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COLLINS' SCHOOL SERIES.

NEW CODE

ANIMAL PHYSIOLOGY

FOR

SIXTH STANDARD.

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Alimentation (Food, Nutrition, Digestion),
Sense Organs, Muscles, and Nerves.

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ANIMAL PHYSIOLOGY.

QUESTIONS.

The Pupil should sketch each of the diagrams more or less accurately. The Teacher is expected to supplement these Questions largely.

1. Whence are derived the *materials* and *forces* by which animal life is maintained? What is the *daily loss* of substance: in what *form* does it *leave* the body? What amount of food is daily required to sustain the human body in vigour? What is *food*; how is it *classified*; what is meant by *flesh-forming*, what by *heat-forming*, food? Why is it more economical to live on an *admixture* of foods than on one kind of food only? What do you mean by *nutrition*, and what are its chief agents? What do you mean by *digestion* and *alimentation*? Draw a diagram of the *alimentary canal*, and name its parts (1-9).

2. Describe the *course* of the food during the process of *digestion*; explain the *changes* it undergoes previous to its being *absorbed* and becoming *part* of the *blood*; name the juices by which these changes are effected. What do you mean by *chyme* and by *chyle*? *Where* and *how* do the *fatty* parts, the *starch*, and the *proteids* (albuminous substances) of the *food* enter the *blood*? Describe the *mouth* and the *organs* contained in it. What is *mastication*, and what are its *uses* in *digestion*? Describe the *two sets* of human teeth (milk and permanent): draw a diagram showing the *shape* of the different *kinds* of the *permanent* teeth. What are the uses of *insalivating* the food? What is *ptyalin*? Describe the properties of the *saliva*, also the *positions* and *functions* of the *salivary glands* and *ducts* (9-18).

3. Draw a diagram of the *pharynx*, and name its various parts, also the adjacent organs. Describe the size, form, and structure of the *oesophagus*; also describe the process of *swallowing*. Describe the position, size, and shape of the *stomach*, name its various parts, and draw a diagram showing the arrangement of the *gastric follicles*, and the relative position of its various *coats*; also describe the structure and functions of these *coats*, and of the *gastric follicles*. Describe the properties and composition of *gastric juice*. What is *peptone*? What do you mean by "*gastric digestion*" (19-28).

4. *Where* and *what* is the *pylorus*: what its *functions*? Name and describe the *size*, *position*, and *functions* of the various *parts* of the *large* and *small* *intestines*, and name the *places* by the *mesentery* *are* *attached* to the *parts* do the *bile* and *pancreatic* *glands* *open* into the *intestine*? What are *villi*, *and* *what* is their *position*, *and* *function*? Describe the *structure* and *function* of the *liver*, *and* *the* *pancreas*, *and* *the* *gall* *bladder*, *and* *the* *thoracic* *duct*, *lymphatic* *system*, *and* *the* *lacteal* *system*. Describe the properties of *chyme* *and* *chyle*.

5. What do you mean by *secretion*? What is *excretion*? What is *osmotic pressure*?
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ANIMAL PHYSIOLOGY.

STANDARD VI.

ALIMENTATION (FOOD, NUTRITION, DIGESTION). THE
SENSE ORGANS, THE MUSCLES AND NERVES.

*The Pupil examined in Standard VI. is also expected to be able to
answer questions put in Standards IV. and V.*

ALIMENTATION.

1. Introductory.—It has been repeatedly shown (Arts. (b) 23, 36, 56, 58, and 70, Stand. V.) that the forces by which life is sustained are generated by the chemical *union* of the respired *oxygen* with the elements of the animal *tissues* and of the *food*.

In this way are daily *burnt* or *oxidised* and thrown out of the human system, by means of the *lungs*, *skin*, and *kidneys*, about 4000 grains of *carbon*, and 250 to 300 grains of *nitrogen*, the former passing off in the form of *carbonic acid gas*, and the latter, chiefly from the *kidneys*, in the form of *urea*.

To counterbalance this daily *loss* of substance, and supply the quantity of *carbon*, *hydrogen*, and *nitrogen* necessary to retain the human body in its *normal* condition of *bulk*, temperature (98° F.), and *vigour*, it is necessary that from 40 to 50 ounces of *solid food* be daily passed into the system through the mouth and *alimentary canal*.

To the series of changes which the food undergoes in the *alimentary canal*, and by which it is converted into *blood*, and thus prepared for the *repair* of the *tissues* or

the *nourishment* of the body, the terms *alimentation* and *digestion* are applied.

2. Food or aliment may be defined as consisting of those *external nutritious* substances which are passed into the *alimentary canal* for the purpose of being *digested*, and restoring the *losses* of the system.

3. Classification of Food.—Food is sometimes classified under *two* heads:—

(1.) *Heat-forming*, fuel, or respiratory food, which does contain *carbon* and *hydrogen*, which serve as sources of heat, but which does *not* contain *nitrogen*, and, therefore, which cannot completely restore the *lost* or *wasted* tissues.

(2.) *Flesh-forming*, plastic, albuminoid, *proteid*, or *nitrogenous* food, which *does* contain *nitrogen*, in addition to *carbon*, *hydrogen*, and *oxygen*, and is therefore capable of *completely* restoring the *lost* tissues.

4. Food Stuffs may be divided into *four* classes, as shown in the following table. For a *description* of the respective substances contained in the table, see Arts. 8 and 24, Stand. V.

Food Stuffs.	{	Inorganic or Mineral	{	Salts. Water.				
		Vital or Organic	{	Amyloids, Fats, Proteids,	{	Starch, Dextrine, Gum, Sugar,	{	Contain Carbon, Hydrogen, and Oxygen.
				Albumen, Fibrin, Syntonin, Casein, Gluten, Chondrin, Gelatin,		{	Contain Carbon, Hydrogen, Oxy- gen, and Nitro- gen.	

5. Economical Admixture of Food.—To obtain the requisite 4000 grains of carbon per day from *dry proteids*, a man would be compelled to eat about 7500 grains; but this would give him nearly 1200 grains of *nitrogen*, or nearly *four* times the quantity of nitrogen (300 grains) he would require.

That is, if he lived on *fatless* meat, he would require

5 to 6 lbs. per day to give him the necessary carbon; whereas he might get the necessary *carbon* and *nitrogen* from 4 to 5 lbs. of *bread*, or from a mixed diet, consisting of 2 lbs. of bread and $\frac{3}{4}$ lb. of meat. He might also get the same from about 1 lb. of *fatless* meat, and $\frac{1}{2}$ lb. of *fat*, or 1 lb. of *sugar*.

If he attempted to get the necessary quantity of *nitrogen* from a purely *potato* diet—a comparatively *innutritious* diet—he would probably be compelled, in order to get the necessary *nitrogen*, to eat 10 to 12 lbs. or upwards per day. On the other hand, if he tried to live on a highly *nutritious* and exclusively *proteid* diet, he might die of starvation, in consequence of the great loss of vital power he would sustain in the digestive attempts to get the *necessary carbon* under these unfavourable conditions.

6. Nutrition (from Lat. *nutrio*, I nourish) is the process by which the tissues of the living body are repaired, built up, or their loss of substance restored out of material supplied them by the *liquor sanguinis* or *blood plasma*. The chief agents of nutrition are the *capillaries*.

7. Digestion or Alimentation (from Lat. *dis*, asunder; and *gestus*, carried), in its larger sense, is the process by which the *nutritious* are separated from the *innutritious* or useless parts of the food, and converted into blood.

8. General View of the Alimentary Canal.—The alimentary canal is a *musculo-membranous* tube, about 26 feet long, which, commencing at the *mouth*, passes, by a series of coils or *convolutions*, the whole length of the body, and terminates at the end of the *rectum*. It consists of *four* coats or layers. Commencing at the *mouth* and the *lips*, and continued into the *pharynx*, it afterwards, in its downward course, forms the *œsophagus* or gullet; then, *expanding largely*, it forms the *stomach*; again contracting, it forms the *small intestines*; and lastly, again *expanding*, it forms the *large intestines*. (See figs. 1 and 7).

Nine-tenths of the *alimentary canal*, together with the rest of the *organs of digestion*, are contained in the cavity of the *Abdomen*, which is lined by the *peritoneum*. That portion of the *peritoneum* by which the *Intestines* are retained in their places is termed the *mesentery*.

9. General View of the Course of the Food and the Changes it undergoes.—The solid food, on entering the mouth, is *masticated* or broken up into minute portions and mixed with the saliva (spittle), *swallowed*, and mixed

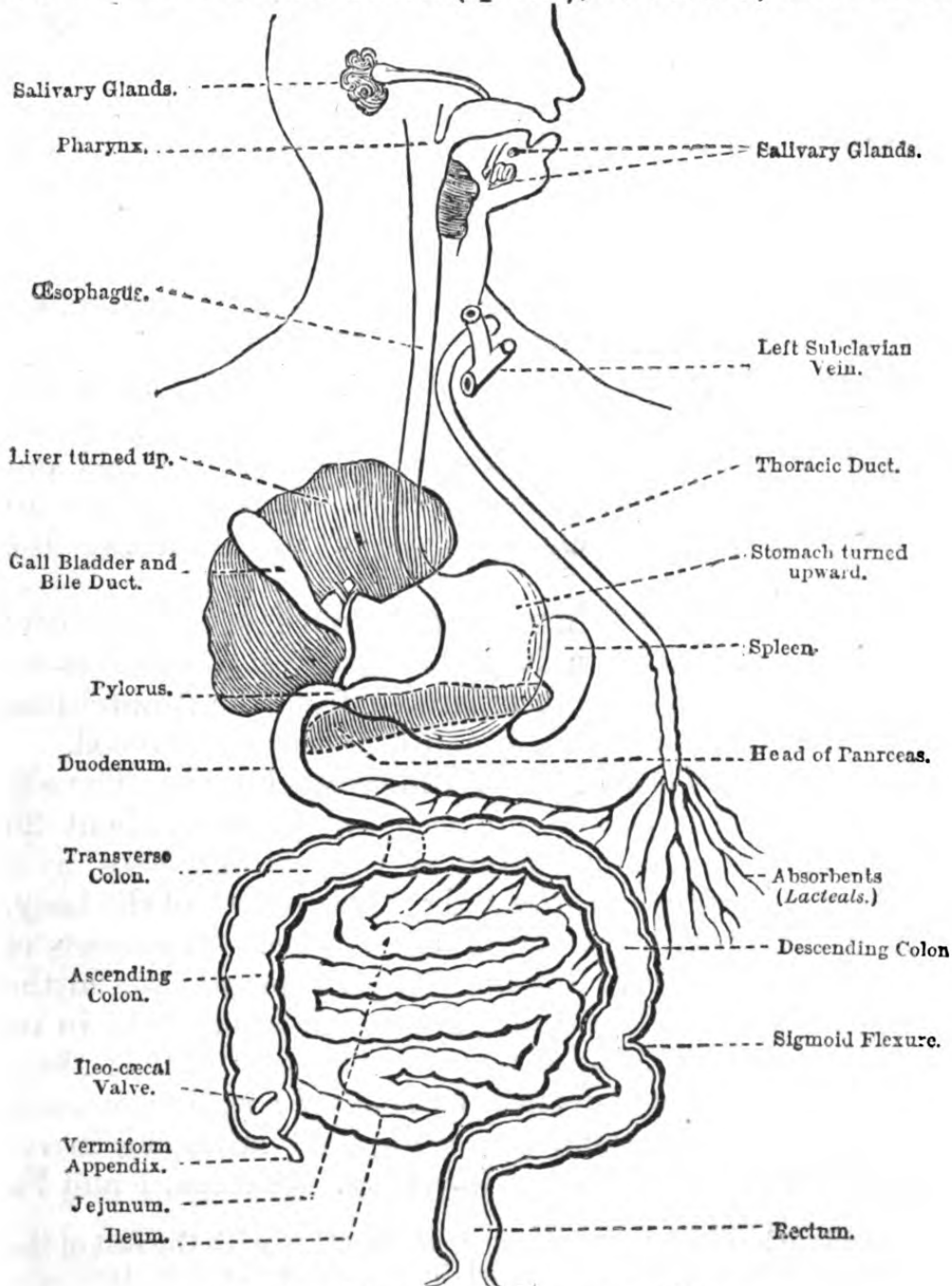


Fig. 1.—SHOWING COURSE OF FOOD.

