ZOOLOGY

FOR SECONDARY SCHOOLS

A COURSE

ON

ZOOLOGY:

DESIGNED FOR

SECONDARY EDUCATION.

BY

C. DE MONTMAHON, AND H. BEAUREGARD,

Inspector-General of Primary Education, Paris.

Assistant Naturalist in the Museum of Natural History, Paris.

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TRANSLATED AND ADAPTED FOR AMERICAN SCHOOLS BY

WM. H. GREENE, M.D.

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PREFACE.

This book forms the basis of instruction upon the natural history of animals in the secondary schools of France. In no other country is so high a place assigned to the natural and physical sciences as a means of education. It therefore follows naturally that the French have the best text-books upon these subjects. Translations of their advanced works have been the authorized class-books in American colleges for the last quarter of a century, and Paul Bert's "First Steps in Scientific Knowledge" and "Primer of Scientific Knowledge" have made the successful teaching of elementary science possible in the earlier years of the educational course.

The present work treats the subject of natural history in a manner adapted to the needs of secondary schools, using methods found by experience to excite most interest on the part of the pupil.

In the translation the plan of the original work has been followed closely; but such changes have been made as were needed to Americanize the book.

The illustrations form an important feature of such a work. We desire to extend our thanks to Messrs. W. and R. Chambers & Co. for permission to use cuts from the new Chambers's Encyclopædia, without which it would have been extremely difficult to give the book its present value in this respect.

Many of the cuts of animals are from photographs, and of special scientific value.

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A COURSE ON ZOOLOGY.

CHAPTER I.

The Organization of Man.

MAN is an organized being,—that is, he is made up of distinct parts, each of which performs a definite function.

By **organization** is understood a combination of parts or **organs,** the word organ being derived from the Greek, and meaning an instrument or tool.

The most superficial examination shows us that the organs are arranged in a symmetrical manner in the different regions of the body, which are the head, the trunk, and the limbs. The head and trunk together form the axis of the body; the limbs are lateral appendages.

A more minute examination reveals to us the existence, in each region, of a solid framework covered by the soft parts and the skin, and protecting, in the head and trunk, organs of great importance that fill the interior cavities.

The framework, which gives its general form to the body, is called the **skeleton.** It is composed of a large number of pieces differing in form and in the manner of joining together, and each piece is called a **bone.** To the bones are attached the muscles that serve to move the parts of the body. The muscles form the red **flesh**; they completely cover the bones, and, by their shapes, their more or less pronounced development, and their projection from the general surface, they give to the body its special outlines.

Three large cavities and several smaller ones are contained within bony structures. First in order is the **cranial cavity** in the head, in which are contained and protected the brain and its immediate connections; in the upper part of the trunk is a large cavity bounded on the sides by the ribs, which form a sort of cage surrounding the space called **thorax, breast,** or **chest,** that contains the important organs, the heart and lungs. Lastly, the great **abdominal cavity** occupies the remaining space in the trunk, and in this are placed the stomach, liver, intestines, kidneys, and bladder. A horizontal partition separates the abdominal and thoracic cavities.

Besides the three large cavities that we have mentioned, there are several smaller ones, most of them situated in that part of the skeleton that forms the face. Among these are the **orbital cavities,** or **orbits,** in which are placed the eyes; the **nasal cavity,** for the organs of smell; the **mouth,** or **buccal cavity,** which contains the tongue or organ of taste. It will be observed that all these cavities of the face serve for the protection of certain organs of sense; they are therefore near the cranial cavity, and consequently close to the brain and its connections, with which, as we shall presently see, the organs of sense are directly joined.

We might also mention the long, narrow cavity contained within the whole length of the spinal column, which is a sort of sheath enclosing the spinal marrow.

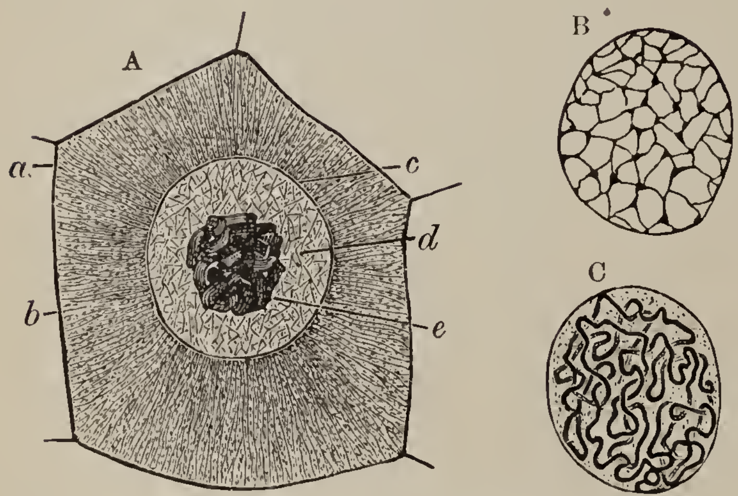
The skeleton not only protects certain cavities, it includes certain prolongations or appendages which serve as the framework of the **limbs.** These limbs, four in number, two upper and two lower, are suspended from the trunk by the aid of what we may call bony belts, of which the upper one helps to form the shoulders, while the lower one forms the floor of the abdominal cavity, and is called the **pelvis,** which means basin.

The various organs that have been mentioned, heart, lungs, stomach, intestines, liver, muscles, bones, etc., all co-operate for the same purpose,—the maintenance of life and the growth of the body. But the parts that they take are very different. Some, like the lungs, are specially adapted to establish between the blood and the air a contact that is absolutely necessary for the life of the blood. The stomach, intestines, and other digestive organs transform the food into substances capable of becoming part of the blood. They are **organs of nutrition** or vegetative life. Other organs, such as the brain, the spinal marrow, the organs of sense, and the muscles, help to establish an understanding between the body and the outside world: they are **organs of relation.** Generally several organs assist in the same work, and such are then grouped together and constitute an apparatus. Thus, the **digestive apparatus** includes the stomach, the intestines, the liver, etc., and each apparatus can be subdivided into smaller groups of organs, each of which performs a particular portion of the work to be done.

If this examination of the organization is pursued still more minutely, the organs are found to be far from simple: the various tissues that constitute the organs are composed of simpler parts or elements, and these elements are all derived from a fundamental element that is called a **cell.**

A cell is a little mass having a varying form, generally spherical or ovoid, and made up of a jelly-like matter that is called **protoplasm.** In this protoplasm is distinguishable a particle somewhat denser than the rest, and this is the **nucleus** of the cell. It is like the stone of a cherry surrounded by the softer fruity matter. These cells are always so small that they cannot be seen without the aid of a powerful microscope.

FIG. 1.



A, cell and typical nucleus: *a*, slight membrane; *b*, radiating protoplasmic net-work; *c*, wall of nucleus; *d*, plasma of nucleus; *e*, nuclear coil. B, nucleus at rest, showing net-work. C, nucleus before division, showing coiled filament.

We have said that the cell is the fundamental element of all **tissues,**—that is, the cell in some one or other of its modifications produces the elements which are grouped together in the various tissues.

Sometimes the cell is elongated like a slender reed, this is a **fusiform cell;** sometimes it is star-shaped, and is said to be **stellate.** Or it may be thread-like, forming a **fibre,** or drawn out into a hollow filament, called a **tube.** All these elements possess peculiar properties, and according to their forms and their properties they have received different names. These names are also given to the tissues which they constitute. **Muscular tissue** is composed of little bundles of fibres, which appear striated under the microscope. **Nervous tissue** is made up by the union of various forms with cylindrical tubes.

We will finish this general account by the definition of a few terms that merit special reference. The various tissues which form the glandular organs, such as the liver, kidneys, spleen, etc., are designated as **parenchyma,** and the collective name **viscera** is applied to the different organs contained within the large cavities of the body.

Membranes are tissues in the form of sheets covering the surfaces of certain organs. **Mucous membranes** are those which line the interior of cavities in direct connection with the exterior,—the mouth, for example, is lined with the buccal mucous membrane. **Serous membranes** line the interior of the large cavities of the body, and are not in communication with the exterior; they separate the organs and facilitate their various movements.

Having acquired the foregoing general notions, we will pass directly to the study of the apparatus of vegetative life and those of the life of relation. The first are those of **respiration, circulation,** and **digestion.** The second are those of **movement (skeleton and muscles)** and of **sensation (nervous organs and organs of sense).**

CHAPTER II.

The Essential Phenomena of Respiration.

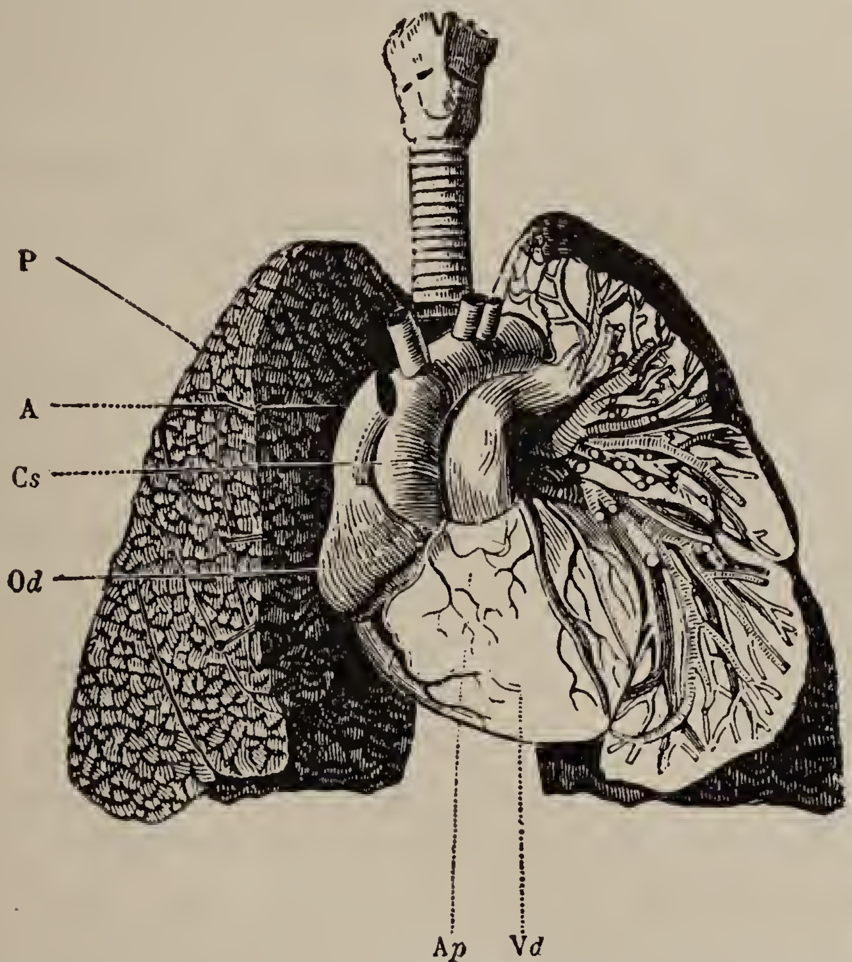
THE atmosphere is composed, to the extent of one-fifth its volume, of a gas having very energetic properties,—it is called oxygen; the other four-fifths are another gas, nitrogen, which may be considered as taking no part in the phenomena which are now to occupy our attention.

All living beings require oxygen for the accomplishment of the various phenomena of which their organizations form the theatre; they derive this gas, which is absolutely necessary for their existence, directly or indirectly from the atmosphere. Animals and terrestrial vegetables are in direct contact with the air; aquatic animals and vegetables support themselves by the air held dissolved in water. This dissolved air represents ordinarily only one-eighth the volume of water, but it contains a proportion of oxygen very much greater than that found in the atmosphere; hence there is a sort of compensation.

If for our study we select an animal breathing the atmosphere by the aid of lungs, there is found a very marked difference between the composition of the air which enters the respiratory organs and that which is expelled from the same organs. In the last case but sixteen or sixteen and a half per cent. of oxygen are found, instead of the twenty per cent. present in the former; on the other hand, carbonic acid gas, which is found in an almost negligible proportion in the atmosphere, represents at least four per cent. of the air that leaves the lungs; in addition, vapor of water is present in as large a proportion as the relatively high temperature of the exhaled air will permit, while the atmosphere rarely contains a quantity bordering on saturation. Disappearance of part of the oxygen, and notable increase in the proportions of carbonic acid gas and water vapor, are, then, the phenomena which seem to result from the passage of air through the respiratory organs.

These phenomena are exactly the same as those produced by all ordinary combustion, and it is not surprising that at a very early date the two orders of phenomena were found similar. Combustion is, indeed, the ultimate object of the respiratory function. Oxygen is the agent necessary for this combustion; carbonic acid gas and water vapor are the products resulting from the combination of oxygen with the carbon and hydrogen which enter into the composition of our tissues and the fluids of our bodies. A candle, lamp, or gas flame that burns in the air yields exactly the same products.

FIG. 2.



LUNGS AND HEART OF MAN.—The left lung has been dissected so as to show the interlacing of air-vessels and blood-vessels. P, right lung; C*s*, upper vena cava; A, aorta; V*d*, right ventricle; A*p*, pulmonary artery; O*d*, right auricle.

Respiratory Apparatus.—In man the respiratory apparatus, strictly speaking, is the **lungs,** which are put in direct communication with the external air by a large tube, called the trachea. The lungs fill almost the whole of the thoracic cavity or chest, which is, as we have seen, within the ribs, occupying the upper portion of the trunk, and separated from the abdominal cavity by a muscle called the diaphragm.

These organs are double and of unequal size, the left lung being less voluminous than the right. The smaller size of the left lung is due to the space occupied by the heart in the left side of the thoracic cavity. The lungs are enveloped by a serous membrane called the **pleura,** which separates them from each other and from the chest walls.

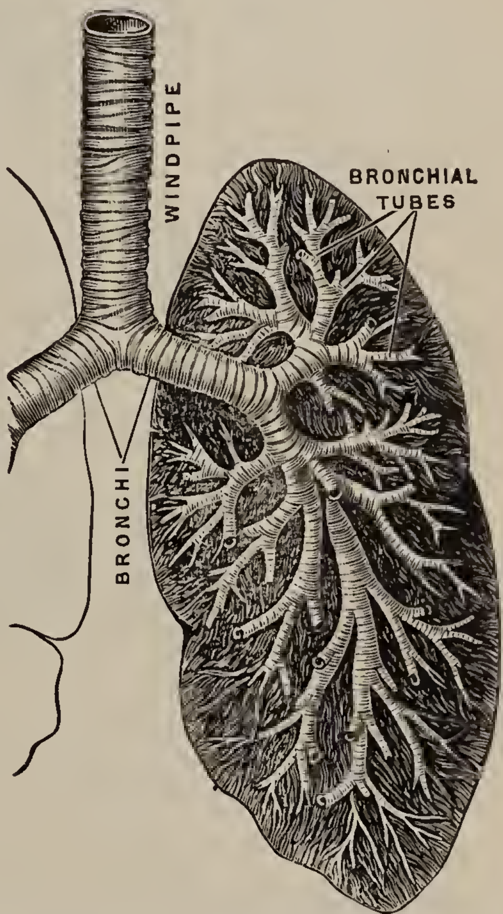
FIG. 3.

DIAGRAM OF TWO PRIMARY LOBULES OF THE LUNGS, magnified.—1, bronchiole; 2, a pair of primary lobules connected by fibro-connective tissue; 3, intercellular air-passages; 4, air-cells; 5, branches of the pulmonary artery and vein.

The lungs are made up of a large number of little **vesicles,** communicating together by a ramifying system of canals. In each lung these canals join to form a single tube, called **bronchus,** and the union of the two bronchi forms the **trachea.** The trachea rises along the front of the neck, and opens in the back of the mouth in front of the œsophagus. It is surrounded by a series of cartilaginous rings, the upper of which form the **larynx** or organ of voice, and produce exteriorly the little projection commonly called **Adam's apple.** A mucous membrane, which is a continuation of the buccal mucous membrane, covers the internal walls of the trachea and bronchi.

Through the trachea, the bronchi, and their ramifications the air penetrates to the farthest vesicles of the lungs. The walls of these vesicles are lined with innumerable little vessels, some of which bring in the blood which has traversed the body (venous blood), while others carry out the blood which here in the lungs becomes charged with oxygen (arterial blood). The first are the last ramifications of the pulmonary artery; the second unite to form vessels more and more voluminous until, on leaving the lungs, they constitute the pulmonary vein.

Fig. 4.



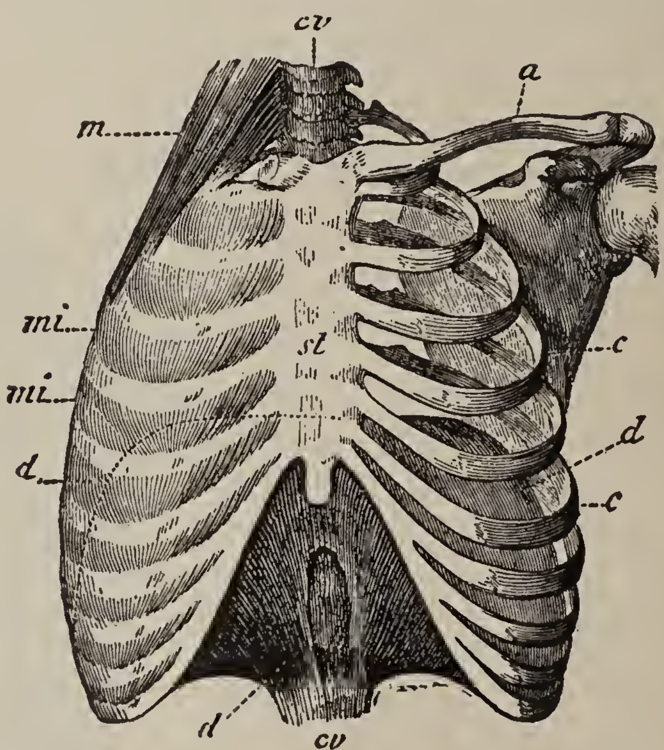
The trachea (windpipe), bronchi, and one of the lungs in section.

Now that we know the structure of the pulmonary apparatus, it will be easy to understand how respiration takes place. It must never be forgotten, however, that respiration, properly speaking, does not take place in the lungs. These organs are simply the locality in which the exchange of gases takes place,—that is, the exchange of pure air brought into the vesicles for impure air charged with carbonic acid gas, which is brought by the blood to the ramifications of the pulmonary artery.

Let us first study how the air gets into the lungs, and how it leaves the lungs after the exchange of gases, to be again replaced by pure air.

The conditions necessary for this entrance and exit of air are provided for by particular movements of **inspiration** and **expiration.** **Movements of inspiration** are those by which air is drawn into the lungs; **movements of expiration** are those by which it is expelled. The mechanism by which both these movements are pro-

FIG. 5.



STRUCTURE OF THE CHEST.—The left side of the chest shows only the bony parts; *cv*, vertebral column; *a*, clavicle; *c*, *c*, ribs; *st*, sternum; *m*, muscles that raise the upper ribs; *mi*, intercostal muscles; *d*, the diaphragm.

duced is exceedingly simple, and its action is much like that of a bellows.

Inspiration.—When the chest expands—that is, when the lifting of the ribs and the breast-bone (**sternum**) and the lowering of the diaphragm increase the capacity of the thorax, and, as a consequence, the rarefaction of the gas which this cavity already contains—equilibrium must be re-established between the external and the internal air. According to well-known physical principles a quantity of air then enters the lungs.

Expiration.—Soon, however, the ribs and the sternum fall; the diaphragm ceases to contract, and is forced upward by the abdominal viscera; the thorax resumes its original volume, and the compression exerted on the lungs forces out a quantity of air corresponding to that which had entered just before.

The alternate movements of inspiration and expiration are repeated in man on an average sixteen times a minute. The capacity of the lungs, when completely filled, is about two and a half quarts, and the actual renewal of air by each respiratory movement corresponds to about thirty cubic inches. If this last number be multiplied by the number of movements, it will be found that in every twenty-four hours there pass through the lungs about three thousand gallons, or four hundred cubic feet. This volume, of course, varies according to numerous circumstances. When the air enters the pulmonary vesicles it is separated from the blood only by the thickness of the walls of the vesicles and the capillary vessels which cover their surfaces. The walls of the vesicles, like those of the capillary blood-vessels, are so thin that the thinnest fabrics could give no idea of them, and the exchange between the oxygen of the air and the carbonic acid gas of the blood takes place through an almost impalpable gauze.

These phenomena of exchange constitute only a part of respiration, and, in fact, the least important part. The most important phenomena take place in the depths of the tissues to which passes the arterial blood charged with oxygen. They are chemical reactions. The oxygen seizes on the carbon and combines with it to form carbonic acid gas, which, as we have seen, is rejected in expiration. It is the tissues then that respire, and for them that the blood passes to the lungs where it becomes charged with oxygen. The tissues do not all respire with the same intensity; experiments have shown that the muscles absorb the largest quantity of oxygen, while the bones seem to require the least.

In any case, as has before been said, respiration is really a combustion, taking place in the midst of the tissues, by the aid of oxygen carried by the blood. It is well known that combustion produces heat, and it can be understood why respiration is the principal source of animal heat.

CHAPTER III.

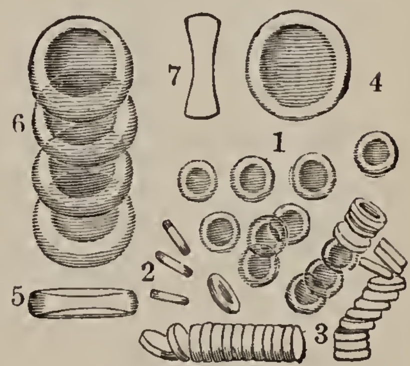
The Essential Phenomena of Circulation.

Circulation is the name given to the course which the blood follows through the system. The blood is a liquid somewhat heavier than water, having an insipid taste and an unpleasant odor; its color varies between dark red and scarlet. It is formed of two distinct parts,—the **plasma,** which is a colorless liquid, and round or flattened globules, most of which are red, and these are called **corpuscles.** The plasma forms eight hundred and seventy-five thousandths of the blood, the corpuscles form the other one hundred and twenty-five thousandths.

The corpuscles are composed almost entirely of a substance closely resembling white of egg, and named, like the latter, **albumen**; their color is due to the presence of a few thousandths of a substance containing iron, and called **hæmoglobin.** The quantity of iron existing in the blood of an adult man does not exceed a drachm.

The plasma contains, for every eight hundred and seventy-five parts, seven hundred and ninety parts of water and sixty of albumen, the remainder being made up of small quantities of more than fifty different substances, each of which either is required to repair the waste of certain organs, or is the waste product eliminated from some organ.

FIG. 6.



RED BLOOD-CORPUSCLES, highly magnified.—1, corpuscles seen on their broad surface; 2, seen on their edge; 3, rolls of corpuscles, indicating the manner in which they are frequently observed to arrange themselves. The remaining figures more highly magnified: 4, corpuscle seen on its broad surface; 5, seen on its edge; 6, a series of corpuscles; 7, a corpuscle in section, indicating its biconcave discoidal form.

The blood has not the same appearance and the same composition in all animals. It has a red color only in the vertebrates and in certain annulates belonging to the group of worms. In all other cases it is whitish, bluish, yellow, green, or violet.

The corpuscles of different animals differ also in shape, size, and relative number. Only mammals have round corpuscles; in other animals the corpuscles are elliptical, and possess a nucleus which very rarely exists in the red corpuscles of mammals. Their size has no relation to that of the individuals: thus, in the horse they are $\frac{1}{5000}$ of an inch in diameter, in the snail $\frac{1}{2500}$ inch, and in man $\frac{1}{3200}$ inch. The long diameter of the elliptical corpuscles of the frog is $\frac{1}{1100}$ of an inch. Lastly, if we study the proportion of these globules to the entire quantity of blood, we find fifteen per cent. of corpuscles in the blood of the tortoise, nine per cent. in that of the horse, and only six per cent. in that of the frog.

Besides the red corpuscles in blood, there are white spherical bodies known as white corpuscles, or **leucocytes**; these are a little larger than the red corpuscles, but much fewer in number, there being in the blood of a healthy man only one white corpuscle for about three hundred and fifty red ones.

We have said in the chapter on **Respiration** that the blood charged with oxygen is called **arterial blood**; it is scarlet in color. The blood which circulates in the tissues, and which is charged with carbonic acid gas, presents, on the contrary, a dark-red color, and is called **venous blood.**

Circulatory Apparatus.—The organs that compose the circulatory apparatus may be divided into groups,—a

FIG. 7.

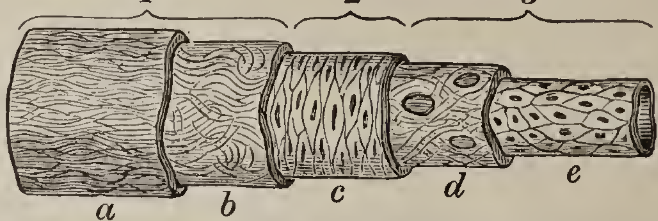


DIAGRAM OF THE STRUCTURE OF AN ARTERY (after Turner).

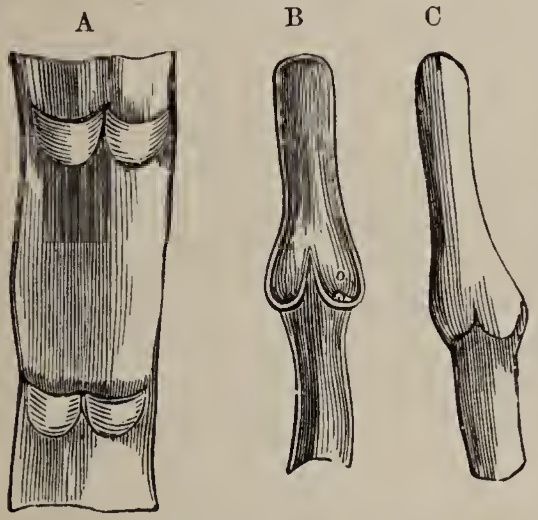
1. External coat.......... { *a*, fibrous. *b*, elastic.
2. Middle coat............ *c*, muscular.
3. Internal coat.......... { *d*, elastic. *e*, endothelial.

central organ, the **heart,** and peripheral organs, the **vessels.**

We recognize three systems of vessels,—the **arterial system,** which receives the blood from the heart and carries it to other organs; the **venous system,** which brings the blood from the organs back to the heart, and the **capillary system,** which joins together the other two, forming in fact the termination of each.

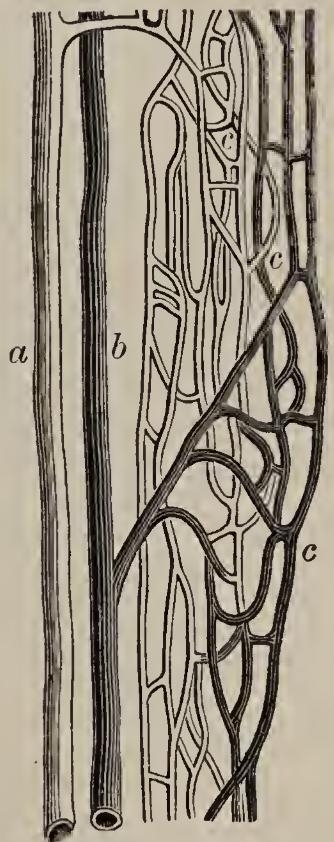
The arteries start from the heart; they are distinguishable by the structure of their walls, which are com-

Fig. 8.



Diagrams exhibiting the arrangement of the valves of veins.—A, vein laid open, showing the valves in pairs. B, longitudinal section of a vein, indicating the mode in which the valves, by apposition of their free edges, close its calibre. The dilated condition of the walls behind the valves is also seen. C, vein distended, showing how the sinuses behind the valves become dilated.

Fig. 9.



Capillaries.—*a*, the artery; *b*, the vein; *c*, the intervening capillaries.

posed of three distinct layers; the external and internal layers are soft and flexible, but the middle layer is elastic and resisting. The veins run to the heart; their walls have two layers, corresponding to the internal and the external coats of the arteries, but the middle one is missing.

The internal membrane of the veins is provided throughout all their lengths (excepting in the veins of the head) with innumerable little folds, shaped much like bird's nests, and designed to prevent the flowing back of the blood. These **valves** of the veins do important work in the circulation: they prevent a backward flow of the blood, which is far from its starting-point, and, having lost a part of its initial speed, meets resistance in rising towards the heart. The arteries are under different conditions, and, with the exception of the large ones that start from the heart, do not possess valves.

The arteries are much less numerous than the veins. Very few of them are superficial; they are generally situated in deep places, and each is usually accompanied by two veins that are called **satellites.** The venous system, on the contrary, independently of the veins associated with the arteries, includes a very large number of superficial vessels.

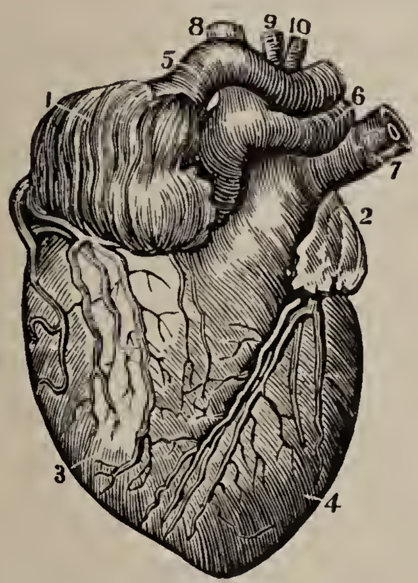
The capillary system may be easily understood as the common continuation of the other two systems. Each of the last arterial ramifications ends in a vessel of very small diameter, and after travelling a certain distance this vessel becomes a prolongation of one of the last venous ramifications. Multiply this example innumerably, and we have an idea of the vast net-work whose ramifications extend in one manner or another to the smallest and most remote particles of our bodies.

The capillary vessels differ in their diameters, which are often microscopic; some are so narrow that the red corpuscles of the blood cannot pass through, and only the plasma circulates in them. Others allow the red corpuscles to pass through only when for any reason the vessels are dilated.

The **heart** is a hollow muscle. It is a muscular mass containing several cavities.

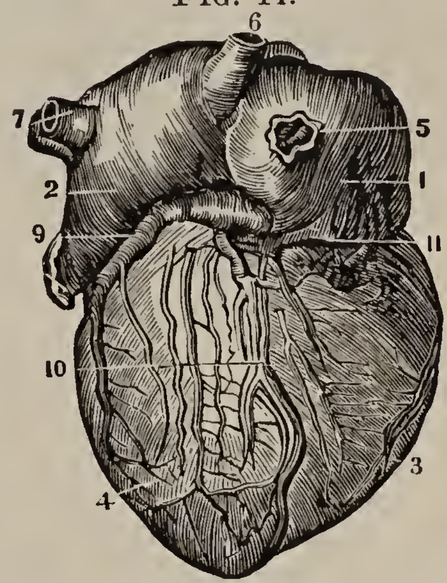
It is situated in the thorax between the two lungs, and is inclined from right to left and from back to front, so that its point strikes against the sixth rib at each of its movements. It is held in position only by the large vessels, and is thus completely independent of other organs. Lastly, like other important organs, it is surrounded by a seroûs membrane, called the **pericardium.**

FIG. 10.



A FRONT VIEW OF THE HEART.—1, the right auricle of the heart; 2, the left auricle; 3, the right ventricle; 4, the left ventricle; 5, 6, 7, 8, 9, 10, vessels through which the blood passes to and from the heart.

FIG. 11.

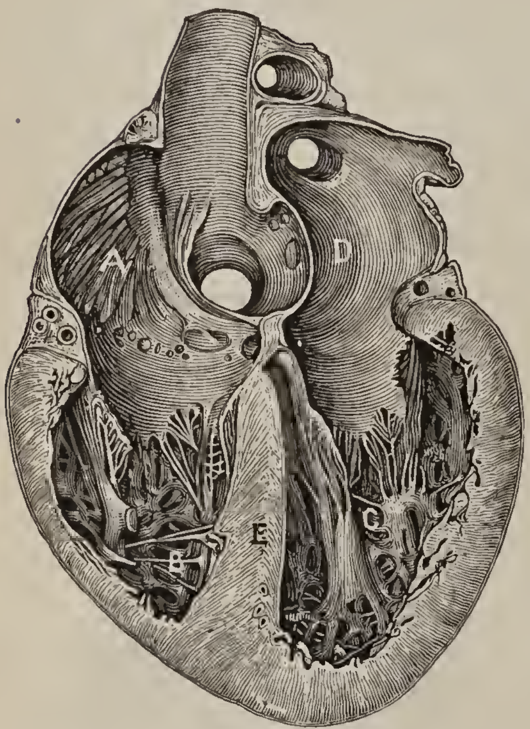


A BACK VIEW OF THE HEART.—1, the right auricle; 2, the left auricle; 3, the right ventricle; 4, the left ventricle; 5, 6, 7, the vessels that carry the blood to and from the heart; 9, 10, 11, the vessels of the heart.

The form of the heart is that of an inverted cone; its size is about equal to that of the fist; its weight is somewhat over eight ounces. Its interior is divided vertically into two compartments that have no direct communication; we might say that there is a right heart and a left heart, having one wall common to both.

Each half is separated horizontally into two compartments, but these compartments communicate by an opening provided with a valve. The upper cavities are somewhat ear-shaped, and they have been named the right and left **auricles**, while the lower chambers are known as the right and left **ventricles.**

Fig. 12.



SECTION OF THE HUMAN HEART (after His).—A, right auricle; B, right ventricle; C, left ventricle; D, left auricle; E, partition between the two ventricles. Between the auricles and ventricles, on right and left, the tricuspid and mitral valves with their cords and associated muscles are shown.

The walls of the auricles are thin muscles that are able to contract with great force, and for this reason the auricles appear very small in a heart emptied of blood. The ventricles, on the contrary, have very thick walls and are very fleshy; their tissue is a beautiful red. The very thin but very strong valves which separate each auricle from the corresponding ventricle are held on their borders by numerous tendinous fibres that are inserted in the muscular walls of the ventricles. They can thus open in only one direction, that which allows the blood to flow from the auricles to the ventricles. These valves are exceedingly important organs; on their regular and normal action depends the accomplishment of a work in which the least irregularity would imperil the existence of life.

The heart is the starting-point or the termination of the large trunks of the arterial and venous circulation; the first opens from the left side, the second opens into the right side, and we might say that the left heart is an arterial heart, while the right is a venous heart. If this be remembered, no mistake can be made in understanding the course of the blood in the circulation. We must also remember that the two hearts are absolutely separated by a middle partition, and that the blood can never pass directly from the one to the other, also that the blood in either auricle can flow only into the corresponding ventricle.

Fig. 13.

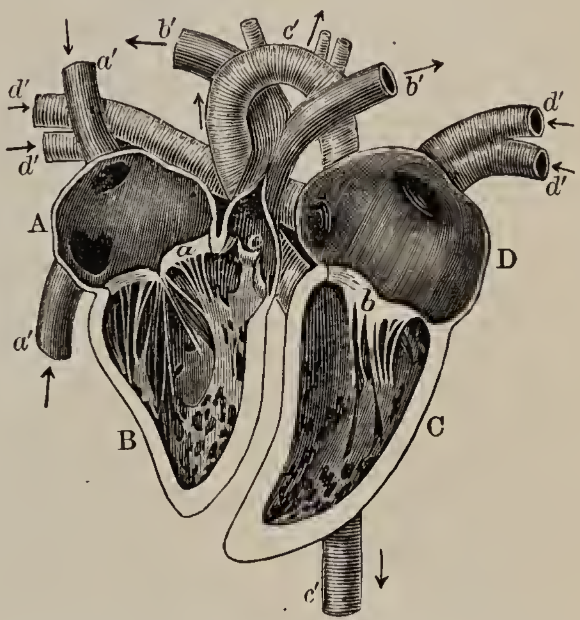


Diagram of heart halved and laid open (after Debierre).—A, B, C, D, as in Fig. 12. *a*, part of tricuspid valve; *b*, part of mitral; *c*, semilunars at base of pulmonary artery. *a'*, *a'*, inferior and superior venæ cavæ entering A; *b'*, *b'*, pulmonary arteries proceeding from B; *c'*, *c'*, aorta proceeding from C; *d'*, *d'*, pulmonary veins entering D.

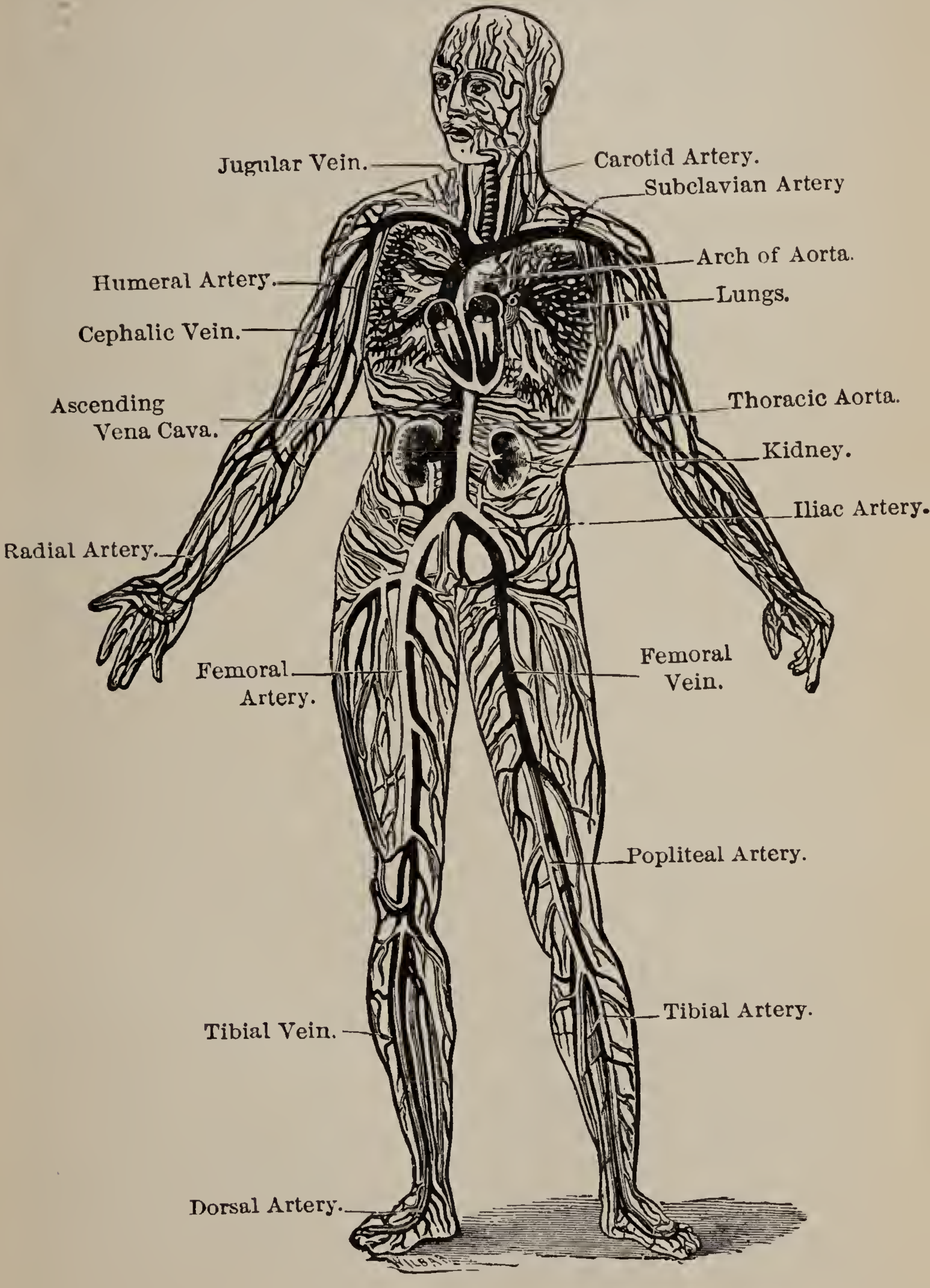
It naturally follows from this arrangement that the blood contained in either ventricle, being unable to escape into the auricle on account of the valve, and also unable to enter the other ventricle, must be forced into the vessels.

