemble blood?

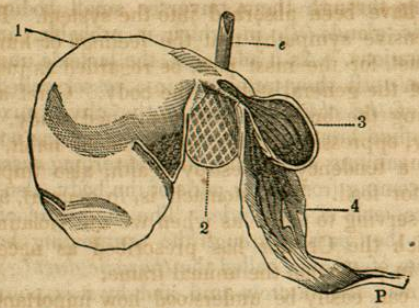

Fig. 14. Section of Stomachs of the Sheep.

has been macerating in the fluids of the paunch and king's-hood, to be again masticated. They then pass it directly into the many-plies, to circulate between its leaves, before getting into the fourth stomach.

40. The object in view in the whole of this apparatus, is the detention of the vegetable food, and the exposure of it to a large surface. The calf passes its animal food, the milk, directly to the fourth stomach. We can note a similar object constantly kept in view in the comparative lengths of the intestines in different tribes. Thus, the ram has these twenty-seven times the length of its body, the ox twenty-two times, man five and a half times, the lion three times, and the shark little more than three-fourths of its length.

41. The stomach may be regarded as a kind of centre, with which every part of the animal economy sympathizes. It is well known that a violent blow in this region has frequently proved instantly fatal; a sudden draught of cold water, when the body is warm, sometimes has the same effect. Professor Christison mentions, that when he injected a poison, called oxalic acid, into the stomach of a dog, death took place instantaneously, and before it could

82. How do the ruminant animals differ from man in respect to the stomach?
83. Describe that of the sheep.
84. Wherein do the intestines of animals differ?
85. What illustrates the vital importance of the stomach?

possibly have been absorbed into the system. It is from this extensive sympathy that the feelings of hunger and thirst must, for the most part, be regarded as indications merely of the general state of the body. Grief and care, overtasking the brain, by long-continued study, indolent inactivity, oppressive labour, every act or habit, in fine, that has a tendency to destroy health, also impairs our appetite for food. The stomach is, in general, a faithful monitor, serving to warn us when we are violating those laws which the Creator has prescribed as necessary to preserve in perfection the animal frame.

42. It can easily be understood how important is the proper performance of the digestive functions. The circumstances most essential in securing this are—1st, and above all, an originally sound constitution. Without this, some part of the animal machinery will continually be found going wrong, and, perhaps, more than any other, the digestive organs. 2d, Temperate habits, regular exercise, and a cheerful mind. 3d, A proper quality and quantity of food. The lower orders in this country suffer from the quality of their food, which is often very indigestible; the better ranks suffer more from the quantity taken. In both, the bad effects are most marked when combined with sedentary or intemperate habits.

43. The alimentary canal is liable to many diseases, and among the most common is inflammation, which affects it variously as its different coats are attacked. When the outer or serous coat is attacked, pain upon pressure is generally intense; when the muscular coat is attacked there is generally violent twisting pain; but its principal effects are shown in impediments to the passage of the excrement, constituting what is commonly called iliac passion. When the mucous or inner coat is inflamed, it quickly becomes softened or ulcerated (eaten away), and vomiting, purging, or both, are its effects. In the cholera of this country, the whole extent of this coat is frequently

86. Does the mind affect the stomach?
87. What reflection is suggested?
88. How may we promote healthy digestion?
89. What of the diseases of the intestines?

affected; in dysentery it is principally the lower portion of it which suffers.

44. The mesenteric glands (Fig. 13, *d d*) occasionally become diseased in childhood, and prevent the chyle from properly entering the system. Children thus affected present the singular spectacle of eating voraciously, at the same time that they are becoming more and more emaciated.

The teacher will increase the interest of this section, by exhibiting the arrangement of the teeth and jaws in the dog, cat, sheep, hare, haddock, &c. A horizontal section of a horse's molar tooth polished shows the enamel going into the interior. In preparing the skulls or bones of any animal, all that is required is to allow them to macerate in water till the flesh rots off, and then clean them.

To show the parts concerned in deglutition, take a sheep's head, being careful that the butcher has left the upper part of the windpipe uninjured. Saw through the whole of the skull and the brain perpendicularly downwards, half an inch anterior to the horns; forcibly separate these two portions of the skull, and detach the posterior from the articulations of the lower jaw and the soft parts with a scalpel, the finger being pushed upwards into the gullet as a guide to prevent the pharynx being injured. This being done, the back part of the pharynx and gullet may be laid open, and the parts seen as in Fig. 11. The lowest portion of the gullet should not be cut, and a cork may be placed in it to show its course. When this has been examined properly, the tongue may be detached from the lower jaw by cutting close to the latter, and its connections with the epiglottis, &c., seen. This preparation is easily made, and at once gives a perfect conception of these complicated parts even to children.

To see the intestinal canal, &c., the abdomen of a hare or rabbit may be opened. The mesentery, liver, stomach, small and large intestines, &c., may be seen; but the latter are considerably different from the human. The sheep's stomachs, as in Fig. 14, are easily got and examined. They should be cut open as shown, and merely well washed with cold water. Note in them the channel formed from the gullet, and the vicinity of the latter to all the stomachs, the great increase of surface produced by their internal structure, foldings, &c., and the thick pylorus at the extremity of the fourth stomach.

In the fowl, the gizzard is a curious object, with its glandular stomach above, and the intestines going off from it on one side.

A short intestinal canal is well seen in the haddock, &c.

As comparatively accessible books in which other appropriate figures to illustrate this section are to be found, we may mention Dr. Roget's Bridgewater Treatise and Dr. Smith's Philosophy of Health.

[The directions given in this note are more curious than useful for practical purposes, especially in the schools.]

90. The effect of early disease in the mesentery.

SECTION III.

THE CIRCULATION.

45. In the preceding section we have traced the progress of the food during its mastication, deglutition, and digestion. We have seen it converted into chyle, taken up by the lacteals, and, through the thoracic duct, poured into the veins of the neck. Here we lose sight of it as chyle. In the new system of vessels into which it has entered, it undergoes alterations, all of which are not yet perfectly understood, but which completely assimilate it to the nature of the blood, of which it hereafter forms a part. We are thus brought to consider a second important department of our science, the circulation of the blood; but first it is necessary to inquire into the nature of the blood itself.

46. With the appearance of *blood*, as it occurs in the higher classes of animals, every one is familiar. When drawn from one of the vessels which immediately receive it from the heart, and which are called arteries, it is of a bright scarlet colour; but when taken, as it usually is in the common operation of bleeding, from a vein, it is much darker, being of the shade called by painters Modena red. When first drawn from the vessel, it is a somewhat glutinous and apparently homogeneous fluid, but, after standing for a short time, it separates into two parts, one a watery part, called the *serum*, the other a more solid part, called the clot, or *crassamentum*. The serum is chiefly composed of water, with a considerable quantity of the same substance as the white of the egg (*albumen*) dissolved in it; so that, if it is exposed to a boiling heat, this coagulates and makes the whole solid. The clot, again, likewise consists of two principal substances, one of which gives it the red colour, and, by repeated washings, can easily be separated from the other, which is a white,

91. Enumerate the successive changes upon the food.

92. Describe the blood, its difference of colour, and the parts into which it separates.