(The *thoracic duct* is pulled to the left of its true position so that its entire length may be seen.)

with an *acid* juice poured into it on its entrance into the stomach, the liquid (the *gastric juice*) flowing out of its walls. Here the *proteids* are more or less *dissolved*, and *absorbed* by the *veins* of the stomach; also so much of the *starch* of the food as has been under the influence of the *saliva* converted into *sugar*. When thus prepared in the stomach it is called *chyme*; the *chyme* then passes into the *small intestines*, where it is mixed with two other juices, this time *not acid*, but *alkaline*, poured out to meet it and make its *fatty* portions soluble, or at least *absorbable*. It is now termed *chyle*. It is gradually *worked* or pressed along the intestines, all the *useful* or *nutritious* parts being gradually *absorbed* by the *lacteals* and *veins*, until its arrival at the end of the *large intestines*, where it is expelled from the body.

10. The *fatty* parts *absorbed* by the *lacteals* make their way directly by the *thoracic* duct to the *left subclavian vein*, and thence by the *upper vena cava* to the heart. The *dissolved proteids* and the *sugar* (and probably some of the *fats*) are, however, obliged to take a *longer* and more *circuitous* route on their way to the heart. They are first *absorbed* by the *veins* of the *stomach and intestines*, then passed by the *portal vein* to, and circulated through, the liver; after which they are passed with the blood from the liver into the *hepatic* veins, hence to the lower *vena cava*, and by it poured into the heart.

11. **The Mouth** is the *irregular*, somewhat oval-shaped cavity which forms the commencement of the alimentary canal, and in which the food is *masticated*. It is bounded in front by the lips; on the side, by the cheeks and portions of the *upper* and *lower* jaws; above, by the *hard palate* which forms its roof; behind, by the *soft palate* and *fauces*; and below, by the tongue and mucous membrane, reaching from beneath it to the front of the inside of the lower jaw, which form a sort of movable floor. (See fig. 2).

12. The mouth contains the tongue and the teeth, by which, with the aid of the jaws and the salivary glands, the food is *masticated* and *insalivated*. It and the tongue

are lined with *mucous* membrane, which is more or less studded with little *buccal* glands, about the size of millet seeds, which supply through their ducts, which open into the mouth, a portion of the necessary moisture. The *parotid*, *sub-maxillary*, and the *sub-lingual* salivary glands, however, supply nearly all the *saliva* that enters the mouth. (See Arts. 17, 18.)

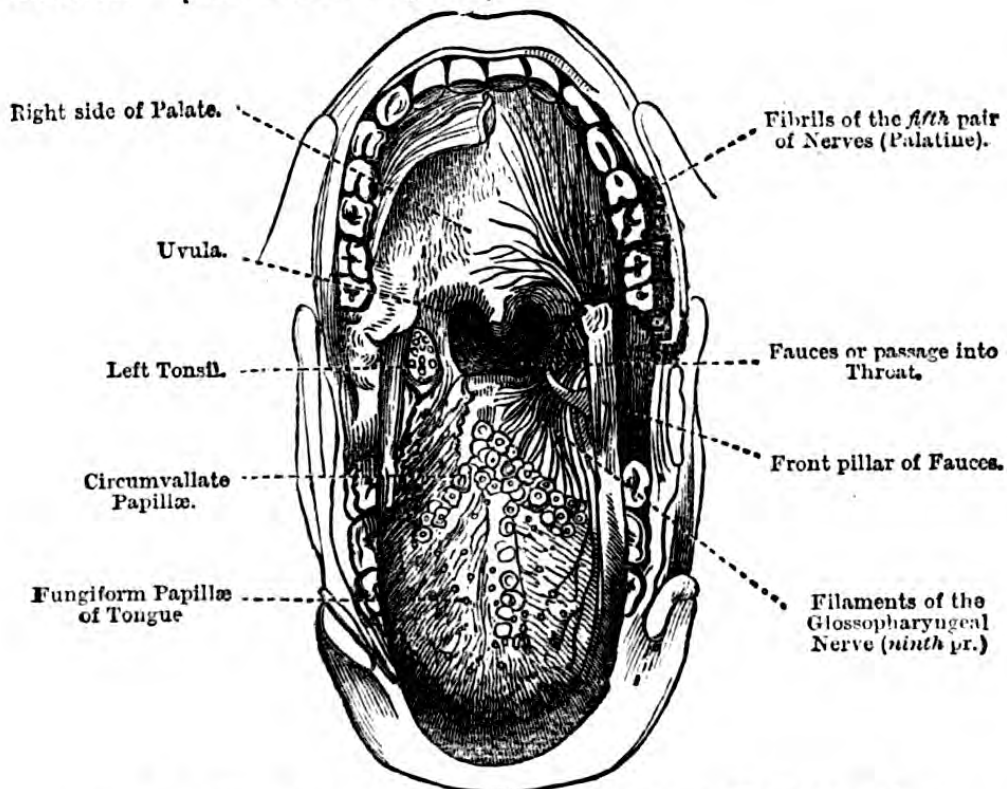


Fig. 2.—THE MOUTH, SHOWING TONGUE, PALATE, etc.

13. Mastication, or Chewing, is the process by which the food is broken, crunched, and ground by the teeth, aided by the tongue, cheeks, lips, and jaws. The object of the process is to overcome the *force of cohesion*, and thus promote the *solution* or liquefaction of the food.

14. Teeth.—Man is provided during life with two sets of teeth—the *first*, which appear during infancy, termed the *temporary, deciduous* or *milk teeth*; the *second* set, which *begins* to appear during childhood, but which is not *completed* until the *wisdom-teeth* have appeared, about the commencement of *adult* life, are termed the *permanent teeth*.

15. **The Permanent Teeth**, when complete, are 32 in number: they are arranged in the form of *arches* in the sockets or *alveoli* of the upper and lower jaws.

Each dental arch (gum) contains 16 teeth. These 16 teeth contain *four* types, shapes, or varieties, as shown in the diagram (fig. 3), viz., four *incisor*, two *canine*, four *bicuspid*, and 6 *molar* teeth.

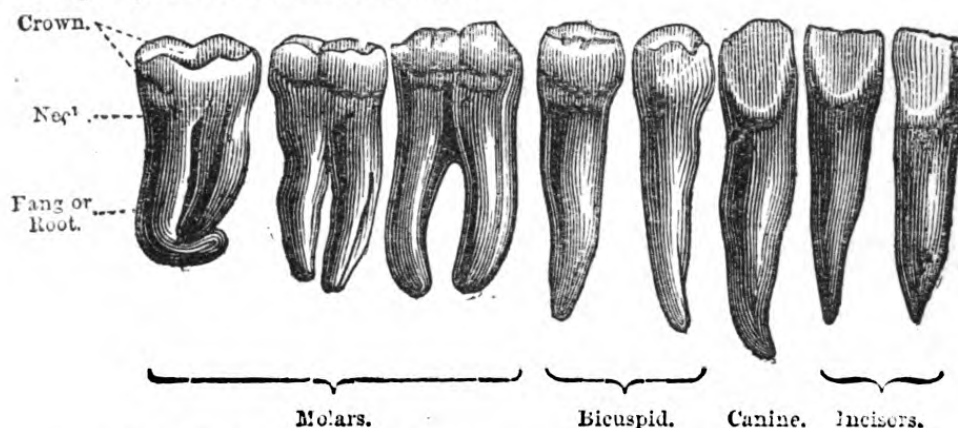


Fig. 3.—SHOWING DIFFERENTLY SHAPED TEETH.

16. **Insalivation** is the process by which the food during mastication is mixed with *air* and *saliva*. The *saliva* facilitates swallowing by *lubricating* the food—it makes the *starch* in the food *soluble*, by ultimately converting it into *sugar*. It also makes the food more permeable to the juices of the stomach, and promotes *taste* by dissolving the *sapid* substances in the food.

17. **The Saliva** or *spittle* is the thin, watery, slightly viscid and frothy liquid poured into the mouth from the *buccal* and *salivary glands*. It usually contains a little *mucus*, also *epithelial scales*, which render it slightly *opalescent*.

It contains a small quantity of a peculiar *nitrogenous* principle, capable of converting starch into sugar; this principle, which does *not* act on *fats* or *albuminous* substances (proteids), is termed *ptyalin*.

18. **The Salivary Glands** are the three pair of *conglomerate* glands which secrete the saliva (see fig. 1). The largest are the *parotid glands*, immediately below and in front of the ear: they weigh from $\frac{1}{2}$ oz. to 1 oz. each. Their *ducts* open upon the inner surface of the cheek by orifices opposite the upper second molar teeth. The *sub-maxillary glands* are situated near the neck, in the lower jaw, under the floor of the mouth. The *sublingual glands* are

also situated, as their name implies, under the tongue. Their *ducts* also pour the saliva into the mouth under the tip of the tongue.

19. The **Pharynx** (from Gr. *pharugx*, the gullet) is the funnel-shaped part of the alimentary canal, which is placed immediately behind the mouth, nose, and larynx. It is separated from the cavity of the mouth by the *soft palate*, *uvula*, and the *epiglottis* (see fig. 4). It is about $4\frac{1}{2}$ inches long, and has seven openings into it, viz., the two *posterior nares* (nostrils), the two *Eustachian tubes*, the *mouth*, *larynx*, and *œsophagus*.