The heart then acts as follows:

It is the pumping organ of the circulatory system. Its contractions communicate to the blood which passes through it a motion that is continued throughout the whole extent of the vascular system. The mechanism must be studied at two distinct intervals. At first there is simultaneous contraction of both auricles, forcing the blood into the ventricles, and consequent passive dilatation of the ventricles by the inflowing liquid. At the second interval there is contraction of the ventricles, and forced passage of the blood into the aorta and pulmonary artery, since the auriculo-ventricular valves prevent its return into the auricles. The entrances to the arteries are also provided with valves which prevent reflux of blood into the ventricles when it has once entered the vessels.

That part of the circulatory course included between the right ventricle and the left auricle is called the **lesser circulation,** because of its lesser length, or the **pulmonary circulation,** because it takes place in the lungs. The pulmonary artery, which takes its origin from the right ventricle, is very short; a little over an inch from the heart it bifurcates, and each branch passing to one lung then divides into a great number of branches, which become smaller and smaller. The last little threads are distributed over the surface of the pulmonary vesicles, and bring the liquid which they contain in almost direct contact with the air. Other capillaries receive the blood, which has now become red arterial blood, and form a new system, which converges more and more, and at length is composed of only four large vessels, which are the **pulmonary veins**; these veins empty into the left auricle. It is well to observe that here the name artery has been given to a vessel that carries venous blood, while vessels that carry arterial blood are in this case called veins. This naming is on account of the structure of the vessels and not because of the character of the blood they carry, and we must define arteries and veins, not as vessels that carry, the ones arterial and the others

FIG. 14.



THE CIRCULATORY SYSTEM.

venous blood, but arteries as vessels carrying blood from the heart, while veins return blood to the heart, that blood being arterial or venous accordingly as it comes from the lungs or from the extremities of the body.

Greater circulation or **general circulation** is the name given to the second portion of the blood's course; its starting-point is the aorta, and by it the blood is carried from the left ventricle to the right auricle, traversing the entire organism. Almost immediately after leaving the left ventricle, the aorta sends out branches for the nourishment of the heart (**coronary arteries**) and the lungs (**bronchial arteries**). It then rises vertically almost to the top of the sternum and bends downward and backward, forming an arch, called the **arch of the aorta.** From the arch arise by two distinct trunks the **left carotid** and the **left subclavian,** and by one common trunk the **right carotid** and **right subclavian.**

The carotid arteries distribute numerous ramifications to the neck and head. The subclavian arteries, so called because they pass under the collar-bone, pass to the arms, which they follow throughout the entire length, taking names corresponding to the different parts they pass through. One of their branches, the **radial artery,** is generally selected by preference in feeling the pulse.

The **descending aorta** follows the whole length of the spinal column, distributing in its course important branches to the thorax and to the abdomen. These are the **intercostal arteries**, for the muscles of the ribs; the **cœliac,** for the stomach, liver, and spleen; the **mesenteric,** for the intestines, etc. A little below the kidneys a bifurcation takes place, forming the iliac arteries, which carry the blood to the lower limbs.

The last arterial ramifications are of capillary dimensions,—that is, their diameter is hardly as great as that of a hair: they penetrate to all parts of the organs, and the work of nutrition is accomplished by their aid. They terminate in other vessels which are not less delicate, and these capillary veins receive the blood deprived of its life-sustaining elements.

The veins, like the arteries, generally take their names from the parts of the body they traverse: thus, there are **jugular, renal, mesenteric veins,** etc. Unlike the arteries, they unite together in their course, and at last form only two large vessels,—the **superior vena cava** and the **inferior vena cava.** There is, however, one exception: the **portal vein** enters the liver and divides up as the pulmonary artery does in the lungs, and the ramifications afterwards unite to form two large vessels, called the **hepatic veins,** just as the capillaries of the lungs unite to form the pulmonary veins.

CHAPTER IV.

The Essential Phenomena of Digestion.

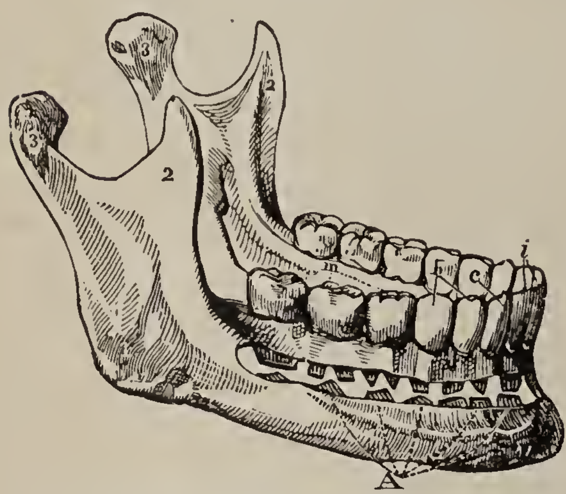
The general name aliments is given to those substances, whatever may be their nature, that are habitually used or are capable of being used for nutrition. **Digestion** is the operation by which these substances are introduced into the organization, either directly or after having been subjected to certain internal processes, which may be chemical or simply mechanical, having for their object the preparation of the substances for absorption. The

digestive apparatus is the collection of organs which serve as agents in digestion.

The digestive apparatus is composed of a long tube open at both extremities, and a number of auxiliary organs, among which are the salivary glands, the liver, the spleen, and the pancreas, most of these organs being contained in the abdominal cavity.

The walls of the digestive tube are formed by the union of several layers of various membranes; interiorly a **mucous** membrane is a continuation of the skin: under this a **fibrous** membrane determines the form of the tube; next to this a **muscular** coat gives the power of contraction, and lastly, a **serous** membrane isolates the tube from other organs.

Fig. 15.

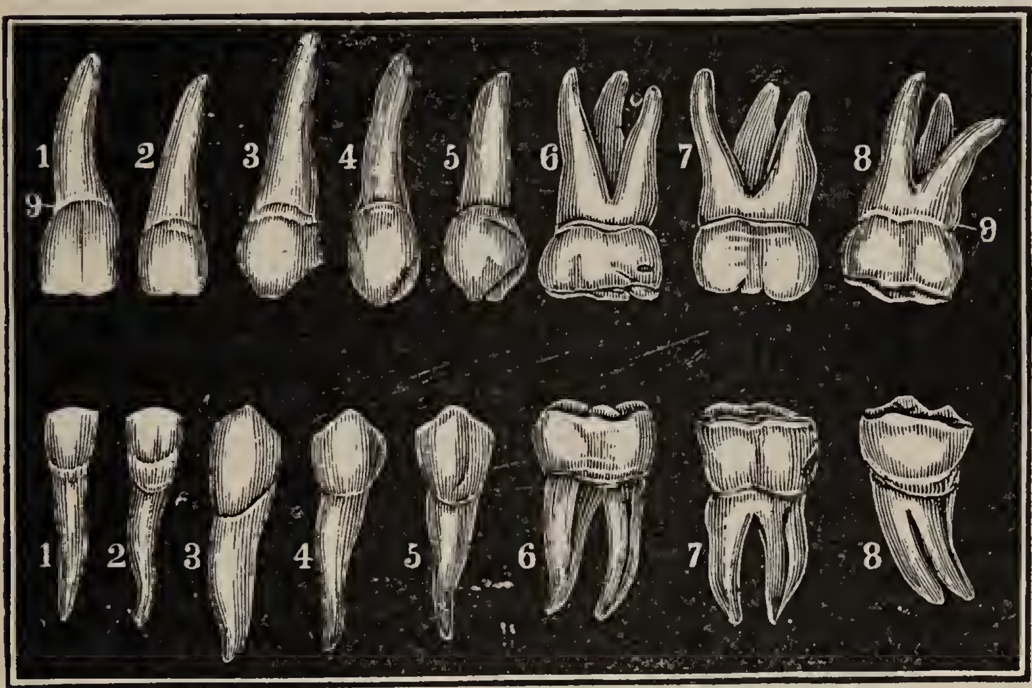


1. The body of the lower jaw; 2, ramus, or branch of the jaw, to which the muscles that move it are attached; 3, 3, the processes which unite the lower jaw with the head; *i*, the lower and lateral incisor teeth of one side; *b*, the bicuspid teeth; *c*, the cuspids or eye teeth; *m*, the three molar teeth; A, shows the relation of the permanent to the temporary teeth.

The **mouth** is a sort of vestibule to the digestive canal; its exterior opening is surrounded by a circular muscle that forms the **lips.** On the edges of the lips begins the mucous membrane that has been mentioned. This membrane differs from the skin by its thinness, its moisture, and its rosy color. The lips retain the food during mastication, prevent the saliva from running out the mouth, and aid in the production of sound and speech.

Behind the lips are the **teeth,** planted in the jaws. There are thirty-two teeth in adult man, but the child has only twenty, and these are called **milk teeth.** The first dentition begins between the ages of six and ten months, the middle two incisors of the lower jaw usually appearing first. A few weeks later the corresponding teeth of the upper jaw cut through, then the

FIG. 16.

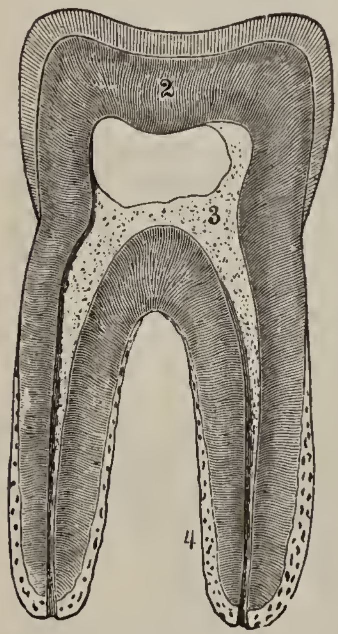


THE ADULT TEETH.—1, 2, the cutting teeth (incisors); 3, canine (cuspid); 4, 5, small grinders (bicuspids); 6, 7, 8, grinders (molars); 9, 9, neck of the tooth.

lower lateral incisors, and afterwards the upper ones. The lower canines, afterwards the upper ones, or eye-teeth, are cut at the age of twelve or fourteen months. Lastly appear successively eight molars, four above and four below. The milk teeth begin to fall out towards the seventh year, and are replaced by teeth of the second dentition. Fig. 15 shows the milk teeth fully developed, and the second teeth as germs. We are born with the germs of the teeth of both dentitions already formed,—that is, with fifty-two dental embryos enclosed in the jaws. When the second teeth fall they are not replaced.

There are then three kinds of teeth: **incisors, canines,** and **molars,** and they are symmetrically arranged. An adult man has on each side of the face, and in each jaw, two incisors, one canine, five molars, which are classified as three true molars and two premolars or bicuspids.

Fig. 17.



Vertical section of a molar tooth, moderately magnified.—1, enamel, the lines of which indicate the arrangement; 2, dentine or ivory; 3, pulp, containing nerves and nourishing vessels; 4, root, covered with cement.

The incisors occupy the front of the mouth; next to them are the canines, and next to these the molars. The last molars do not often appear before adolescence; sometimes they are much later, and more rarely they are entirely wanting. They are commonly called **wisdom teeth.**

The teeth are formed of a peculiar substance called **dentine** or ivory, and that portion of the dentine which projects beyond the gums, and which is called the **crown,** is covered with a thin layer of a hard substance, called **enamel.** The root of the tooth—that is, the portion which is embedded in the cavities or **alveoli** of the jaws—is covered with a thin coating of osseous tissue, called **cement.** The roots are single in the incisors, canines, and premolars; double and often triple in the true molars.

The teeth, like all other organs, are provided with nerves and nourishing vessels. These nerves and vessels penetrate to a cavity in the centre of the tooth, which is filled by a soft substance called the pulp.

The tongue is a muscular organ attached to the posterior portion of the floor of the mouth. Perfectly free in front, and endowed with extreme mobility, it aids in the perception of tastes, in the formation of the voice, and in deglutition or swallowing. Its surface is covered with a digestive mucus that furnishes useful indications to the physician. Indeed, since all parts of the digestive mucus are in close sympathy with each other, and ordinarily participate in the same affections, the condition of the tongue usually indicates in a positive manner a corresponding condition of the stomach and other portions of the digestive canal.

FIG. 18.

VERTICAL SECTION OF THE HEAD AND NECK.—*c*, cavity of skull; *f*, falx; *s*, spinal canal, leading from cavity of skull; *n*, right nasal cavity. Below the hard and soft palate: *t*, tongue; *p*, pharynx; *o*, œsophagus; *e*, epiglottis; *l*, larynx.

There are six **salivary glands,** symmetrically arranged, three on each side of the face. The largest are the **parotid** glands, and are situated in front of the ears in the thickness of the cheeks; the **maxillary** glands are under the angle of the lower jaw; the sublingual are under the tongue. Special canals or ducts lead the saliva secreted by these glands into different parts of the mouth.

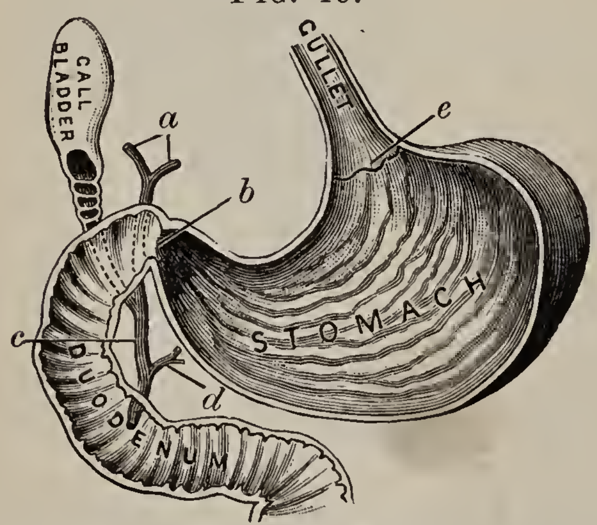
The **pharynx** is a sort of funnel just back of the mouth. Into it open the nasal chambers, called **fossæ,** from above; the air-passages and œsophagus below, and on the sides narrow canals which connect with the middle ear.

The **veil of the palate** forms an imperfect curtain between the mouth and the palate, and its central prolongation, the uvula, is raised during the act of swallowing. Behind the veil of the palate, on each side, are the **tonsils,** small glands that secrete a somewhat viscous liquid.

The **œsophagus** is a cylindrical membranous tube which opens from the back of the pharynx, passes down behind the windpipe, traverses the thorax, and, entering the abdominal cavity, ends in the stomach.

The **stomach,** as well as all the remaining parts of the digestive apparatus, is contained in the abdomen, a capacious cavity separated from the chest by a flat muscle, called the **diaphragm.** The stomach occupies the left upper portion of the abdomen, and extends towards the right, somewhat beyond the point commonly called the **pit of the stomach.** It is a sort of pocket, shaped like a pear, and having a large and a smaller curvature and two orifices. By its upper orifice, called

FIG. 19.

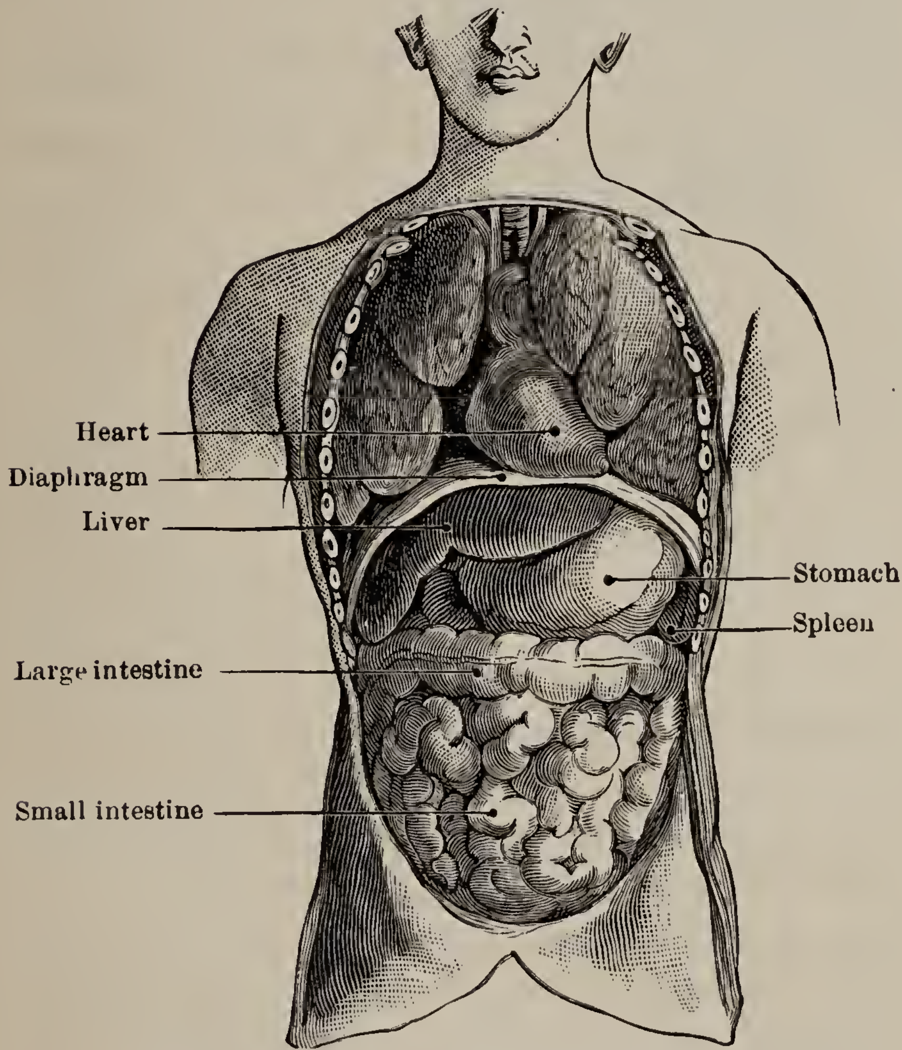


SECTION OF THE STOMACH.—*a*, ducts of liver; *b*, pylorus; *c*, bile-duct; *d*, pancreatic duct; *e*, cardiac orifice.

the **cardiac,** the stomach is a continuation of the œsophagus; by its lower orifice, the pylorus, it communicates with the small intestine. Its mucous membrane secretes an acid liquid, which is a very active agent in digestion, and is called the **gastric juice.**

The **small intestine** is a smooth, thin, and narrow tube,

Fig. 20.



Position of the principal organs of digestion.

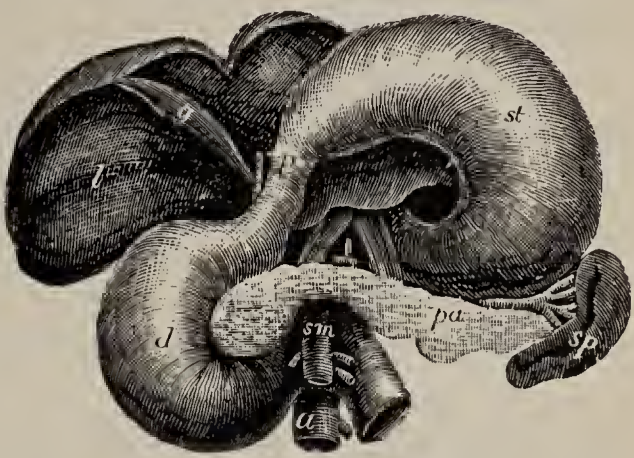
having an average length of five or six yards, and forming a large number of coils, which occupy a large portion of the abdominal cavity. At close intervals its mucous membrane forms folds, called **connivent valves,** whose function is to retard the progress of the food and present a larger surface for absorption. This membrane bristles all over with a sort of little hairs or **villi,** which give it the appearance of velvet, and which are true absorbent organs. The serous membrane, or **mesentery,** is a prolongation of the **peritoneum,** a general serous membrane which lines the abdomen. The mesentery forms loops which sustain at various points the small as well as the large intestine, thus separating the folds, and preventing the tube from twisting and becoming tangled. Without knowing the arrangement, it would be difficult to understand how the food can pass through a tube so long and so many times coiled on itself. It is also through the mesentery that the nerves and the various vessels pass to or from the intestines.

Although the small intestine possesses about the same form and the same structure throughout its entire length, it has been arbitrarily divided into three sections, named **duodenum, jejunum,** and **ileum.** The duodenum is the portion directly connected with the stomach, and into it empty two ducts, one of which carries the **bile,** and the other the **pancreatic juice.**

The large intestine is much shorter than the small one, but it is much greater in diameter; it also differs by having numerous enlargements, by the very small number of absorbent organs, and by the absence of convolutions. It is considered as made up of three portions: first, the **cæcum,** which is simply an enlargement into which the small intestine opens; then the **colon,** which first passes upward in a straight line, bends over in front of the stomach, and turns down, forming a letter S. The **rectum** forms the end of the large intestine and of the digestive tube.

The **spleen** is a thin, flat gland, of a dull-red color, situated in the left upper portion of the abdomen, and reaching from the large curve of the stomach to the ribs. This organ is usually considered as forming part of the digestive apparatus; but up to the present time its functions remain unknown.

FIG. 21.



THE UNDER SURFACE OF THE STOMACH AND LIVER, WHICH ARE RAISED TO SHOW THE DUODENUM AND PANCREAS.—*st*, stomach; *p*, its pyloric end; *l*, liver; *g*, gall-bladder; *d*, duodenum, extending from the pyloric end of the stomach to the front, where the superior mesenteric artery, *sm*, crosses the intestines; *pa*, pancreas; *sp*, spleen; *a*, abdominal aorta.

The **liver** weighs sometimes as much as four and a half pounds, and is the largest of the viscera. It occupies the whole of the right upper portion of the abdomen, and is divided into several **lobes,** separated by depressions or furrows. It partly covers the stomach, and is itself protected by the lower ribs. Its internal structure is granular, being formed of little glands, which secrete the bile, and of an elaborate vascular net-work. For the bile there is a reservoir, called the **gall-bladder.** The gall is a sort of liquid soap; the contents of the gall-bladder of the ox are used to wash delicate fabrics.

A duct leads from the gall-bladder, and another directly from the liver, and these unite to form the **common gall-duct,** which empties the bile into the small intestine, a little below the pyloric opening. When for any cause the bile-duct becomes obstructed or the secretion of bile is suspended, the elements of the bile are no longer removed from the blood, and that liquid acquires a characteristic yellow color, which is communicated to the skin.

The **pancreas,** which is analogous to the salivary glands in structure, forms a sort of tongue lying against the vertebral column, and behind and below the stomach. Two ducts carry into the duodenum the **pancreatic juice,** these openings being close by that of the gall-duct.

It will be well to review the reciprocal relations of the various organs contained in the abdominal cavity. (Fig. 20.) The **stomach** occupies the upper part to the left; the **liver** is to the right of the stomach, and somewhat in front; the **spleen** is left of the stomach and slightly behind it; the **transverse colon** in front of it; the **pancreas** below it; the **small intestine** directly under it. The **kidneys**—organs that excrete the urine—are placed, one on each side, in the lumbar region, and the **bladder,** the common reservoir into which they discharge, fills the front of the abdomen at the point corresponding to the anterior junction of the bones of the pelvis. All these organs are closely pressed together, and yet, by means of the separating prolongations of the peritoneum, they are perfectly isolated one from the other.

Phenomena of Digestion.—Some of the phenomena of digestion are purely mechanical, relating to the division, trituration, and forcing forward of the food; others are chemical, and these include all the transformations which the food undergoes in its onward passage in order to become fitted for absorption.

These transformations must end in the rendering of the food soluble, or, as in the case of fats, its division into exceedingly small particles; these conditions are indispensable that absorption may occur.

The successive operations of digestion have been classified as a certain number of functions, to which have been given the names **mastication, insalivation, deglutition, stomachic digestion, and intestinal digestion.**

The mouth is the place of **mastication** and **insalivation.** By the first of these operations the food is divided into fragments small enough to pass without difficulty the narrower portions of the digestive tube, and to become saturated with the different liquids it encounters in its course.

During this operation the tongue constantly carries between the teeth those portions of food that require division, while the lips retain such portions as are forced outside the dental arches.

Insalivation is the name applied to the action of the saliva on the food while in the mouth. The saliva acts mechanically in rendering sufficiently liquid such aliments as are too dry; it aids in the agglomeration of the triturated particles into little masses called **boluses,** and helps these boluses to glide easily into the œsophagus. It exerts a chemical action on starch and sugar, converting them into a sweet substance, called glucose, and glucose is the soluble form in which such substances are absorbed.

The saliva is composed almost entirely of water, containing two or three per cent. of alkaline salts and two or three thousandths of a peculiar principle, called **salivary diastase** or **ptyalin,** which acts in the same manner as the diastase of barley in the manufacture of malt. The presence of food in the mouth causes the saliva to flow, and the flow is greater with food which is rich in taste and flavor.

Solid substances would be absolutely tasteless were they not moistened and partially dissolved by the saliva. The odor or the sight of food will cause a flow of saliva, the expression "to make the mouth water" being universally understood.

At the moment of **deglutition** the tongue gathers the food into a sort of ball and carries it into the pharynx, whose walls then contract and force the bolus into the œsophagus.

As has already been seen, the pharynx has several openings: the entrance of little portions of food into the nasal passages would not have serious consequences; but the smallest particle entering the respiratory tube at once causes a convulsive cough that continues until the foreign body is expelled. Happily this accident is rare, because the opening of the air-passage is protected in a very thorough manner by a membranous trap-door, called the **epiglottis,** which closes at the instant of swallowing.

The progress of the food in the œsophagus is caused by the contractions of the muscular coat; the weight of the food has nothing to do with it. The alimentary mass hardly enters the stomach before the fibres of the muscular tissue of that organ take up the contractions of the œsophagus, and begin to knead the mass, carrying it at the same time from one end to the other. Towards the end of this work the movements tend to direct the food to the pyloric opening, but at the beginning the direction is just the contrary,—that is, towards the large curvature and the cardiac orifice.

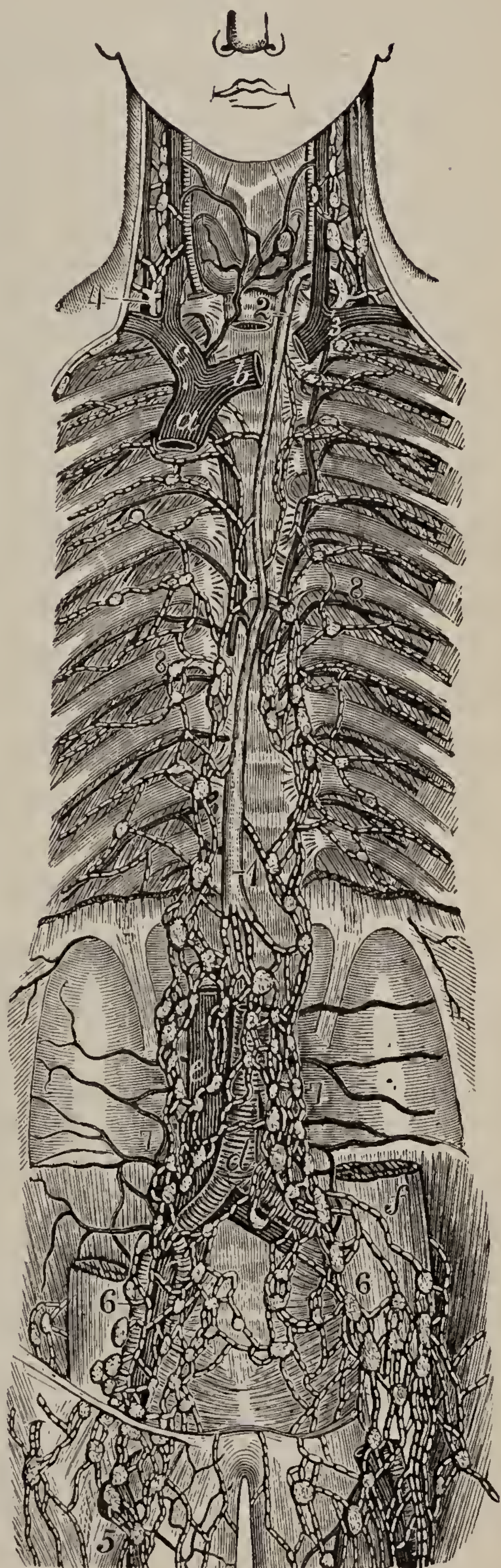
In the stomach the food comes in contact with the **gastric juice.** This is a very acid liquid, secreted by the mucous membrane of the stomach, and owing the greater part of its digestive power to a substance whose action is in some respects analogous to that of yeast, and which is called **pepsin.**

The gastric juice acts on nitrogenous matters, such as meat, white of egg, cheese, the gluten of bread, etc. It dissolves them and renders them absorbable.

It has been stated, in the description of the small intestine, that the ducts carrying the bile and the pancreatic juice open only a short distance from the pylorus.

The **pancreatic juice**, an alkaline liquid, whose appearance resembles that of the saliva, but which differs somewhat from the latter in composition, acts on the starchy or saccharine matters that have escaped the action of the saliva in precisely the same manner as

Fig. 22.



View of the great lymphatic trunks.—1, 2, thoracic duct; 4, the right lymphatic duct; 5, lymphatics of the thigh; 6, iliac lymphatics; 7, lumbar lymphatics; 8, intercostal lymphatics; *a*, superior cava; *b*, left innominate vein; *c*, right innominate vein; *e*, inferior cava; 3, left subclavian vein.

the latter; besides, it exerts an action on fatty substances, converting them into emulsions, mixtures in which the fat is broken up into microscopic drops.

The action of the bile is not as certainly determined. It is probable that it aids the pancreatic juice in emulsifying fats, at the same time partially saponifying them,—that is, converting them into soluble soaps.

While the food undergoes the action of the bile and the pancreatic juice, it is pushed forward by the contractions of the muscular tissue,—these contractions, having been first started by the introduction of the bolus into the œsophagus, resulting in what are called **peristaltic movements,**—and continues its passage through the many turnings of the intestinal tube. Absorption takes place during this passage by the aid of innumerable villi which cover the mucous membrane, and the liquids pumped in by these little suckers enter vessels, called **lacteals** or **chyle-ducts.** These vessels cover the mesentery with an extensive net-work, and finally unite to form one large canal, called the **thoracic duct,** which passes upward along the vertebral column, and pours into the **left subclavian vein** a whitish, milky liquid, which is usually called **chyle**; this owes its opacity and its white color to the fat globules it holds in emulsion, just as milk is white because of the numerous little butter globules suspended in it.

Those parts of the food which have resisted all digestive action pass on into the large intestine, whose length is but a small fraction of that of the small intestine, and are finally expelled as refuse.

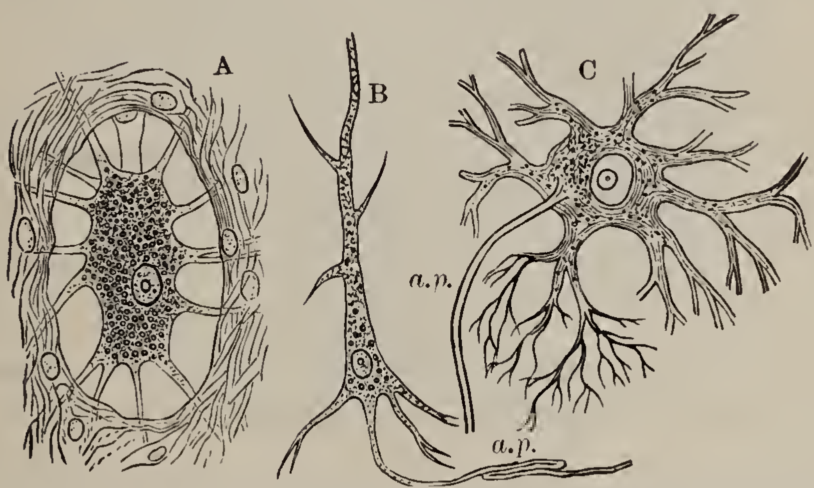
CHAPTER V.

Functions of Relation—Nervous System.

THE functions of relation establish our intercourse with the outside world. They may be classified as functions of sensation and functions of locomotion. Their study is intimately connected with that of the nervous system.

Nervous tissue is made up of ramified cells, called **nerve-cells,** and little tubes that contain the ramifica-

FIG. 23.



NERVE-CELLS.—A, from sympathetic ganglion; B, from cerebrum; C, from spinal cord; *a. p.* axis cylinder process.

tions of the cells. By their union nerve-cells form a tissue called **gray matter** on account of its color. Nerve-tubes when united together form **white matter.** The nerves are made up exclusively of these tubes.

In certain localities the nervous tissue forms long cords, in others it constitutes masses of varying size and form. The cords are called **nerves,** and the masses are **ganglions** or **nerve-centres.**

The various parts of the nervous system are usually classified in two groups:

First. The **cerebro-spinal system,** which includes the **brain,** the **spinal cord,** and the **nerves** which emanate from different points of the system and are distributed to the different organs.

Second. The **great sympathetic system,** which is composed of series of small masses or **ganglions** connected together by a large number of nervous ramifications, one series being located on each side of the body.

The Cerebro-spinal System.—The cerebro-spinal system comprises a central mass, the **brain**, a long, central appendage, called the **spinal cord,** and a chain of **nerves,** all of which have their origin in the brain or in the spinal cord.

The **brain** is the collection of organs contained within the cranium or skull: they are the **cerebrum,** the **cerebellum,** and the **medulla oblongata.**

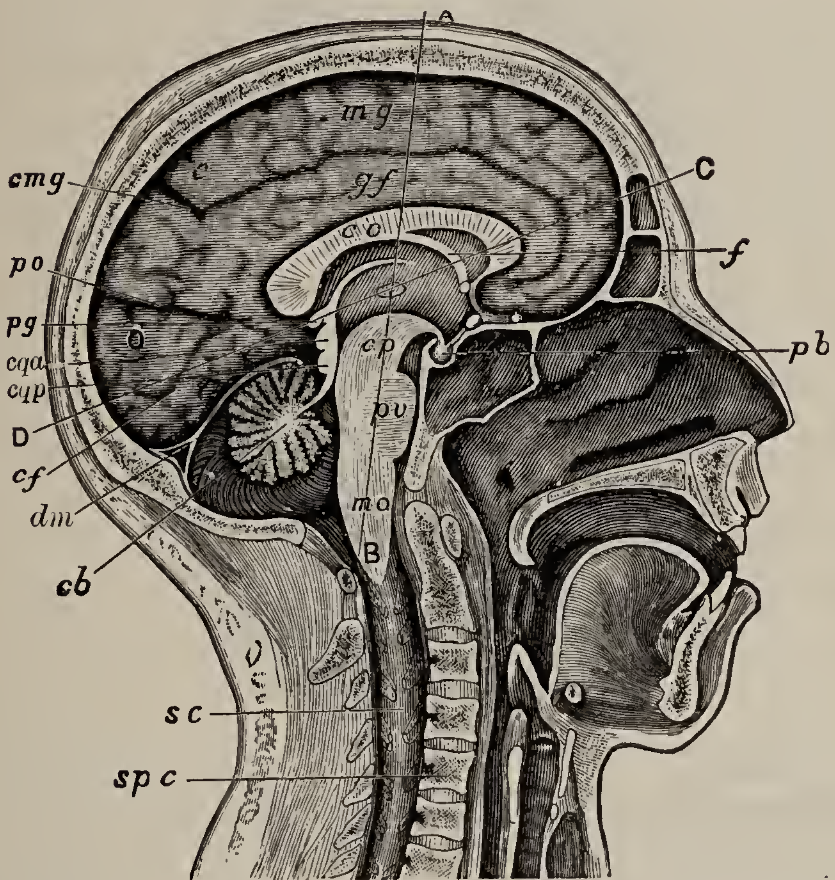
Three membranes cover the brain: beginning at the outside, they are the **dura mater,** which is thick and strong; the **arachnoid,** so called because it resembles a spider's web; and the **pia mater,** which is full of vessels.

The cerebrum, by itself, occupies almost the entire cranial cavity. Its average weight in man is somewhat less than fifty ounces, while the cerebellum weighs only about six ounces, the medulla oblongata only about an ounce, and the spinal cord an ounce. The cerebrum fills the front and upper portion of the skull; a very deep fissure in the middle divides it into two hemispheres, each of which is divided into several lobes, and contains an interior cavity called a **ventricle.** The surface appears made up of hills and valleys by folds called **cerebral con-**

volutions. The nervous matter of the outside is gray, the interior is white.

The **cerebellum** is in the lower back portion of the

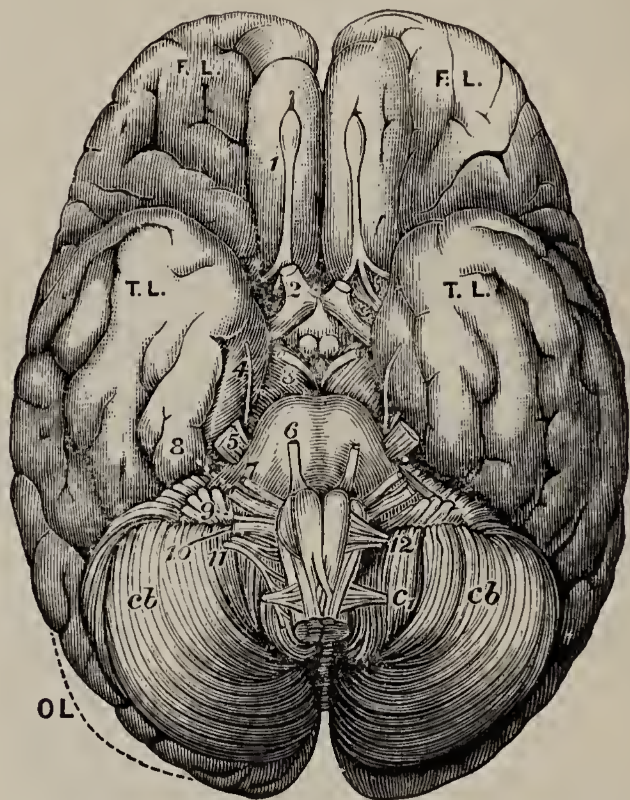
FIG. 24.



MEDIAN LONGITUDINAL SECTION THROUGH HEAD AND UPPER PART OF NECK, TO SHOW RELATION OF BRAIN TO CRANIUM AND SPINAL CORD (Original drawing from a preparation in the Anatomy Rooms at Surgeons' Hall, Edinburgh).—C, cerebrum; *cb*, cerebellum; *sc*, spinal cord; *spc*, spinal column; *mo*, medulla oblongata, passing through foramen magnum into the spinal cord; *pv*, pons Varolii; *cp*, cerebral peduncles, or *crura cerebri; cqa*, anterior corpora quadrigemina; *cqp*, posterior corpora quadrigemina; *pg*, pineal gland; *pb*, pituitary body; *cc*, corpus callosum, divided transversely; *f*, fornix; *mg*, marginal gyrus; *gf*, gyrus fornicatus; *cmg*, calloso-marginal sulcus; O, occipital lobe; *po*, parieto-occipital fissure; *cf*, calcarine fissure; *dm*, dura mater, separating cerebrum from cerebellum.

skull, and is separated from the cerebrum by a transverse fold of the dura mater. Instead of convolutions its surface presents a large number of parallel striations, and the white matter of the interior penetrates into the

FIG. 25.



UNDER SURFACE, OR BASE, OF BRAIN.—FL. TL. and OL, frontal, temporal, and occipital lobes of the cerebrum; *cb*, *cb*, cerebellum, the medulla oblongata lying between its two lobes. *Cranial Nerves.*—1, olfactory lobe (the nerve of smell); 2, optic nerve (nerve of sight); 3, third or oculo-motor nerve (motor nerve to most of the muscles of the eye); 4, fourth or trochlear nerve (motor nerve to the superior oblique muscle of the eye); 5, fifth, trigeminus or trifacial, sensory and motor, the large root sensory to the face and eyes, etc.; the small root (motor) to muscles of mastication; 6, sixth or abducens nerve, to external rectus muscle of eye, turns eyeball outwards; 7, seventh or facial, motor to muscles of expression; 8, eighth or auditory nerve, sensory for hearing (cochlea) and for equilibration (semicircular canals); 9, glosso-pharyngeal, sensory nerve of taste, and motor to some of the muscles of deglutition; 10, pneumogastric, sensory and motor to larynx, lung, heart, and stomach; 11, spinal accessory, motor to muscles of heart (inhibitory) and sterno-mastoid and trapezius; 12, hypoglossal, motor to all the muscles of the tongue; c_1, first cervical spinal nerve.

gray matter of the exterior, producing an appearance like the branches of a tree; this may be easily seen on cutting open the cerebellum of a sheep, and was by the early anatomists called the tree of life. The cerebellum has no interior cavity, but below it and in front are two ventricles that communicate with the ventricles of the cerebrum.

The **medulla oblongata** connects both the cerebrum and the cerebellum with the spinal cord. From the posterior base of the cerebrum and from the cerebellum project large columns that appear like stems, and are called **cerebral peduncles.** Below is a thick transverse band or bridge, called **pons Varolii,** and above, between the cerebrum and cerebellum, are little eminences, called **optic thalami** or **quadrigeminal tubercles.** The union of the peduncles of the cerebrum and those of the cerebellum forms the **rachidian bulb.** The fibres of this bulb, six in number, four in front and two behind, are direct continuations of those of the spinal cord. The middle two in front, or **anterior pyramids,** as they are called, come from the cerebrum, and are crossed in such a manner that those which arise in the right hemisphere form the left pyramid, while those having origin in the left hemisphere constitute the right pyramid.

This crossing explains why paralysis that affects one hemisphere of the brain produces loss of sensibility or of movement on the opposite side.

The **cranial nerves,** so called because they come directly from the brain, inside of the skull, form the first twelve pairs of the forty-three pairs in the cerebro-spinal system. Their functions are very different, comprising the special senses, and the mobility and sensation of different parts of the face. One of them, the **pneumogastric,** passes down into the thorax and abdomen, and plays a very important part in respiration, digestion, and circulation.

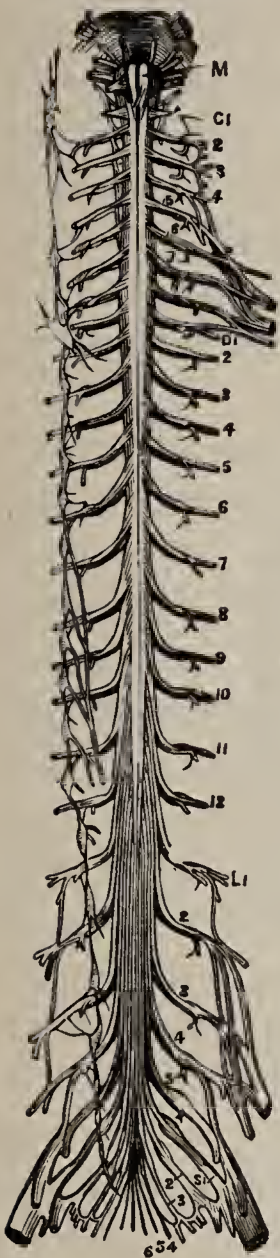
The **spinal cord** is a direct continuation of the medulla oblongata, and is contained in the hollow canal of the vertebral column, down which it passes as far as the loins. It is composed of gray matter interiorly and white matter exteriorly, a structure opposite to that of the brain. The different bundles of fibres of which it is made up are separated by regular grooves, and have enlargements at the points where the nerves distributed to the upper and lower limbs have their origin.

The matter of the cord is very delicate. A violent shock or a strong pressure upon it may occasion immediate paralysis or even death. Such a condition happens when the vertebræ, especially those of the neck, are dislocated, and their articular surfaces no longer exactly correspond.

The thirty-one pairs of **spinal nerves**—that is, nerves proceeding from the spinal cord—are classified as eight pairs of **cervical,** twelve **dorsal,** five **lumbar,** and six **sacral.** These nerves have exit from the spinal column through lateral openings, called **intervertebral openings.** They have double roots, anterior and posterior. The anterior roots are **motor** nerve-fibres, while the posterior are **sensory nerves.** These two roots soon unite to form little masses of nerve-cells, called ganglions, and from the nerve that starts from the ganglions proceed the branches which divide up into smaller and smaller nerves as they are distributed to the extreme surface of the body.

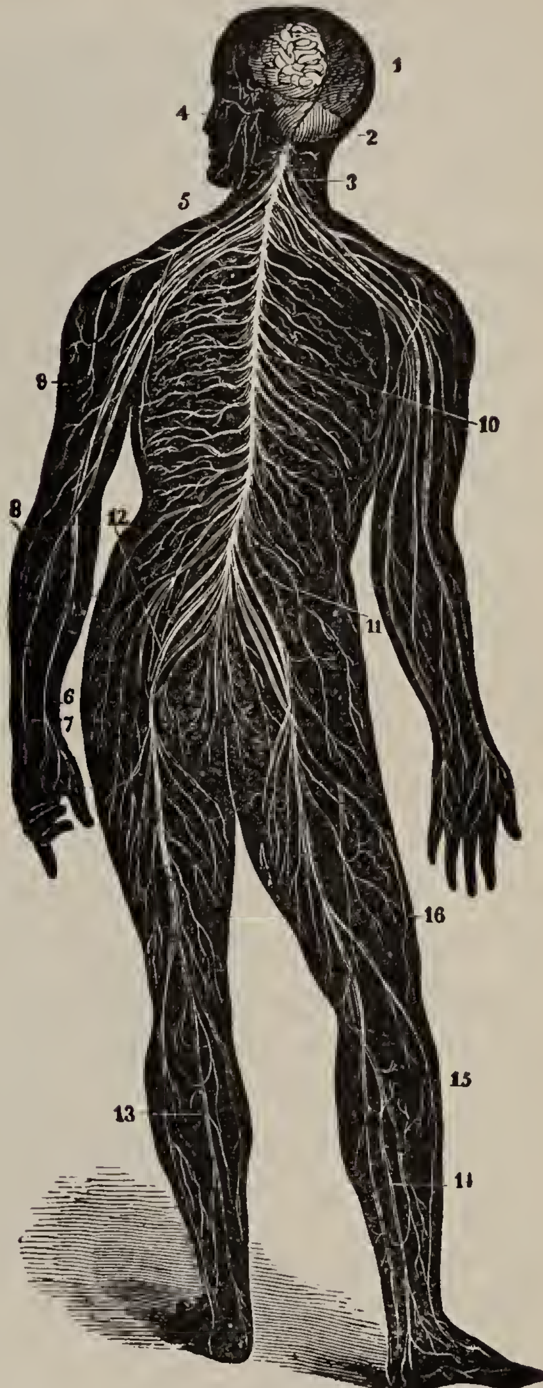
The interlacing of nerve-branches forms what is called a **plexus.** The first four pairs of cervical nerves form the **cervical plexus,** supplying the neck; the other four pairs

Fig. 26.



Cerebro-spinal system. —M, medulla oblongata; C 1 to 8, cervical nerves; D 1 to 12, dorsal nerves; L 1 to 5, lumbar nerves; S 1 to 6, sacral nerves.

Fig. 27.



A back view of the brain and spinal nerves.—1, cerebrum; 2, cerebellum; 3, spinal cord; 4, nerves of the face; 5, brachial plexus of nerves; 6, 7, 8, 9, nerves of the arm; 10, nerves that pass under the ribs; 11, lumbar plexus of nerves; 12, sacral plexus of nerves; 13, 14, 15, 16, nerves of the lower limbs.

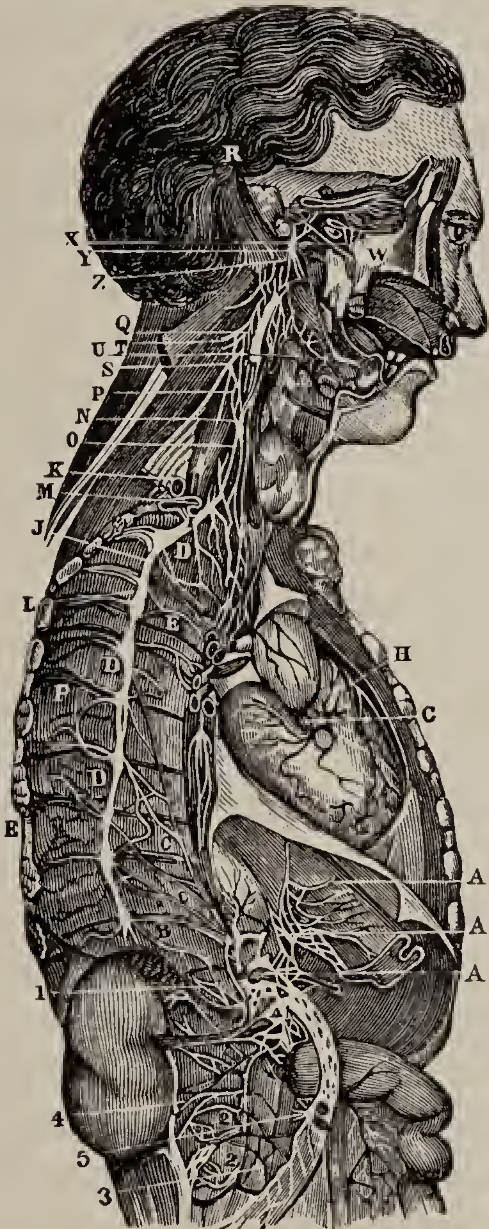
form the **brachial plexus,** whose branches are distributed to the arms. The dorsal nerves are distributed to the trunk, and are very simple in their directions, having no plexus. The lumbar nerves, on the contrary, all unite to form a large and deeply-placed plexus, called the **lumbar plexus.** Lastly, from the first pairs of sacral nerves is formed the **sacral plexus,** which terminates in a flattened trunk, the **great sciatic nerve,** and this is both the thickest and the longest nerve in the body. It supplies the lower limb, sending branches to all parts of the leg and foot.

The principal nerves are generally named after the parts in which they are situated. Thus, there is a **crural nerve,** a **brachial nerve,** a **cubital nerve,** etc. By following out in minute examination the nerves as they pass to the organs, it may be seen that the last filaments of motor nerves penetrate into the muscular tissue, while those of the nerves of general sensation terminate in the thickness of the skin.

Great Sympathetic System.—The great sympathetic system is composed of ganglions and nerves, the ganglions being nerve-centres. The ganglions in the neck and thorax are arranged in a regular manner in pairs along the spinal column. In the other parts of the system they are scattered, being found in the neighborhood of all the organs, or even in the organs themselves.

The nerves that make up this system form numerous plexi, the plexi appearing at frequent intervals and in the most complicated forms. Each organ has an important plexus: thus there is a **cardiac** plexus, a **mesenteric** plexus, a **renal** plexus, a **hypogastric** plexus. The last is situated, as its name indicates, in the upper part of the

Fig. 28.



Represents the sympathetic ganglia, and their connection with other nerves.—A, A, A, the semilunar ganglion and solar plexus, situated below the diaphragm and behind the stomach. This ganglion is situated in the region (pit of the stomach) where a blow gives severe suffering. D, D, D, the thoracic (chest) ganglia, ten or eleven in number; E, E, the external and internal branches of the thoracic ganglia; G, H, the right and left coronary plexus, situated upon the heart; I, N, Q, the inferior, middle, and superior cervical (neck) ganglia; 1, the renal plexus of nerves that surrounds the kidneys; 2, the lumbar (loin) ganglion; 3, their internal branches; 4, their external branches; 5, the aortic plexus of nerves that lies upon the aorta. The other letters and figures represent nerves that connect important organs and nerves with the sympathetic ganglia.

abdomen, and may be considered as the centre of the sympathetic system. It has even been called the abdominal brain.

Functions of the Nervous System.—The nervous system is the seat of sensation, of intellectual perception, and of voluntary and involuntary motion; at the same time it presides over the acts of nutrition and secretion, and regulates the whole economy.

It is easy to prove the universal influence of this system. Whenever nerve-action is arrested the function of the part is interrupted, and all manifestations of life are destroyed. If the nerve supplying the kidneys be cut, those organs immediately cease to produce their ordinary excretion; if the nerve distributed to any member be cut, the member at once loses all sensation, all possibility of motion. This is a law to which there is no exception.

Each of the different parts of the nervous system has its own particular work to do. Nutrition, sensation, and movement are not under the influence of the same nerve-centres.

Nutrition is, to a great extent, under the supervision of the great sympathetic, and for this reason the name nervous system of organic life has been sometimes applied to the sympathetic system. On the other hand, sensation and movement are under the control of the cerebro-spinal system. If, as is the case, ramifications of both systems are found distributed all over the body, it is because all our organs must live and be nourished, and to a certain extent all are endowed with sensation and movement.

To understand the operations of the nervous system, it must be remembered that the nerves have no other function than to establish communication between the nerve-centres and the peripheral organs, and that they are therefore conductors comparable to the telegraph-wires connecting the telegraphic stations. Those nerves which go from the organs of sense to the nerve-centres are called **sensory** nerves: they transmit to the nerve-centres the impressions they receive at the organs of sense. The nerves which go from the nerve-centres to the muscles are **motor** nerves: their action excites the muscles and therefore produces movements.

CHAPTER VI.

Organs of Sense.

Organs of sense is the name applied to the organs placed in intimate communication with the nervous system, and having for their purpose the establishment of our relations with the outside world,—that is, the objects around us. These objects are known to us only by the impressions they produce on our senses. An apple is something that presents to our fingers a certain contour and a certain hardness and feeling, to our eyes a certain form and color, to our taste and smell a peculiar taste and a characteristic odor. Four different kinds of impressions—touch, sight, taste, and smell—here combine to give us a definite idea of an object. Whenever we are as perfectly informed of any matter as in this case, there is little that can be risked of the correctness of our conclusions; but, if we were guided by the impressions of one sense alone, that of sight, for example, we would be easily deceived; the form and color of an apple ably painted on canvas could deceive our eyes and make us believe that the fruit was actually present. If all our means of perception—our organs of sense—were absent, the apple would disappear, and for us would cease to exist.

Fig. 29.

Vertical section of the skin of the forefinger across two of the ridges of the surface (highly magnified).—1, dermis, composed of an intermixture of bundles of fibrous tissue; 2, epidermis; 3, horny layer; 4, soft layer; 5, subcutaneous connective and adipose tissue; 6, tactile papillæ; 7, sweat-glands; 8, duct; 9, spiral passage from the latter through the epidermis; 10, termination of the passage on the summit of ridge.

In the physiological examination of the functions of sensation in man, we must consider five distinct apparatus, serving as the instruments of five distinctly characterized series. These are **touch, taste, smell, hearing,** and **sight.**

Touch.—The sense of touch notifies us of the contact of other bodies with our persons; it gives us many notions concerning the different physical properties and conditions of bodies, such as form, dimensions, consistence, elasticity, weight, temperature, etc. In man the sense of touch exists more or less developed over the entire surface of the skin.

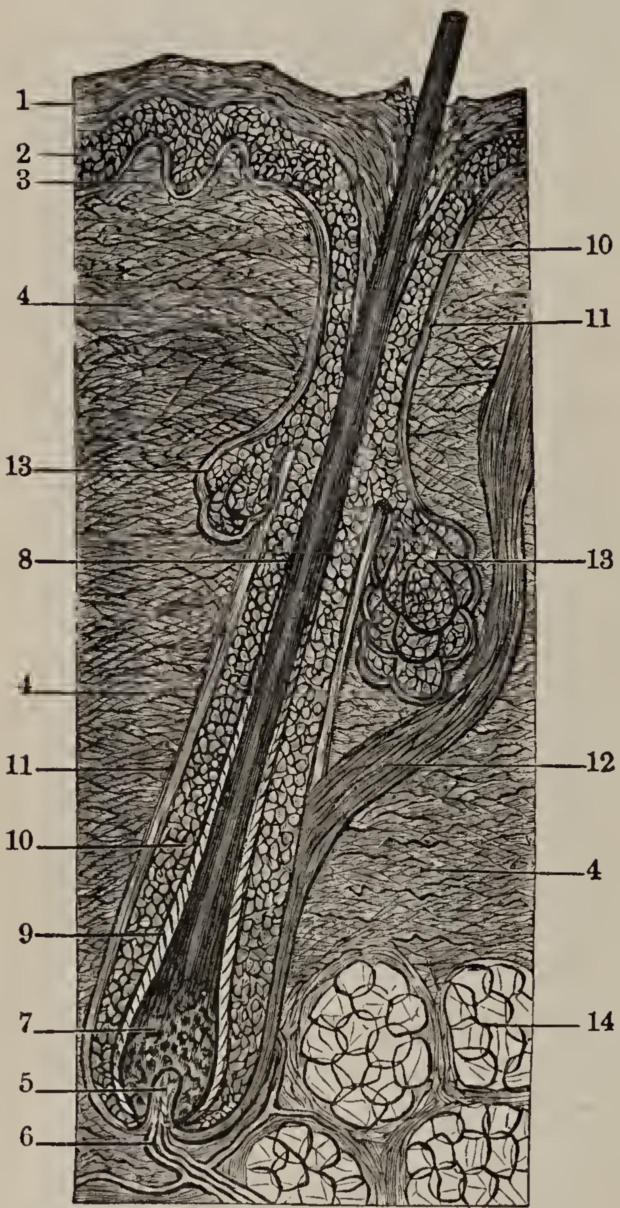
The **skin** is composed of two layers, the **epidermis** and the **derm.** The epidermis is the external layer; it is formed of superposed layers of epithelial cells, of which the deeper are prismatic and regular. As they are nearer the surface, these cells are more and more flattened, and, instead of being thick and soft, as in the interior, they are thin and horny. The most superficial are like little scales, and they gradually become detached and fall off, but are at the same time continually replaced by new layers of cells produced from the deeper ones. This desquamation of the epidermis takes place continually and imperceptibly in man, but in many animals it occurs at the same time over the whole surface, so that at certain intervals the body seems to emerge from a thin covering.

The coloring matter or pigment is in the deep layers of the epidermis. The pigment consists of a large number of microscopic granules of a brown color, which give to the skin a darker or lighter shade.

The **derm,** which is just under the epiderm, is composed of strong fibres, crossing and interlacing in every direction. Little conical eminences may be seen projecting from the surface of the derm, and in these **papillæ,** as they are called, are the terminations of the nerves of touch. The projections of the papillæ are the cause of the regularly-arranged series of elevations that are separated by little furrows on the surface of the skin. Their number is large in all parts, but becomes enormous in positions where the sense of touch is most acute.

The **sudoriferous glands** are contained in the **subcutaneous** cellular tissue; their excreting ducts pass through the derm and open obliquely on the surface of the epiderm in the furrows between the papillæ. The perspiration is an acid liquid, having a chemical composition that is complicated as well as very variable. The **sebaceous** glands are in the thickness of the derm; they are abundant in certain parts of the face, as on the forehead and on the sides of the nose. The oily matter they secrete lubricates the skin, preserving its softness and elasticity.

Fig. 30.

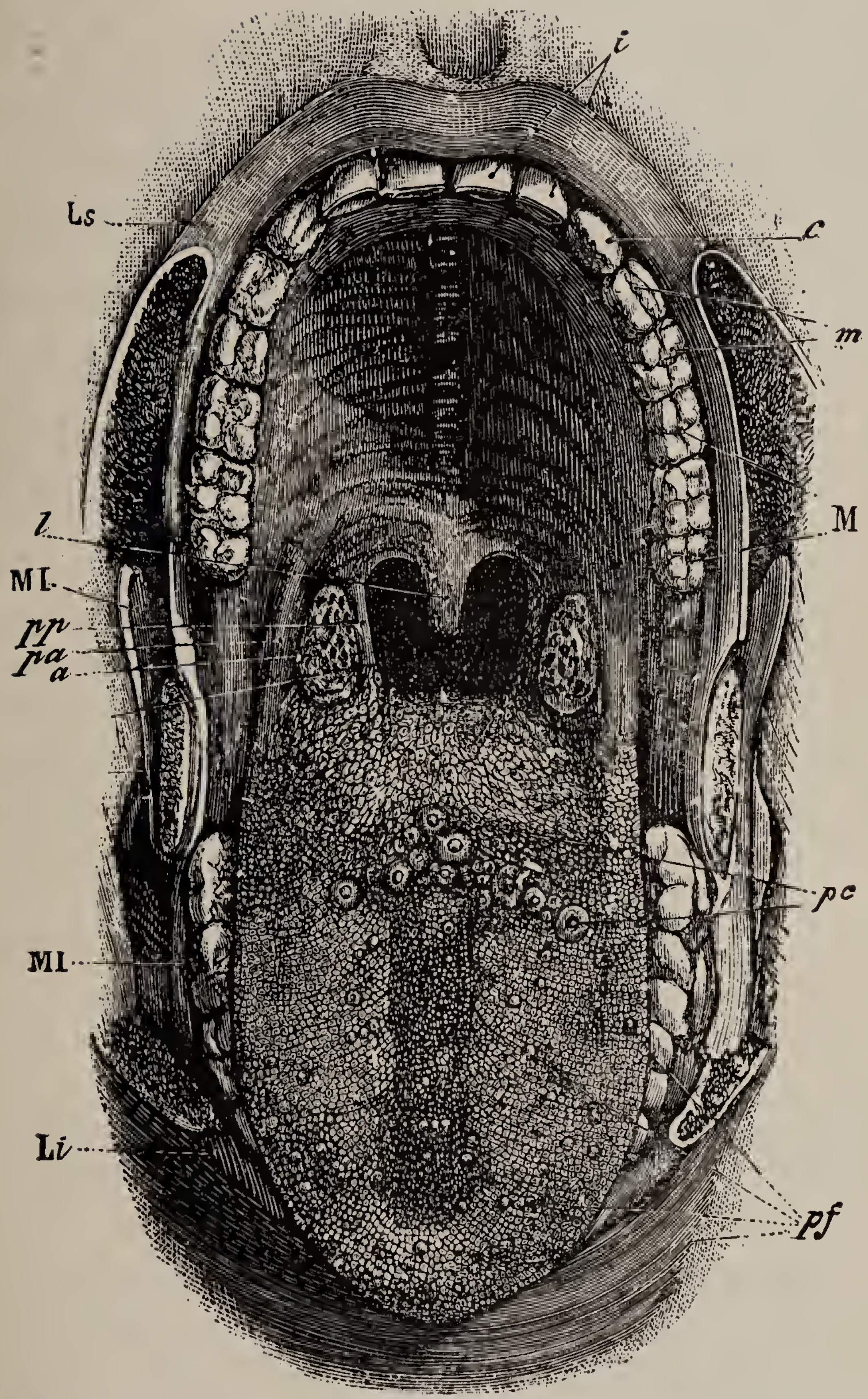


Section of the skin of the scalp, with a hair-follicle (highly magnified) (*Leidy*). —1, cuticle; 2, epidermal rete; 3, tactile papilla; 4, dermis; 5, hair papilla; 6, vessel; 7, hair-bulb; 8, hair; 9, inner root-sheath; 10, outer root-sheath; 11, wall of the hair-follicle; 12, erector muscle; 13, sebaceous follicles; 14, subcutaneous areolar tissue and fat.

The **hair** appears in its most advanced development on the skin covering the cranial bones, but, excepting on the palms of the hand and soles of the feet, a colorless down, having a velvety appearance, may be observed over the whole body. The nails are for the anatomist only agglomerated hairs, somewhat changed in form and color.

The hairs grow from small bulbs or swellings placed in minute cavities in the derm. They are fibrous tubes containing a semifluid matter, and in this is found the coloring principle,

Fig. 31.



The mouth, cut and stretched open to show the tongue and palate.—MI, lower jaw; L*i*, lower lip; L*s*, upper lip; *i*, upper incisors; *c*, canine; *m*, premolars; M, molars; *l*, uvula; *pp*, posterior pillars of the palate; *pa*, anterior pillars; *a*, tonsil; *pf*. fungiform papillæ; *pc*, calciform papillæ.

usually consisting of various sulphides and salts of iron.

Taste.—The sense of taste gives us notions of savors. Its principal organ is the tongue, whose upper surface is covered with papillæ that are similar to the papillæ of touch, and are called **gustatory papillæ.** They receive nerve-filaments coming principally from the glosso-pharyngeal nerve. These papillæ are shaped like mushrooms (fungiform), or like the calyces of flowers (calciform), and the latter form seems to be the kind particularly serving as organs of taste. The calciform papillæ may be seen regularly distributed on the posterior upper surface of the tongue, where their grouping forms a letter V, called the **lingual V.**

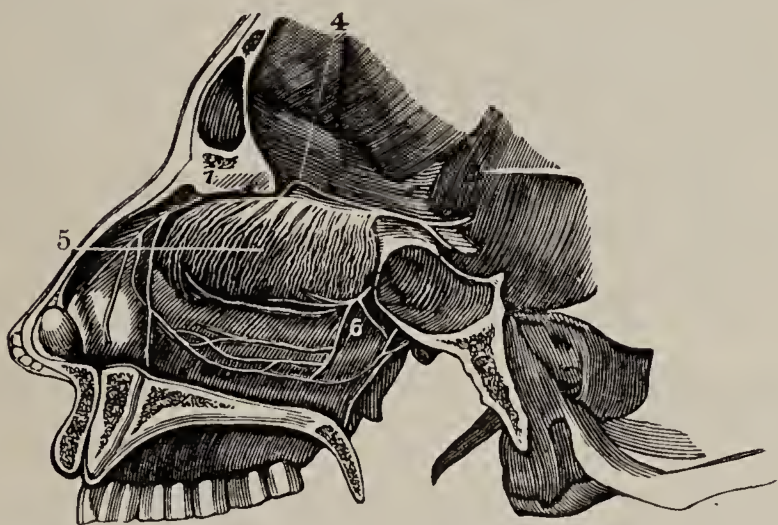
Not all substances are tastable: thus a piece of glass produces on the tongue only an impression of touch. In order that a substance may be tasted it must either be liquid or capable of being dissolved by the saliva. This fact explains why the taste becomes dulled when the mouth and tongue are dry. The causes of the difference in tastes are unknown. Frequently certain impressions are considered as tastes that depend much more directly on the sense of smell.

Smell.—The sense of smell, which gives us notions of odors, is located in the nasal fossæ.

The direct cause of odorous impressions is the contact with our olfactory organs of minute particles of the odorous substance in the form of gas or vapor. As the air we breathe passes continually over the parts in which the sense of smell resides, it is impossible that an odor should exist around us without our noticing it almost immediately.

The nasal fossæ form a double cavity above the roof of the mouth, and opening behind into the pharynx. (Fig. 32.) Their walls are bony, as well as the median septum between them, excepting towards the nares or nasal orifices, where they are cartilaginous and gifted with a certain amount of mobility. Interiorly the nasal fossæ are lined with a **pituitary membrane**; this membrane, which is a continuation of the mucous membrane of the mouth, follows all the sinuosities of the nose and penetrates into the cavities or sinuses of the frontal bone and of the superior maxillary bones. In it is spread out the olfactory nerve, whose ramifications collect the impressions left by odorous particles.

Fig. 32.



A SIDE-VIEW OF THE PASSAGE OF THE NOSTRILS AND THE DISTRIBUTION OF THE OLFACTORY NERVE.—4, the olfactory nerve; 5, the fine divisions of this nerve on the membrane of the nose; 6, a branch of the fifth pair of nerves.

The perception of odors takes place almost entirely in the upper part of the nasal fossæ. The nose proper seems to have only a mechanical function in the operation; it is a receiver, which takes in and arrests the passage of the particles of odorous substances. After accidents which have resulted in its loss, the nose may be replaced by an artificial nose without the olfactory organs losing their sensibility.

The nasal fossæ receive the lachrymal secretion by a duct coming from the internal angle of the orbit. This maintains that condition of humidity of the pituitary membrane necessary for its perception of odors.

Hearing.—The sense of hearing resides in the ear and enables us to perceive sounds.

The ear receives sounds as the nose receives odors, but there is this difference, that while odors are probably material particles emanating from odorous bodies, sounds represent only the result of vibrations of a sounding body. Sonorous vibrations are transmitted more or less perfectly according to the elasticity of the medium interposed between the vibrating body and the ear. They proceed from one place to another like the waves produced by a stone falling in water, and in this manner they penetrate the ear, where they are received by the nerve whose province is to transmit the impression to the brain.

Although the propagation of sound is quite rapid, it is far from being instantaneous. Those who observe the firing of a gun at a little distance notice the flash of light before hearing the sound. In the air, sound is transmitted with a velocity of about 1180 feet per second; in water, the velocity is four times as great, in iron ten times, and in pine wood eighteen times as great.

The ear is divided into three parts: the **external ear** includes the **concha,** or **auditory pavilion,** as it is variously called, and a canal hollowed out in the temporal bone, lined with skin, and called the **external auditory canal.** At the extreme interior of this canal is the

tympanum, a fibrous membrane stretched on a bony frame.

The middle ear, within the tympanum, is an irregularly-shaped cavity, containing a chain of four little bones, named from their forms the **hammer**, the **anvil,** the **lenticular bone,** and the **stirrup.** This chain is attached at one end, the hammer and anvil, to the tympanum, and by the other, the stirrup, to the oval window.

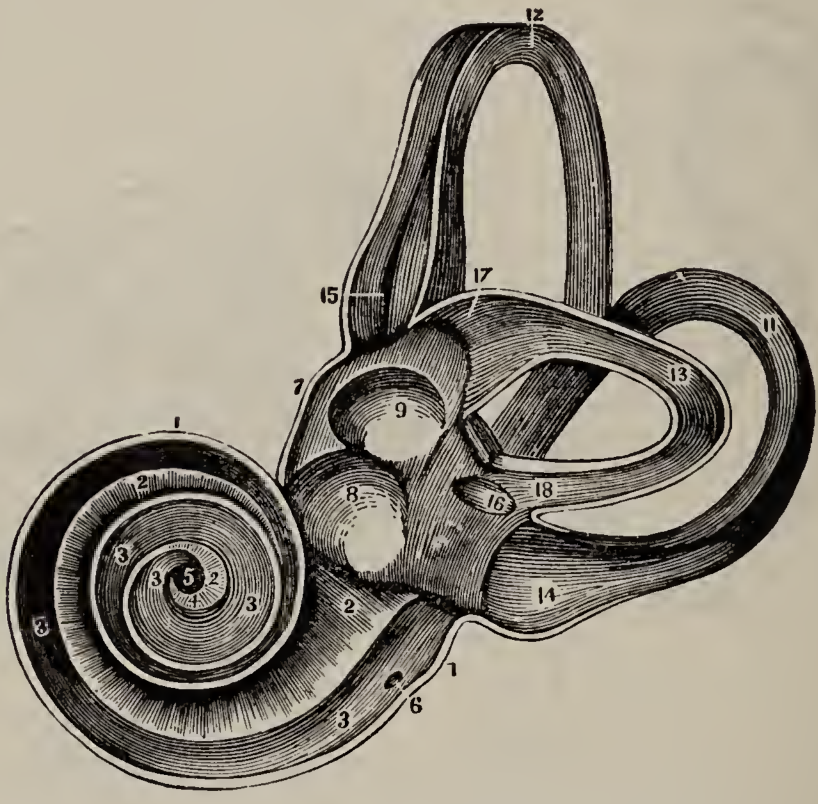
FIG. 33.

A VIEW OF ALL THE PARTS OF THE EAR.—1, Meatus or canal; 2, the membrana tympani; 3, 4, 5, the bones of the ear; 6, membrane of the foramen ovale; 7, the central part of the labyrinth (vestibule): 8, 9, 10, the semicircular canals; 11, 12, the channels of the cochlea; 13, auditory nerve; 14, the opening from the middle ear, or tympanum, to the throat (Eustachian tube).

The **oval window** and the **round window** are two openings, each closed by a membrane, which establish communication between the middle and the internal ears.

A curvilinear canal, called the **Eustachian tube,** extends from the middle ear to the pharynx, putting the middle ear in communication with the external air; in this manner the internal face of the tympanum is exposed to the same pressure as the external face to which the air penetrates through the external auditory canal.

FIG. 34.



A VIEW OF THE LABYRINTH LAID OPEN (highly magnified).—1, 1, cochlea; 2, 3, two canals that wind two and a half turns around a hollow axis (5); 7, vestibule; 8, fenestra rotunda; 9, fenestra ovalis; 11, 12, 13, 14, 15, 16, 17, 18, the semicircular canals.

The **internal ear,** or **labyrinth,** is made up of the **vestibule,** three **semicircular canals,** and a spiral tube, shaped like a snail-shell, and called the cochlea. These compartments communicate with one another, and are filled with a liquid in which terminate the delicate filaments of the **auditory nerve**; the latter enters the labyrinth through the **internal auditory meatus,** which, like the internal and middle ear, is situated in the hardest part of the temporal bone.

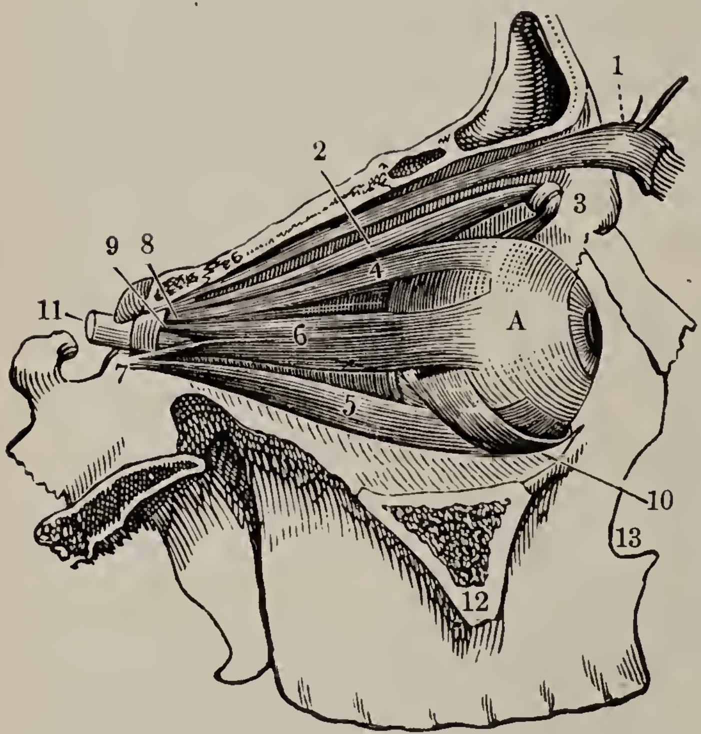
Vibrations of the air are collected by the concha and directed to the external auditory meatus, gaining in force by concentration. The tympanum takes up the vibrations and transmits them to the chain of bones, by which they are exactly reproduced on the oval window. Here they impress the liquid in the labyrinth, and, reaching the nerve filaments, produce perception. Such is the mechanism of audition, a mechanism so perfect that the human ear can distinguish the most delicate shades of sounds varying between thirty-two and seventy thousand vibrations per second.

Imperfect hearing usually depends on too great tension of the tympanum, or a want of elasticity of that membrane. In such cases hearing is improved by the use of ear-trumpets which concentrate the vibrations. Deafness caused by paralysis of the auditory nerve or similar accident is hopeless, but when due to obstruction of the Eustachian tube or of the external meatus, disappears under appropriate treatment.

Sight.—The sense of sight acquaints the brain with luminous impressions, and gives us notions of the color, form, and external condition of bodies. It is, of course, dependent on the eye.

Lodged in the upper and front portion of the face, surrounded by muscles that turn it at will in any direction, the eye observes from far, and gathers impressions of all that exists in the complete hemisphere embraced by its survey. It rests on a fatty cushion at the bottom of the bony cavity of the orbit, whose thick walls protect it effectually on the sides, while the eyebrows and lashes arrest dust that might enter in front. The tears with which its surface is continually moistened prevent the drying up of its membranes, and during sleep the eyelids cover it as with a sheath.

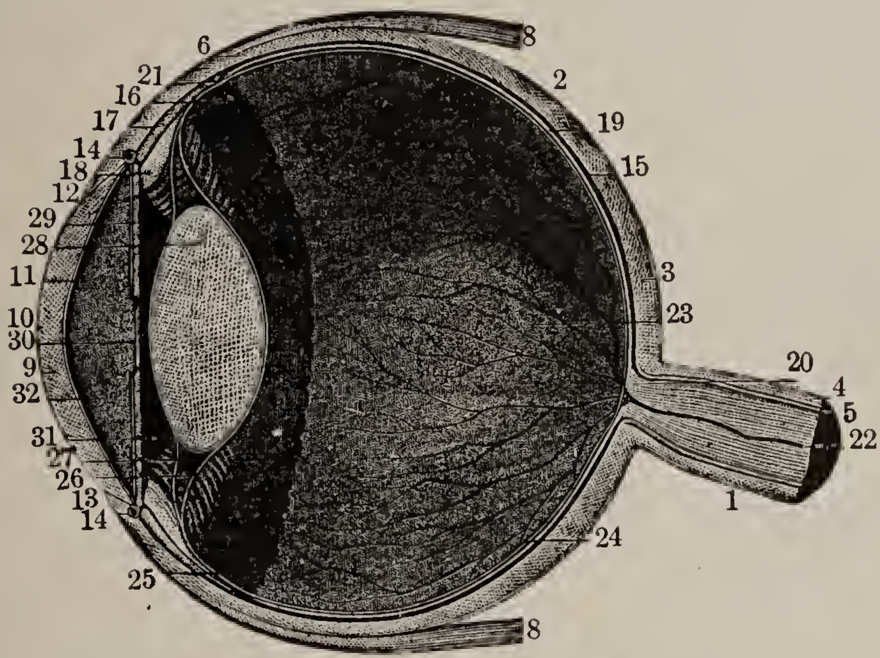
Fig. 35.