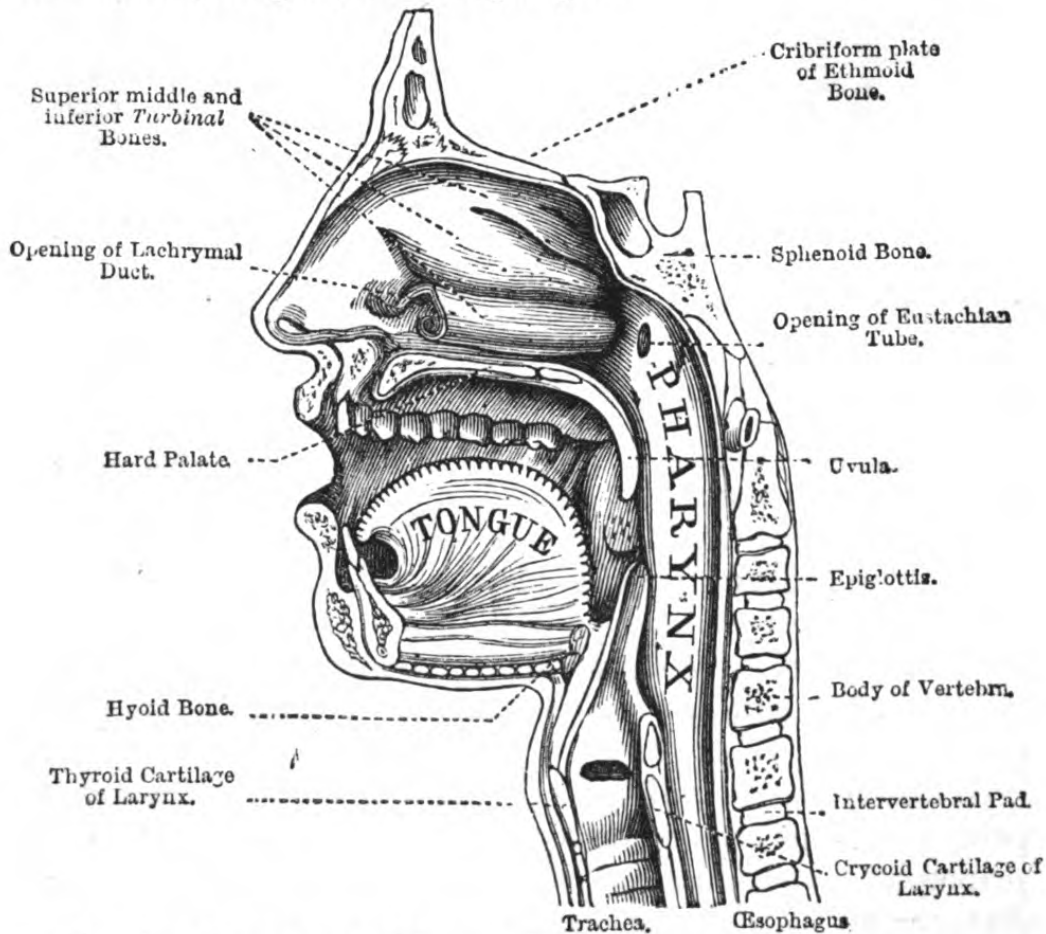


Fig. 4.—SECTION OF MOUTH, NOSE, PHARYNX, ŒSOPHAGUS, LARYNX, TRACHEA, etc.

20. The **Œsophagus** (from Gr. *oisō*, I carry; and *phago*, I eat), gullet, or food-pipe, is the *musculo-membranous* tube which forms that part of the alimentary canal which passes from the *pharynx* through the *diaphragm* to the

cardiac orifice of the stomach. It is about 9 inches long, and forms the narrowest part of the alimentary canal. (See figs. 1, 2, 4, 5 and 7.)

21. Deglutition, or swallowing, is the process by which food or drink is *forced* down the *œsophagus* or gullet into the stomach.

That solids and liquids do not simply *fall* by the action of *gravity* into the stomach is proved by acrobats and others, who sometimes perform the feat of eating and drinking “while standing on their heads.” In the case of horses and other similar animals, the food and drink have to pass from the mouth *upwards*, against gravity, before they can reach the stomach.

22. The Stomach, or principal organ of digestion, is a large (when distended), bent, conical, or “bag-pipe” shaped bag, pouch, or expansion of the alimentary canal, capable of containing *three to five* pints of liquid. When moderately full, it is about 12 inches long, and about 4 inches in its larger extremity. (See figs. 1, 5 and 7).

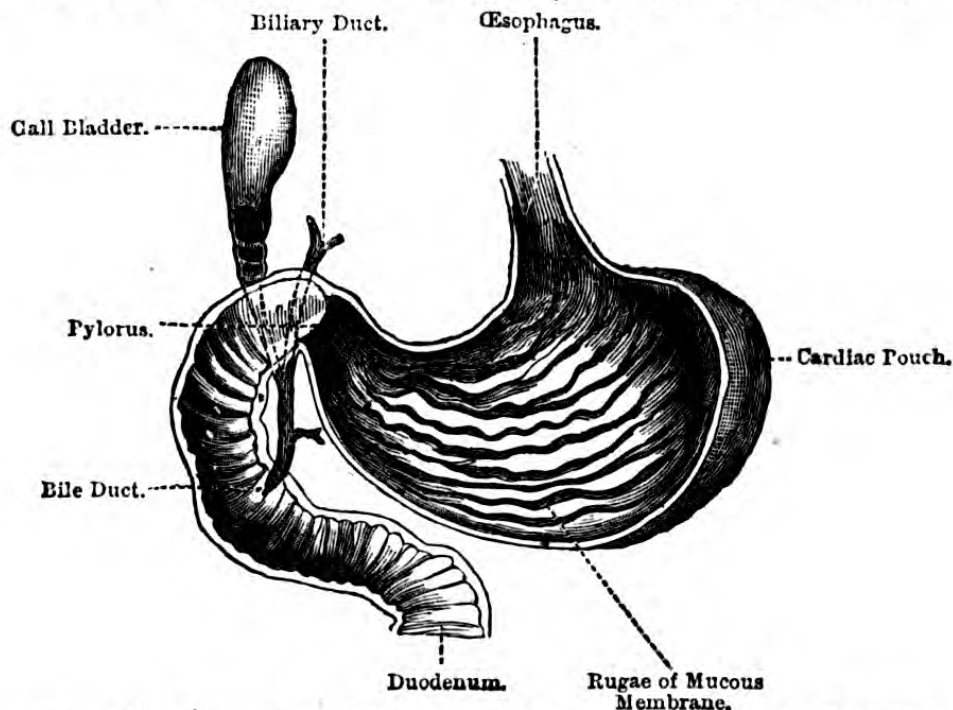


Fig. 5.—SHOWING THE STOMACH AND ITS INTERIOR LINING OF MUCOUS MEMBRANE, THE DUODENUM WITH THE VALVULÆ CONNIVENTES IN ITS INTERIOR; ALSO THE GALL BLADDER AND BILE DUCTS.

The stomach lies *transversly* across the upper part of

the front of the cavity of the abdomen (see figs. 2 and 7), its *left* lying under the ribs and diaphragm, and in contact with the spleen; its *right* end underlies the liver.

Its *left* extremity, the convexity of which lies against the concave side of the *spleen*, is termed the *greater* or *splenic* end: it contains the *cardiac pouch*. Its *right* extremity, which is much smaller than the *left*, terminates at the *pylorus*, where it joins the *duodenum* or first portion of the small intestines. (See fig. 5).

23. The stomach has two orifices, the *œsophageal* or *cardiac orifice* on the top, so called because it is on the same side of the body as the heart; and the right *pyloric orifice*, by which it opens into the intestines. The muscular fibre around the latter is thickened and so arranged as to form a kind of *sphincter* (ring-like) muscle, termed the *pylorus* or *pyloric valve*. (See fig. 5.)

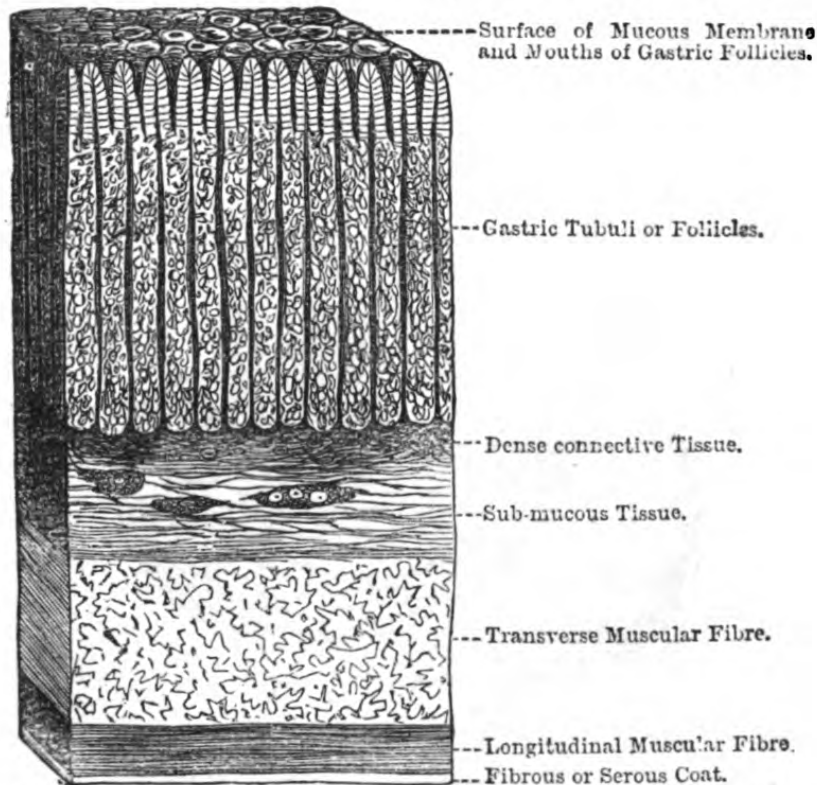


Fig. 6.—VERTICAL SECTION OF COATS OF STOMACH.

24. Immediately food is passed into the stomach, it begins to *contract*, and *roll* the food about by its *peristaltic* action, while simultaneously the gastric juice is poured out of the numerous follicles in its walls, and thus be-

comes thoroughly mixed with it. These movements were actually observed by Dr. Beaumont in the stomach of a patient who had suffered from a gun-shot wound.

25. The Coats of the Stomach.—The stomach is usually described as consisting of four coats or walls—

1. An outer *fibrous (serous)* coat, which serves to strengthen it.
2. A *muscular* coat, consisting of smooth muscular fibre, by which the *peristaltic* movement is carried on.
3. A *submucous* coat of *connective tissue*, in which the blood-vessels and nerves break up before reaching the mucous coat.
4. A *mucous* coat, consisting of a layer of *basement membrane*, covered by an inner layer of *epithelial cells*. Its surface is covered with minute *shallow* pits. The bottoms of these pits are studded with the mouths of the *gastric follicles* which dip into this membrane. It is abundantly supplied with nerves and blood-vessels.

The **Gastric Follicles** are the minute *microscopic* closed tubes somewhat resembling in shape the fingers of a glove. They consist of an outer layer of exceedingly thin transparent *structureless* membrane, termed *basement membrane*, which is lined in its interior with a layer of minute *secreting cells*, termed *columnar epithelium*. These cells secrete the *gastric juice*.

26. The Gastric Juice is the clear, colourless, or pale straw coloured, slightly *acid* liquid secreted by the *mucous membrane* of the stomach and its follicles.

It has powerful *antiseptic* properties, is a good solvent of *proteid* and *albuminoid* substances, of fresh meat, etc., converting them into a liquid termed *peptone*. It not only does not appear to act on *fats* and *starches*, but arrests the action of the other juices upon them.