Muscles of the eye.—1, the palpebral elevator; 2, the trochlear muscle; 3, the pulley through which the tendon of insertion plays; 4, superior rectus muscle; 5, inferior rectus muscle; 6, external rectus muscle; 7, 8, its two points of origin; 9, interval through which pass the oculo-motor and abducent nerves; 10, inferior oblique muscle; 11, optic nerve; 12, cut surface of the malar process of the superior maxillary bone; 13, the nasal notch; A, the eyeball.

The **eyeball** is covered exteriorly with a hard, white, opaque membrane, called the **sclerotic coat,** in the centre of which is inserted a thick, perfectly transparent disk, much like the crystal of a watch. Within this membrane, which is named the **cornea,** is seen a variously-colored circle, called the **iris,** in whose centre is a round opening, the **pupil.** The pupil is the window by which the light enters; it enlarges or contracts by the play of the muscular fibres composing the iris, thus allowing the entrance of a larger or smaller amount of light, as may be required for vision. A transparent liquid, called **aqueous humor,** fills the space in front of the iris, and behind it to the **crystalline lens,** a sort of kernel composed of a gelatinous, transparent substance. Then comes the **vitreous humor,** transparent but much firmer than the aqueous humor, and behind it, in the form of a delicate film, the **retina** which is the termination of the optic nerve. The retina is at the

FIG. 36.



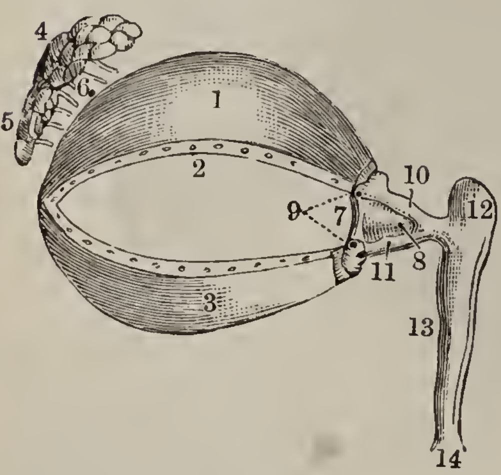
VERTICAL SECTION ANTERO-POSTERIORLY OF THE EYEBALL.—1, optic nerve; 2, sclerotic; 3, its posterior thicker portion; 4, sheath of the optic nerve continuous with the sclerotic; 5, the nerve within the sheath; 6, insertion of the recti muscles into the sclerotic; 8, 8, superior and inferior recti muscles; 9, cornea; 10, its conjunctival surface; 11, aqueous humor; 12, 13, bevelled edge of the cornea fitting into the sclerotic; 14, circular sinus of the iris; 15, choroid; 16, the anterior portion, constituting the ciliary body; 17, the ciliary muscle; 18, the ciliary processes; 19, retina; 20, its origin; 21, the ora; 22, central retinal artery; 23, vitreous humor; 24, 25, 26, hyaloid tunic; 27, suspensory ligament of the crystalline lens, 28; 29, iris; 30, pupil; 31, posterior chamber, and 32, anterior chamber, occupied by the aqueous humor.

back of the eye, resting on a deep black membrane called the **choroid,** which absorbs the indirect rays of light, and prevents them from disturbing by reflection the sharpness of the luminous image on the retina. The iris and the frame holding the crystalline lens, and called the **ciliary process,** are really folds of the choroid.

The **eyelids** are formed by folds of the skin, and their movements are controlled by several muscles. They are sustained by a thin cartilage, the **tarsal cartilage,** and their borders are fringed by the **lashes.** Little glands contained within the upper eyelid secrete a viscous liquid that aids the lashes in arresting dust.

The lachrymal apparatus which supplies the tears is composed: 1st, of the **lachrymal gland,** situated in the superior and external portion of the orbit, and distributing by six or seven ducts its secretion over the internal surface of the upper eyelid; 2d, of the **nasal duct,** placed in the inferior and internal angle of the orbit, and carrying the excess of secretion to the interior of the nasal fossæ. As an optical apparatus the eye functions like the photographer's camera. Photographers place a sensitive plate—that is, one that is capable of being acted on by light—at the back of a box blackened inside, and called a camera. At the front of the box is an aperture into which is fitted a tube, called the objective, hold-

FIG. 37.



THE APPENDAGES OF THE EYE.—1, the cartilage of the upper eyelid; 2, its lower border, showing the openings of the Meibomian glands; 3, the cartilage of the lower eyelid, also showing on its border the openings of the Meibomian glands; 4, 5, the lachrymal gland; 6, its ducts; 7, the plica semilunaris; 8, the caruncula lachrymalis; 9, the puncta lachrymalia, opening into the lachrymal canals; 10, 11, the superior and inferior lachrymal canals; 12, the lachrymal sac; 13, the nasal duct, terminating at 14 in the lower meatus of the nose.

ing one or more glass lenses, which project on the sensitive plate the luminous rays coming from the object to be photographed.

The eye, lined with the choroid, is comparable to the camera. The crystalline lens is the objective, for it is a convex lens, and the nervous membrane, the retina, is the sensitive plate on which the images of objects before the eyes are reproduced.

In normal vision the form of the crystalline lens is such that the luminous rays passing through it make their sharpest image on the retina. Short-sightedness is due to too great a convexity of the different lenses that the light traverses before reaching the retina; the image is then produced in front of the retina, and objects are not distinctly perceived unless they are placed near the eye. Far-sightedness depends, on the contrary, on too great flatness of the lenses of the eye: the image would be more distinct behind the retina, and objects can be seen most distinctly when at some distance. Under ordinary conditions the distance at which small objects are most distinctly seen without straining the eyes is ten inches. This distance may fall to less than eight inches in near-sightedness, or may be as great as thirty inches in far-sightedness. **Myopia** or near-sightedness may diminish as age increases, but **presbyopia** or far-sightedness always increases. These two infirmities are corrected by the use of glasses, either concave or convex, as the fault of the crystalline lens is too great or too little convexity.

CHAPTER VII.

Functions of Locomotion—Organs of Speech.

We must now consider the skeleton as the solid framework of the body, serving for the attachment of the muscles, and furnishing points of resistance for their contractions.

The skeleton is a system of **bones.** Bones are composed of a gelatinous matter, hardened by the deposit of a calcareous mineral matter in its substance. In an adult the gelatinous matter represents only a third of the total weight of the bones, the remaining two-thirds consisting of mineral matter; but early in life the mineral matter is present only in small proportion. Then many parts of the bones have but a cartilaginous structure; an example is seen in the **fontanels** in the skull of a very young child, and, on account of the close proximity of the brain, shocks to the head are then very dangerous. The gradual hardening of the bones by calcareous matter is called **ossification,** and ossification is only completed towards the time of the complete development of the individual,—that is, towards adult life. The bony substance does not present throughout its mass the same characteristics. In some parts it is hard, compact, and strong, resembling ivory; in others it is spongy, being perforated with holes throughout. Ordinarily the exterior portions of the bones are made up of compact tissue, while the interior portions and extremities are composed of spongy tissue.

The bones have been classified as of three kinds, according to their forms and structures: **long** bones, **flat** bones, and **short** bones.

As their name indicates, the **long bones** are elongated. At each end they have an enlargement,—**head** or **epiphysis,**—the interior of which is composed of spongy tissue. Between these is the **shaft** of the bone or **diaphysis,** made up exclusively of compact tissue, and having a central canal, the **medullary canal,** in which is the **marrow**. The structure of the long bones combines all the conditions of lightness and strength, for these bones act as levers for the great movements. The bones of the upper arm and forearm, and those of the thigh and leg, belong to this class.

The **flat bones** have considerable surface; they contain practically no spongy tissue, and this accounts for their great strength. They occur particularly in those parts of the body where the bony system is required to protect other organs: they form the envelope of the skull, the pelvis, etc.

The **short bones** are composed of spongy tissue in the interior, covered by a thin layer of compact tissue. They are not large, having about the same dimensions in all directions, and several of them are usually arranged together in places where only small movement is required, as in the wrist and the instep of the foot; the vertebral column is composed entirely of bones of this class.

On the surfaces of the bones are found ridges or **crests** for the insertion of the muscles, **apophyses** or **condyles** for reciprocal articulation, and numerous holes that serve for the passage of nerves and nourishing vessels. Their tissue has great vitality, a proof of which is shown by the rapidity with which the broken ends are mended in case of fracture, by the formation of new tissue called **callus.**

The name **articulation** is given to the joining or fitting together of the bones. All the bones of the human body, with a single exception, the **hyoid bone,** are joined or articulated together in the solid framework, called the skeleton. The manner of articulation varies according to the kind of movement that must take place.

FIG. 38.

STRUCTURE OF A LONG BONE.—*a*, head or epiphysis, filled with spongy tissue; *b*, body or diaphysis.

FIG. 38*a*.

VERTICAL SECTION OF THE KNEE-JOINT.—5, tibia; 1, femur; 3, patella; 2, 4, tendon, enclosing the articulation in front and enclosing the patella; *e*, ligament of the articulation; *s*, synovial membrane forming the articular capsule.

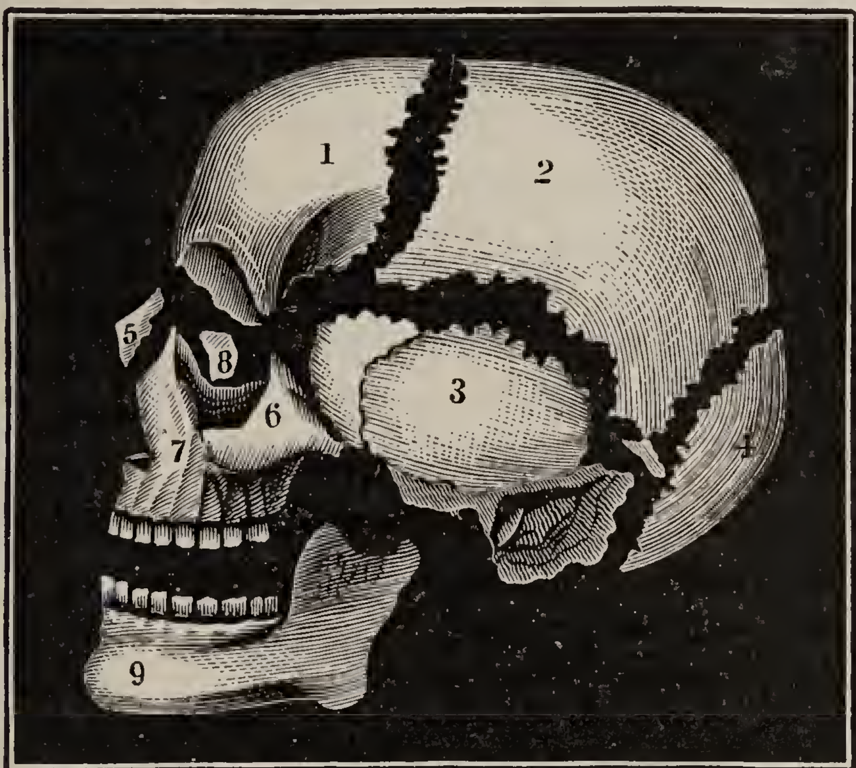
There are three principal kinds: **fixed articulation, mixed articulation**, and **mobile articulation.**

In the fixed articulation the bones are so joined as to be incapable of any movement one on the other; they sometimes are joined by smooth edges, sometimes by notches that dovetail together. Such are the articulations of the cranial bones.

In mixed articulation the bones do not touch, but are joined by an intermediate fibrous and elastic tissue, which allows a certain amount of motion. The short bones are articulated together in this manner.

In the mobile articulation the extremities of the bones that come together are free; they touch by surfaces reciprocally concave and convex, each being covered by a

FIG. 39.



BONES OF THE HEAD.—1, frontal bone; 2, parietal bone; 3, temporal bone; 4, occipital bone; 5, nasal bone; 6, malar bone; 7, upper jaw; 8, os unguis; 9, lower jaw (maxilla).

cartilaginous pad. This pad facilitates the gliding of the surfaces one on the other, and the friction is still further diminished by a viscous liquid, called **synovial fluid,** secreted by **synovial capsules**, membranes that surround all mobile articulations. Strong fibrous cords, called ligaments, are attached to the extremities of both articulating bones, and hold the ends in position. Motion is very easy in articulations of this class, which is the general method for the long bones.

The Skeleton.—We must limit ourselves to a very brief description of the different regions of the skeleton; these are three in number, the **head,** the **trunk,** and the **limbs.**

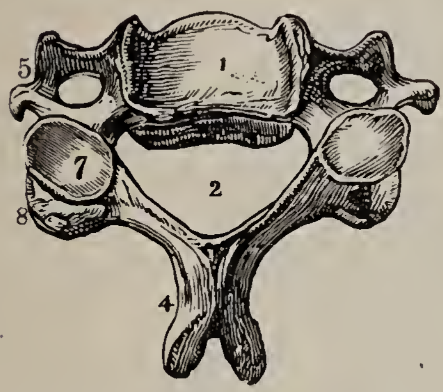
The bones of the head are classified as those of the **skull** and those of the **face.** Those of the skull form a box in which the brain is enclosed. They are eight: the **frontal bone** of the forehead, the **occipital** behind, the **parietal bones** forming the top of the head, the **temporals** at the sides or temples, the **sphenoid** below, and the **ethmoid** in front, and dovetailed into the frontal. There are fourteen bones in the face; several—among which are the **palatine** and **turbinated** bones of the nose, the **lachrymals** and the **vomer**—are not shown in the accompanying figure, either because they are situated in the interior, or because they are too small; but there are shown the **inferior maxillary** bone, which forms the lower jaw, the two **superior maxillary** bones which make up the upper jaw, the two **malars** or cheek bones, and the **nasal** bones that form the sides of the nose.

Among the bones of the head must be mentioned the **hyoid bone,** a small isolated bone that supports the tongue, and gives rigidity to the upper part of the respiratory apparatus.

The bones of the trunk include the **vertebral column,** the **ribs,** the **sternum,** and the **pelvis.**

The middle part of the vertebral column with the ribs and sternum constitute the **thorax,** a sort of bony cage that encloses the principal organs of circulation and respiration. The lower portion of the vertebral column, with the **iliac bones,** which project at the hips, forms a strong bony belt for the support and protection of the digestive organs. The **vertebral column** is composed of a series of small bones called **vertebræ.** The vertebræ are

FIG. 40.



A VERTEBRA OF THE NECK.—1, body; 2, foramen; 4, spinous process, cleft at its extremity; 5, transverse process; 7, inferior articulating process; 8, superior articulating process.

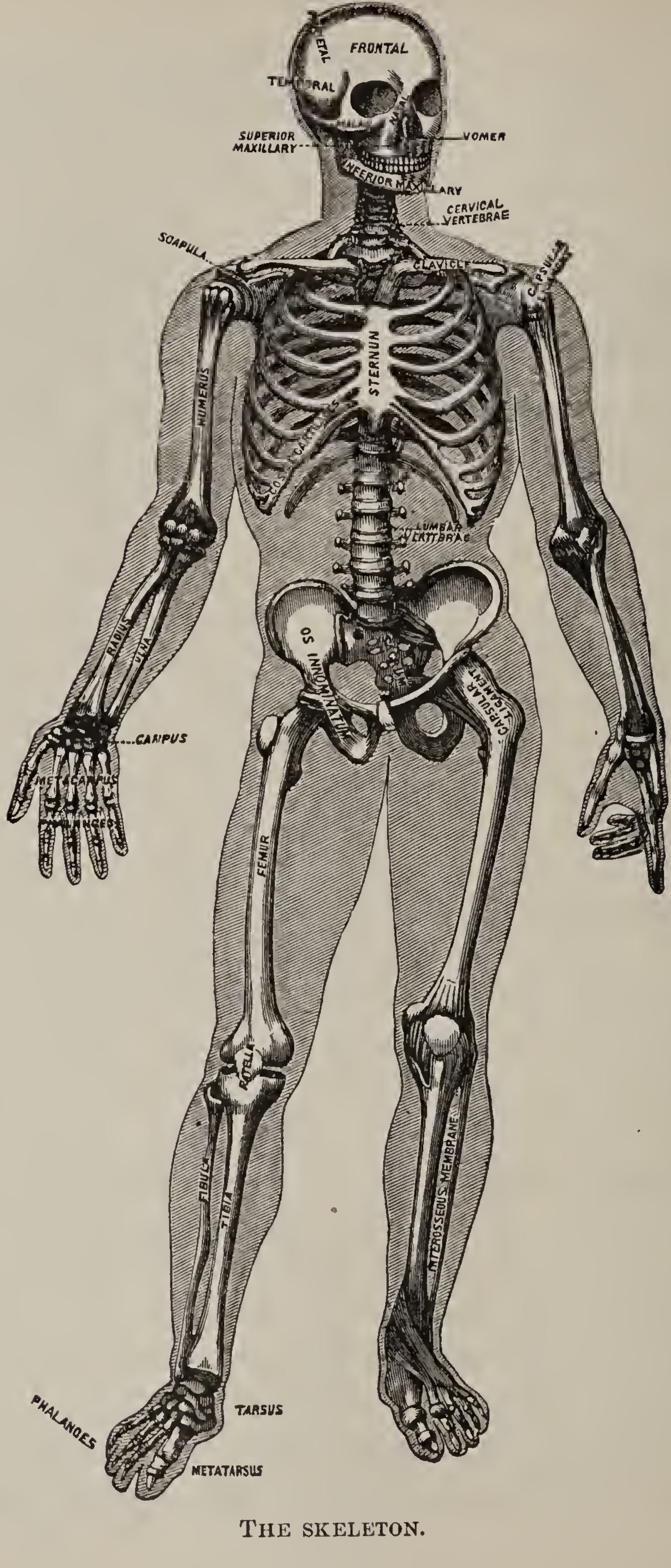
FIG. 40*a*.

A LUMBAR VERTEBRA.—1, the cartilaginous substance that connects the bodies of the vertebræ; 2, body; 3, spinous process; 4, 4, transverse processes; 5, 5, articulating processes; 7, foramen.

placed one on another, and are separated by cushions of fibro-cartilaginous tissue that allows a certain degree of movement to the articulation. Figures 40 and 40*a* represent two of these small bones. The vertebral column is divided into five regions. In man there are seven vertebræ in the neck, twelve in the back, five in the loins, five others firmly articulated in a single piece in the sacrum, and two or three that are quite rudimentary in the coccyx. In animals, these last are ordinarily much more numerous, much more developed, and form the framework of the tail.

In man there are twenty-four **ribs,** twelve on each side of the chest. They are articulated with the vertebræ behind and with the sternum in front, but they are connected with the latter only by cartilaginous prolonga-

Fig. 41.



THE SKELETON.

TABLE OF THE BONES.

HEAD (22)	*Skull* (8)	Frontal (forehead).
		2 Temporal (temples).
		2 Parietal (side).
		Occipital (posterior base).
		Sphenoid (base).
		Ethmoid (base of nose).
	Face (14)	2 Superior maxillæ (upper jaw).
		2 Nasal (bridge of nose).
		2 Malar (cheek).
		2 Lachrymal (corner of orbit).
		2 Turbinated (within nostrils).
		2 Palate (posterior hard palate).
		Vomer (nasal partition).
		Inferior maxilla (lower jaw).
CERVICAL REGION (8)		7 Cervical vertebræ (neck).
		Hyoid bone (base of tongue).
THORAX (37)		14 True, 6 False, 4 Floating ribs.
		12 Dorsal vertebræ (back).
		Sternum.
UPPER EXTREMITIES (64)	*Shoulder*	Clavicle (collar).
		Scapula (shoulder-blade).
	Arm	Humerus (arm).
		Radius, Ulna (forearm).
	Hand	8 Carpal (wrist).
		5 Metacarpal (hand).
		14 Phalanges (fingers).
LUMBAR REGION (5)		5 Lumbar vertebræ (loins).
PELVIS (4)		2 Innominata.
		Sacrum.
		Coccyx.
LOWER EXTREMITIES (60)	*Thigh*	Femur.
	Leg	Patella (knee-pan).
		Tibia (large bone).
		Fibula (outer bone).
	Foot	7 Tarsal (instep, heel).
		5 Metatarsal (arch).
		14 Phalanges (toes).

tions, and so possess a very considerable freedom of motion.

The **sternum** is a flat bone, shaped like a dagger, in the front of the thorax and in the median line. It is connected with the ribs, and also with the collar-bones or **clavicles,** to which it affords a central support.

The **iliac** bones are large flat bones; they are articulated together in front, and with the sacrum behind, and they form the floor of the trunk.

The upper and lower limbs are very analogous in the number and arrangement of the bony pieces that compose them. The hand corresponds exactly to the foot, the forearm to the leg, the arm to the thigh, the shoulder to the pelvis, which latter may be considered anatomically as forming part of the lower limbs. While there are certain differences in form and in the apparent number of corresponding bones in the upper and lower limbs, these differences are due to the difference in function.

The upper limb includes the **shoulder,** the **arm,** the **forearm,** and the **hand.**

The bones of the shoulder are a large flat bone fitting close to the back, and called the **scapula** or shoulder-blade, and the **clavicle,** or collar-bone, forming a sort of bow in front, and articulated with the sternum and the scapula. This bone is frequently broken by falls, but its fracture is repaired with great facility.

The arm contains but one bone, the **humerus.** This is articulated with the scapula in such a manner that it possesses a freedom of motion so great as to allow it to make a complete rotation on its axis.

The forearm is composed of two bones,—the **radius,** towards the outside, and the **ulna,** on the inside. The latter is the only one which is articulated with the humerus; its upper end forms the projection of the elbow. The other bone, the radius, is articulated with the ulna above, and by its lower extremity supports the hand; it turns freely around the ulna. This simple but ingenious mechanism allows us to make easily the various movements and changes of position of the hand.

The **hand** includes the wrist or **carpal bones,** eight in number, and all belonging to the class of short bones, the five **metacarpal bones** that form the framework of the palm of the hand, and the **phalanges,** of which there are three in each finger, except the thumb, which has only two.

The lower limb, correctly speaking, is composed of the **thigh,** the **leg,** and the **foot.**

The **femur,** or thigh-bone, is articulated with the iliac bone above, and with the tibia below. It is the largest bone of the skeleton. Its somewhat arched form contributes to increase the supporting base of the body, and renders the erect position easier.

The leg has two bones,—the **tibia,** inside, and the **fibula,** outside; the latter takes but a secondary part. The articulation of the tibia and femur is protected by the **patella** or knee-pan, a small, flat bone, in which anatomists find the analogue of the eminence of the ulna, which forms the elbow.

The foot includes the **tarsal bones,** of which there are but seven (two of them are joined together in a single bone that forms the heel-bone or **calcaneum**), five **metatarsal** bones like the **metacarpals,** and the phalanges of the toes corresponding in number and distribution to those of the fingers.

Locomotion.—The study of locomotion is that of the changes of position of the body in space. These changes are produced according to the general laws of mechanics; they result from the action of certain forces on various systems of cords and levers. In animal mechanics the bones represent levers, the muscles are cords, and the

FIG. 42.

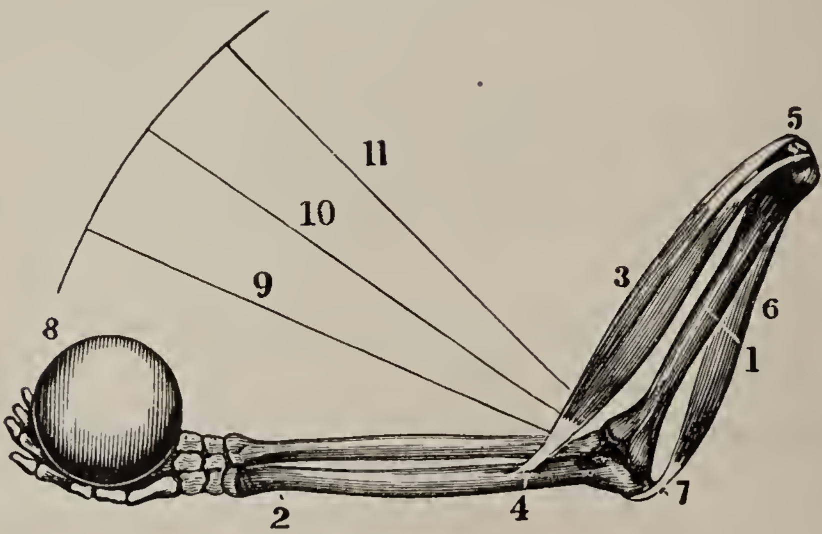


DIAGRAM OF THE THIRD ORDER OF LEVER.—1, the bone of the arm above the elbow; 2, one of the bones below the elbow; 3, the muscle that bends the elbow; this muscle is united, by a tendon, to the bone below the elbow (4); at the other extremity, to the bone above the elbow (5); 6, the muscle that extends the elbow; 7, its attachment to the point of the elbow; 8, a weight in the hand to be raised. The central part of the muscle 3 contracts, and its two ends are brought nearer together. The bones below the elbow are brought to the lines shown by 9, 10, 11. The weight is raised in the direction of the curved line. When the muscle 6 contracts, the muscle 3 relaxes, and the forearm is extended.

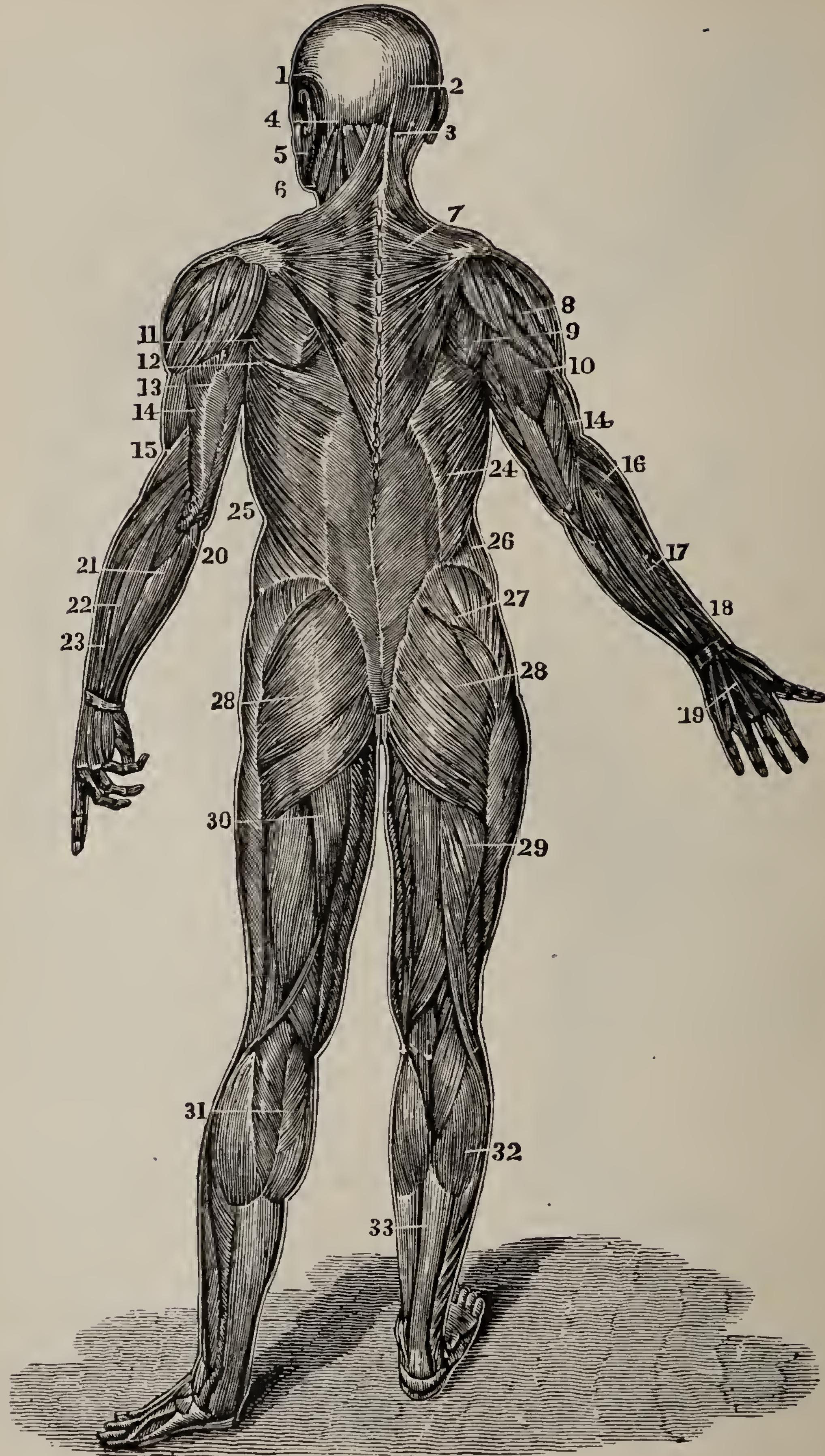
nervous system by its motor fibres acts as the cause of the movements.

The **muscles** are composed for the most part of a special tissue having contractile power, called **muscular tissue,** and their contractile activity is excited by impulses from the nervous system. Movements result from the change of position of the long levers to which

Fig. 43.

OCCIPITO FRONTALIS
ORBICULARIS PALPEBRARUM
TEMPORAL
ORBICULARIS ORIS
MASSETER
STERNO-CLEIDO-MASTOI
FLEXOR CARPI RADIALIS
FLEXOR DIGITORUM
BICEPS
TRICEPS
STERNUM
PECTORALIS MAJOR
DELTOID
RECTUS ABDOMINIS
OBLIQUUS EXTERNUS
SERRATUS MAGNUS
EXTENSOR DIGITORUM
EXTENSOR CARPI RADIALIS
ANNULAR LIGAMENT
GLUTEI MUSCLES
RECTUS FEMORIS
SARTORIUS
ADDUCTOR MUSCLES
RECTUS FEMORIS
VASTUS EXTERNUS
BICEPS FEMORIS
GASTROCNEMIUS
TENDO ACHILLIS
EXTENSOR DIGITORUM
PERONEUS LONGUS
ANNULAR LIGAMENT

Fig. 44.


1
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33

TABLE OF THE PRINCIPAL SKELETAL MUSCLES.

(See Figs. 43 and 44.)

THE HEAD.

Occipito-frontalis, moves the scalp.
Orbicularis palpebrarum, closes the eye.
Orbicularis oris, closes the lips.
Masseter,
Temporal, } elevate the lower jaw.
Digastric, depresses the lower jaw.

THE NECK.

Sterno-cleido-mastoid, moves the head forward or to one side.
Trapezius (7), moves the head and neck backward.

THE TRUNK (anterior).

Diaphragm, muscle of respiration.
Pectoralis major, moves the humerus and scapula.
Serratus magnus, aids in violent respiration.
Intercostals, muscles of respiration.
Rectus abdominis,
Psoas magnus, } bend the body forward.
Obliquus externus (26),
Obliquus internus, } assists in violent expiration. bends the body forward.

THE TRUNK (posterior).

Rhomboideus major,
Rhomboideus minor, } move the scapula backward.
Latissimus dorsi (24), moves the humerus downward and backward.
Serratus posticus inferior, muscle of expiration.

THE UPPER EXTREMITY.

Deltoid (8), elevates the arm.
Subscapularis,
Supraspinatus,
Infraspinatus (12), } rotate the humerus.
Brachialis anticus,
Biceps, } flex the forearm.
Triceps (10),
Anconeus, } extend the forearm.
Flexor carpi ulnaris and *radialis*, move the carpus.
Flexor digitorum, flexes the fingers.
Extensor carpi radialis and *ulnaris* (21), antagonize the flexors.
Extensor digitorum (22), antagonizes the flexors.

(Upward of thirty muscles act on the fingers.)

f

The Lower Extremity.

Glutæus maximus (28), *Glutæus medius*, *Glutæus minimus*,	keep the body erect, rotate the thigh, move the thigh backward.
Psoas magnus, *Pectineus*, *Iliacus*, *Adductor longus*,	raise the thigh. When the limbs are flexed, bend the body forward.
Rectus femoris, *Cruræus*, *Vastus externus* and *internus*,	extend the leg. Their common tendons (*quadriceps femoris*) contain the patella.
Sartorius (tailor's muscle),	flexes the leg on the thigh.
Biceps femoris, *Semi-tendinosus* (30), *Semi-membranosus*,	flex the leg.
Gracilis, *Abductors*,	move the thigh inward.
Tibialis anticus, *Proprius pollicis*,	flex the foot.
Gastrocnemius (32), *Soleus*,	acting through the *tendo Achillis*, extend the foot.
Extensor digitorum, *Flexor digitorum*,	move the toes.

Upward of twenty muscles act on the toes.)

the extremities of the muscles are attached, and which are drawn together or separated by the contractions.

The movements of extension, as well as those of flexure of the members, are produced by muscular contraction, the difference depending on the position of the points of insertion of the muscles; in the hand, for example, the extensor muscles are attached to the dorsal or back surfaces of the phalanges, while the flexor muscles are attached to the interior surfaces. The contractions of the extensors compel the fingers to straighten out, while those of the flexors bend them in against the palms. Those muscles are called **antagonistic** of which the actions are thus opposed the ones to the others, and those whose actions combine to produce a common movement are said to be **congenerate.**

Muscular tissue is composed of parallel fibres arranged in bundles. The fibres are of microscopic dimensions, and the separate bundles are all enveloped by a fibrous covering, called **aponeurosis**; an envelope of the same nature surrounds the whole muscle and isolates it from the surrounding parts.

Ordinarily the muscles have elongated forms, like spindles; the middle portion, composed of muscular tissue, strictly speaking, is red and fleshy, and constitutes the meat of edible animals. The two extremities of the muscle are formed of a very strong, white, pearly substance, and this is a direct continuation of the **periosteum** or fibrous envelope covering the bones. The end of the muscle connected with the bone which the muscle moves is usually elongated like a cord, is called the **tendon,** and is the **origin** of the muscle; that end which is attached to the fixed bone is usually wide and flattened, and forms what is called the **aponeurosis of insertion.**

The life of the muscles is very active, and they therefore receive many blood-vessels. They are also provided with many nervous filaments, but most of these are from the motor system, and the sensibility is not highly developed.

We cannot enter into details concerning the muscles. These organs, which number more than four hundred, are symmetrically arranged, and usually by pairs. They form several superposed layers. Figures 43 and 44 show the superficial muscles of the trunk,—that is, those which in this region are placed immediately under the skin.

So far as their primary action is concerned, the muscles are divided into two classes:

1. Those whose action is controlled by the will, such

as those of the limbs, of the face, etc. These are **voluntary muscles.**

2. Those whose action cannot be controlled by the will, such as those of the heart, of the muscular coats of the intestines and stomach, etc. These are **involuntary muscles.**

The differences in individual vigor are essentially dependent on the greater or less development of the muscular system. This development may be natural, but it is frequently the result of suitable exercise and appropriate diet and habit of life. So physicians prescribe for young persons of deficient development different exercises for the body, such as fencing, boxing, swimming, etc. The ancients formed their athletes in the same manner, and even our horses are not permitted to compete at the races without previous **training.**

The contraction of a set of muscles cannot be prolonged beyond a certain time, always quite limited. A continuation of the state of contraction brings about fatigue, and the necessity for a cessation of the muscular tension.

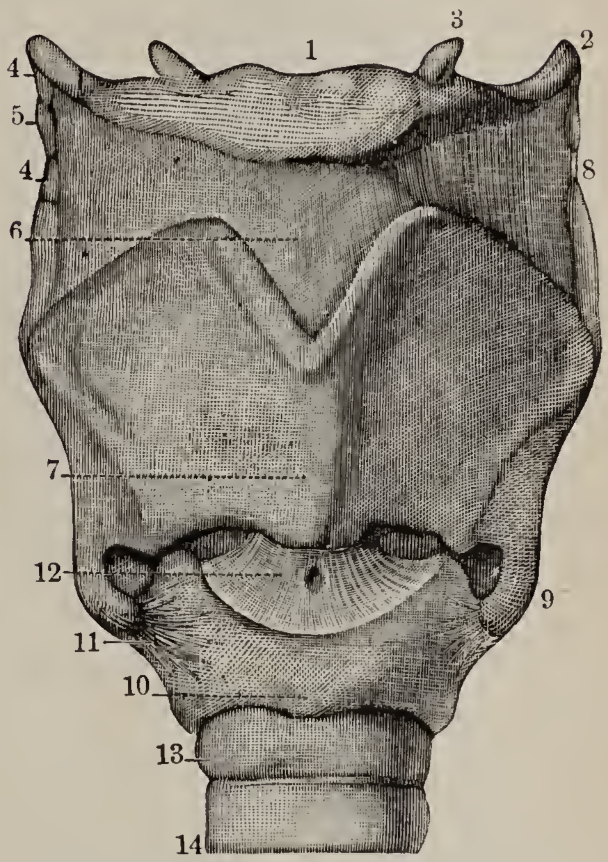
As for the involuntary muscles, their intermittent action continues throughout the course of life without producing any direct sensation of fatigue; and yet, to give but a single example of the work they accomplish, the heart beats about one hundred thousand times a day.

The Voice and Vocal Apparatus.—The sounds which constitute the human voice are produced by the passage of the air expelled from the lungs through a very simple apparatus called the **larynx.**

This apparatus is in the upper part of the trachea, and is a tube formed by the union of a number of elastic, cartilaginous rings, separated from the pharynx by the hinged cover called the **epiglottis.** The interior of the tube is lined with a continuation of the mucous membrane of the mouth.

The cartilages that help form the larynx are the **thyroid** in front, the **cricoid** below and behind, and the two **arytenoids** above and behind. These parts are joined by ligaments that allow some motion, and by certain muscles that somewhat change their respective positions. The more important ligaments, and the only ones that are indispensable for the formation of the voice, are the **inferior ligaments** or **vocal cords;** these are more or less stretched, and closer together or farther apart, according to the movements given by the muscles of the larynx to the different cartilages. The opening between them through which the air passes is called the **glottis.** During the production of vocal sound, the form of the glottis is a narrow slit; when at rest, the opening is triangular. Above the vocal cords are two other liga-

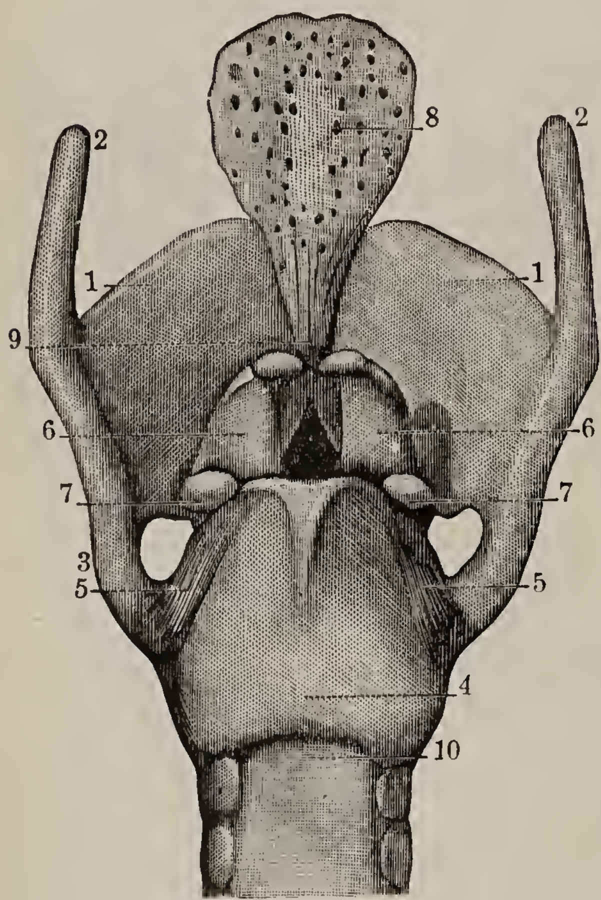
FIG. 45.