Its *solvent* power over the *proteids* appears to depend upon the presence of a peculiar principle termed *pepsin*. The following table shows its approximate composition:—

Gastric Juice,	{	Water, about . . .	99·2
		Pepsin, „ . . .	·3
		Hydrochloric acid, . . .	·2
		Salts, about . . .	·2

27. Chymification, or Gastric Digestion, is the process by which the food is converted into *chyme*, by the action of the *saliva* and *gastric juice*.

28. The Chyme is the slightly *acid* gruel or pea-soup like, more or less viscid product of *gastric digestion*; it

varies considerably in appearance and consistence with the nature of the diet. It consists of a heterogeneous *mixture* of various substances, comprising chiefly the *indigestible* portions of the food, the *amyloids* (starchy substances), not yet converted into *sugar*, and the sugar and *peptone* not yet absorbed; also, more or less *saliva* and *gastric juice*.

29. The **Pylorus** (from Gr. *pule*, gate; *ouros*, guardian), or pyloric valve, is a sort of *sphincter*, or *ring-shaped* muscle formed by the reduplication of the *mucous* and *muscular* membranes of the stomach. It encircles and regulates the size of the *pyloric aperture*. (See figs. 5 and 7.)

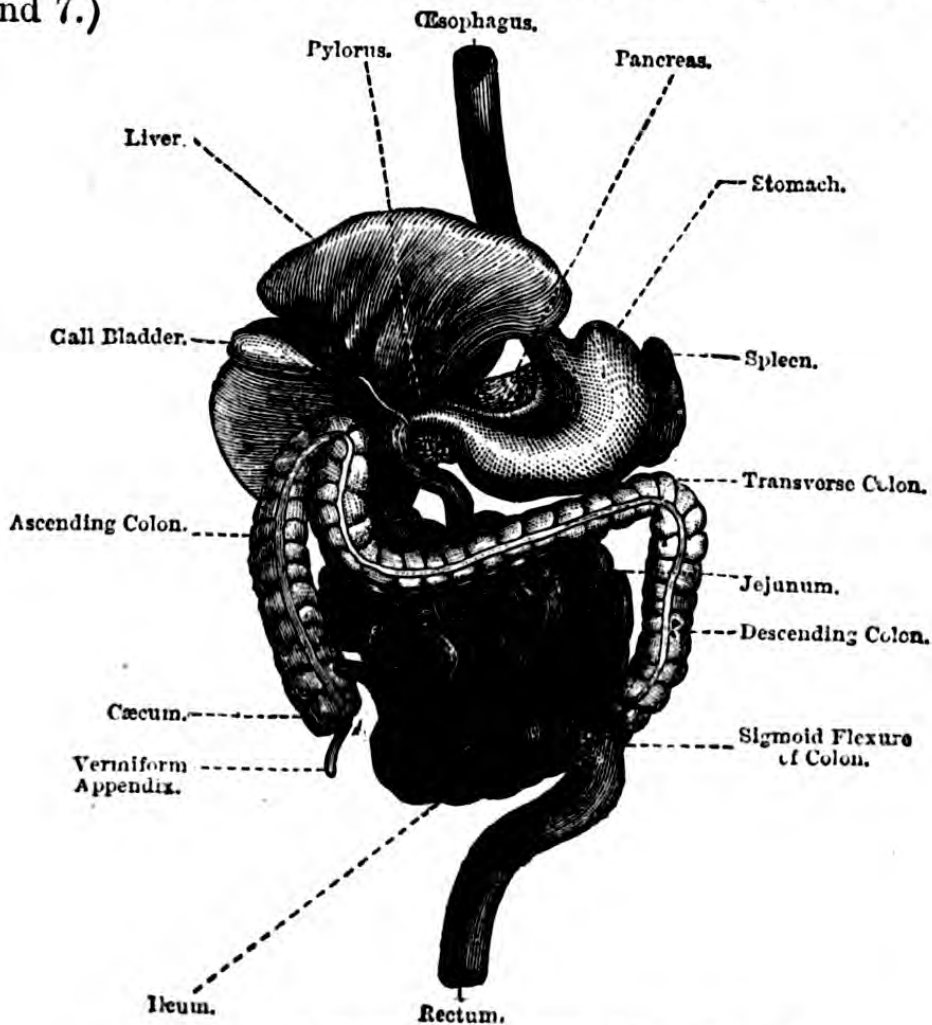


Fig. 7.—LARGE AND SMALL INTESTINES.

30. Large and Small Intestines.—The *small intestines*,

consisting of the *duodenum*, *jejunum*, and *ileum*, are coiled up in the *abdomen*, being enclosed in the *mesentery*, and attached by it to the spine. They form a tube about 20 feet long. The surface of their interior lining of mucous membrane is increased by the *valvulæ conniventes*, which consist of small transverse circular folds of *mucous* membrane, which promote absorption by the gentle resistance they offer to the passage of the food.

The *large intestines* commence at the end of the *ileum*, and terminate at the end of the *rectum*.

They are about six feet long, and consist of the *cæcum*, the *colon* (ascending, transverse, and descending the sigmoid flexure), and the *rectum*.

The *mucous membrane*, lining the interior of both the large and small intestines, is more or less studded with *villi*, *Peyer's glands*, and *Lieberkühn's* follicles.

31. Intestinal Digestion.—Chylification.—The *chyme*, having passed into the small intestines, receives and mixes with the *bile* and the *pancreatic juice*, by which the *fatty* parts of the food are reduced to the form of a sort of *emulsion*, termed *chyle*, which is absorbed by the *lymphatics* of the intestines (the *lacteals*). (See fig. 1.)

The conversion of the starch into sugar, and its absorption, as also that of the remaining *peptone* by the veins, are likewise completed in the intestines.

The *indigestible* parts of the food are pushed along, losing more and more of the nutritious matter (the *peptone*, *fats*, and *sugar* mixed with them), until, after passing through the *cæcum*, they acquire their peculiar offensive *faecal odour*, ultimately passing into the *rectum*, from which they are expelled as *fæces*.

32. The Villi are the microscopic thread-like processes which project from and cover the surface of the small intestines, like the pile on velvet; they contain a central *lacteal*, and a *capillary network*.

33. Peyer's Glands are minute oval bodies scattered over the large and small intestines; their *function* has not yet been determined.

34. Lieberkühn's Follicles are the minute follicles

distributed over the surface of the large and small intestines, which secrete the alkaline intestinal juice. In *size* and *structure* they closely resemble the *gastric follicles*.

THE LYMPHATICS, LACTEALS, AND THORACIC DUCT.

35. The Lymphatic or Absorbent System, by which the *chyle* and the *lymph* are absorbed, consists chiefly of the *thoracic duct*, right lymphatic duct, receptaculum chyli, the lymphatic vessels, the *lacteals*, and the *lymphatic* and *mesenteric* glands. (See fig. 1.)

36. The Thoracic Duct, which is the main trunk of the *lymphatic* system, is about 18 or 20 inches long, and about the diameter of a moderate-sized goose-quill. Commencing in the abdomen, opposite the *second lumbar* vertebra, it passes through the diaphragm, ascending the chest near the vertebral column to the neck; it then curves downward, and joins the *subclavian* vein at the angle formed by its junction with the *jugular* vein. (See fig. 1.)

37. The Lymphatics are the vessels which *absorb* and elaborate the *lymph*, and convey it to the *thoracic* duct.

The *lymph*, or transparent fluid contained in the lymphatics, probably consists of that portion of the *liquor sanguinis* which has *exuded* through the *walls* of the *capillaries*, but has not been *used up* in the process of *nutrition*.

38. The Lacteals (from Lat. *lac*, milk) are the *lymphatic* vessels of the intestines. They are so called because of their *milky* appearance, *two* or *three* hours after a meal, when filled with *chyle*.

The *chyle* is the *milky-white*, *fatty*, *alkaline* fluid formed by the action of the *bile* and *pancreatic juice* on the *chyme* after it has entered the intestines.

The small *glandular bodies* distributed through the course of the lymphatics and the lacteals (in the *mesentery*) are respectively termed the *lymphatic* and *mesenteric glands*.

SECRETION AND EXCRETION—THE GLANDS.

39. Secretion is the process by which solids or liquids, differing from the constituents of the blood, and necessary for the proper performance of the digestive and other functions of the body, are elaborated or separated from

it by means of *glands* or other organs, as in the secretion of the *saliva*, the *bile*, and the *gastric* and *pancreatic* juices.

40. Excretion is the process by which *waste*, useless, and *injurious* matter is separated from the blood, and thrown out of the body by the *excretory glands*, as the *urea* by the kidneys.

41. A Gland is an organ whose function is that of *secretion* or *excretion*, or both combined, and which contains *ducts* or vessels for the escape of matter elaborated or excreted by the gland. The principal *glands* of the body are the liver, the kidneys, the pancreas, the salivary, and the lachrymal glands.

42. Each of the glands consists essentially of a large surface of secreting structure, comprising—(1) an inner layer of *epithelial* (glandular) *cells*, which really do the *secreting* work of the gland; (2) a middle layer of *basement membrane*; and (3) an outer layer of *capillary* blood-vessels, folded up into the smallest convenient space. The various glands differ internally, chiefly in the mode of folding these structures presented therein.

For Liver, Pancreas, and Kidneys, see Arts. 115 and 116, Standard IV.

43. Bile is the greenish-yellow, viscid, extremely bitter, slightly odorous and slightly *alkaline* fluid secreted by the liver. Its chief *function* is apparently to aid the digestion of *fatty* matters, by *neutralizing* the *acid* of the gastric juice, and converting the fat into an *emulsion*.

44. The Pancreatic Juice is the colourless, nearly tasteless, slightly viscid, *alkaline* fluid secreted by the pancreas. Its general appearance and properties are very similar to those of the saliva. This *secretion* acts powerfully on *starchy* substances, and aids the digestion of the *fats*, but it is not supposed to act on the *proteids*.

THE MUSCLES.

45. The Muscles.—For general arrangement and functions of the muscles, see Arts. 88 to 92, Standard IV. For structure and composition of muscle, see Arts. 24 to

27, Standard V. There are about 540 voluntary muscles in the human body, most of which are arranged in *antagonist* pairs (*flexors* and *extensors*).

Among the chief muscles of the human body are—the *gastrocnemius* muscle, or large muscle of the calf of the leg; the *trapezius* muscle, or the muscle of the back, which, attached to the back of the head, raises it after nodding; the *sartorius* (tailor) muscle, which, passing across the front of the thigh, draws the leg up in the fashion tailors sit while working; the *biceps* muscle, the thick muscle of the front of the upper arm; the *orbicularis* muscle of the mouth, by which it is closed; the *orbicularis* muscle of the eye, by which it is also closed; the *masseter* (chewing) muscle; the *intercostal* muscles, and the *diaphragm*.

46. **The Erect Position of the Human Body** is due to the very complex but nicely balanced action of a large number of *antagonist* muscles. Thus, one set of muscles acting under the commands of the *will* pulls the bones of the skeleton forwards, while another set of muscles simultaneously pulls them backwards; the action of the two sets of voluntary muscles so nicely balancing each other as, while giving the necessary *rigidity* to the body as a whole, at the same time to bring its *centre of gravity* over its *basis of support*, viz., the ground on which it stands.