FRONT VIEW OF THE LARYNX.—1, hyoid bone; 2, greater cornu; 3, small cornu; 4, lateral thyro-hyoid ligament; 5, nodular cartilage; 6, middle thyro-hyoid ligament; 7, thyroid cartilage; 8, superior horn; 9, inferior horn; 10, cricoid cartilage; 11, crico-thyroid ligament; 12, crico-ary-thyroid ligament; 13, 14, first and second rings of the trachea.

ments, much more relaxed, and the opening between them is not nearly so narrow as that between the vocal cords. These are the superior ligaments. Between the upper and lower ligaments on each side are the spaces or cavities called the **ventricles of the larynx.**

Fig. 46.



Back view of the larynx.—1, thyroid cartilage; 2, superior horn; 3, inferior horn; 4, cricoid cartilage; 5, crico-thyroid ligament; 6, arytenoid cartilage; 7, prominent external angle of the base into which the crico-arytenoid muscles are inserted; 8, epiglottic cartilage; 9, thyro-epiglottic ligament; 10, posterior membrane of the trachea.

Mutes are persons deprived of the power of articulate speech or of producing any definite sound. This infirmity may result from paralysis of the nerves which control the movement of the parts of the vocal apparatus, but complete loss of speech is of rare occurrence excepting in cases of idiocy or in those born deaf. It then is caused by a complete absence of the sense of hearing and the consequent impossibility of acquiring the principles of language.

CHAPTER VIII.

The Dog.

Every one is familiar with the great variety in size, proportion, fur, and color presented by the different races of dogs.

We will not consider the external characteristics, but will study in the dog the structure of the different regions of the body, and compare this structure with that of the corresponding parts of our own organism, noting the resemblances and the differences.

In examining the opened trunk we would find at once that the large cavity extending from the base of the neck to the origin of the posterior limbs is divided, as it is in ourselves, into two parts, separated by a muscular partition or **diaphragm**.

In the thoracic cavity, bounded by the ribs, we would find the same organs that we know,—the heart, lungs, and œsophagus. In the abdominal cavity are likewise lodged the stomach, intestines, liver, spleen, kidneys, etc.

There is nothing specially noteworthy about these organs, excepting a greater development of the **cæcum,** which is that portion of the large intestine into which the small intestine empties.

The **circulatory** apparatus, **respiratory** apparatus, and **digestive** apparatus are constructed according to the same type that we have found in man. However, in the digestive apparatus we will detect an important difference in the number, form, and arrangement of the teeth. In front the jaws carry twelve incisors, six above and six below. Back of them, on each side, and above and below, is a long conical canine, about three times the size of the incisors. Still back of these are the large, thick, and irregular molars, seven on each side below, and six above, having great conical projections, somewhat pressed together from the sides.

Some of the molars have a single root, and are called **premolars**; these are in front of the true molars, which have double roots. In the upper jaw there are three premolars on each side, while there are four in the lower jaw.

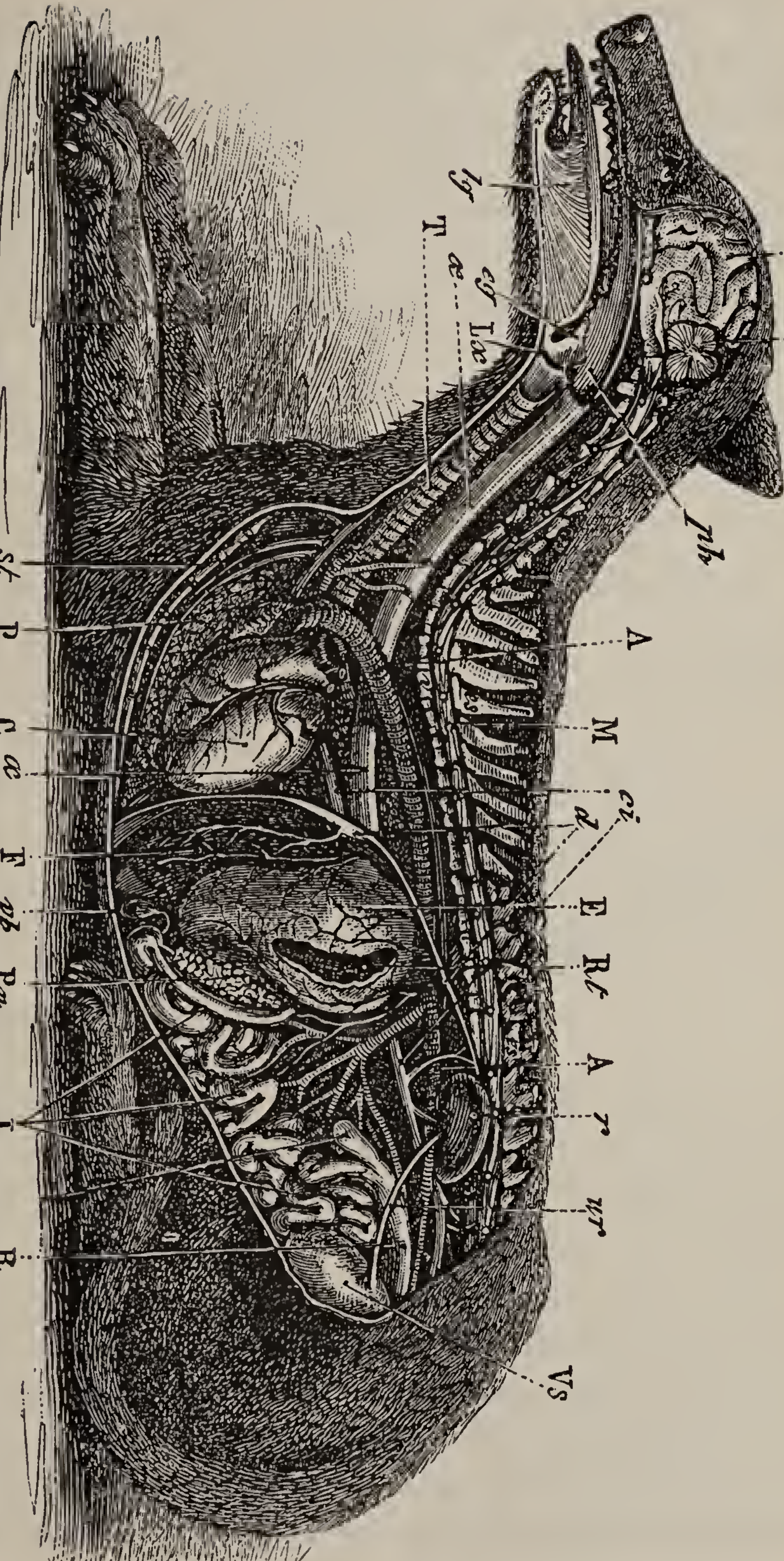
The prominences that are noticeable on the crowns of the true molars are ordinarily rounded; however, the anterior lower molar on each side is armed with several sharp points, and hence is called the **carnivorous** tooth. In the upper jaw the last premolar on each side is carnivorous.

In the mammals the number and kind of teeth in the jaws are expressed briefly by dental formulæ. These formulæ are composed of the first letter of the name of the kind of tooth, followed by a fraction whose numerator is the figure expressing the number of teeth in the upper jaw, while the denominator gives the number of corresponding teeth in the lower jaw. The formulæ are still further simplified by expressing the teeth on only one side of the face, and, as the teeth are always symmetrically arranged, double the number given by the formulæ will be the total number of teeth. Thus, the formula for a dog's teeth is

$$I\ \tfrac{3}{3},\ C\ \tfrac{1}{1},\ Pm\ \tfrac{3}{4},\ M\ \tfrac{3}{3}.$$

The sum of these numbers is 21; there are, therefore twenty-one teeth on each side, or forty-two in all.

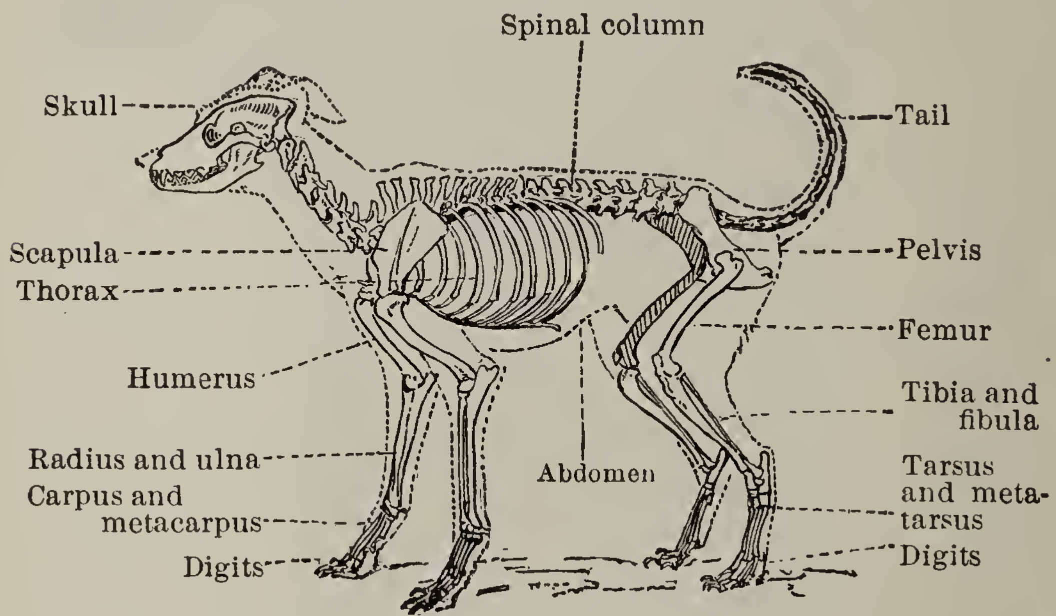
FIG. 47.



ORGANIZATION OF THE DOG.—A, aorta; C, heart; C′, cerebrum; K, cerebellum; M, spinal cord; E, stomach; F, liver; I, intestine; R, rectum; Vs, bladder; Pn, pancreas; st, sternum; P, lung; T, trachea; Lx, larynx; lg, tongue; eg, epiglottis; ph, pharynx; œ, œsophagus; d, diaphragm; ci, inferior vena cava; vb, gall bladder, Rt, spleen; r, kidney; ur, ureter.

The dog has an interior bony framework analogous to that which has been described in man, excepting in parts modified by the horizontal position of the trunk and by the quadruped locomotion. Thus the occipital foramen, through which passes the spinal marrow, is at the back of the skull. There are seven cervical vertebræ, as in man, and this number is uniform in nearly all mammals;

FIG. 48.



SKELETON OF DOG.

but there are thirteen dorsal vertebræ, instead of twelve as in man, and consequently the dog has thirteen pair of ribs; there are seven lumbar vertebræ and three sacral.

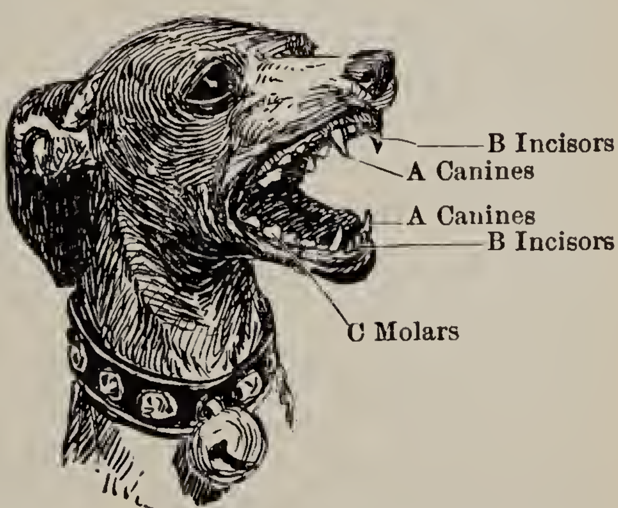
The coccygeal vertebræ, which in man are joined in one little mass, have mobile articulations, number from eighteen to twenty-two, and form the framework of the tail. They are called **caudal vertebræ.** In general among the quadrupeds the spinal processes of the lumbar and sacral vertebræ are inclined upward from back to front, while those of the dorsal vertebræ incline from front to back. In man and in the monkeys that maintain an erect posture all the spinal processes incline from front to back.

The skull of a dog presents no striking feature, but the face is very different from that of man. The branches of the lower maxillary bone are proportionally much elongated, and are almost straight, while the articulating condyle is transversely developed in the form of a roller, permitting only an up-and-down motion of the jaws, and no lateral movement as in man.

The powerful jaws of the dog constitute his only weapon and his only means of defence. The mouth is slit far back, permitting it to open very wide; the motor muscles of the jaws are very strong; they are so attached to the bones as to afford the quickest and the strongest action.

The dog is constructed for rapid running, and has only rudimentary clavicles; his paws and feet are formed by the same bones as in man, and their position is more or less vertical. There are five digits to the forefeet, the thumb being recognizable by its shortness. The hindfeet have only four digits. When the dog stands, his metacarpal bones do not touch the ground; they are in an almost vertical position, and the foot rests on the phalanges. Even the

FIG. 49.



JAWS AND TEETH OF DOG.—The skin has been cut away in order to show the teeth.

latter which carry the nails or claws are raised in such a manner that the claws are held above the ground and are not too rapidly worn away.

The bones of the limbs are long; the muscles, thick and strong on the shoulders and haunches, terminate in hard, dry tendons; the articulations are very flexible, and allow a great extension of the four limbs. The possible vigor of projection of the body in running and jumping is sufficiently indicated by the great fleshy development of the hind-quarters.

The feet are provided with strong nails or claws, slightly curved, and affording great aid in climbing steep and slippery hills. Under each digit is a sort of pad, rough, strong, and elastic, and a clover-leaf shaped pad of the same nature is placed under the palm. By these protecting pads, that come directly in contact with the ground, the digits are removed from the ordinary causes of hurts and irritations. There is between the digits a fold of skin, somewhat like the web-foot of a duck; this is quite rudimentary in most dogs, but is largely developed in the Newfoundland and the spaniel, and explains the great facility with which these dogs can swim. Most dogs are capable of swimming for a long time.

The body of the dog is slender in the region of the belly, but much enlarged in the chest, indicating easy and deep respiration. It is light, relatively to the strength of its limbs; and because these latter have but a slight weight to support, they do not quickly become fatigued, and the animal is able to run a long time without losing breath or requiring rest.

All animals that hunt game must have an accurate vision, and another gift, perhaps still more important, a delicate sense of smell. Now, the dog has excellent sight, and possesses a sense of smell superior to that of nearly all other animals. The faculty of distinguishing odors resides in the delicate membrane lining the interior of the nose and covering certain small bones contained in the nasal fossæ. The greater the surface of this membrane the more easy becomes the perception of odors, and the sense of smell is more delicate and subtle. The nose of the dog is very long; it takes up two-thirds the length of the head, and contains largely-developed turbinated bones. Besides, the sensitive membrane, which in most animals is limited to the interior of the nasal organ, in the dog extends beyond and covers the fleshy protuberance on the end of the nose. The dog has thus, we may say, two noses,—one internal and the other external; the latter is always moist, and always turning from side to side in the air and gathering odorous impressions. The ears of the dog are well developed, and in most cases the pavilion is much elongated.

All the organs of sense are in direct relation by connecting nerves with the nervous system, of which the general arrangement is the same as that which has been described in man. However, in the dog and in all carnivorous animals, the cerebrum extends far beyond the cerebellum, which is thus completely covered. The olfactory lobes are strikingly developed, being proportional to the delicacy of the sense of smell, already mentioned.

The convolutions are much more simple than those existing in the brain of man.

The female dog nourishes her young with milk secreted by **mammary glands**; these latter are abdominal.

All races of dogs,—bull-dogs, terriers, pug-dogs, shepherd dogs, spaniels, beagles, greyhounds, setters, pointers, etc.,—whatever their external differences of appearance may be, have many points in common, and it cannot be denied that all have descended from a single primitive type. This type is not known to us, for there is no wild dog, using the word in its true sense. There is, indeed, in the Antilles a race of wild dogs living in an untamed state, but they are descendants of dogs taken there by Christopher Columbus and his followers, and have become savage by the absence of civilization and masters. It is worthy of note that wild dogs do not bark, neither do the wolf and jackal, both species being closely allied to the dogs; they howl, and acquire the faculty of barking only after they have been domesticated.

We cannot enter into details concerning the distinctive characters of the races of dogs that have been mentioned, saying only that the form of the head and the strength and length of the limbs are the points in which differences are most marked. In this chapter we have limited ourselves to an anatomical study of the dog in general, this animal serving as our type of **quadruped.**

CHAPTER IX.

The Chicken.

If we first study the external characteristics of the chicken, we notice the following peculiarities:

The animal is covered with an epidermic growth called **feathers.**

It is **biped,** and supports itself on its posterior digits, while the forelimbs are profoundly modified to form new organs, the **wings.**

We have before us an animal organized for flying, and the more deeply we study its different parts the more new characteristics do we find, these being required by the new mode of locomotion. And, first, the feathers that cover the whole surface of the body are not like hairs, organs only epidermic in nature. Each feather has a stem, hollow at its lower end, solid at its extremity, and this stem has slender, flat beards or **barbs,** arranged symmetrically on each side. The barbs themselves have smaller barbs, ordinarily hooked at the ends, holding themselves firmly fixed one against the other, and called **barbules.**

The name **down** is given to the very light, soft feathers that are hidden under the true feathers; these have a very slender stem with many branches, and possess barbs without barbules. Consequently, when a breath of air is blown upon the down the barbs separate one from the others, which cannot take place in true feathers whose hooked barbules hold the barbs together. In the eider duck the down is remarkably developed and exceedingly light, and in all birds that inhabit cold countries there exists under the superficial feathers a great abundance of down, more or less delicate, that is sought for filling pillows and cushions.

The **tectrices** are feathers that serve only as a sort of clothing to protect the body from cold and wet, and they are covered with a thin layer of a fatty matter that makes them quite water-proof. The feathers of the upper limbs are enormously developed, and so arranged that they form the surface on which the bird rests while flying. They are called **quill-feathers, wing-feathers,** or

remiges. The hand always has ten, called **primary remiges.** The forearm has between fifteen and twenty, called **secondary remiges.** Smaller quill-feathers are attached to the humerus, and are named **scapularies**; others to the thumb, and these are the **bastards.** The **coverts** of the wings are the feathers that cover and shield the bases or quills of the quill-feathers. The large feathers that form the tail, and which are attached to the coccyx, are generally twelve in number, but sometimes there are more. They serve as a sort of rudder during flight, and are called **tail-feathers.**

The superficial examination of a fowl shows us also

FIG. 50.

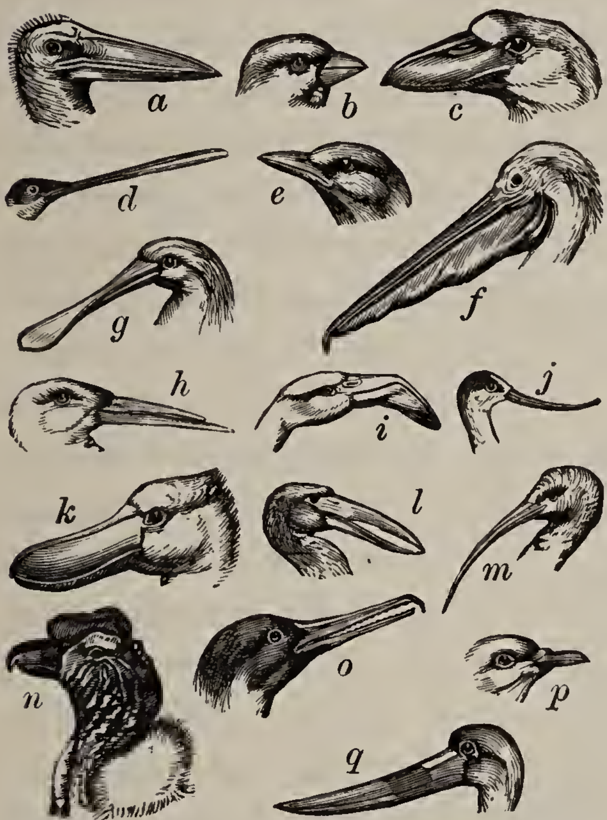
WING OF PIGEON, showing primary (*a*) and secondary (*b*) feathers, and "bastard wing" (*c*) at thumb.

that its head has a peculiar form, its face terminating in a horny **beak.**

In the interior of the body, however, we observe that, contrary to what we have noticed in the dog, the thoracic and abdominal cavities are not separated by a complete diaphragm; there is, however, a certain independence of the two cavities, and a certain resemblance to those we have studied.

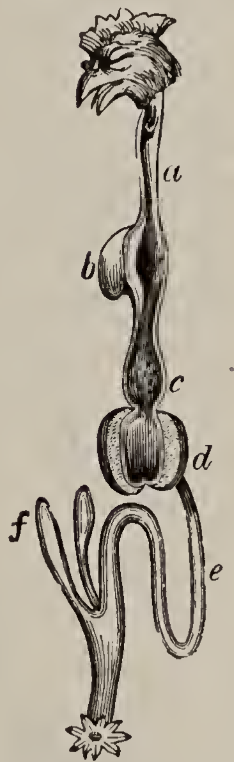
In the thoracic space are the heart, lungs, trachea,

FIG. 51.



BEAKS OF VARIOUS BIRDS.—*a*, marabou stork; *b*, sparrow; *c*, boatbill; *d*, swordbill humming-bird; *e*, species of thrush; *f*, pelican; *g*, spoonbill; *h*, scissorbill; *i*, flamingo; *j*, avocet; *k*, boatbill stork; *l*, openbill stork; *m*, ibis; *n*, condor; *o*, merganser; *p*, *Columba œnas;* *q*, mycteria or saddle stork.

FIG. 52.



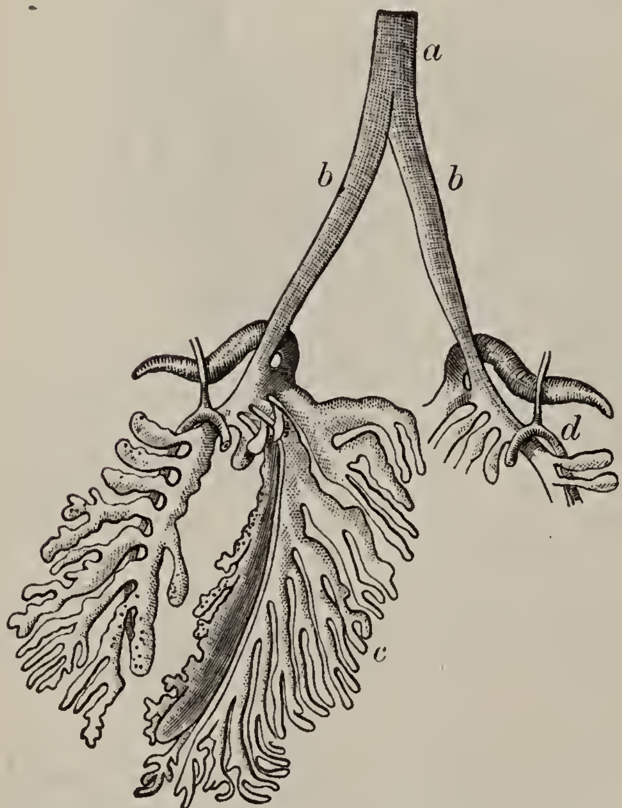
ALIMENTARY CANAL OF FOWL.—*a*, œsophagus; *b*, crop; *c*, proventriculus, or secreting stomach; *d*, gizzard, or triturating stomach; *e*, intestinal canal; *f*, two long cæcal tubes indicating the theoretical commencement of large intestine.

and œsophagus, and in the lower cavity are the various parts of the digestive apparatus, the liver, and the kidneys.

However, the apparatus that participate in the various functions of nutrition and relation present marked differences from the corresponding organs of man and the dog.

The digestive apparatus has really three stomachs: 1st, the **craw,** or first stomach, which is only an enlargement of the lower end of the œsophagus; the food accumulates in this reservoir so as to make it protrude in front of the neck, but the aliments do not here undergo any elaboration; 2d, the **succenturial ventricle,** or second stomach, which has thick, glandular walls that secrete a fluid to moisten the food; 3d, the **gizzard,** or third stomach, formed of thick, muscular walls lined interiorly with a hard, horny epithelium. The succenturial ventricle represents the stomach of the dog, but the gizzard is an apparatus of trituration, and is consequently largely developed in all graminivorous birds. The cæcum is represented by two tubes, the terminal orifice of the intestine being also that of the urinary ducts, and forming what is called the **cloaca.**

FIG. 53.



LUNGS OF BIRD.—*a*, base of trachea; *b, b*, bronchial tubes; *c*, branches of bronchi; *d*, blood-vessel.

The respiratory apparatus differs sensibly from that of the dog. The bronchi, instead of being entirely distributed to the lungs, are only partially distributed there. They are prolonged to the orifices of openings that pass through the lungs, and are continued beyond them to large sacs, called **aerial sacs,** which extend into the abdominal and thoracic cavities, and even into the neck and along the spinal column. These sacs communicate with the interior of the bones, which are hollow, so that the bird is, so to say, filled with air.

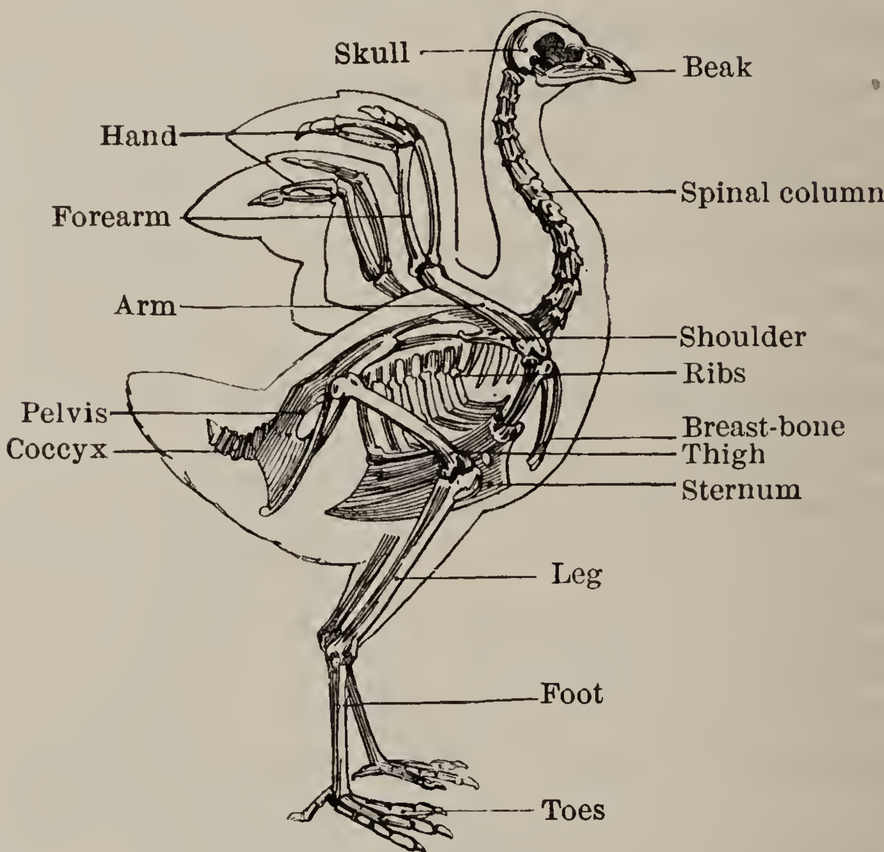
The circulatory apparatus has nothing specially peculiar; the blood-corpuscles are, however, elliptical, and the arch of the aorta, which turns from right to left in the dog and in man, curves from left to right in the fowl. In the courses of the blood-vessels are numerous vascular plexuses in which circulation is energetic; in the hen an abdominal plexus furnishes the heat necessary for the hatching of the eggs during incubation. The exceedingly active circulation and respiration raise the temperature of birds to 108°; that is considerably above the temperature of mammals, which is from 98° to 100°.

The skeleton of the chicken, like that of most birds, is peculiar in that there is no marrow in the bones, these being hollow, as we have seen. Besides this there are numerous modifications having for their object the presentation of large surfaces for the origin and insertion of the muscles of flight. Thus, the sternum has on the median line a prominent ridge like the keel of a ship, and this is the breast-bone. This ridge furnishes a very great surface for the insertion of the muscles of the wing. The ribs are completely ossified, instead of having a cartilaginous extremity, as in the dog and in man, and each has towards the posterior third a bony prolongation directed towards the back and resting on the next rib. These peculiarities have the effect of making the thoracic cage stronger. A certain number of the lumbar and sacral vertebræ are firmly united together.

There are fourteen cervical vertebræ, all long and very mobile, and seven dorsal vertebræ.

The skull is well developed, and its bones are united in

FIG. 54.



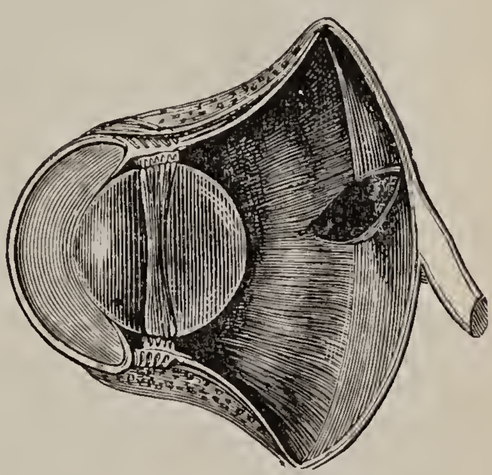
SKELETON OF CHICKEN.

a single compact mass. It is articulated with the vertebral column by a single condyle.

The forelimbs are only supports for the feathers which serve in flight. The hand is only a sort of stump, commonly called the pinion. The shoulder, besides the clavicles, properly speaking, which are united together in front, forming the "wish-bone," has a well-developed support in the coracoid process of the scapula, which forms a flying arch extending entirely to the sternum. The posterior limbs are made up of a short, strong thigh, a leg, and a tarsus, corresponding at the same time to the tarsus and metatarsus, and digits ordinarily four in number. The much-elongated metatarsus constitutes what is ordinarily called the leg of the fowl. The number of phalanges follows a rule that is constant for birds. The first digit has two phalanges, the second has three, the third four, and the fourth five. Besides these, the cock has a **spur,** which is a sort of bony prolongation of the metatarsus, and must not be mistaken for a digit.

The nervous system comprises the same parts as in the dog, but these are modified to some extent. The convolutions of the cerebrum are almost wanting; the cerebellum, instead of being formed of largely-developed lateral lobes with a thin median lobe, has a large median lobe and very small lateral lobes. Lastly, there is no corpus callosum.

Fig. 55.



Eye of bird.

The organs of sense are for the most part well developed. However, the tongue is reduced to a pointed, horny, and very thin appendage; this leads us to the conclusion that the sense of taste is very feeble.

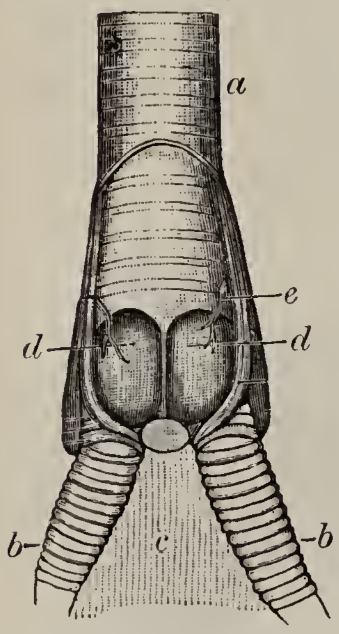
The eye is very large in proportion to the size of the head, and is in all birds protected by three eyelids, two horizontal and one vertical; the latter comes from the internal angle of the eye, and is called the **nictating membrane.** The iris is large and pierced by a round pupil. A black membrane, folded like a fan, and called the comb, starts from the retina and proceeds towards the interior of the crystalline lens. The power of vision is very acute in birds. They can perceive their prey, however small it may be, at enormous distances.

The narines are situated at the base of the beak, and the sense of smell appears to be feebly developed.

The ears are well formed, but have no pavilions.

The chicken, like all crowing and singing birds, has two larynxes, of which the one situated at the upper end of the trachea corresponds to the larynx of mammals, but is without vocal cords, while the lower one, placed at the lower end of the trachea, at the bifurcation of the bronchus, is more particularly adapted for the production of the voice. This explains why a barn-yard fowl often continues to produce sounds even after its head is cut off. The lower larynx is called the sing-box or syrinx.

FIG. 56.



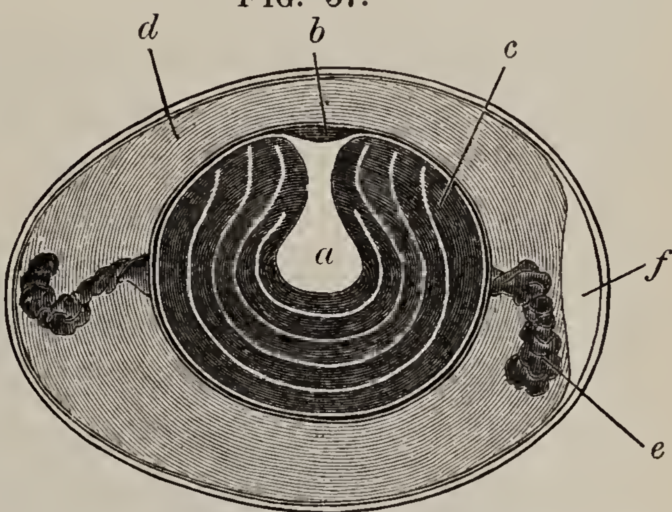
SYRINX OF THRUSH.—*a*, trachea (opened below); *b*, bronchi (with rings); *c*, internal tympaniform membrane; *d*, muscles; *e*, nerve supplying muscles.

All birds are **oviparous,**—that is, they reproduce the species by eggs, and have no organs designed for nourishing their young.

The egg of the chicken will give us an excellent idea of the structure of the eggs of all birds. The external envelope, or **shell,** consists of a calcareous crust, very porous, and lined internally with a thin double membrane, called the **chorion.** Inside of this is a viscous, transparent liquid, coagulable by heat; this is the white of egg, or **albu-**

men. In the centre is a yellow, spherical mass, the **vitellus** or **yolk,** fixed in its position by very delicate ligaments composed of the albumen twisted on itself. The vitellus is formed of an agglomeration of very small vesicles enveloped by an exceedingly thin pellicle. Upon one point of its surface is found a whitish rounded spot; this is the **cicatricle,** or germ of the young bird. During incubation this germ develops, becomes organized, and absorbs for its own nutrition all the matter contained in the egg. The white and the yolk are only magazines of nourishment. In the egg of the chicken these two substances exist in about equal proportions. The white is composed of thirteen per cent. of a nitrogenized matter, named albumen, and eighty-seven per cent. of water. The yolk contains nineteen per cent. of a nitrogenous matter, called vitelline, twenty-nine per cent. of a fatty matter, called egg-oil, and fifty-one per cent. of water, with a small quantity of a sulphurized matter. The decomposition of this matter produces hydrogen sulphide, which gives the characteristic unpleasant odor to rotten eggs.

FIG. 57.



SECTION OF FOWL'S EGG.—*a*, central plug of white yolk; *b*, position of germinal area; *c*, yellow yolk; *d*, white of egg; *e*, "tread" or chalaza; *f*, air-space between outer membranes.

In the egg the bird finds nitrogenized and fatty matters,—that is, all the elements necessary for its development and the formation of its tissues,—and the shell furnishes the rudimentary substance for the mineral matter of the bones. The air which must be supplied for the respiration of the embryo passes through the pores of the shell, and there is at the large end of the egg a sort of reservoir, the **air-chamber,** contained between the two layers of the chorion. Air is indispensable for the development of the germ. When eggs are to be preserved for food they are dipped in a solution of lime or some other substance that will close up the pores of the shell.

The constituent parts of the egg are not all formed in the same organs. The yolk or vitellus is organized in the ovaries, which form a bunch suspended from the posterior walls of the abdomen of the bird. When detached from the ovary, the yolk descends towards the cloaca through a canal called the oviduct; here it becomes covered with the albumen, and as the yolk has in its descent a motion of rotation on its axis, there results a torsion that forms the albuminous ligament. In the lower parts of the oviduct are secreted the calcareous matter of the shell and the coloring substances that in certain species tint the surface. The egg is then passed into the cloaca and is expelled.

In order that the egg may be hatched it must for a certain length of time be maintained at a temperature of about 107°, and for this reason the mother sits on it.

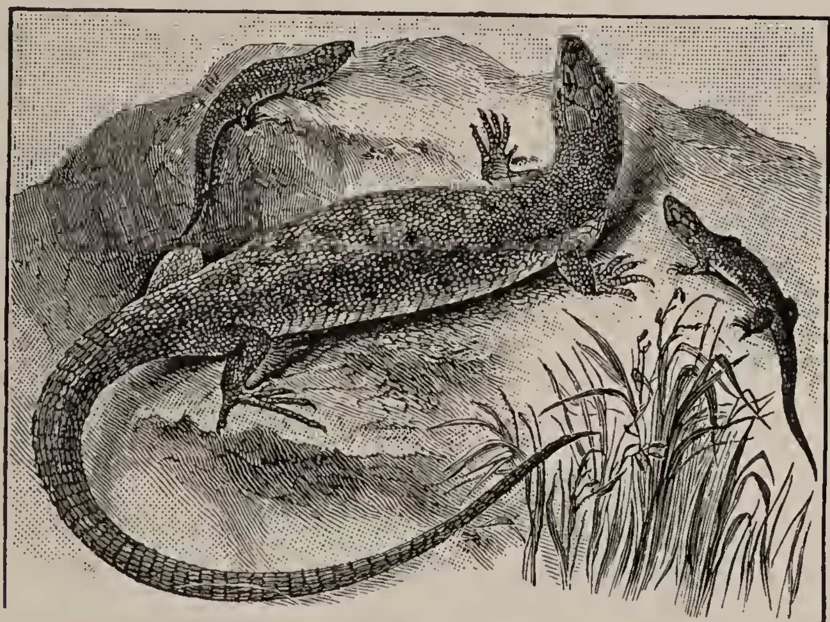
In the domestic state the cock does not help the hen either in the cares of incubation or in the rearing of the young family, but he intrepidly defends his hens and chicks from all attacks and dangers.

CHAPTER X.

The Lizard and the Frog.

The Lizard.—Lizards are small terrestrial reptiles, most of them perfectly inoffensive, found in great abundance in the warm and even the temperate parts of both continents. They live on worms and insects, and so destroy large numbers of creatures annoying to man. There are several species of lizard,—the gray, green-spotted,

FIG. 58.



COMMON LIZARD (*Lacerta vivipara*).

brown, and red. The common lizards of temperate countries are rarely longer than six or eight inches. They usually prefer to live in rocky places or walls exposed to the sun. The tail is made up of articulations that are broken off with great ease, but the lost part is afterwards reproduced. The colors of many of the species are very brilliant, and the length of those found in warm climates may exceed sixteen or twenty inches; in such countries they live in hedges and bushes.