When a person is *shot* or receives a violent blow on the head, the *nervous shock* thus produced causes the sudden *withholding* of the *nervous force* by which the muscles, under the action of the *will*, retain the body in the *erect* position, he therefore *falls* suddenly, the sustaining muscles ceasing for the time to be able to perform their function.

THE NERVOUS SYSTEM.

THE BRAIN, NERVES, AND SENSE ORGANS.

47. **Introductory.**—Just as man excels all other animals in his *intellectual* and *moral* qualities, so he excels them in the development of his *nervous system*—at once the *seat* of those faculties, and the *organs* by

which they are manifested. Of the nature of the mysterious connection between the human *spirit* and its *corporeal* habitation in this world, that is, of the intimate connection existing in this world between *body* and *soul*, science hitherto has been, and possibly at all future times will continue to be, unable to raise, even in the slightest degree, the veil obscuring the grand mystery.

But to our knowledge of the human *mind*, and the condition of its *exercise* and *manifestation*, no such barrier has been imposed. Human physiology clearly proves the *brain* to be the seat of the *mind*, that is, of the *intellect*, the *passions*, the *affections*, and the *will*. Other conditions *being equal*, a *large* brain implies a *powerful* mind, a *healthy* brain a *sound* mind; but a really *diseased* or *injured* brain is invariably attended by *idiocy* or *insanity*.

48. Not only does physiology prove the brain to be the *organ of the mind*, but it also tends to prove that the *intellect* and the *emotions* reside *chiefly* in the thin pinkish layer of *nerve corpuscles* which forms the surface of the brain. On this, however, all modern physiologists are agreed, viz.—that *thought*, *sensation*, and other *mental processes*, are the results of *brain oxidation*, and that for every *thought* we think, every *emotion* we experience, and every *sensation* of which we become conscious, so much *brain tissue* is destroyed.

49. The *Nervous System* has been frequently compared to a *Telegraphic System*, in which the brain is considered as being analogous to the *voltaic battery*, or rather to the *head-office* containing the battery. The *nerves* which go to and from the *brain* to all parts of the system, and which carry its commands or impulses to even the most remote parts of the body, and which *conduct* or *transmit* intelligence from these parts to the *brain*, have been compared with the *telegraphic wires* of the system.

Thus the *optic* nerves (the *sensory* nerves of the eye) convey an impression to the brain of the existence of a tempting object—say a nice apple—we desire to eat; the *motor* nerves from the brain and spinal cord immediately transmit or conduct a *command* or *impulse* to the muscles of the arm and hand, causing them to contract, and directing them to seize and carry

the object to the mouth, which command they at once obey. The *brain* and *nerves* thus *regulate* the action of the *voluntary* muscles.

50. The Nervous System consists of a central part, the cerebro-spinal axis, which comprises the *brain*, *medulla oblongata*, *spinal cord*; and an outer part, the *cerebral* nerves, and the *spinal* nerves, the latter being distributed to all parts of the body; and of the *sympathetic* or *organic* nerve system.

The Brain and Spinal cord are enclosed within three coverings. The *dura mater*, which also lines the skull—the *arachnoid* membrane—and the *pia mater*, which adheres to the brain.

51. The Brain or Encephalon.—The principal parts of the brain are the *cerebrum* or brain proper, the *cerebellum* or lesser brain, the *pons Varolii* and the *medulla oblongata*. It also contains a series of *ganglia* at its base, the functions of which are not all understood.

The average weight of a man's brain is 54 ounces, and that of a woman's 45 ounces. The maximum weight known is 64 ounces.

52. Nerve Corpuscle.—The outside (*cortical* layer) of the brain, and the greater part of the small nervous masses termed *ganglia*, consist of nerve *corpuscle* or *vesicle* (sometimes termed nerve cell). The nerve corpuscles consist of microscopic, spheroidal, *nucleated* cells, filled with minute granular matter.

53. The Cerebrum or Brain Proper, which forms the principal mass of the brain, is divided by the great *longitudinal fissure* into two hemispheres—each hemisphere is again divided into three lobes—*anterior*, *middle*, and *posterior*. Its outer surface is deeply *convoluted*, thus presenting a crumpled-up appearance.

54. Function of the Cerebrum.—That the *cerebrum* is the principal seat of the intellect, volition, and of the emotions, is shown by the following facts:—When the human *cerebrum* is below a given size, its possessor is always an *idiot*. *Disease* or *injury* produces *idiocy* or *insanity*. The *size* of the *cerebrum*, its quality being equal also, bears some proportion to the *mental power* of the animal.

If the *cerebrum* be removed from a pigeon or other animal that

can stand the *nervous* shock incurred in its removal, it will live and move, but will show no signs of *consciousness* or *intelligence*.

Poisons—as alcohol, opium, etc.—which act upon the *cerebrum* also produce temporary insanity, or *loss of intelligence*, or of *consciousness*.

55. The **Cerebellum** or *lesser* brain, situated at the base of the back of the skull, is separated from the cerebrum by the *tentorium*, a process of the *dura mater* which lines the inside of the skull, forming a *floor* for the cerebrum and a *roof* for the cerebellum.

When cut *perpendicularly*, it presents a peculiar *arborescent* appearance, termed the *arbor vitæ* of the *cerebellum*. Its weight is about $\frac{1}{10}$ of that of the whole brain. (See fig. 8.)

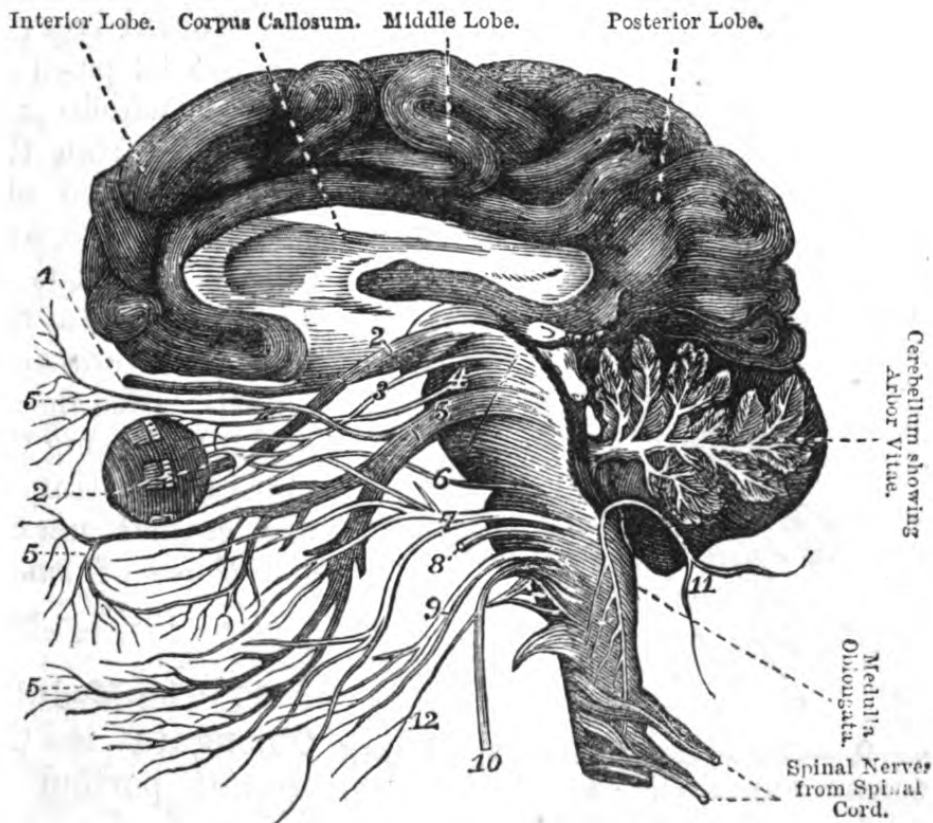
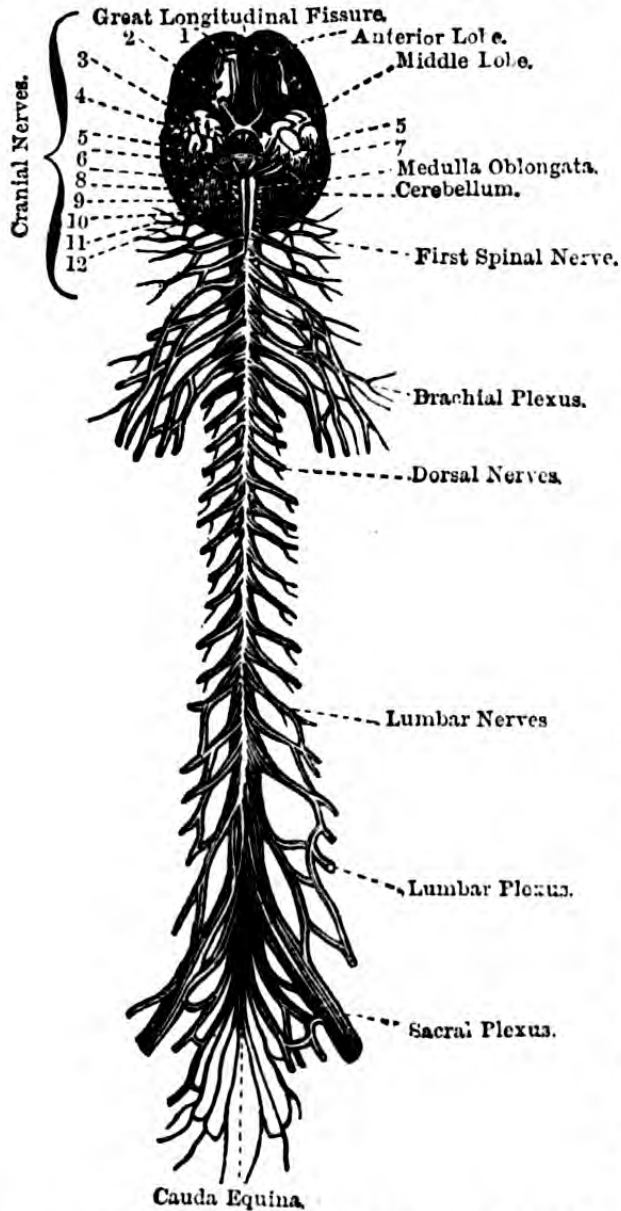


Fig. 8.—SIDE VIEW OF HUMAN BRAIN, showing Cerebral Lobes and Cranial Nerves (of Right Hemisphere), Cerebellum, Medulla Oblongata, and Corpus Callosum.

The observer is supposed to be looking at the right side of the great Longitudinal Fissure, and the cut portion of the *Corpus Callosum*.

Its function is not fully known: it, however, in some

way or other regulates muscular movement. If removed from the head of a pigeon, the pigeon will continue to



move backward, or round and round, having apparently lost all power of *regulating* its movements.

The Pons Varolii, or bridge of Varolius, connects the cerebrum, cerebellum, and medulla oblongata together.

56. The Cranial or Cerebral Nerves are the 12 pairs of nerves which are given off from the brain and the medulla oblongata, and which pass out of nine openings at the base of the cranium (skull). (See figs. 8 and 9.) Among the more interesting of the cranial nerves are those of *smell*, *sight*, *taste*, and *hearing*.