The common lizard may be taken as a type for the study of the organization of all reptiles. It has four feet, supporting a long, slender body, terminated by a long tail, and is covered with a scaly, naked skin that bears neither hair nor feathers. At a certain season of the year the lizard gets a new skin, and throws off the old epidermis.

On dissecting the lizard we find that there is no division between the thoracic and abdominal cavities: there is no real diaphragm. The digestive apparatus is simple, and after the mouth, which is armed with short teeth, we find a straight œsophagus, a stomach, and an intestine, ending in a cloaca, as in the birds.

The circulatory apparatus differs from those which we have already studied: there are but three cavities in the heart, two auricles and one ventricle. In this ventricle the arterial and venous blood are mixed, so that the circulation, instead of being complete, as in mammals and in birds, is incomplete,—that is, there is a mixture of the two kinds of blood.

The blood-corpuscles are elliptical, like those of birds, but they are much larger, and have a distinct nucleus.

There are two aortic arches, one right and one left, which unite back of the heart to form a single vessel.

The respiratory function is accomplished by lungs, but these are much less developed than in the animals we have studied.

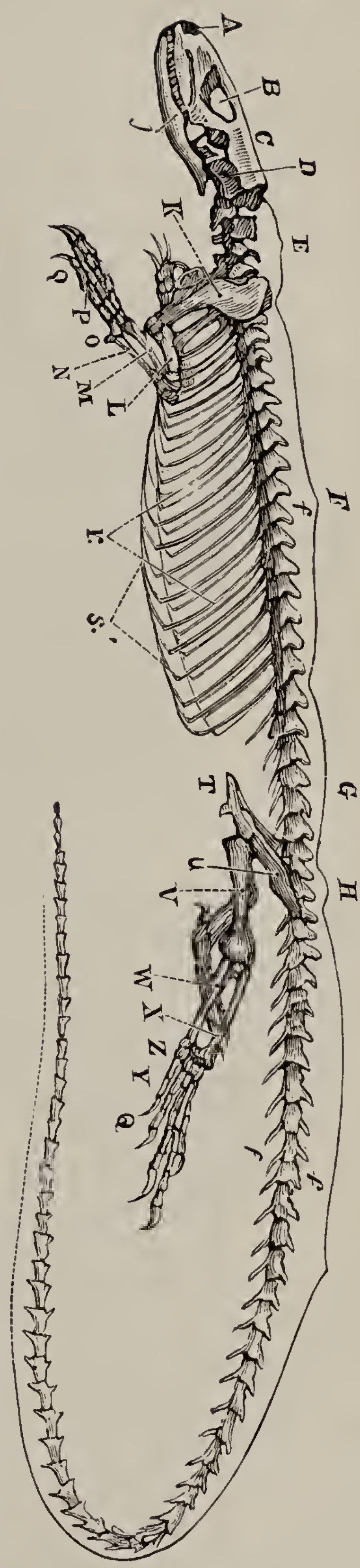
The skeleton is not unlike those we have examined. The skull is flat and depressed. The vertebræ are concavo-convex,—that is, at the posterior extremity they are convex, while at the forepart they are concave. Each of the four limbs is terminated by five digits.

The organs of sense are much like those of the bird. The tongue is forked. The eyes are furnished with a nictating membrane or third eyelid. The ears have no pavilion and no external meatus, so that the tympanum is on a level with the skin.

The olfactory lobes are placed in front of the cerebral hemispheres, and these latter are separated from the cerebellum by the optic thalami. In brief, those parts of the brain that in mammals and birds are massed together are in the lizard spread out and grouped in linear series, the ones behind the others.

Like all other animals of the class of reptiles, and like birds, the lizard

FIG. 59.



SKELETON OF LIZARD.—*A*, orifice of the nasal fossæ; *B*, orbit; *C*, cranium; *D*, square bone; *E*, cervical vertebræ; *F*, dorsal vertebræ and their spinal apophyses, *f*; *G*, lumbar vertebræ; *H*, sacral vertebræ; *I*, caudal vertebræ; *J*, lower jaw; *K*, scapula; *L*, humerus; *M*, radius; *N*, ulna; *O*, carpus; *P*, metacarpal bones; *Q*, digits; *r*, ribs; *s'*, sternal ribs; *T*, pubis; *U*, ilium; *V*, femur; *W*, tibia; *X*, fibula; *Z*, metatarsus; *Y*, tarsus.

reproduces its species by eggs; but the mother does not sit on the eggs; they are laid in places which are most likely to be favorable for the hatching.

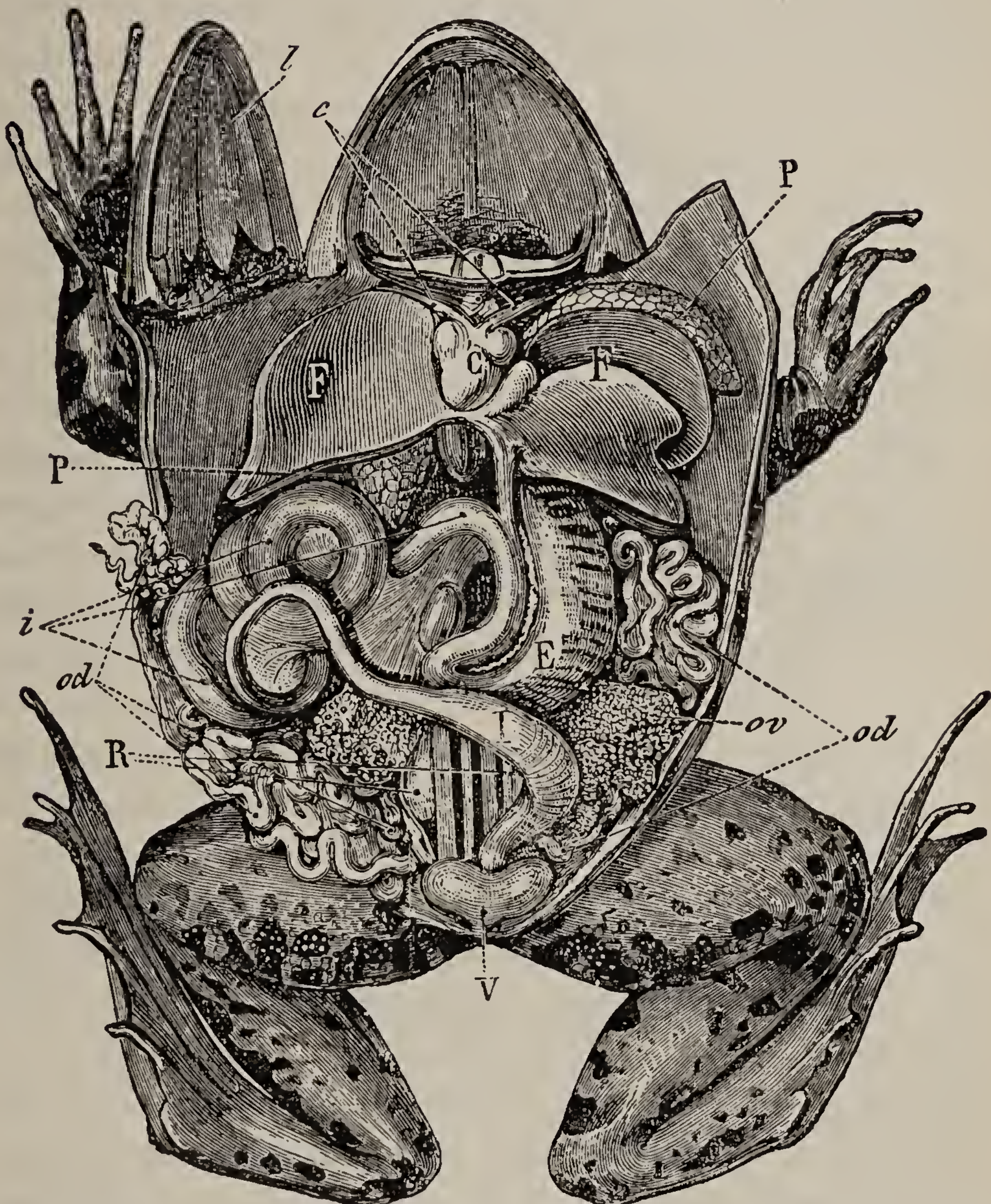
From what has already been said of the mixture of venous and arterial blood, the conclusion can easily be drawn that the blood that circulates in the lizard is not pure. Hence there is a less activity in the respiratory combustion, since the blood is less charged with oxygen; consequently the temperature of the animal is lower, and reptiles are called **cold-blooded animals**, in comparison with birds and mammals, which are spoken of as **warm-blooded** animals. These terms must not be interpreted literally. It would be more exact to say that reptiles have a **variable** temperature,—that is, the temperature is about that of surrounding objects, while birds and mammals are animals of **constant** temperature. When it is cold, the latter are able to increase the respiratory combustion and to maintain the bodily heat; while, when the weather is warm, a more restricted diet and less active movement are followed by a diminished combustion, and consequently the high external temperature meets an internal balance. Lizards, and in general all reptiles, have no power to maintain such equilibrium of temperature.

The Frog.—The frog belongs to the class of batrachians. It has a naked, clammy skin, covered with a thin epithelial layer, which is continually being renewed. It has two pair of feet and has no tail.

The thoracic and abdominal cavities are not separated by a diaphragm. The digestive apparatus is not unlike that of the lizard; the jaws are provided with small teeth.

In the respiratory apparatus, the lungs are only two sacs opening directly into the larynx; there is no trachea.

FIG. 60.



FROG OPENED FROM BELOW.—E, stomach; C, heart; *c*, aortic arches; P, lungs; F, liver; R, kidneys; I, large intestine; V, bladder; *i*, small intestine; *ov*, ovary; *od*, oviducts; *l*, tongue, turned to one side together with lower jaw.

The heart has three cavities, two auricles and one ventricle, so that circulation is incomplete, as in reptiles.

There are two aortic arches, springing from a dilatation or aortic bulb.

The skeleton is remarkable by the shortness of the vertebral column, which has only eight vertebræ. There are neither sternum nor ribs, and consequently there is no thoracic cage; the frog is therefore unable in respiration to make movements of inhalation and exhalation, such as we have studied in the animals already considered; it swallows the air by **deglutition,** as we would swallow a mouthful of food.

Fig. 61.

Skeleton of frog.

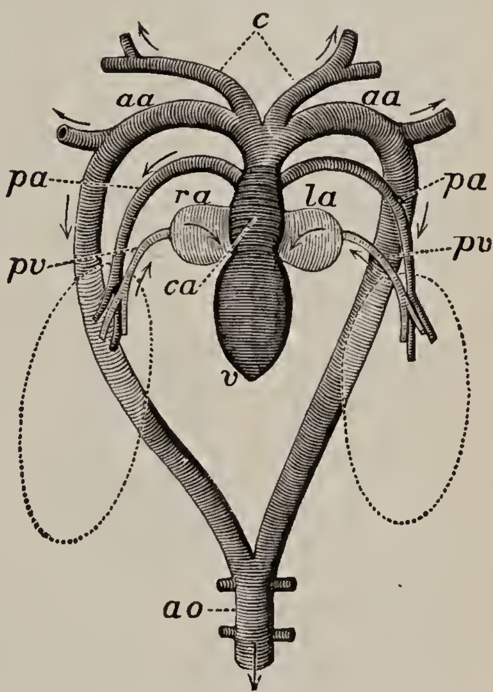
The brain of the frog has two elongated cerebral hemispheres, two large **optic thalami** behind the hemispheres, and a cerebellum consisting only of a transverse nerve band close to the optic thalami.

The organs of sense are well developed. The eye has a nictating membrane; the ear has neither pavilion nor external canal, and its tympanum, like that of the lizard, is on a level with the skin.

The organization of frogs corresponds to their manner of life. Like toads and aquatic salamanders they can live under water as do fishes, and they possess a power entirely absent in fish,—to live quite as well in the air. Animals thus gifted with what really constitute two modes of life are said to be **amphibious.**

We must understand the meaning of this word amphibious. An accomplished diver can spend quite an interval of time under water. The otter, the seal, and some other animals can remain submerged several minutes without inconvenience. However, neither the diver, the seal, nor the otter is an amphibian; while they can remain a short time under water, they cannot do so indefinitely. While they are submerged, pulmonary respiration is completely suspended, and their stay under water cannot be prolonged beyond the time, always very limited, in which arrested respiration is followed by death.

Fig. 62.



Arterial system of amphibian. —*ra*, right auricle; *la*, left auricle; *v*, ventricle; *ca*, conus arteriosus; *c*, carotid arteries; *aa*, aortic arches; *ao*, dorsal aorta; *pa*, pulmonary artery; *pv*, pulmonary vein; *ra*, receives venous blood from body; both the pulmonary arteries enter *la*. (After Nuhn.)

It is not so with true amphibians. If a frog be placed in a vessel full of water and kept at the bottom so that it cannot possibly come to the surface, it will nevertheless continue to live indefinitely without appearance of discomfort as long as it is furnished with food, provided the water be aerated or frequently changed. It lives under water as naturally and as easily as a fish; it also lives in air as comfortably as do terrestrial animals: it is truly amphibious. In order thus to live in water like a fish, the frog, the toad, and the salamander must possess respiratory organs adapted to aquatic life; and in order to live in the air like man, the dog, or the lizard, they must also possess the organs necessary for aerial respiration.

The frog, the toad, and the salamander have indeed lungs. We can satisfy ourselves on this point by watching them for a moment, when we will observe the movements of swallowing, by which they replace the respiratory movements, as we have already seen. But we would seek in vain in these animals any respiratory organs adapted for aquatic life, such as we find in the fish.

The aquatic respiration of the frog is not effected by any special organ: it takes place over the entire surface of the **skin.** The latter is thin, always moist, very porous to the air, and the blood which circulates under it comes into almost immediate contact with the atmosphere. The cutaneous respiration is thus so active that it is able to maintain the life of the animal under water. Frogs from which the lungs had been entirely removed have continued to live several months under water by cutaneous respiration only, while others, whose skin had been covered with an impermeable varnish, preventing entirely the passage of air, soon died, and apparently of suffocation. If the skin of a frog be dried, the animal quickly dies, because the drying prevents the passage of air to the blood beneath. These facts explain why amphibians always select for their abodes cool and moist places, such as the banks of streams and ponds.

An important peculiarity of frogs and other animals of the same group is the **metamorphosis** that accompanies their development. The eggs are laid in considerable numbers in marshes and ponds, and are agglutinated by a colorless, mucilaginous substance. Now, if we watch the development of these eggs we find that they give birth, not to frogs, but to small beings known as **tadpoles,** organized, like fishes, for an entirely aquatic life. An elongated ball containing the head and body; a long tail, flattened on the sides; neither limbs nor fins; external respiratory apparatus, consisting of little bags or branchiæ on each side of the head; a mouth adapted only for vegetable food: such is the general appearance of an amphibian in the tadpole state. The animal retains this form during a longer or shorter time,

Fig. 63.

METAMORPHOSES OF THE FROG.—A, frog's eggs; B, tadpole, first without feet; C, the two hindfeet appear; D, the two forefeet appear; E, the animal has four feet and a tail; F, the tail disappears,—the animal is perfect.

according to the species, and depending on external conditions. Then the limbs begin to appear and become developed; the form changes; the head becomes outlined; the tail either disappears entirely, as in frogs and toads, or remains, as in the salamander; the branchiæ shrink away and are obliterated, and the lungs develop. Now the animal begins to seek the air; it nourishes itself by preference on worms, insects, and little mollusks. It abandons the water as its constant home; sometimes, as in the toad, it gives up aquatic life entirely, selecting as its abode a damp hole in an old wall or a cool place under stones, and only returning to the water in order to deposit its eggs, impelled by that instinct of necessity that makes known to all animals the conditions most favorable for the preservation of their young, and consequently of their species.

Frogs live on the borders of water and feed on insects and worms, and during cold weather they bury themselves in the mud of marshes. The green frog is common in ponds, and is sought after as food in many countries. Brown frogs and toads prefer gardens, where they render great service by destroying snails and destructive insects. The little green tree-frogs have suckers in the ends of their digits, by the aid of which they can climb trees and crawl from branch to branch in search of the insects on which they live.

In conclusion, we must lay stress on the importance in classification of the metamorphosis of the frog. The organization of the tadpole, absolutely that adapted to aquatic life, relates the amphibians to the fishes, while by the organization of the adult animals they are related to other terrestrial animals. The amphibians thus form a natural passage from the study of terrestrial animals to that of fishes.

CHAPTER XI.

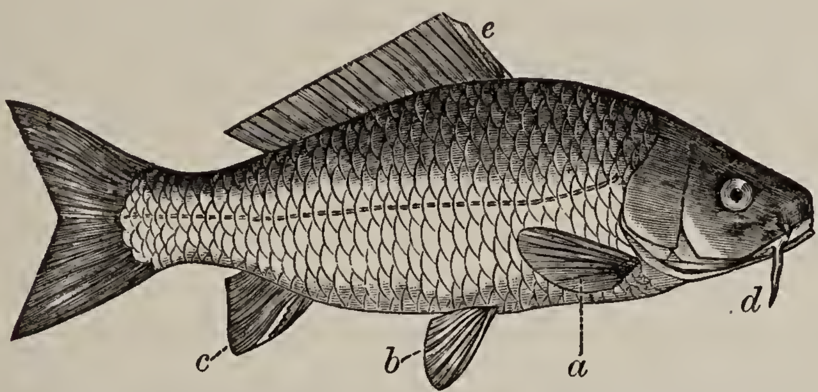
The Carp.

THE carp belongs to the class of fishes, and we will study it as the type of this category of animals. An examination of its external character shows us at once that there are great modifications that distinguish it from all that we have so far studied. Its organization, like that of all fishes, is adapted for an entirely aquatic existence.

The profile of the carp presents a wide body, flattened at the sides, the back more or less arched in front and dropping towards the head, which is short, having a small mouth, with two fleshy processes, called **barbels,** at each side.

The body is not naked, as in the frog; it is covered not with hair nor feathers, but with little organs, called scales, which are arranged in longitudinal rows; from the head to the tail each row contains about thirty-six or thirty-

FIG. 64.



CARP (*Cyprinus carpio*).—*a*, pectoral fin; *b*, ventral fin; *c*, anal fin; *d*, large barbel; *e*, dorsal fin.

eight scales, and there are about a dozen rows, separated into two nearly equal groups by a line that is apparent in all fish, and known as the lateral line.

The carp, being organized for life under water, does not possess—like the animals already studied—long and slender limbs. It has a special motor apparatus that is common, with more or less modifications, to all fishes.

This apparatus is composed of two kinds of organs, known as fins; some of these are arranged on the sides of the body, and represent the limbs; the others are in the median line, and are more or less directly connected with the spinal column. In the first of these varieties of fins are found, greatly modified it is true, the bones that form the limbs of mammals. The median fins are supported by little rods or **rays** of a bony nature.

The fins that correspond to the upper limbs are called **pectoral fins.** They are absent in but a small number of fishes; they are usually in pairs, nearly always independent of each other, and are situated near the gills.

The fins corresponding to the lower limbs are named **ventral fins**; they are absent in some fishes, among which is the eel, and in those in which they exist they are placed either under the throat, as in the codfish and whiting, below the pectoral fins, as in the perch and mullet, or under the abdomen. The latter is the case in the carp, in which these fins have ten or eleven rays.

Of the median fins the most noticeable is the **dorsal,** which is missing in some fishes, and presents great modification in form and number in the different species. The carp has one large dorsal fin, of which the first ray is strong and notched like a saw, and succeeded by eighteen or twenty others that support the fin.

At the extremity of the vertebral column a terminal forked fin constitutes the tail of the fish. Lastly, near the anus, and always in the median line, is the **anal fin,** the anterior ray of which is saw-toothed.

Fish swim in water as birds fly in the air,—that is, they exert, by the aid of their organs of locomotion, a pressure upon the fluid that surrounds them sufficient to enable them to offer firm resistance. The posterior portion of the body acts as a sort of oar, whose rapid motions play the principal part in progression. The actions of the median fins and of the tail are combined to determine the direction of the motion. The lateral fins appear to have their most important function in maintaining equilibrium.

If we open a carp in order to examine its internal structure, we find before us an organization quite different from anything we have observed in the animals already studied.

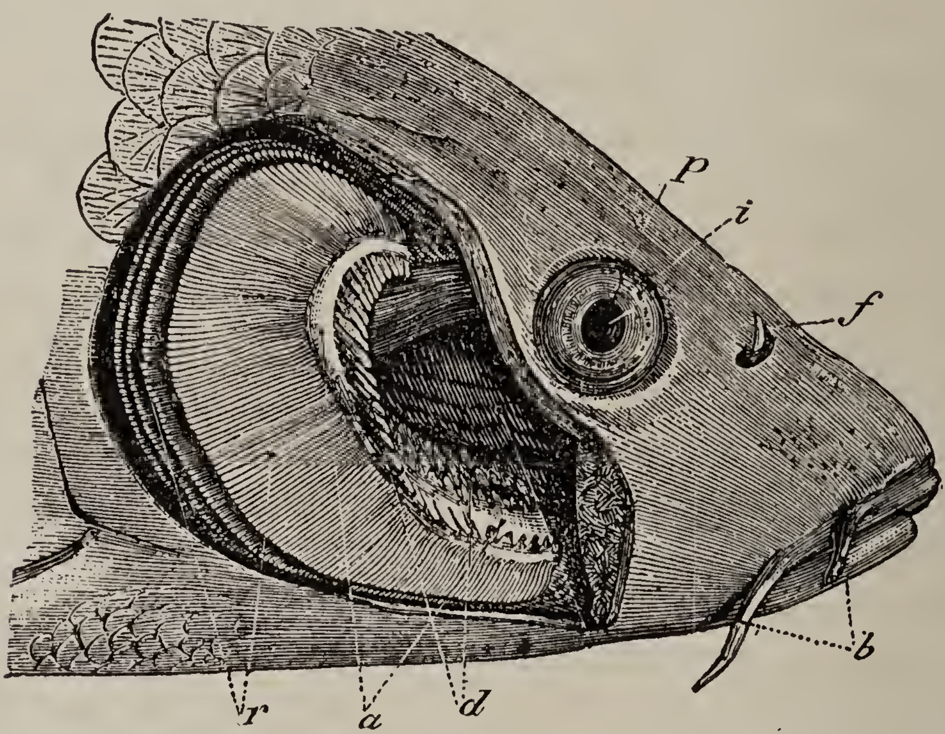
At first we notice that a large portion of the abdomen is filled with a capacious bladder, tightly contracted in the middle, and communicating with the œsophagus by a long canal. This is the **swimming-bladder,** which exists in a large number of the species of fishes, and contributes in an efficacious manner to simplify the mechanism of locomotion. This bladder is filled or emptied of air at the will of the fish, so that the body, being decreased or increased in density, rises or sinks in the water without any effort of the fins. The gas in the swimming-bladder does not come from the exterior: it is secreted by the walls of the membrane. There is no swimming-bladder in those species that constantly remain at the bottom of the water near the mud in which they seek their food.

The digestive apparatus also occupies a considerable portion of the abdominal space. The intestinal canal of the carp, indicating an essentially vegetable diet, is long, folded, and partly hidden among the numerous lobes of the liver. The mouth has no teeth in its jaws; the palate is thick and fleshy; the tongue is largely developed, as it is indeed in all fishes.

The respiratory apparatus presents important peculiarities, due to the aquatic life. Like all animals, fishes require air in order to live, and they find this air in the water; their organs for renewing the air are so constituted that they can only function usefully in water.

It can easily be shown that water contains dissolved air. This air separates and collects in little bubbles on the walls of a glass in which water is allowed to stand

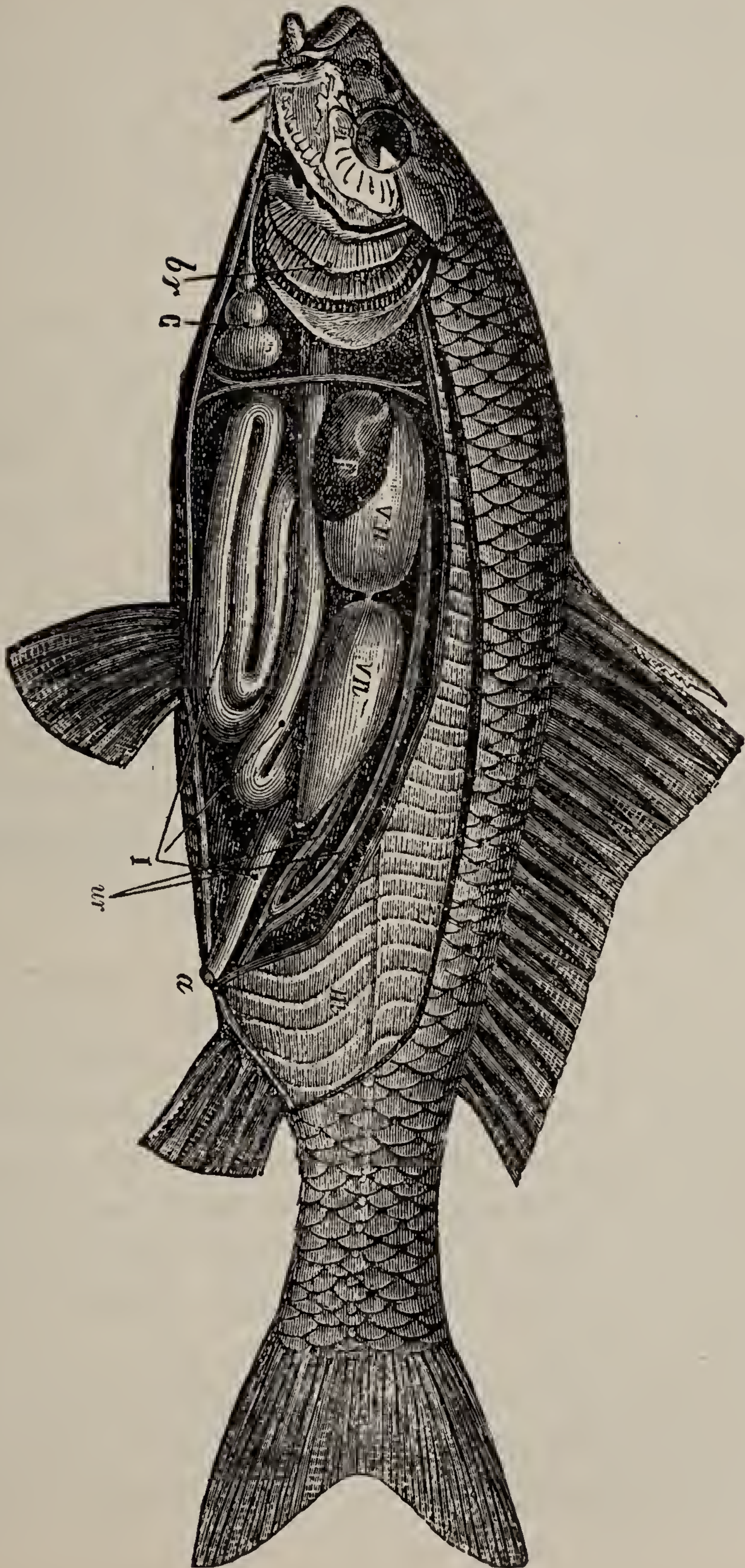
FIG. 65.



HEAD OF CARP WITH THE GILL-COVER REMOVED.—*b*, barbels; *i*, iris; *p*, pupil; *a*, branchial arches, having the comb-like teeth, *d*, on the internal border; *r*, rays of the gills.

and become warm. If water be boiled in a glass vessel the bubbles may be seen to rise and escape at the surface, and with the proper apparatus the gas may be collected and its chemical composition determined. It is then found to be air. This air is expelled from the water by the elevation of temperature, and all the air may be thus

FIG. 66.



ANATOMY OF THE CARP.—*br*, gills; C, heart; F, liver; *vn*, swimming-bladder; I, intestine; *a*, anus; *m*, muscles; *ur*, ureters.

driven out. When this happens the water is no longer able to sustain the life of fish, and the experiment is easy to perform. It must not be forgotten, however, that water dissolves a certain quantity of air with great ease, and that when the dissolved air has been expelled by boiling it is soon absorbed again when the water is exposed to the air.

The respiratory organs of fishes are located at the back and sides of the mouth, in a cavity that communicates with the exterior by two lateral openings, called the **gill-openings.** These organs, called the **gills** or **branchiæ,** are generally composed of plates arranged like the teeth of a comb upon four pair of bony arches, called the **branchial arches.** They are directly under the bony plates that form the cheeks of the fish, and that attain a great development and are very distinctly striated in the carp. These are the **opercula** or **gill-covers,** and when they are raised the gill-openings gape behind them.

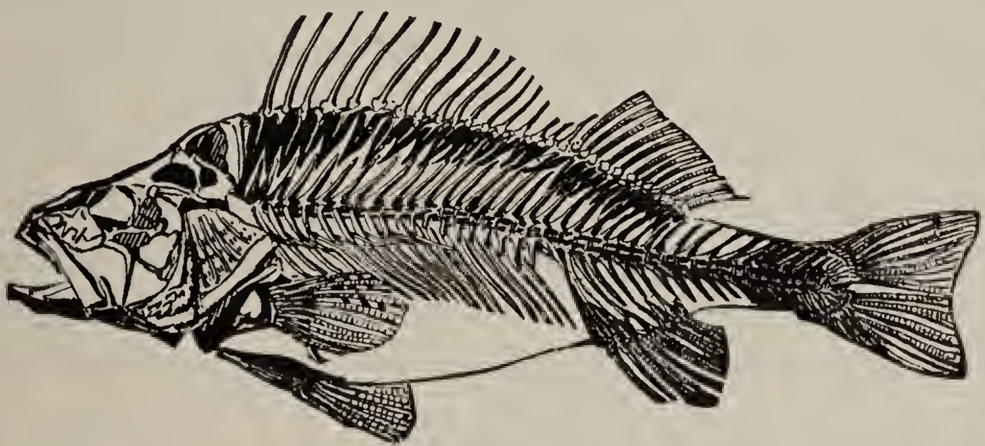
Certain rays, three only in number in the carp, support a membrane which closes the respiratory cavity below and at the sides.

The branchial plates receive innumerable little blood-vessels; the water which is drawn in at the mouth comes in contact with these respiratory organs, yielding to the blood through the thin membrane separating the two liquids a part of the oxygen it holds in solution, and taking in exchange carbonic acid gas that must be removed. After having served its purpose for respiration the water is then expelled through the gill-openings.

Fishes thus respire in reality like other vertebrates,—that is, they absorb oxygen and eliminate carbonic acid, but their respiratory organs are so constituted that they can act efficaciously only under water, although that liquid contains but a small proportion of air in solution. Fish die in the air because the branchial plates, no longer floating and separated by the water, stick together and present but a small surface to the air.

In the circulatory apparatus the heart has only two cavities, one auricle and one ventricle. It is a venous heart, and represents the right heart of the mammals. The venous blood arrives from the body to the interior of the auricle, passes hence to the ventricle, and is then propelled to the respiratory apparatus. This is the

Fig. 67.



Skeleton of a fish.

function of the right heart in mammals. From the gills, however, instead of returning to a left heart, the blood is at once distributed over the system ; there is but one circuit, and the circulation is said to be single, instead of double as in the other vertebrates. It is a complete circulation, for there is no mixture of venous and arterial blood. We may add that the ventricle is followed by a sort of swelling or aortic bulb.

The skeleton of the carp, like that of other fishes, is constructed according to the general plan of the vertebral organization, but its parts are naturally modified to suit the special conditions of the medium in which fishes live. The bones that form the head are very numerous, but those of the limbs are never present except in a rudimentary condition, and the posterior limbs are often absent. In some species the ribs also are missing, while in compensation the existence of the median fins necessitates the presence of a large number of supplementary cartilages or bones for their support. On the other hand, though the bones of most species of fish have a chemical composition analogous to that of the bones of mammals, birds, and reptiles, yet in a large number of species the mineral matter is almost entirely absent, and the skeleton is almost wholly cartilaginous. This difference in composition coincides with other very considerable organic differences, and it has been deemed necessary to classify fishes in two distinct groups,—bony fishes and cartilaginous fishes. Among the bony fishes are the salmon, the carp, perch, eels, etc. As examples of cartilaginous fishes may be named the shark, ray, sturgeon, and lamprey.

The brain, like that of batrachians, is formed of linearly-arranged parts. Two olfactory lobes, often largely developed, are in front of the hemispheres, while behind them the optic thalami, followed by the cerebellum, are easily seen.

In general the organs of sense are quite well developed. The crystalline lens is spherical, the eye but slightly convex in front, and without eyelids.

The ear comprises only the internal parts: in it there is a sac containing a calcareous stone, often quite large, which corresponds to a calcareous powder found in the ears of mammals.

The organ of smell appears to be well developed, the olfactory nerve being large, and sending off branches to the nasal sacs, little blind sacs in the nasal fossæ.

The touch is exercised by the barbels or lips.

There appears to be no sense of taste.

Reproduction takes place by eggs. The fecundity of the carp, like that of many other fishes, is so great that it has become proverbial. A female carp of good size contains not less than five or six hundred thousand eggs. These eggs are deposited on the leaves of aqueous plants in March or April, and hatch in seven or eight days. The growth of the young is very rapid; if the conditions are favorable a young carp attains in three years' growth a weight of five or six pounds; afterwards the growth is much slower.

Carp flourish in ponds as well as in rivers whose currents are slow. They feed on larvæ, worms, grain, aquatic herbs, and young vegetable sprouts; often, indeed, they rise and seize insects on the surface of the water.

CHAPTER XII.

Review of the Distinguishing Features of the Five Classes of Vertebrates.

In the preceding chapters we have taken one example from each of the five classes of the great group of vertebrates. We have seen the differences that distinguish the **mammalian** dog from the chicken, and have studied the peculiarities in structure of **reptiles, batrachians,** and **fishes.** That which has been said of each type applies to the whole class to which the type belongs, excepting, of course, the peculiarities of the species. We will now review the distinguishing features of each of these classes of vertebrates.

I. All the **mammals** are beings whose organization presents remarkable analogies with that of man. Their double and complete circulation starts from a heart divided into four compartments, of which the two on the right are completely separated from those on the left. The arterial blood cannot, therefore, mix with the venous blood in any manner. Their respiration is aerial, and is effected by the lungs. They have a constant and tolerably high temperature: they are warm-blooded animals. We may add that they are viviparous,—that is, the young are at once produced alive,—and that they nourish their young with milk. This last peculiarity is the cause of the name mammal, meaning an animal having teats. Lastly, their bodies are usually covered with hair.

Examples of mammals: man, monkey, dog, cat, bat, rat, sheep, goat, horse, cattle, seal, whale.

II. **Birds** have a complete and double circulation like mammals. They are warm-blooded animals. Their respiration is aerial and pulmonary, and they exercise this function with an activity in perfect proportion to the great exercise of force required by their ordinary mode of locomotion. They are oviparous, their bodies are covered with feathers, and their forelimbs are never organized for walking.

Examples of birds: eagle, chicken, parrot, turkey, quail, stork, duck, canary, sparrow.

III. **Reptiles** are cold-blooded animals; their circulation is incomplete; the two ventricles of the heart are generally in communication with each other; the heart has then only three chambers; the arterial blood and the venous blood are thus mixed in the lower chamber, so that only a portion of the venous blood goes to the lungs for aeration before passing to the arteries, and a portion of the arterial blood returns immediately to the lungs without having traversed the general circulation. Respiration is aerial and pulmonary, but it is a function always somewhat sluggish. Reptiles are oviparous, or exceptionally ovoviviparous; their bodies are usually covered with scales.

Examples of reptiles: alligator, lizard, tortoise, snakes.

IV. **Batrachians** are related to reptiles by their general characters, but they are distinguished from these by the fact that during the early part, and sometimes during the whole course, of their lives respiration is aquatic and is accomplished by gills. The skin of batrachians is naked, having neither hair, feathers, nor scales.

Examples of batrachians: frog, toad, salamander.

V. **Fish,** like reptiles and batrachians, are cold-blooded animals. They have complete circulation,—that is, there is no mixture of arterial and venous blood; but the heart is single instead of double, and has only two cavities. These cavities correspond to the right heart of mammals; they are traversed only by the venous blood, which then passes to the respiratory organs. Respiration is aquatic, and takes place by the aid of gills. Fish reproduce their kind by eggs; several species are ovoviviparous. Their bodies are covered with scales.

Examples of fishes: pike, carp, bass, eel, sturgeon, ray, trout, salmon, perch, catfish.

The following table gives in *résumé* the peculiarities of the five classes of vertebrates:

VERTEBRATES.	Respiration always pulmonary	MAMMALS	Viviparous, suckling the young; udders; warm blood; double and complete circulation; heart with four chambers; skin ordinarily covered with hair.	
		BIRDS	Warm blood; double and complete circulation; heart with four chambers; feathers.	Oviparous.
		REPTILES	Cold blood; circulation double, but incomplete; heart usually with three cavities; scales.	Oviparous.
	Respiration branchial, at least in early life	BATRACHIANS	Lungs, in the adult state; cold blood; double but incomplete circulation; heart with three cavities; naked skin.	Oviparous.
		FISHES	Permanent gills; life always aquatic; cold blood; circulation single, but complete; heart with two cavities; scales.	Oviparous.

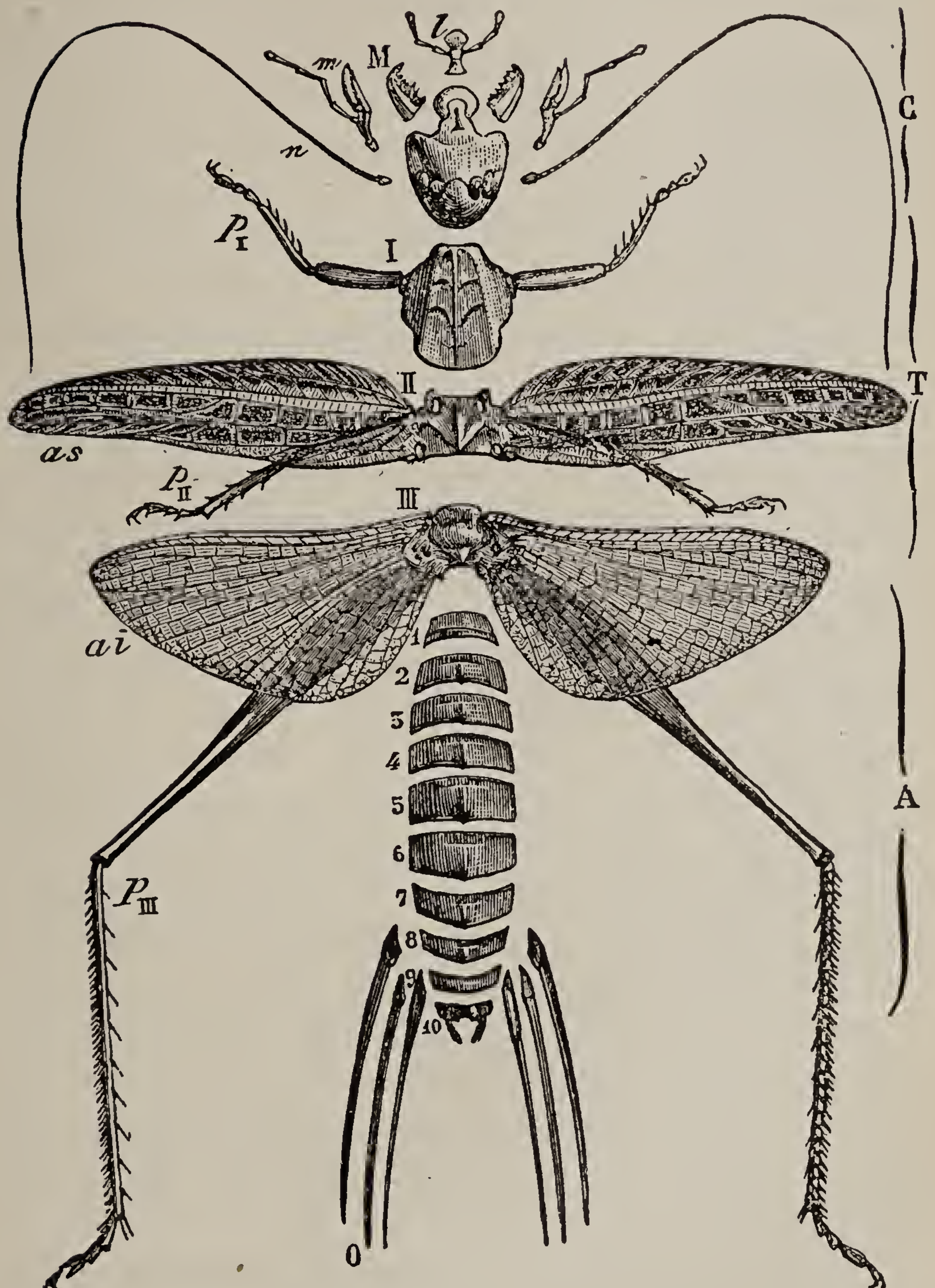
CHAPTER XIII.