57. The Medulla Oblongata is the cranial portion of the spinal cord; that is, that portion of the spinal cord which is contained within the cranium or skull. It is the *nervous* centre of the *respiratory* movements; its injury will therefore cause death by suffocation; irritation of the medulla may also cause stoppage of the action of the heart.

58. The Spinal Cord is that portion of the *cerebro-spinal axis* which is contained within the spinal column.

It commences at the termination of the *medulla oblongata*, and extends from the *foramen magnum* (the large aperture in the occipital bone at the base of the skull) to the *first lumbar vertebra*, where it terminates in the *cauda equina*. It is about 16 inches long. (See fig. 9.)

59. Functions of the Spinal Cord.—1. The spinal cord transmits the commands of the will directly from the brain to the voluntary muscles by the *motor* nerve fibres it gives off in the spinal nerves. 2. It transmits *sensory* impressions direct to the brain, where they excite consciousness, or *sensation*. 3. It receives *sensory* impressions by the *sensory* nerves which it does *not* transmit to the brain, but which, acting as a stimulus, cause it to send back the *motor impulses* to the muscles which cause them to contract altogether independently of our consciousness, or of the brain. This constitutes *reflex* action. It is in this way that the various movements of digestion are carried on.

If a frog be *decapitated*, and its feet or legs be irritated by the point of a needle or a drop of acid, it will kick violently, and will even in some cases, where one leg only is irritated, bring or try to bring its second leg to aid the first in its attempt to get rid of the cause of irritation. In this case both the *brain* and *medulla* being *removed*, there can be no power of *thought* or *consciousness* remaining in the frog. These movements must therefore result from the *reflex* action of the spinal cord.

60. Reflex or Excito-Motor Action.—If the spine be broken or injured, all parts of the body below the injury become *paralysed* (lose their power of sensation and voluntary movement). If a hot iron be applied to the feet in such a case, the legs will kick out violently, though the patient is quite unconscious of a sense of heat or pain, even tickling the feet will produce this effect.

The *sensory* nerve fibres conduct the stimulus (the irritation of the hot iron) to the spinal cord, which immediately, as it were, *reflects* it back by the *efferent* nerves, in the shape of *motor impulses*, to the legs, which therefore kick unconsciously. *Coughing, sneezing, winking*, when an object suddenly approaches the eye, *infantile convulsions, tetanus* (lock-jaw), the *peristaltic* movements of the stomach and intestines, are all so many cases of *reflex* action.

61. The Spinal Nerves consist of the 31 *pairs* of nerves

which pass off from the *sides* of the *spinal cord*, leaving the vertebral canal by the *intervertebral foramina* (see Art. 46, Stand. IV.) on each side of the vertebral column.

Each spinal nerve arises by *two roots*, an *anterior root*, consisting of *motor nerves*, and a *posterior root*, consisting of *sensory nerve fibres*. The *two roots* on each side unite as they leave the spinal cord to form *single trunks*, which shortly subdivide, giving off smaller branches, *which ramify through the whole of the system*. The posterior, afferent, or *sensory roots* have ganglia.

If these nerves be cut or injured just as they leave the vertebral column, *paralysis* is produced.

62. A Nerve or Nerve Trunk consists of a bundle of *nerve fibres*, surrounded by a thin *sheath*, termed the *neurilemma*. The primitive *nerve fibrils* or *tubules* are microscopic, transparent, homogeneous, nearly cylindrical, very fragile fibres, about $\frac{1}{3000}$ of an inch in diameter. After death a sort of *axis*, termed the *axis-cylinder* is formed by *coagulation*.

63. The Sympathetic Nerve System comprises—1. A double chain of ganglia, one on each side of the spinal column. 2. The *isolated ganglia* of the viscera, including the *cardiac*, *hypogastric* and *solar plexuses*. 3. The *ganglia* on the *posterior roots* of the *spinal nerves*.

The *sympathetic* nerve system, most probably to a great extent, though not exclusively, presides over, influences, and co-ordinates the various processes of involuntary motion, of secretion, and of nutrition, including the circulatory, respiratory, and peristaltic movements of the heart, lungs, stomach, and intestines.

64. Sensation is the process by which we become *conscious* through the *brain* of *impressions* received and transmitted to it by the *afferent* or *sensory nerves* (Art. 49). When sensation is excited *normally*—that is, by *external agency*—it is termed *objective* sensation; but when it arises *without any external cause*, that is, is produced by the unprompted or rather *intrinsic* action of the brain or nervous system itself, it is termed *subjective* sensation, as in the case of the “ringing in the ears” sensation with which most are more or less familiar, also in the seeing of ghosts as the result of indigestion. Sensation requires—

(1.) A suitable medium for *receiving* the external impression or stimulus—as the eye to receive light.

(2.) A means of *transmitting* the impression to the brain—as the optic nerve.

(3.) Brain organization to develop *consciousness* of impression.

65. The Organs of the Senses are the instruments by which the mind is brought into *relation* with the *external* world; or, in other words, the instruments by which the mind is acted upon by natural agencies *external* to the brain.

They consist essentially of *nerve expansions* (spread out and specially prepared to receive the stimulus of the particular agent, mechanical, optical, sonorous, olfactory, or gustatory), which are in general connected with the *brain* by special nerves. The nature of the sensation depends to a great extent upon the nature of the *covering* of the nerve expansion intervening between the terminal nervous *network* and the external exciting agent.

There are six senses, viz.—the *muscular* sense, the sense of *touch*, of *taste*, of *smell*, of *hearing*, and of *sight*.

In all cases sensation takes place in the *brain*, and *not* in the nerves or their outer extremities.

66. The Muscular Sense is the sense by which we judge of the *relative weight* of a body, or the *degree of resistance* it offers to effort made to put it into movement.

67. The Sense of Touch, or the sense by which we become acquainted with the existence, shape, and properties of bodies, is common to the whole body, but more especially to the *skin* (see Art. 100, Standard IV.), some portions of which are much more highly endowed with this power than others.

The organ of *touch* consists essentially of an *external* layer of *epithelium*, which, being in contact with the external agent, first receives and modifies its action, which it then transmits to the *internal* layer of the *tactile* organ (consisting of plexuses of nerve fibrils) immediately below it, which transmit the *stimulus* thus originated to the brain, by means of the *cerebral*, or the posterior branches (sensory) of the *spinal* nerves.

68. The Tongue is the chief organ of **Taste**; but this power is also possessed by the back of the *palate* and the *fauces*. The tongue consists essentially of masses of voluntary muscular fibre, covered externally with a layer of *mucous membrane*, in which the sense of taste resides.

The *mucous membrane* of the tongue is studded with *papillæ* (see fig. 2). The *glossopharyngeal* or *ninth* pair of cranial nerves supplies nervous fibrils to the *back* of the *tongue* and *palate*, which is the chief region of taste.

69. The Sense of Smell is exercised through the *mucous* (Schneiderian) membrane, which lines the upper parts of the *nasal cavities*, and receives nerve-filaments from the *olfactory lobes*, and not from the *fifth* pair of nerves (see fig. 10). It is excited by the contact of *odoriferous* particles.

SMELL.

70. The Nose is the triangular-shaped organ situated in the middle of the face. Its *roof* is formed by the *cribriform plate* of the *ethmoid* bone of the skull, through the *sieve-like* apertures of which the *olfactory* nerves pass. It is bounded in front and laterally by the *nasal bones* and *cartilages*; its floor is formed by the hard and soft *palate*. It is divided into *two cavities* by the *nasal septum* (which consists partly of bone, the *vomer*, and partly of *cartilage*). These cavities open out into the air in front of the nose by means of the two *nostrils*, and into the *pharynx* behind by the two *posterior nares* (nostrils) situated immediately over the sides of the *velum* or soft *palate*. (See figs. 4 and 10.)

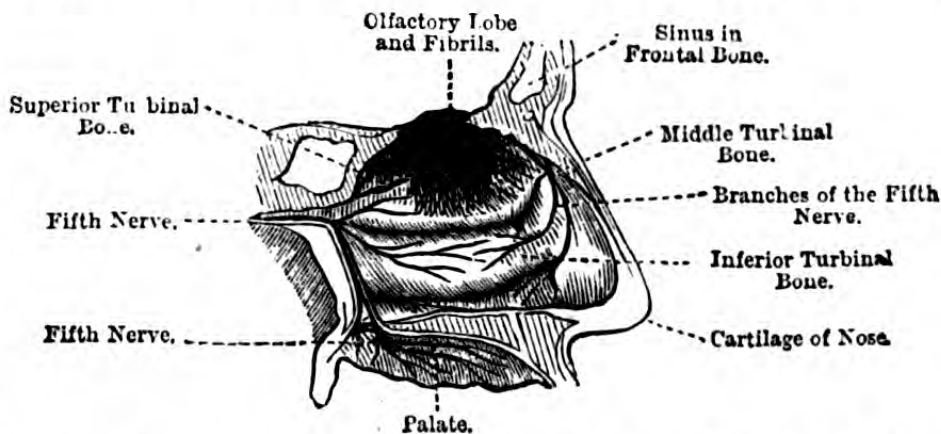


Fig. 10.—VERTICAL LONGITUDINAL SECTION OF THE NASAL CAVITY, showing Olfactory Lobe and distribution of the Olfactory Filaments, and the Fifth (Cranial) Nerve, on the right wall of the Nose.

71. Sound.—The *external* cause of sound is mere *mechanical* movement. Sound is almost invariably produced by *air* in a state of *sonorous vibration*; that is, air oscillating *backwards* and *forwards* with great rapidity.

If the *wave movement* be either too *quick* or too *slow*, it will not produce sound.

72. The Sensation of Hearing is excited in the brain by means of a *molecular movement*, set up in the *nerve fibrils* of the *internal ear* or *labyrinth*, by the rapid vibration of some external *elastic body*, and transmitted to the brain by the *auditory nerve*. The essential parts of the organs of hearing are the *membranous labyrinth*, and the *scala media* of the *cochlea*.

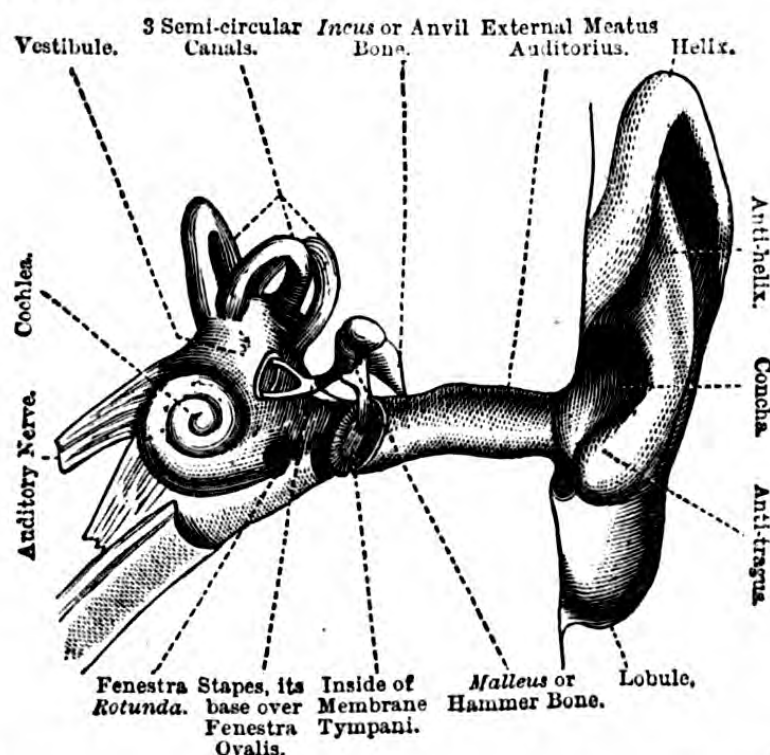


Fig. 11.—DIAGRAM SHOWING GENERAL STRUCTURE OF EXTERNAL AND MIDDLE EAR, AND LABYRINTH OR INTERNAL EAR.