Generalities Concerning the Articulates.

ALL the animals that we have so far studied, however different they may be in form, structure, and habits, resemble one another in one point,—their bodies all contain a strong internal framework, to which the soft parts are attached.

There are other animals, much more numerous than those in the division we have just studied, in which the arrangement of soft and hard parts is exactly the opposite of that in the vertebrates,—that is, the skeleton is on the outside, while the flesh and muscles are within.

FIG. 68.



TEGUMENTARY SKELETON OF A LOCUST, DISARTICULATED.—C, head; T, thorax; A, abdomen; *l*, lower lip; M, mandibles; *m*, jaws; *n*, antennæ; I, prothorax; p_I, first pair of feet; II, mesothorax; p_{II}, second pair of feet; *as*, upper wings; III, metathorax; p_{III}, third pair of feet; *ai*, lower wings; 1 to 10, joints of the abdomen; O, appendages.

To this class belong all the animals named by Cuvier **articulates** because their bodies consist of rings having articulated ends,—that is, mobile pieces or articles adapted for locomotion and for nutrition. According to the species the solid rings or segments are furnished each with one or with several pairs of appendages.

The bodies of these animals present three distinct regions, the **head**, the **thorax**, and the **abdomen**.

The head is the front part; it is formed of several rings, but these are so closely united together that their limits cannot be distinguished; however, the number of appendages indicates the number of rings composing the head. Among these appendages, some placed near the eyes are called **antennæ**; others near the mouth aid in the functions of nutrition. The head contains the organs of sense, and also an important nerve-centre composed of the cerebral ganglions.

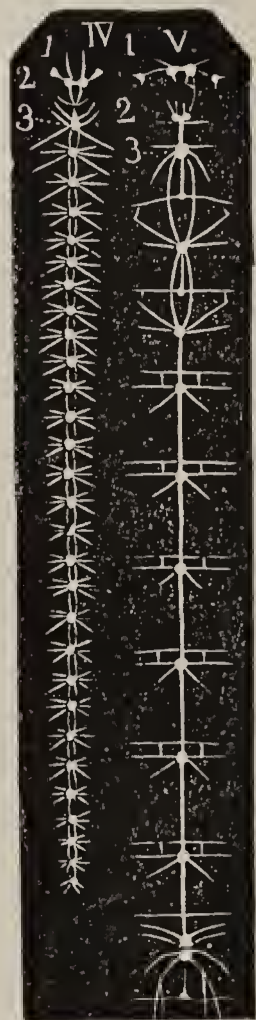
The thorax is composed of rings that are sometimes firmly joined together, sometimes entirely separate; in the latter case they are usually three in number. This region is generally quite separate from the head, but sometimes it forms with the latter but a single piece, which is then called **cephalo-thorax**.

The rings that form the abdomen are distinct and vary considerably in number.

Both the thorax and the abdomen may have appendages, but the limbs are specially related to the pieces of the thorax.

We have said that the rings of the body and those of the members form in the articulates an external skeleton that we have compared to the internal skeleton of the vertebrates. It must not, however, be supposed that there is any real resemblance between the two substances, which are essentially dissimilar. The substance that forms the skeleton of the vertebrates is bone, while that which makes up the skeleton of the articulates is a rigid matter called **chitin,** that in most cases becomes incrusted with carbonate of lime. The skeleton of the vertebrates is said to be **bony,** while the covering of the articulates, and in general that of all invertebrates, is **chitinous.**

FIG. 69.



IV, nervous system of a myriapod; V, nervous system of a caterpillar. The subintestinal ganglia are far apart, and show distinctly the chains to which they belong.

The articulates possess a distinct digestive apparatus, as well as apparatus of circulation and of respiration; the latter, however, are much simplified. The study of the peculiarities of these apparatus we will take up as we study the types selected for each of the classes of articulates.

In all articulates the nervous system has about the same organization, but this is so different from that with which we have become familiar in the vertebrates that it is entirely characteristic. It is composed of a series of **ganglionic masses,** joined together in a long chain by nerve-filaments or **commissures.** The largest of these masses are situated in the head, and form what is called the brain or **cephalic ganglion.** Behind and under the œsophagus we find another ganglion, called the subœsophageal, joined to the cephalic ganglion by two commissures that circle around the œsophagus: altogether this constitutes the

œsophageal ring. Farther back is the **ganglionic chain,** properly speaking, composed of thoracic and abdominal ganglia, all united together by commissures. This whole chain is, like the subœsophageal ganglion, placed under the intestinal canal so that the cephalic ganglion alone is above the digestive apparatus.

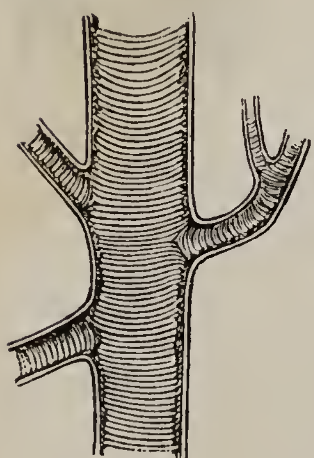
The organs of sense are pretty well developed in the articulates, and it is even possible that these animals possess certain senses different from ours, and therefore such as we can understand only very imperfectly.

To review, the articulates or arthropods are distinguished by bodies composed of rings carrying processes formed of mobile articles, and by their ganglionic nervous systems, arranged in a ventral chain that is connected with a cerebral mass by an œsophageal ring.

The division of articulates comprises four principal classes: **Crustaceans, Insects, Arachnida,** and **Myriapods.** The peculiarities of these classes is as follows:

I. In **Crustaceans** respiration is branchial or cutaneous. The thorax has five or seven pair of limbs. The crayfish, lobster, crab, prawn, and wood-louse are crustaceans.

Fig. 70.



Enlarged trachea of an insect.

II. **Insects** have tracheal respiration; that is effected by means of tubes, called **tracheæ** or **spiracles,** kept open by a sort of coiled spiral thread, and distributed over the body and in all the organs. Insects always have three pair of feet, never more nor less. Flies, butterflies, moths, and beetles are insects.

III. In the **Arachnida** respiration is sometimes tracheal, sometimes pulmonary. The head and thorax, instead of being separate, as in the two preceding groups, are joined in a single piece,—the **cephalo-thorax.** All have four pair of limbs. Spiders and scorpions are arachnidæ.

IV. The **Myriapods** are distinguished by bodies composed of numerous rings, all alike after the head, and each carrying one or two pair of legs. Consequently the number of feet is quite large in all the myriapods, and they are commonly called centipedes or thousand-legs.

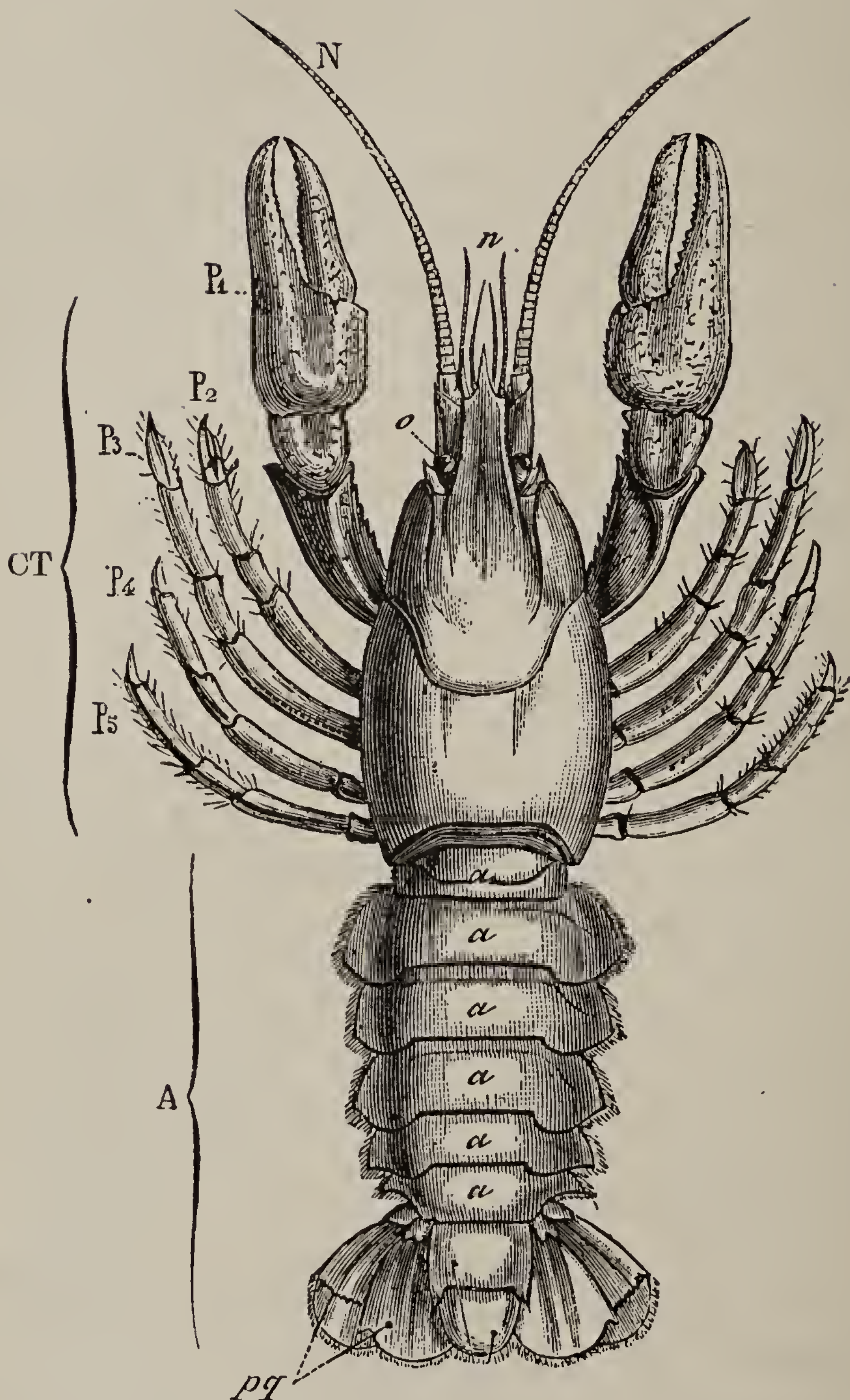
CHAPTER XIV.

The Crayfish.

The crayfish is a crustacean. Crustaceans owe the name to their hard carapace, stiffened with calcareous matter. The color of the crayfish is variegated blue and red. The head has projecting eyes, said to be pediculated or stalked, and two pair of antennæ of unequal length. The mouth is situated in a sort of depression, partly covered by the region of the antennæ, and surrounded by six pair of articulated processes, which are only so many limbs modified for the purposes of prehension and mastication of the food.

The first pair—one of which is at each side of the mouth, and which are covered by the others—constitute the **mandibles.** The mandibles are short, thick, and present a large surface and sharp edges ; they are specially adapted for mastication, and each has a little lateral process called the **maxillary palp,** or feeler of the jaw.

FIG. 71.



CRAYFISH FROM ABOVE.—CT, head and thorax; A, abdomen; *n*, internal antennæ; N, external antennæ; *o*, eye; P_1, jaws of the first pair of walking feet; P_2 to P_5, walking feet; *a*, rings of the abdomen; *pq*, pieces of the tail.

The next two pair are called the **maxillæ,** although, in fact, these members do not serve in crushing the food. They are hairy joints, and are used to hold the food against the mouth during mastication.

The last three pair of **peribuccal** (surrounding the mouth) **limbs** are called the **jaw feet**; they indeed look like feet, but they are kept folded before the mouth, and their use, like that of the maxillæ, is to hold the food.

The thorax of the crayfish is formed of segments which above are united in one large **carapace,** and below carry five pair of articulated feet, more or less lengthy and hairy; these are the **ambulatory feet,** for they are used in walking. Their number, in the natural group to which belong the crayfish, the lobster, and the crab, is five pair, and the name **Decapods** has been given to these animals.

In the crayfish, the lobster, and the crab the first pair of ambulatory feet are curiously modified. They are terminated by a sort of hand formed like a large pair of pincers; the interior edges of the blades of these strong pincers are studded with rounded tubercles. The organ thus serves more than its primary purpose, and is useful for prehension. It is called the **claw.**

The segments of the abdomen are quite distinct and movable one on the other. On the under surface they have small feet, but very little developed, and called **false feet,** between which the female carries her eggs after they have been laid. The abdomen is terminated by a number of joints spread out like a fan, and forming the tail.

The carapace of the crayfish is hard, but the animal, like many other crustaceans, sheds its coat at certain seasons,—that is, it abandons its carapace, out of

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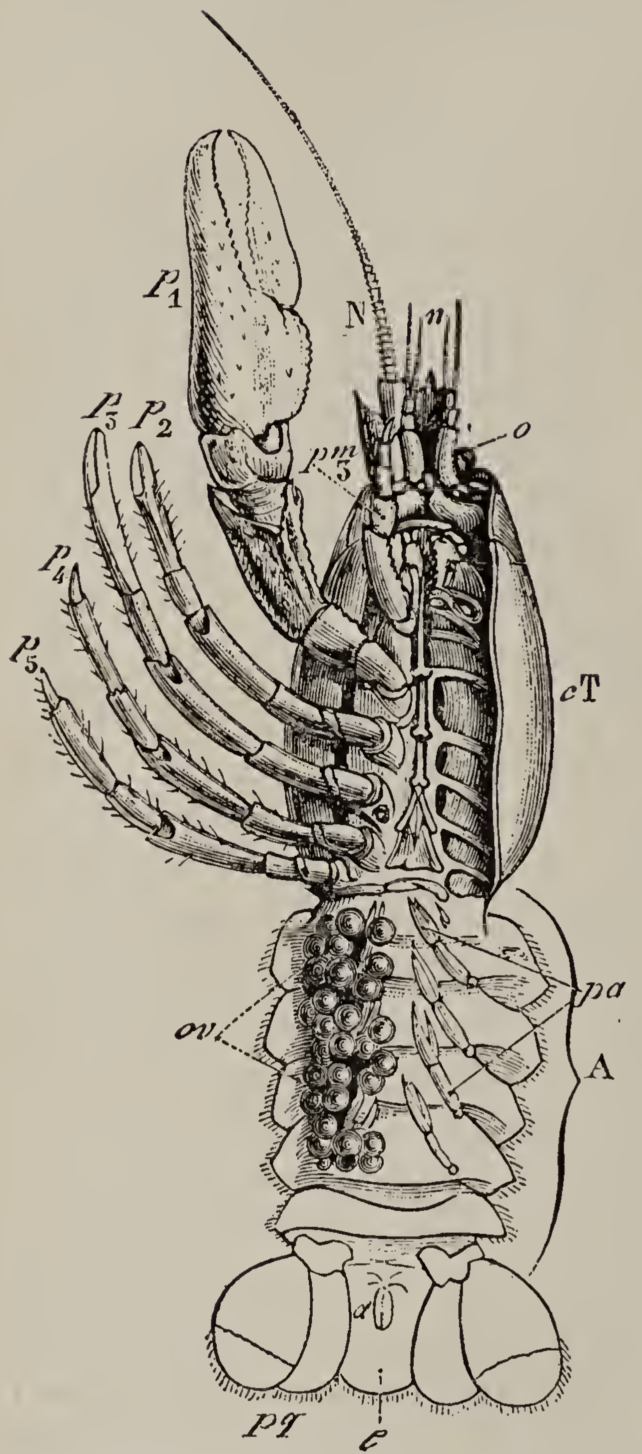
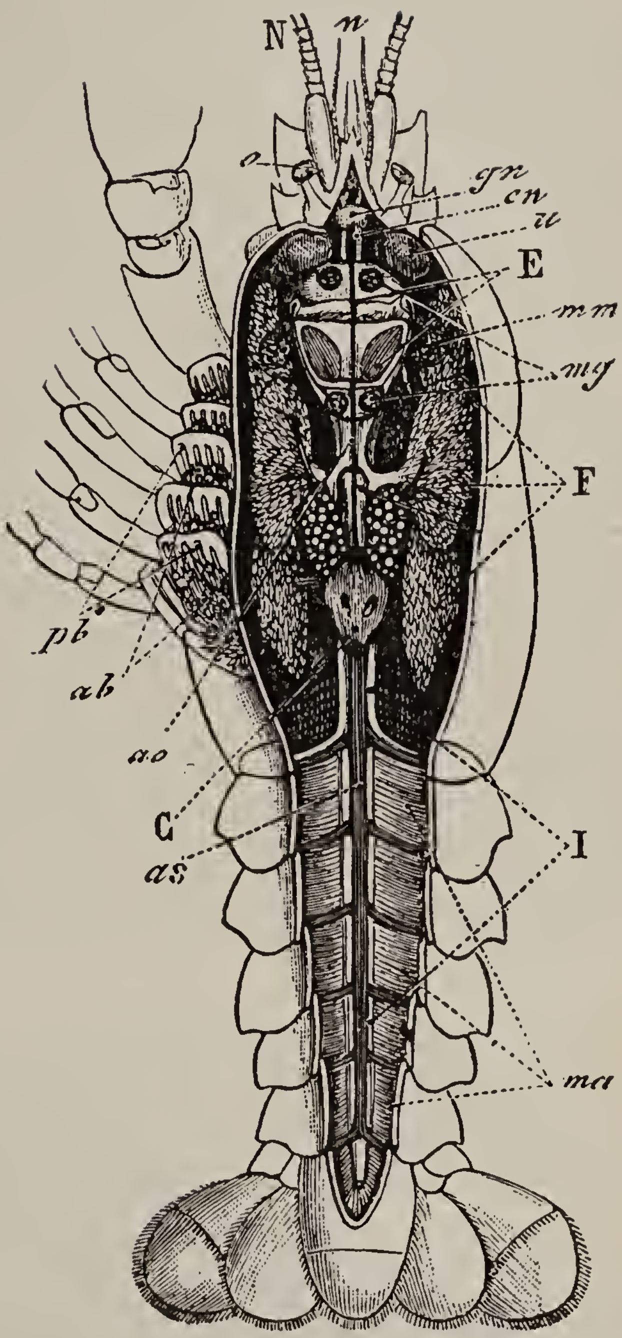
Fig. 72.



Crayfish seen from below (letters have the same significance as in the previous figure). —M, mandibles; pm_3, jaw feet; *ov*, eggs held between the abdominal false feet *pa*.

which it comes as out of a case. The moulting is accompanied by an increase in size. After this has taken place, the new shell remains soft for a certain length of time; then it also gradually becomes hard, and the animal resumes its habitual life. The hardening of the new shell is effected by the aid of a reserve of calcareous matter that the animal secretes in its stomach, in the form of white, calcareous disks, convex on one face, and concave on the other, and formerly used in medicine under the name crab's-eyes or crabstones. When the new carapace is formed, these concretions have disappeared, having been absorbed for the formation of the new shell.

Fig. 73.



Crayfish opened on the back. — *gn*, cerebral ganglion; *cn*, œsophageal ganglia; *u*, green gland; E, stomach; *mm*, muscles; *mg*, stomach teeth; F, liver; C, heart; *as*, posterior aorta; *pb*, *ab*, gills; *ao*, anterior aorta; *ma*, muscles.

On opening a crayfish or a lobster we find that the interior of the head and of the thorax is more or less regularly divided into cavities for the accommodation of the muscles. These divisions are formed by internal processes of the shell that together form a sort of internal skeleton. There are similar processes in the joints of the limbs, where they serve for the attachment of muscles.

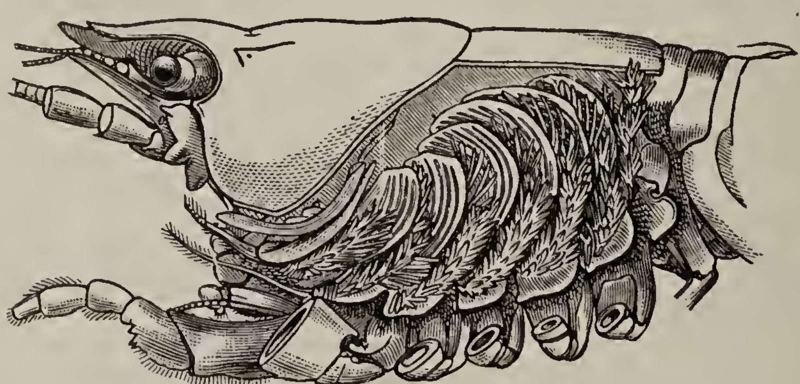
The stomach forms a sort of large pocket, separated from the mouth only by a very short œsophagus. This organ is thus brought forward far into the head. In its posterior half its walls are supported by a solid framework of joints that support three hard tubercles. These notched tubercles project into the stomachic cavity, and are so arranged as to crush the food again just as it passes into the intestine which opens from the bottom of the stomach.

The intestine is a straight tube leading to the posterior end of the body.

The liver is largely developed, and forms two masses of a yellowish color, divided into lobes and lobules on each side of the stomach.

The respiratory apparatus consists of gills or branchiæ that are located under the thoracic carapace, which forms a sort of respiratory chamber on each side, communicating with the exterior by two orifices. One of these openings serves for the admission of water, and is located on the outside between the base of the feet and the edge of the shell; the other is near the mouth, and is employed for the exit of the water. A plate-like appendage of the second pair of jaws moves continually before this orifice, and sets up a current by which water is continually caused to flow through the cavities.

FIG. 74.



GILLS OF CRAYFISH EXPOSED (after Huxley).

The heart is situated just under the carapace of the thorax, and consists of a single fleshy pocket, having six openings, by which the oxygenated blood coming from the gills may penetrate into its cavity. This heart is contained in a sort of sac or sinus that receives directly the blood coming from the gills. The heart then forces the blood it contains into the arterial vessels. These are an **anterior aorta,** for the head, eyes, and other processes, and a **posterior aorta,** which soon divides into a dorsal branch and the ventral branch, and these penetrate into the interior of the organs, and reach the lower surface of the body, where they distribute the blood in front, behind, to the feet, and the neighboring organs. There are no veins; after circulating in the arteries, the blood penetrates into interorganic spaces, sorts of communicating chambers, situated between the organs and the muscles, and thus returns to the gills.

The blood of the crayfish is colorless or somewhat bluish. The nervous system is ganglionic, consisting, as we have seen in the chapter on generalities, of a cerebral ganglion, joined by an œsophageal chain with a double chain of ganglia, extending from one end of the body to the other.

The organs of sense cannot be well understood, excepting the eyes, which are two in number and stalked.

The sense of touch is exercised by the antennæ, and perhaps also by the palps that form part of certain buccal processes.

Crayfish live in fresh water, preferring rocky and shallow streams. They hide under stones and in holes, which they leave rarely except when in search of their food, consisting of mollusks, fish, worms, shreds of rotten flesh, etc. They are very voracious, and gorge themselves with all animal matters coming within their reach.

Crayfish lay eggs which remain attached in clusters to their abdominal false feet. These eggs are developed without undergoing metamorphosis, which is not the case with all crustaceans. The spring or rock lobster, for example, passes through metamorphoses. Before arriving at adult size, the crayfish, crab, and lobster moult a number of times,—at least thirty. During all this time the animal does not change in form; it simply grows larger. While without a hard shell the creature is perfectly helpless, and lies hidden in some crevice.

CHAPTER XV.

The Beetle.

As a representative of the great division of insects, we select one that is known throughout the whole world, and which is far too abundant in many agricultural countries. It is the cockchafer; but almost any beetle would answer as well.

When we examine a beetle we at once notice that the animal as a whole is made up of three distinct parts,—head, thorax, and abdomen. Each of these parts is enclosed in an envelope, consisting of hard, horny substance that forms the external skeleton; under this envelope are attached the muscles, and within it are sustained and protected the soft parts. It is composed of a series of strong rings, joined together edge to edge by the intervention of a more flexible membrane that allows a certain amount of motion. The arrangement of these rings is easily seen on the abdomen of the beetle; in other parts, as the head and thorax, it is less marked. It may, however, be noticed, and the same applies to all insects without exception, that the thorax is composed of three segments,—an anterior, called the **prothorax,** a middle one, the **mesothorax,** and a posterior, the **metathorax.** To each of these is attached a pair of legs.

The head of insects is provided with special organs, called **antennæ**; they are a sort of horns of very variable form, and composed of rings articulated end to end. The antennæ are gifted with great mobility, and most probably serve to enable the creature to recognize by touch the nature of surrounding objects. In the beetle these organs are terminated by a series of superposed plates which unfold like the leaves of a fan.

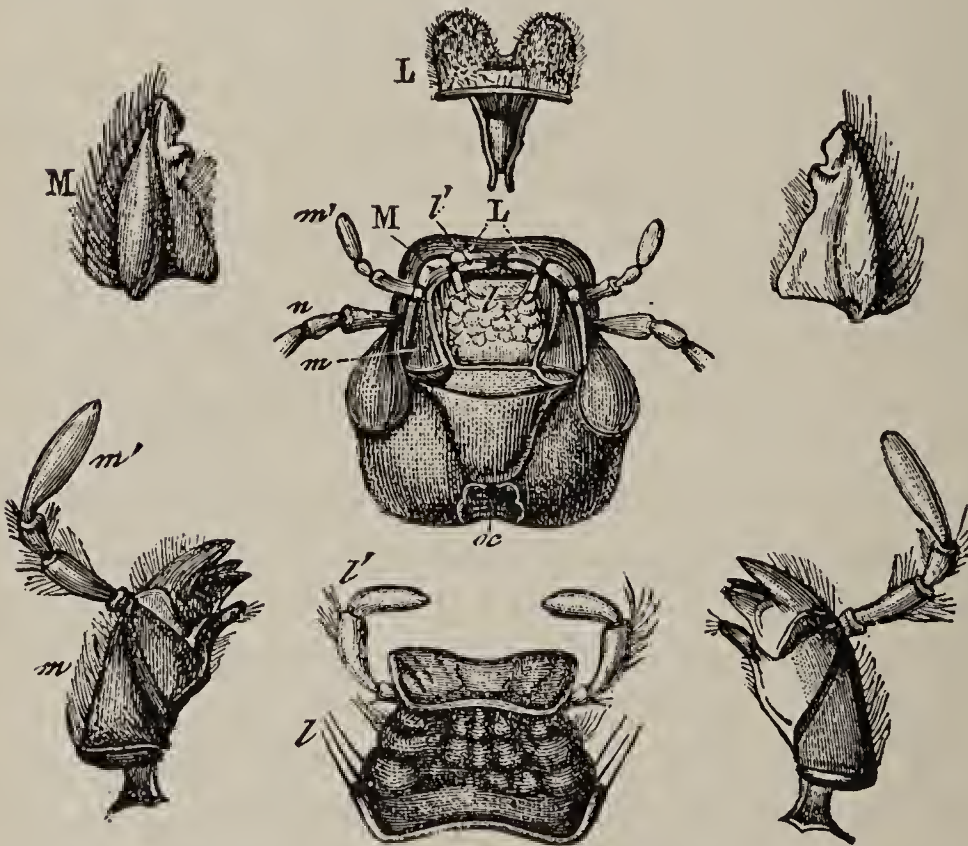
Beside the antennæ and near the mouth are the eyes, which have a structure altogether peculiar. They have no eyelids, and their surface, which is very prominent and bulging, presents the appearance of a hemisphere cut in facettes. On examination with a microscope, or even with a simple magnifying glass, it is found that each facette corresponds to a distinct eye, and that the entire eye is in reality composed of a large number of little eyes placed very close together: sometimes there are several thousand facettes. Independent of these multiple eyes, several species have two or three other eyes, which are simple, and arranged in the form of a triangle in the forehead. These simple eyes are called **ocellæ,** to distinguish them from the compound eyes, composed of facettes, which are the only ones possessed by the beetle.

Underneath the head is the buccal orifice. As in the crustaceans, this orifice is surrounded by modified limbs that are used in mastication by insects that, like the beetle, masticate their food.

We distinguish a pair of mandibles, hard, horny, curved, and sharp, capable of tearing and crushing; then a pair of jaws formed by hairy joints. Each jaw has a palp composed of three joints, and called the maxillary palp.

These two pair of processes are covered above by a plate that prolongs the head in front, and is known as the **labrum.** Underneath the labrum, and consequently below the processes just described, is another plate called the lower lip, or **labium,** which carries a pair of palps known as the **labial** palps.

Fig. 75.

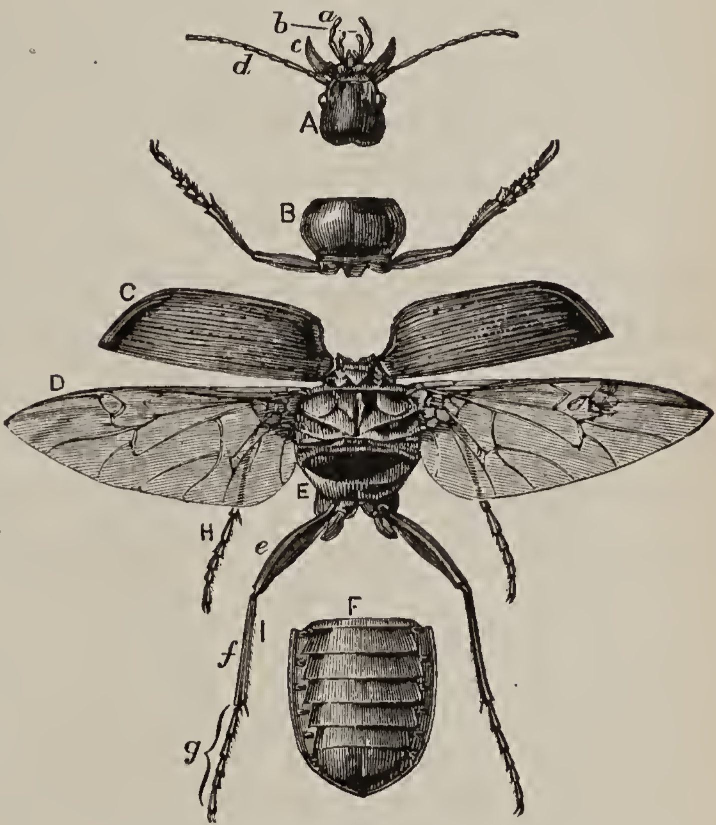


Head of May-bug (the middle figure is the whole head seen from below, while around it are the separate pieces making up the mouth).—L, labrum; M, mandibles; *m*, jaw, with the maxillary palp *m'*; *l*, lower lip, with the labial palp *l'*.

This organization of the mouth is found with very slight differences in all masticating insects; in others, the joints are modified to form a proboscis, either long and coiled in a spiral, as in the butterfly, or short and straight, as in the fly.

We have said that the thorax carries the legs. The beetle has six. The existence of these three pair of legs is a general and distinguishing feature of the order of insects. Each leg is composed of several joints articulated together, which are named, starting from the end next the body, the thigh, the leg, and the tarsus, which terminates in hooks, claws, or other processes, according to the habits of the particular species. Each of these joints is a sort of horny tube, in the interior of which are arranged the motor muscles. The legs of the beetle end in sharp hooks; besides, they are furnished with piercing-points or spines, and this explains why it is difficult to remove a beetle from leaves or stuff to which it is clinging. The formation of the feet enables the insect to maintain itself

FIG. 76.



DISARTICULATED BEETLE.—A, the head; F, the abdomen; between A and F, the three rings of the thorax; *a*, maxillary palps; *b*, labial palps; *c*, mandibles; *d*, antennæ; B, prothorax, with first pair of legs; C, wing-covers or elytra; D, functional wings; H and I, two posterior pair of legs; E, coxa of leg, with projecting trochanter; *e*, femur; *f*, tibia; *g*, tarsal joints.

firmly on leaves and branches from which it would otherwise be shaken by the lightest breeze.

To the thorax are likewise attached the organs by whose aid the beetle transports itself through the air. Some insects, much fewer than the others, have no wings; some, such as the house-fly, have two; others, such as the bee, the dragon-fly, and the beetle, have four. But while the four wings of the dragon-fly are flexible, thin, and transparent like gauze, in the beetle two are hard and horny, and serve only in fact as covers for the other two. The latter are very delicate, very fragile, and much larger, and during repose they are folded up and protected beneath their covers. The hard wings are called **elytra, sheaths,** or **wing-cases.**

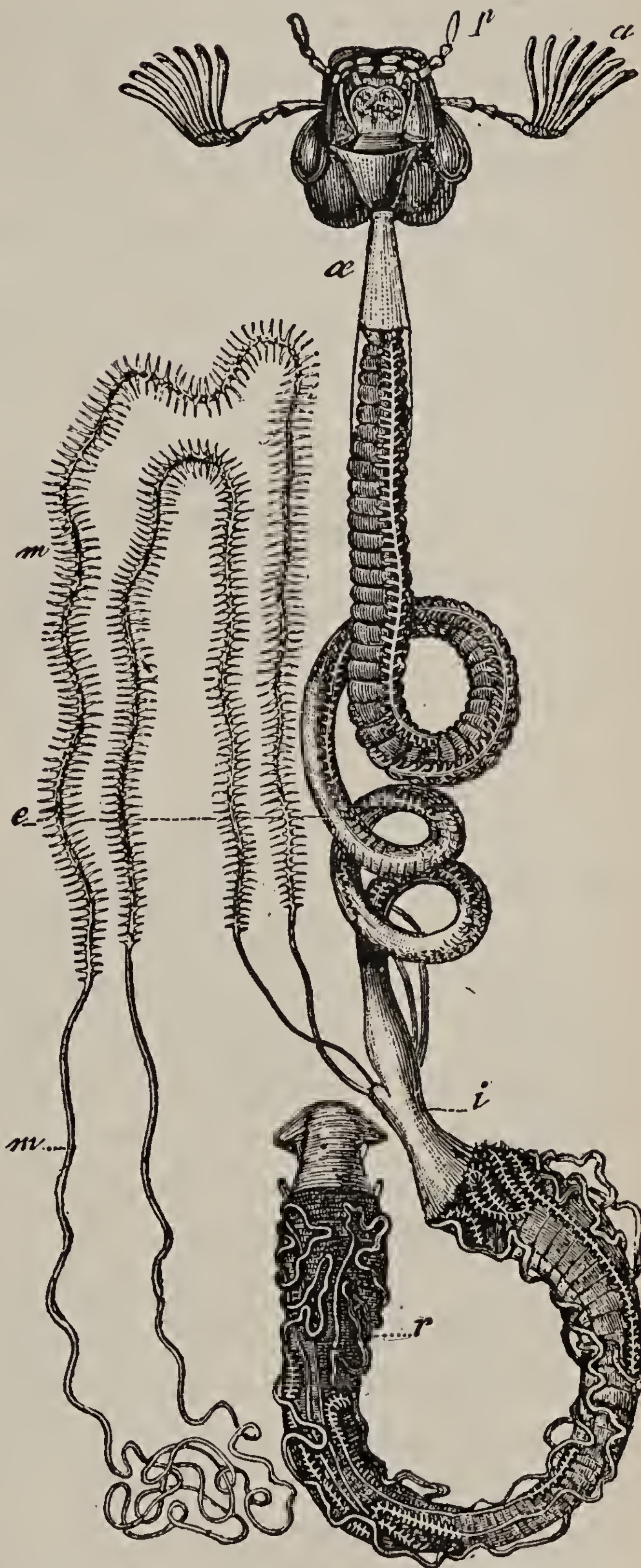
The membranous wings are attached to the mesothorax, and the elytra are fixed to the metathorax. The prothorax is designated more particularly as the **corselet,** and carries only the first pair of legs and the dorsal appendages. This segment is very largely developed in its dorsal part, and forms the greater part of the thorax; the remainder is concealed by the wings.

Insects differ from animals having an interior skeleton not only by the inverse arrangement of their hard and soft parts: the whole organization presents profound modifications which we must study.

The digestive apparatus includes an œsophagus, then an enlargement or gizzard, followed by a stomach studded with pepsin glands. Then comes the intestine, more or less lengthy and coiled. There is no liver; three pair of coiled tubes open into the intestine at its junction with the stomach, and appear to fill at the same time the functions of liver and of urinary apparatus. They are called Malpighian tubes.

The functions of circulation and of respiration are accomplished in insects in the most simple manner. Excepting a movement that is visible in a vessel located in the region of the back, called the dorsal vessel, there is, so to say, no circulation; the blood penetrates into the organs as water soaks into a sponge, and appears to be stagnant in the lacunæ of the tissues. Nevertheless, this blood, like that of man and other higher animals, must be aerated by contact

Fig. 77.



Digestive apparatus of the may-bug.—*a*, antennæ; *p*, maxillary palps; *æ*, œsophagus and craw; *e*, stomach; *i*, intestine; *r*, rectum; *m*, Malpighian tubes. One of these tubes is in its natural position, close to the digestive apparatus; the other has been removed to show its structure.

with the atmosphere; now, as the blood does not circulate, as insects have no lungs nor gills to bring the vital fluid in contact with the air, this contact must take place throughout the whole body of the creature wherever the blood may be, and this is what actually occurs. The segments that compose the external envelope are pierced laterally with small holes called **stigmata,** and these open into little tubes called **tracheæ,** which distribute the air throughout the interior of the organism

FIG. 78.

CIRCULATION OF AN INSECT.—*a*, *c*, *c*, dorsal vessel. The arrows indicate the direction of the blood.

by dividing up into small branches of exceeding fineness that penetrate into all the organs. The walls of the tracheæ are supported by a coiled fibre, and so are always kept open for the free circulation of air.