73. The Organs of Hearing (the ears)—each consist of three parts, viz:—

(1.) The external ear, comprising the *pinna* or auricle, the gristly appendage attached to the side of the head (which both serves as a natural ornament and to collect the vibrations of the air); and the *auditory canal* (meatus), by which the vibrating air is conducted to the membrane of the *tympanum*. The canal is lined by mucous membrane, studded with wax glands.

(2.) The *tympanum*, or *middle ear*, which consists of an irregular cavity in the *petrous* part of the *temporal bone*, is bounded on its outer side by the *membrana tympani*. It is tra-

versed by a chain of movable bones, consisting of the *malleus* or hammer bone, the *incus* or anvil bone, the *stapes* or stirrup bone, by which the vibrations are conveyed from the external air, through the middle ear, to the membrane in the *fenestra ovalis* in the side of the labyrinth. The tympanum opens into the *pharynx* by the *Eustachian tube*; by this arrangement the air enclosed in the tympanum is kept at the same pressure as that of the external atmosphere.

(3.) **The labyrinth**, or internal ear, consisting of the *vestibule*, the *three semi-circular canals*, and the *cochlea*, and their *membranous*, nerve, fluid, and other contents.

74. The Vestibule (bony and membranous), is the middle or central chamber of the *internal ear* or *labyrinth* which opens into the *cochlea* and the *semicircular canals*. It is situated at the inner side of the tympanum, with which it communicates by means of two *membrane-stopped* openings, viz., the *fenestra ovalis* and the *fenestra rotunda*.

75. The Semicircular Canals are three long arched tubes about $\frac{1}{20}$ of an inch in diameter. These three hollow arches, which form the greater parts of circles, consist of two nearly *vertical* canals (*anterior* and *posterior*) and a *horizontal* canal.

76. The Membranous Labyrinth consists of a closed membranous sac of the same form as, and a little smaller than, the bony walls by which it is enclosed. It occupies the middle of the bony labyrinth, and is separated from it by a clear *liquid* termed the *perilymph*, its interior being filled with a similar liquid, termed the *endolymph*. The fibres of the *auditory nerve* are distributed over the inner walls of the *membranous labyrinth*.

77. Otoconia (from Gr. *ous* the ear, and *conia*, dust).—The effect of the *concussions* (originally set up by the aerial vibrations) on the *auditory nerve filaments* is intensified by means of little masses of minute crystalline grains of stone, termed *otoconia*.

78. The Cochlea (Lat. a snail's shell), a conical shell-like structure, forms the front portion of the *labyrinth*. It possesses a central *axis*, round which a partition (partly of bone, partly of membrane), termed the *lamina spiralis*, winds spirally, $2\frac{1}{2}$ times, dividing the spiral canal of the cochlea into two passages, termed respectively the *scala vestibuli* and *scala tympani*. Between these two passages is a third, termed the *scala media*. One of its walls is

covered over with minute rod-like bodies, termed the *fibres of Corti*, which, looking like so many keys on a keyboard, serve more readily to take up the vibrations communicated to the *endolymph*. The *interior* of the walls of the *scala media* are covered with fibres of the *auditory nerve*.

79. The Mode of Action of the Organs of Hearing.—The air is put into rapid *sonorous vibration* by the bell, pistol, or other sounding body, the aërial waves enter the *external auditory canal*, strike against the *membrane* of the *tympanum*, and put it into the same rate of vibration; the *malleus*, pressing against its interior side, is put into vibration by the *membrane* of the *tympanum*; the *malleus* puts the *incus* into vibration; the *incus* attached to the *stapes*, puts it into vibration; the *stapes* attached to the *membrane*, filling up the *fenestra ovalis*, an oval aperture in the vestibule, puts it into vibration; this membrane puts the *fluid* in the interior of the labyrinth into vibration; this *fluid* dashing against the auditory nerve *fibrils*, *otoconia*, and *fibres of Corti*, puts them into vibration—the *fibres of Corti*, like the keys on a pianoforte, only taking up the vibrations corresponding to their length and special note. The vibrations thus set up *synchronously* with the external vibrating air, acting as an *excitant* on the *auditory nerve*, cause it to transmit to the *brain* a *nerve-movement* or stimulus which wakens up in it the *sensation of sound*. A little round membrane-stopped hole, the *fenestra rotunda* in the vestibule, facilitates the *movements* of the *endolymph*, by giving it more play.

80. Light is the *external agent* or *cause* of *normal vision*; that is, in all cases in which we acquire a knowledge of the *existence* and *nature* of *external objects* through the organ of *sight*, or in which, in ordinary language, we *see external objects*—as a horse, a man, a house; such perception or act of vision is excited through the *agency* of the *light*.

81. Undulatory Theory of Light and Colour.—All scientific men now regard *light* and *colour* as consisting of an extremely rapid vibratory or *up* and *down* wave-

like movement of an exceedingly *rare*, imponderable, elastic fluid termed *luminiferous ether*. They also regard the *sensation of light and colour* as set up in the *brain* by means of the nerve fibrils of the *retina* and *optic nerve*—the nerve fibrils of the *retina* being put into vibration by the concussion of the *waves of ether* which strike against the back of the eye, as *sea waves* strike against a *sea wall*.

The nature of the sensation, that is, the colour seen, depends upon the *number* of the waves which strike against the retina per second; thus, if about *400 millions* of *millions* of *ethereal waves* per second come rolling in and pitching against the back of the eye, a sensation of *redness* will be produced; *510,000,000,000,000* of such waves would produce a sensation of *bright yellow*; and *830,000,000,000,000* of such waves the appearance of the extreme *violet* colour of the rainbow.

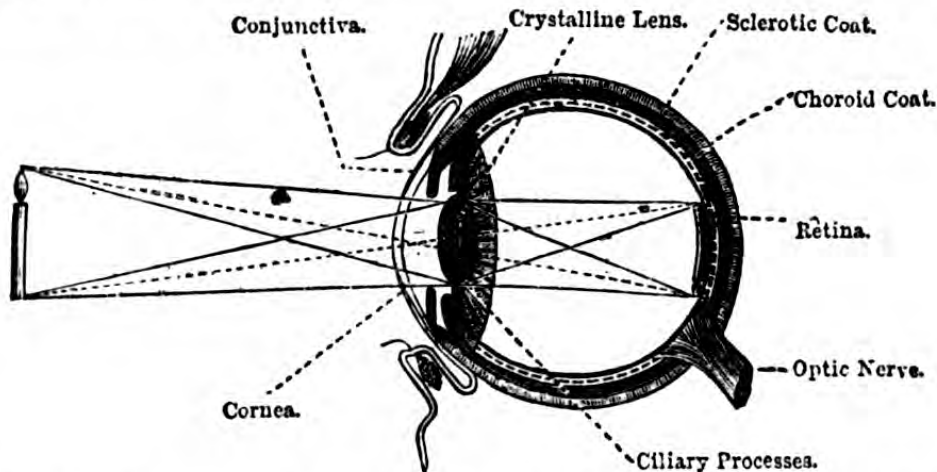


Fig. 12.—SHOWING THE FORMATION OF *inverted* OPTICAL IMAGES ON THE RETINA AT THE BACK OF THE EYE.

82. The Eye is an *optical* instrument, constructed for receiving, *bending* (refracting), and throwing the rays of light on to a screen (the retina) at its back, so that it shall receive a very *minute* and *inverted*, but clear and definite, *picture* or *image* of the surrounding objects (fig. 12).

In no case do we see the external objects themselves, but *vision* is excited by *pictures of them* formed by the light sent from them, and *focussed* on the retina, as described. The eye is, in fact, a sort of *water camera obscura* moved by *six* muscles attached to its external coat. The eyes are lodged, for protection, in packings of fat in the bony *orbits* of the skull.

83. Structure of the Eye-ball.—The eye is a nearly

round ball, about 1 inch in diameter, which encloses *three* lenses or *humours* and *two* muscles, and which consists of three *coats* or layers. It also contains nerves and blood-vessels. It is attached to the *optic nerve* behind, as an apple to its stalk.

	Coats of the Eye.	Refracting Humours.	Muscles.
1. (Outer)	Sclerotic and cornea.	Aqueous.	The Iris.
2. (Middle)	Iris, ciliary, and choroid.	Crystalline (lens).	} Ciliary muscle.
3. (Inner)	Retina.	Vitreous.	

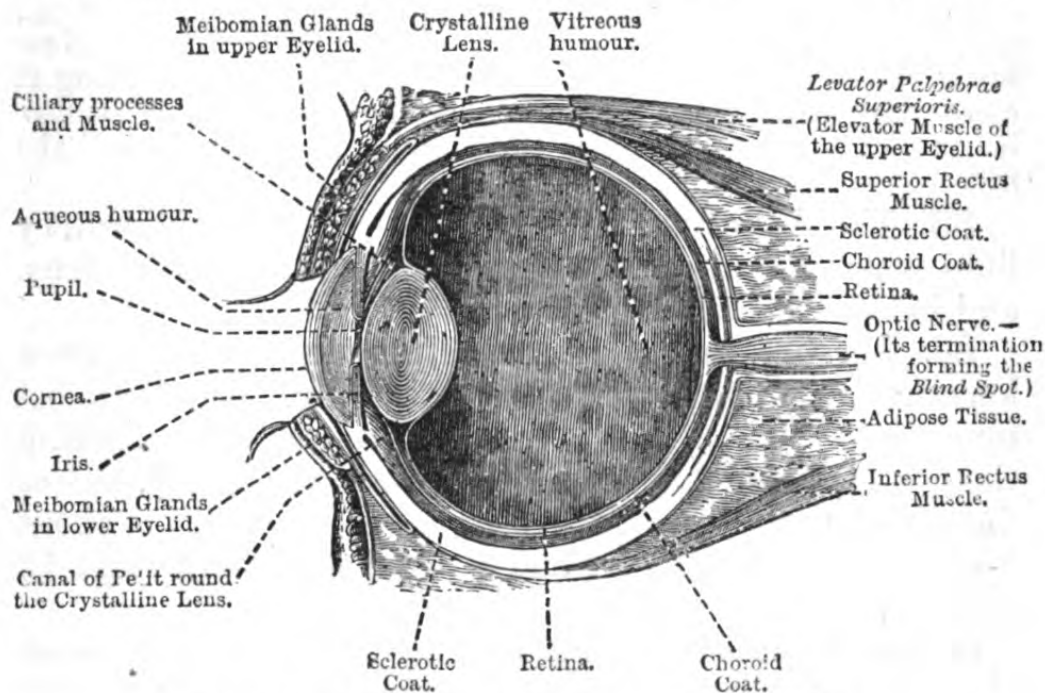


Fig. 13.—VERTICAL SECTION OF EYE-BALL.

84. The Sclerotic Coat (from Gr. *skleros*, hard), which forms the external wall of the eye-ball, the “white of the eye,” is an opaque, tough, fibrous membrane, which cuts like leather.

85. The Cornea (from Lat. *cornu*, horn) is the circular watch-glass shaped, transparent body inserted in the aperture in the *sclerotic coat*, at the *front* of the eye, that admits and aids in focussing the light which enters the eye, and by which vision is excited. (See figs. 12 and 13.)

86. The Choroid Coat (from Gr. *chorion*, the outer skin of the egg) is the delicate coat of *blood-vessels* and *black pigment cells* which form the *middle* coat of the eye, and causes the black appearance of the pupil. When the pigment is *wanting* the pupil

has a red or pinkish appearance, as in the case of Albinos, the blood-vessels showing through the aperture of the pupil (fig. 13).

87. **The Iris** (from Lat. *rainbow*), so called from the diversity of its colour, is the *circular*, flattened, perforated *curtain*, which, placed *behind* the *cornea*, *regulates*, by the contraction and expansion of its central aperture (the *pupil*), the quantity of light admitted to the eye (fig. 13).

EXPERIMENT.—Place yourself before a looking-glass in a *dark* room with a *lighted* candle in your hand, hold the light as far away to the side as you can, while you look at the image of the *pupil* of your eye. It will appear very *large* and *dark*. Now bring the candle gradually nearer and nearer until you bring it close before the eye—the pupil becomes *smaller* and *smaller* because of the contraction of the circular muscular fibre of the iris.

88. **The Aqueous Humour** is the clear, limpid, watery fluid which fills the space in *front* of the crystalline lens, and bathes both sides of the *iris*.

89. **The Crystalline Lens or Humour** is the biconvex lens-shaped, transparent, jelly-like body, placed almost immediately *behind* the *iris*, by which the light entering the eye is *focussed* and made to form *inverted pictures* or *images* on the *retina* at the back of the eye. It is about $\frac{1}{3}$ of an inch in diameter and $\frac{1}{8}$ of an inch thick (figs. 12 and 13).

90. **The Vitreous Humour** is the large, spherical, transparent, *glassy-looking*, jelly-like lens or humour which fills up the greater part of the interior of the eye-ball. (See fig. 13.)

91. **The Retina** (from Lat. *rete*, network) is the delicate coat or membrane which may be seen lining the interior of the back of the eye, when the eye-ball is carefully cut into a *front* and *back* half. It consists partly of an *expansion* of the *optic nerve*, and partly of *other* structures, which probably assist in enabling the *light* to produce the requisite *vibrational* impression on the *nervous fibrils* of the optic nerve. (See figs. 12 and 13.)

92. **The Blind Spot**, or *optic pore*, is the *insensible* (to light) portion of the *retina*, situated at the back of the eye at the *entrance* to the *optic nerve*. *Images* of objects falling on the *blind spots* of the eyes are incapable of exciting *vision*.

93. **The Bright Spot of Sömmering**, or “*yellow spot*,” is a

round, yellowish spot, situated in the *centre* of the back of the eye in the *axis of vision*, and about $\frac{1}{10}$ of an inch *outside* of the *blind spot*. It is the seat of most *acute vision*.

94. The **Duration of the Impression of Light** on the retina is about $\frac{1}{8}$ of second. If, therefore, a lighted stick be rapidly moved round in a circle so that it shall return to the point from which it started in less than $\frac{1}{8}$ of a second, it will be seen as though it were a *luminous circle*. The appearance of the firework termed the "Catherine wheel," and of the pictures in a *zoetrope*, are due to this cause.

95. The **Muscles of the Eye-Ball**, by which the eyes are rolled about and the *axis of vision* is moved in any given direction, consist of the four *recti* (straight) and two *oblique* muscles, viz:—

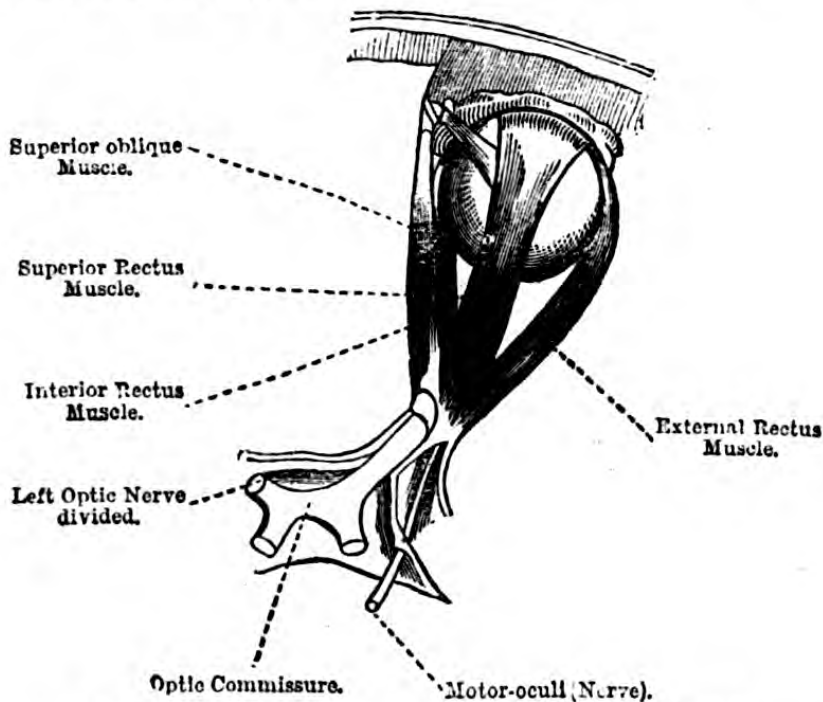


Fig. 14.—THE MUSCLES OF THE EYE-BALL.

1. Superior rectus (*attolens*) muscle, pulls the eye-ball upwards.
2. Inferior rectus, " " " downwards.
3. Internal rectus (*adductor*), " " " inwards.
4. External rectus (*abductor*), " " " outwards.
5. Superior oblique (*trochlearis*, or pulley muscle), rotates the eye outward and downward.
6. Inferior oblique, rotates the eye outward and upward.

96. The **Chief Appendages of the Eye** are the eye-brows, eyelids, and the lachrymal glands and ducts,

97. The **Eyebrows** are the arched integumentary prominences which project over the upper part of the front of the orbits. They shade and protect the eyes, and, with the aid of the hairs with which they are studded, prevent the perspiration from running into them.

98. The **Eyelids** consist of thin plates of movable cartilage surrounded by folds of skin. Each of their *free* edges is fringed with a row of hairs (the eyelashes), and contains a row of from 20 to 30 minute glands termed the *Meibomian glands* (see fig. 13), embedded in the cartilage. The *upper* eyelid is raised by the contraction of a special muscle termed the *levator palpebrarum superioris*. The eyelids are closed by the contraction of a ring-shaped muscle (*orbicularis palpebrarum*).

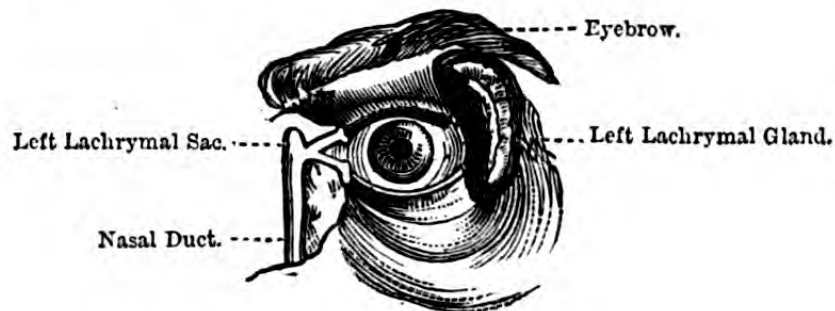


Fig. 15.—THE LACHRYMAL GLANDS.

99. The **Lachrymal Glands** consist of two small glands, each about the size of an almond, lodged in depressions at the upper and outer angles of the orbits (see fig. 15). They secrete the *lachrymal* fluid which *moistens* and *lubricates* the front of the eye, and which passes off from the inner angles of the eye into the nose by means of the *lachrymal* and *nasal* ducts.

When secreted in very large quantities, as during certain kinds of mental excitement, or in consequence of the action of *irritants*, a part of it escapes as *tears* down the cheeks.

QUESTIONS.

(Continued from page 2 of Cover).

a gland, and what its general *internal* structure? What is the *bile*; what the *gastric juice*; and what are their properties and uses? (38-44)

6. How are the *voluntary muscles* arranged, what is their number, function, structure, and composition? Name a few of the chief voluntary muscles and their *special functions*. How is the *erect* position of the body maintained; why does a man *fall* when *shot*? What does physiology teach with regard to the *size* and *functions* of the brain, also with regard to the *outside* of the brain, and to *brain oxidation*. How does *nervous system* resemble a *telegraphic system*; illustrate this with regard to the *optic nerves* and voluntary muscles (45-49).

7. Name the chief parts of the *nervous system*—of the *brain*. What is the usual *weight* of the brain. What are *nerve corpuscles*, and where chiefly found? Describe the *cerebrum*, the *cerebellum*, the *pons Varolli*, the *medulla oblongata*, and the *spinal cord*, and their function. What do you mean by *reflex action*? Mention a few special cases. What are the *spinal nerves*, what their number, how do they *arise* or *leave* the spinal cord, and what effects are produced in the human body when they are *cut* or *seriously injured*? Describe the structure of a *nerve trunk* and a *nerve fibril*. Of what does the *lymphatic nerve system* consist, and what are its *functions*? (50-63)

8. What is *sensation*. Describe the general *plan* of structure of the *organs* of the *senses*. How *many* senses are there. Describe the *muscular sense*—the *organs* and *sense* of *touch*—of *taste*—of *smell* (64-70).

9. What are *sound* and *hearing*? Describe the structure and functions of the *external*, *middle*, and *internal* ear; of the *vestibule*, *semicircular canals*, and the *membraneous labyrinth*; describe the nature and uses of *endolymph*, *perilymph*, and *otoconia*. What are the *cochlea*, *lamina spiralis*, *scala media*, *scala tympani*, *scala vestibuli*, and the fibres of *corti*? Explain the action of the various parts of the ear in the *process* of *hearing* (71-79).

10. What is *light*? Explain *light* and *colour* on the “*undulatory hypothesis*.” How does the eye enable us to *see*? What is its *structure*? Describe its coats. How does the *iris* regulate the *quantity* of *light* which enters the eye? (80-87).

11. Describe the *aqueous humour*, the *crystalline humour*, the *vitreous humour*, and the *retina* and their *functions*, also the *blind spot*, and the *bright spot* of *Sömmering*. What is “*duration* of *impression*” of *light* on the eye, and the effect on *sensation* (88-94).

12. Name the *tear glands* and describe their *action*. Describe the *lacrimal gland* and their *functions*. Where are the *tear glands* and their *functions*? How are the eyes *closed* and *opened*? Where are the *tear glands*, whence do they come, and what are their *functions*? (95-99).

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