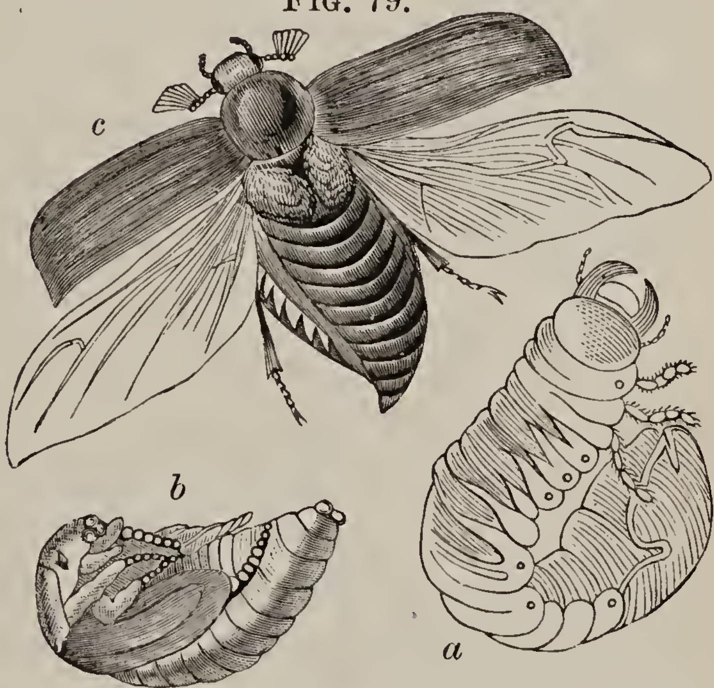
The nervous system is ganglionic, and nothing need be said concerning it more than has been given in Chapter XIII.

To conclude this brief description of insect organization, we must consider one fact that we have noticed as an exception in the division of vertebrates, and which acquires a remarkable generality in the articulates. This is metamorphosis.

Insects lay eggs, usually in large numbers, and these the female, guided by wonderful instinct, deposits in places best adapted for their hatching. After a certain time there bursts from each egg a soft creature, whose form is ordinarily that of a worm. This creature is never winged, often has no feet, and is very different from the insect that gave it birth. It is called a **larva.** It eats, grows, and regularly accomplishes all the acts of its life, but in a manner often strangely different from that observed later, when the same insect has arrived at complete maturity. Thus, the May-bug, which lives in the air, on trees and plants, and which eats leaves, has for its larva a white maggot that lives deep in the ground and feeds on roots.

At the end of a second interval of time, varying according to the species, the larva, after having several times changed its skin, ceases to feed, and becomes motionless; its form becomes obliterated, and the worm becomes a **nymph** or **chrysalis.** While in this condition it begins to show the various parts that characterize the individual when fully developed.

Fig. 79.



Cockchafer (*Melolontha vulgaris*).—*a*, full-grown larva; *b*, pupa; *c*, perfect insect.

At last, at the end of the third lapse of time, the perfect insect appears, and does not long delay in producing eggs which undergo the same series of metamorphoses.

The fecundity of insects is enormous; fortunately, the female of the ordinary beetle lays only thirty or forty eggs, which she deposits in a hole made by herself in the ground, and which she covers with earth. From these eggs come the larvæ, which become perfect insects only after three or four years, and which during this time make great ravages on the roots and subterranean parts of vegetables. In winter the larvæ bury themselves deep in the ground, and pass the cold season in a sort of lethargic sleep. In the spring they come up towards the surface, and if their moment of metamorphosis is come, they appear as beetles in early summer.

During the heat of day the perfect beetles hide under leaves, on which they feed, cutting out as they eat curious and capricious figures; in the evening they begin to move about with a noisy, ill-directed flight. In some years certain varieties of beetles appear in enormous numbers, and devastate the fields of the farmers, leaving them absolutely bare of verdure.

CHAPTER XVI.

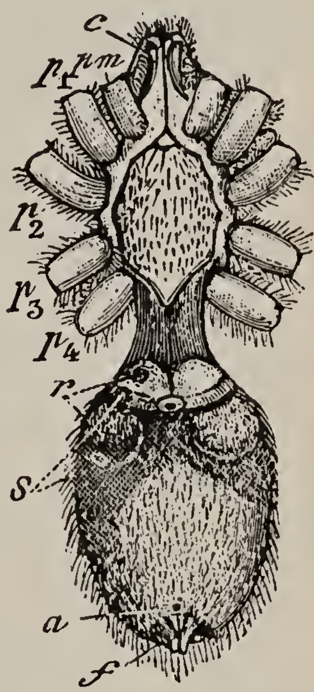
The Spider.

The spider belongs to the class Arachnida, which, like insects and crustaceans, forms part of the division Articulates.

The body of the spider is composed of but two parts, the head and thorax together forming but a single joint, called the **cephalo-thorax.** This joint carries on its dorsal surface a number of simple eyes, variously arranged, according to the species, but always embracing a very large field of vision. Underneath the cephalo-thorax are inserted eight legs, terminated by notched hooks; this number of feet is constant in the spiders, and distinguishes the latter from insects, all of which have six.

The abdomen is attached to the anterior portion of the body by a very thin stalk; it is soft and round. Behind it is furnished with the spinning glands, which form rounded eminences; these are four or six in number, and are pierced with a large number of minute holes opening into internal canals filled with a gummy matter analogous to silk. This matter produces threads of exceeding fineness, for more than a thousand would be required to make the thickness of a human hair. As these threads leave the spinning glands the spider, by the aid of its feet, notched like combs, unites them in a single filament, which it draws out from the point at which it has first attached one end by pressure of the abdomen. With these threads the spider weaves its web, or stretches a bridge from one place to another, or descends to the ground, as it desires. And with the same substance it lines its hiding-place, or makes the silky sac in which it deposits its eggs. The long white fibres sometimes seen floating in the air, and often called

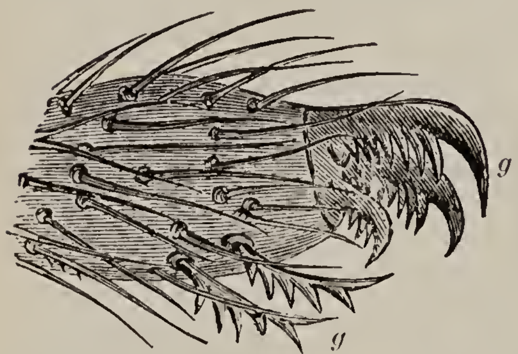
FIG. 80.



SPIDER WITH THE LEGS CUT OFF. The figure shows the union of the head and thorax in one piece, forming the cephalo-thorax. — *c*, chelycera; *pm*, jaws; p_1 to p_4, the four pair of feet; *r*, respiratory sacs; *s*, stigmata; *a*, anus; *f*, spinners.

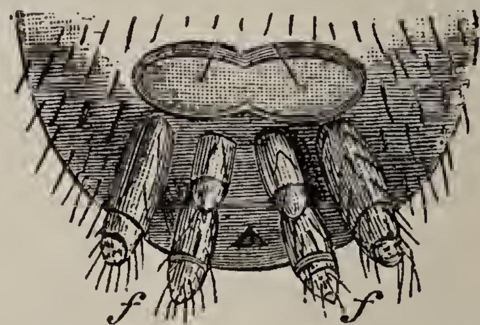
gossamer threads, are only the *débris* of innumerable webs woven during the summer by spiders, with which the country places are filled. The webs are broken up by

Fig. 81.



Much-enlarged spider's foot, showing the toothed claws, *g g*.

Fig. 82.



Extremity of a spider's abdomen, enlarged to show the spinning apparatus, *f f*.

the winds and scattered broadcast, and often in their folds carry off the creature that has woven them.

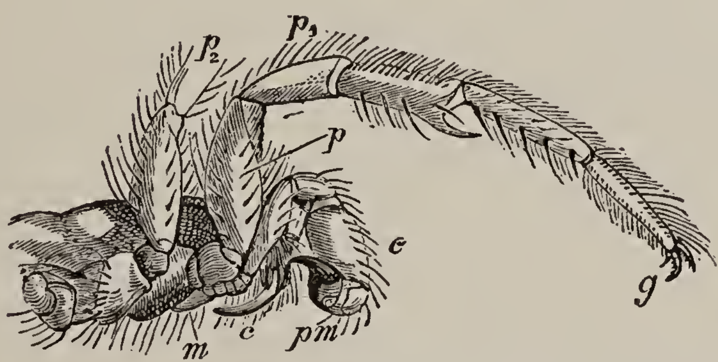
All spiders are spinners, but all do not weave webs. Some of them simply line their homes with a sort of wadding, and, hidden in the hole of a wall, or behind a clump of earth, remain in ambush, motionless and patient, waiting until some prey comes within their reach; they then like a flash spring out with the impetuosity and the ferocity of a tiger, and use their web to tie up and paralyze their victim.

Those that construct webs do not all work in the same manner. Some weave a sort of circular net-work, of which certain lines form rays from the centre to the circumference, while other finer ones hold them together; these are closer and closer towards the centre. Others select the angle of a wall, in which they arrange a horizontal, triangular web, closely woven together; they then live in a cylindrical canal placed at one of the angles, and throw out isolated threads, connecting their lair with the edges of the trap; in this case, as soon as an unfortunate fly touches the web the scarcely-perceptible shock is communicated by the conducting threads to the spider, who rushes out and strangles his prey by enveloping it with new threads, at the same time paralyzing it by the thrust of a poisonous dart with which the end of his jaw is armed. Then he fixes himself on his immobile victim, sucking the juices and humors, and abandoning the cadaver only when it is reduced to a dry and empty shell.

Spiders eat their kind: two of these creatures put together begin a mortal combat, and the vanquished is eaten by the victor. This natural ferocity has been the cause of the failure of all efforts to raise colonies of spiders, efforts undertaken with the object of utilizing their silky secretion, which is analogous to that of the silk-worm.

The buccal apparatus of the spider is very powerful;

FIG. 83.

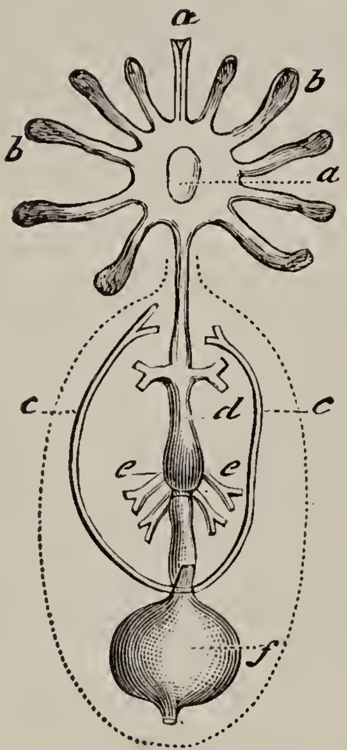


CEPHALO-THORAX OF SPIDER, FROM THE SIDE.—*c*, claws; *pm*, jaws; p_1, p_2, the first two feet; *g*, hooks.

it consists of a pair of mandibles or forceps having two joints. The upper one is a sharp hook, very hard, and having near its point a hole for the projection of a poisonous liquid secreted by a gland situated at the base of the organ. A pair of jaw-feet with six joints completes the buccal apparatus.

The digestive apparatus consists of a narrow, cylindrical œsophagus, opening into a large pocket, which empties into a second stomach that is followed by the intestine.

FIG 84.



DIGESTIVE APPARATUS OF SPIDER.—œ, œsophagus; *a*, stomach; *b*, ramifications of the stomach; *d*, intestines; *e*, glandular tubes; *f*, rectum; *c*, urinary canals.

Respiration is effected by means of tracheæ, some of which are so enlarged as to form a kind of lungs, and hence the respiration of spiders is sometimes called pneumotrachean, to distinguish them from other arachnida whose respiration is purely trachean, like that of insects.

The circulation, as in insects, is accomplished by means of a dorsal vessel that supplies the arteries, the venous blood circulating in interorganic lacunæ.

The nervous system of the arachnida consists of two ganglionic masses, a cephalic ganglion, situated above the œsophagus, and a thoracic ganglion, placed below it. The latter represents the thoracic and abdominal ganglia joined in one, and sends nerves to the legs and to the abdomen. This coalescence of ganglia occurs in some crustaceans and also in some insects; it is not characteristic of spiders.

Spiders reproduce their species by means of eggs, from which the young creatures are hatched directly without metamorphosis. The eggs are deposited in a delicate soft sac spun by the female spider, and remain enclosed in this until the hatching. Spiders that spin webs fasten this sac to their dwellings, while migratory spiders attach it to their abdomens and carry it around with them. The hatching occurs in about a fortnight, and the mother provides for her young until they are able to take care of themselves; then she abandons them. When once the family bonds are broken, brothers and sisters have no mercy one for the other, nor would they receive any from the mother who has reared them.

The species of spiders are very numerous, and the bites of very few of them produce any alarming symptoms. Among those whose bites appear dangerous most prominent is the tarantula of the West Indies, whose poison generally produces grave symptoms. The bite of other spiders may occasion some swelling of the part bitten, but usually there is no general intoxication. The domestic spiders that make their homes in our dwellings usually select a corner between the ceiling and the walls; they prefer stables, the only places in which they appear to render service to men by diminishing the number of insects that annoy cattle; the spiders that infest cellars are like the preceding. Then we have the field-spiders that weave their nets in meadows and live in silk-lined holes; those that make between two branches of a tree or bush vertical webs in very regular, circular, or polygonal forms, and live in the centre; lastly, the wolf-

FIG. 85.

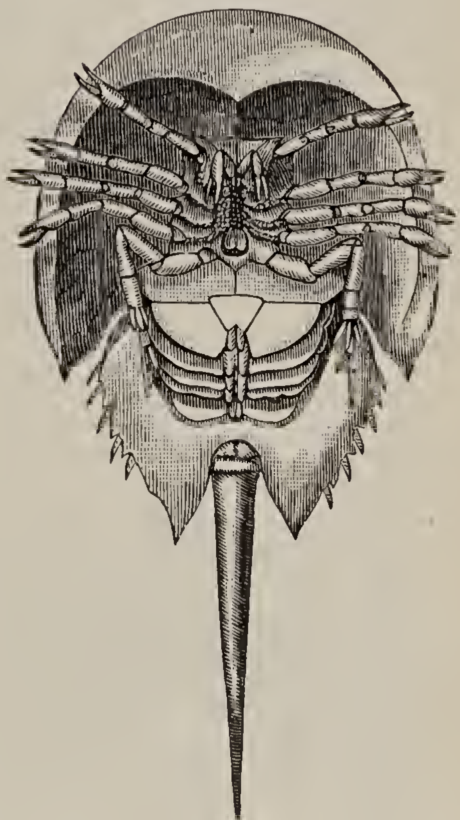
COMMON SPIDER.

like spiders that hold themselves in ambush, jumping out on their prey as it passes, or even chasing it in its flight.

Two species—the trap-door spider and the water-spider—are particularly curious in their habits, exercising great ingenuity in the construction of their homes. The trap-door spider is found in Africa, Italy, and the south of France; its form is much like that of the common spider. It digs in a dry and sloping soil a cylindrical hole from four to twelve inches deep, which it lines with a soft coating of silk, and makes the entrance as round as if it were traced with a compass. It then makes a thin but strong and regular cover of clay, which it fixes to one edge of its hole by means of an elastic hinge which allows the door to be raised but at once closes it again. The outside of the door is rough and irregular, and cannot be distinguished from the surrounding earth; the inside is smooth, excepting a few small notches on the edge opposite the hinge. If we try to lift the door of a hole containing a trap-door spider, we feel a strong resistance, sometimes so great as to make the raising of the door a matter of considerable difficulty. After having gently opened the door we see that the little creature has put the hooks of two of his legs in the small notches we have mentioned, and with the other feet is clinging to the walls of his tube, and that it is he who has been holding shut the door.

The water-spider, although it can live under water, possesses, like all other arachnida, aerial respiration, and it procures its supply of air in an interesting manner. Coming to the surface of the water it puts out its abdomen, which is covered with a sticky, greasy matter, then, suddenly plunging in, it carries down a bubble of air that it disengages under the leaf of some aquatic plant, and weaves around the bubble a tissue that keeps it from moving away; the spider then goes up and gets another bubble in the same manner, brings it down, and adds it to the first. By repeating these operations enough air is collected to last some time, and the little creature now encloses the whole in a closely-woven net, and weaves for itself a chamber as large as a walnut, having an opening below for ingress and egress. The water-spider is carnivorous, like all other spiders, and feeds indifferently on terrestrial and aquatic insects; when it has seized a prey, the latter is attached to a thread and dragged into the den for consumption at leisure. The water-spider is found in most calm and stagnant waters.

Fig. 86.



Under surface of a king-crab (*Limulus polyphemus*).

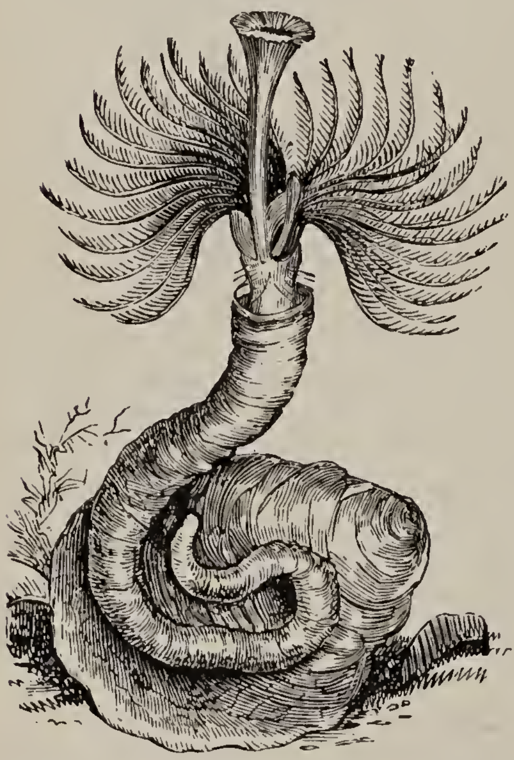
The largest of the arachnida is the marine species, called the **king-crab**; it is common on our Atlantic coasts.

CHAPTER XVII.

Worms—Parasites—General Character of Anarthropoda.

UNDER the name **worms** or **annelides** are designated creatures of a class that resembles the articulates, because the bodies of its members are composed of rings joined end to end and movable one on the other; but the anarthropoda differ from the articulates in that they never have limbs composed of articulated joints. Many of them have no limbs whatever, and when such appendages are present, they are reduced to simple rounded prominences carrying stiff hairs, called **cirri**.

FIG. 87.



SERPULA CONTORTUPLICATA (with expanded gills) on the back of an oyster-shell.

The order of anarthropoda includes two important classes, the **worms** and the parasites or **entozoa**.

WORMS.

Most species of worms have red blood; their respiration is either branchial or cutaneous. Their apparatus of locomotion consists sometimes of **cirri** variously grouped on fleshy tubercles, sometimes of short ventral hairs, sometimes of suckers.

Those worms furnished with hair form the order **setigera** or **chetopoda,** while the others are called **asetigerous** or **apoda.**

Among the setigerous worms are some that live in tubes that they construct; they are the **tubicolæ;** others, that have no regular holes, are called wandering worms.

The tubicolate annelidans inhabit the strong tubes that are often found covering rocks, stones, and other submarine masses; among them the most common is the serpula; their tubes are found in great numbers on the shells of scallops, and if one of these shells, freshly taken from the sea, be immersed in salt water, the creatures come out of their tubes and spread out their gills like fan-shaped crests, red or blue in color, and having branches of exceeding delicacy.

Fig. 88.

Lobworm (*Areni-col. piscatorum*).

The **lobworm,** which is a type of the wandering species, lives in the sand of rivers, and is used as bait in fishing.

Earthworms are the only annelides that are not aquatic. They live in moist soils, feeding on animal and vegetable *débris;* they sometimes appear to render important service to agriculture by breaking up and rendering porous soils that are too compact because of a large proportion of clay. Earthworms have no gills, and respire through their skin; they are thus distinguished from the lobworms and tubicolidæ, both of which have gills. They have very short hairs on the ventral surface, but they use these hairs in locomotion, and must therefore be classed as setigera.

The leech, on the contrary, has neither bristles nor hairs, but at each end of its body is a sucker, by which locomotion is accomplished. The mouth is situated at the bottom of the anterior sucker; it has three little triangular jaws, each armed with two rows of sharp teeth, that can cut through the human skin and that of other animals, leaving a Y-shaped incision. There are several species of leeches; all are carnivorous, and several are used in medicine, the most valuable being known as the medicinal leech. To supply the demand for leeches, these annelides are now bred in large numbers in artificial ponds, where they can find conditions favorable to their multiplication.

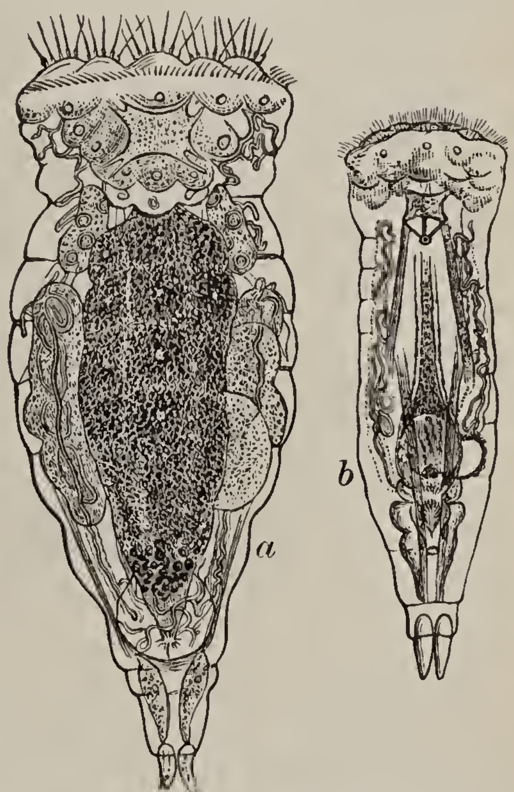
FIG. 89.

THE MEDICINAL LEECH (*Hirudo medicinalis*).

The manner of nutrition of the leech requires in the structure of its digestive apparatus profound modifications of the similar organs that we have thus far examined. The simple tube that exists in nearly all worms is replaced by a series of eleven pockets or chambers, spread out on the sides and communicating successively with one another; the intestine terminates on the back at the base of the posterior sucker; in these chambers the creature stores the blood which it takes in at its anterior sucker. Like all worms, the leech is made up of rings, of which it has ninety-five. Powerful muscles are attached to the skin, and enable it to contract with great force. It then takes the form of an olive, while when the muscles are relaxed it stretches out like a long ribbon.

As in all worms, the nervous system consists of a ganglionic chain united by an œsophageal band with a bilobar anterior ganglion. The eyes are ten in number, being ocular points situated on the upper lip.

Fig. 90.



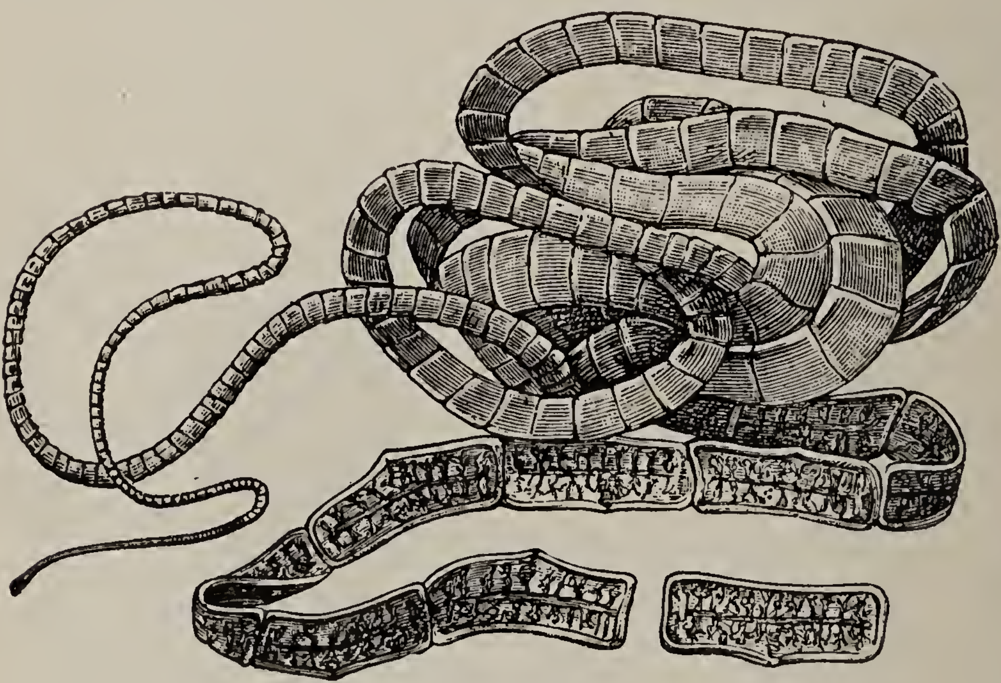
Hydatina seuta (*Rotifera*, Hudson and Gosse).—*a*, female, dorsal view; *b*, male, ditto.

Certain creatures that were long considered to be **infusoria** are properly considered among the worms: they are the **rotatoria.** These are microscopic creatures, furnished in front with two or more ciliary lobes. Cilia are a sort of very fine hairs animated with a continual motion, which, however, can be arrested at the will of the animal; the movements of the cilia are called **vibratile movements.** These creatures can support a state of great desiccation and also, after drying, a tolerably high temperature, and yet, when a proper degree of moisture is restored to them, they again become endowed with the functions of life.

PARASITIC WORMS OR HELMINTHES.

Under this heading are classed the intestinal worms formerly considered as zoophytes, but which certainly present much greater analogies with the anarthropoda. Their bodies are composed of rings, or rather segments, arranged in linear series. They have no organs of

FIG. 91.



TAPE-WORM.

locomotion, and sometimes no digestive apparatus, in the latter cases they absorb through the skin the juices with which they nourish themselves; they also respire by the skin, for there is no special respiratory apparatus. Intestinal worms are divided into three classes:

1. Ribbon-like worms, or **cestoidea.**
2. Round worms, or **nematoidea.**
3. Flat worms, or **trematoidea.**

1. The **cestoidea**, which include the **tæniæ** or tape-worms and the **bothriocephalus**, may in the adult stage reach a very great length, at the same time keeping a very narrow width. Thus the **tænia solium**, the common tape-worm, is sometimes a hundred yards in length; it then presents the appearance of a long ribbon formed of numerous rectangular segments, somewhat longer than they are wide, and joined end to end. Each of these segments contains male and female organs, and may be considered as an individual, while the whole worm is regarded as a colony of individuals arranged in a chain.

Fig. 92.

Head of tape-worm, enlarged. — c, hooks; u, air-holes; S, first segments.

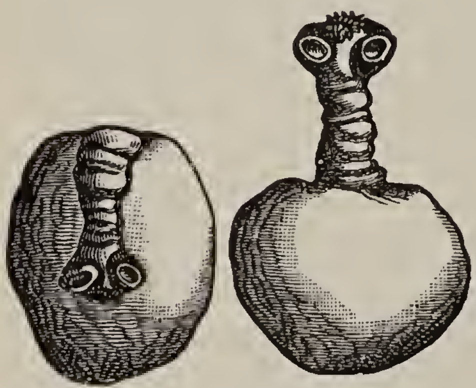
However this may be, the first segments are much smaller, and are more closely pressed together, forming a sort of neck, at the end of which appears what is called the head, a small swelling that is not as large as the head of a pin, and that carries a double crown of thirty-two hooks and four suckers, arranged like a cross. The hooks and suckers enable the creature to fix itself firmly to the walls of the intestine in which it lives.

The tænia has no digestive apparatus. The only ones of its organs that have been studied with definite results are those of the sexual apparatus. A large number of eggs are produced, and when a segment is ripe it becomes detached and is carried out of the intestine.

We have said that the tape-worm lives as a parasite in the intestines of man, and it is by eating measly pork that man acquires the unwelcome guest. In order to understand this indirect transmission, we must understand the mode of development of the creature, which undergoes metamorphoses that are quite complicated.

The eggs, after having been expelled from the intestine with the matured segment, are carried by the rains into dung-hills and feeding-troughs, where they are swallowed by the pig, which animal we know is not delicate in the selection of its food. There the egg, which had begun to develop, gives birth to a sort of larva having six little hooks. By the aid of these hooks the embryo perforates the intestinal wall of the pig, and migrates into the muscles and cellular tissue; here it becomes encysted,—that is, completely enveloped by a membrane. It loses its hooks, but soon on the wall of the cyst appears a little bud, which is a head with hooks and suckers, and there thus exist in the flesh of such pork little sacs or cysts containing a stalked head fixed to the wall of the sac.

FIG. 93.



BLADDER-WORM.

This form of the tape-worm is called the **cysticercus** or **bladder-worm.** It remains in its fleshy enclosure without further development; but when the pig is killed and its flesh eaten by man, the cysticercus arrives in new surroundings, throws off its envelope, fixes itself to the intestine by its head and hooks, and in a few weeks produces a long chain of joints. The creature is now an adult.

Here, then, is a parasite that to attain complete maturity must pass through two different stages in two different animals. This mode of development is quite frequent in animal parasites. For the development of each of these forms, embryonic and adult, a particular field is required. The process is parasitic transmigration.

2. **Nematoidea.**—The parasitic worms of this class are more or less thread-like.

The **hair-worm** or **dracunculus** is an example. This is a sort of long thread-like creature which penetrates under the skin, and produces symptoms of less or greater gravity. It is viviparous, and in this respect resembles the **trichina spiralis,** a small filiform worm that produces the disease known as **trichinosis,** that is communicated to man by the pig. In the embryonic state the trichina inhabits the muscles of the pig, so much so that the infected flesh is literally crowded with them. Under the microscope the parasite appears as a little worm coiled in a spiral in a little sac or cyst. When man eats such flesh the young trichinæ are developed in his intestine, and thousands of these creatures perforate the intestines and pass into the muscles. Trichinosis is a dangerous disease, very common in sections of countries where raw pork is eaten. The trichina is destroyed by thorough cooking.

The other nematoidea are all oviparous. Such are, for example, the pin-worms or seat-worms of children, the oxyurus vermicularis, that inhabits the rectum, the ascarides that live in the small intestine, etc.

3. **Trematoidea.**—Under this title are considered those worms that are flattened in the form of a heart or leaf, and that are generally known as **gourd-worms.** Their digestive apparatus usually consists of two branching tubes. Two suckers, one oral and one ventral, serve to fix the creature in position. These parasites pass through various stages in the course of their development. They have been found in the kidneys and in the liver of man, and they are not uncommon in cattle.

It must not be thought that worms are the only species that live as parasites. Parasitic animals are found among insects, such as lice, fleas, etc.; among spiders, as the ascaris or itch parasite; and among crustaceans. Parasitism is only the condition of a certain number of creatures incapable of supplying their own wants. We will return to the subject when considering animals injurious to man.

We will now resume the generalities on the organization of annelida in the following table, which indicates the different groups:

Nervous System.	ganglionic; well developed.			Annelides.
	rudimentary	non-parasitic: mouth furnished with vibratile cilia.		Rotatoria.
		parasitic; no cilia; 3 forms	ribbon-like.	Cestoidea.
			cylindrical.	Nematoidea.
			flattened.	Trematoidea.

CHAPTER XVIII.

General Ideas concerning Mollusks.

The mollusks have no internal skeleton like the vertebrates, nor an external skeleton formed by a hardening of the skin, as in a large number of articulates and arthropodæ; this is indicated by the name mollusk, which means soft animals. Most of them are, however, provided with a shell, which serves for protection, and represents a sort of skeleton.

The shell is either **univalve** or **bivalve** as it is composed of one or two pieces. Whatever its form may be, it is always a product of secretion of the skin.

The skin forms around the bodies of mollusks an envelope that is usually largely extended at one part, and folded on itself, and this arrangement is called the **mantle.**

When we examine a bivalve shell, that of the oyster, for example, we find that each half is formed of a number of layers, which are wider as they are closer to the interior. The external layers are the older, and as the oyster grows larger it extends the internal surface of its dwelling. In the shell of the snail, which is univalve, the effect of growth is to increase the number of turns of the spiral. When the shell is bivalve the two halves are held apart by the action of the ligaments that form the hinge; they are tightly pressed together by the contraction of two muscles. The only opening of univalve shells is generally closed by a small mobile disk called the **operculum.**

In certain species the shell is so small that it can be of no apparent use. In others there is no external shell, but there is then often an internal calcareous piece analogous to what is called cuttle-fish bone.

Most of the mollusks have the power of movement; a large number of them, however, live fixed to rocks and other submerged masses, to which they adhere sometimes by the aid of a fleshy foot, sometimes by filaments that develop on the external surface of the shell.

The organs that serve the functions of digestion, circulation, respiration, and relation, show in the mollusks a great variety of form. Yet certain peculiarities are sufficiently characteristic to be mentioned.

The digestive tube, composed of a canal having more or less numerous pockets in its course, according to the species, is always arranged somewhat or entirely in the form of a U,—that is, the two extreme orifices are quite close to each other. Besides, the relations of the intestine with the heart are very intimate, and often the heart straddles the intestine. The liver is very large.

The heart is arterial,—that is, it is traversed by red blood, and there are arterial vessels and venous vessels. However, there are no capillaries, these being replaced by lacunæ between the organs and in the muscles.

The respiratory organs differ both in their structure, their form, and their arrangement. We must note in a general manner that they are placed under the mantle, which forms a respiratory chamber designed to contain either air or water. Ordinarily respiration is aquatic, and is effected by gills usually located on the exterior; however, in certain mollusks, naked snails for example, it is aerial, and has for its seat an interior cavity that has been compared to the lungs. It is a curious fact that among the pulmonary mollusks several species are aquatic. The latter, like the corresponding members of the insect class, are obliged to seek frequently the surface of the water for a supply of air.

Fig. 94.

Nervous system of a mollusk.—1, œsophageal chain; 2 and 3, ganglia.

The nervous system always presents an œsophageal collar, joining the cerebral ganglions with those situated in the foot, in the base of the gills, or in the mouth; but the latter ganglia are not united in a chain or linear series as in the anarthropods.

All mollusks are oviparous.

We cannot go into detail on the classification of mollusks. The division includes six orders, of which only three—the cephalopods, the gasteropods, and the acephalans—are worthy of our special notice.

CEPHALOPODS.

Cephalopods have a well-defined head, generally surrounded by a number of **tentacles,** which are large, fleshy arms, serving both for locomotion and prehension.

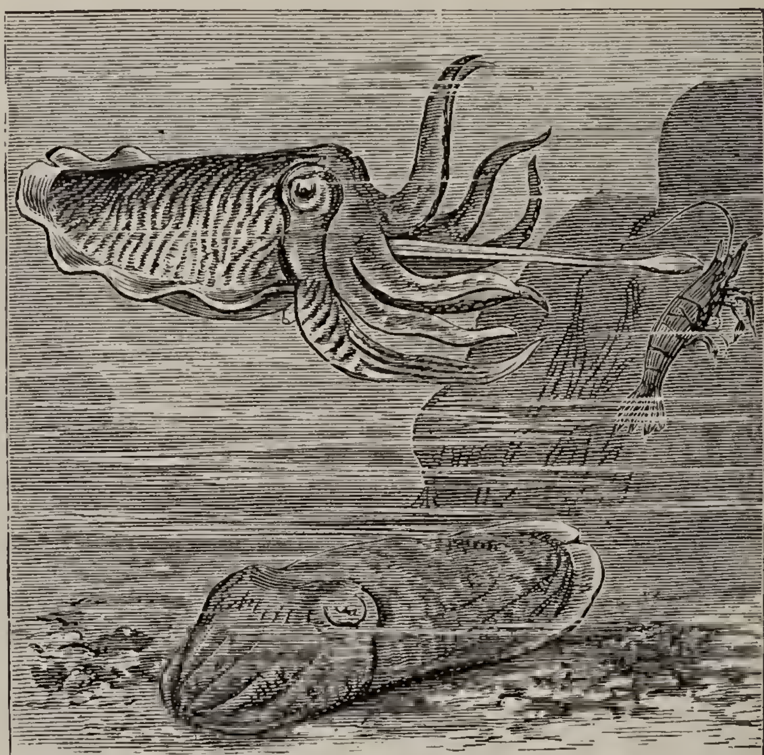
FIG. 95.

COMMON OCTOPUS (*Octopus vulgaris*).

In these animals, which are the most perfect of the mollusks, two large, contractile venous sinuses force the blood into the gills, which occupy the bottom of the respiratory chamber formed by the mantle. In the calamary or squid, the cuttle-fish, the poulp, etc., there is near the anus the orifice of a gland called the "inkbag," that produces a black liquid from which the artists' color, **sepia**, was formerly prepared.

Cephalopods have been classified in two groups, according to the number of gills. The dibranchial are those that have two gills, like the **argonaut**, the **sepia**, and the **squid**. The tetrabranchial have four gills, and are now represented only by the genus **nautilus**, which was

FIG. 96.



CUTTLE-FISH (*Sepia officinalis*), swimming and at rest.

very abundant in geologic ages; the **ammonites**, now found only as fossils, belong to this group.

Cephalopods all live in the sea; we can mention only the squids and the cuttle-fish.

Squids are abundant on the Atlantic coast. By the aid of their eight strong arms, which are furnished with suckers, they swim in the water or climb over the rocks. Those which are seen usually are rather small, but out at sea some have been encountered that weighed as much as two tons. In Greece and in Italy the flesh of squids is eaten, but it is very tough and dry.

Cuttle-fish are common in all seas; they are very voracious, living on fish and crustaceans. Like many other cephalopods, they have the power of throwing out an inky liquid that darkens the water and allows them to escape from pursuers. The **cuttle-fish bones** of the drug-store are the calcareous remains of the bodies of the cuttle-fish; they are used as polishing stones, and are given to cage-birds, both to furnish calcareous matter and to enable them to sharpen their beaks.

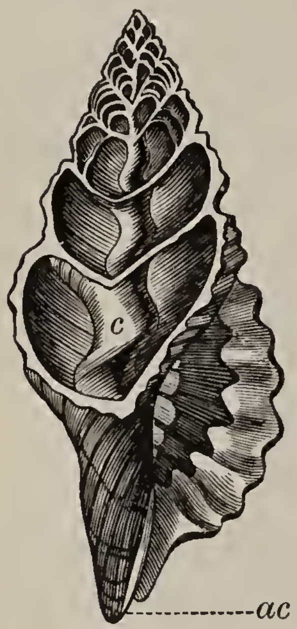
GASTEROPODS.

The gasteropods climb about by the aid of a fleshy disk with which the inferior surface of the body is provided, and which sometimes has the form of a fin. The head is always visible outside of the mantle, and has above the mouth tentacles that appear to be organs of sensation; these tentacles are sometimes furnished with eyes.

Some gasteropods are naked, but most of them have a univalve shell in which the body may be more or less completely enclosed. The form of this shell presents infinite variation: sometimes it is a straight cone, but more often it is curved and rolled up on itself several times, forming a spiral. It is said to be **discoid** when the spiral is in one plane, and **turbinated** when the coils are piled on one another. In some cases the coils are independent and not contiguous; but in most cases they are exactly fitted one on another, so that the central axis is occupied by a sort of twisted column.

The species of gasteropods are very numerous. Nearly all are aquatic, some living in fresh, others in salt water. In some the respiratory organs are analogous to lungs; in others they are gills, which are situated sometimes internally, sometimes externally.

Fig. 97.



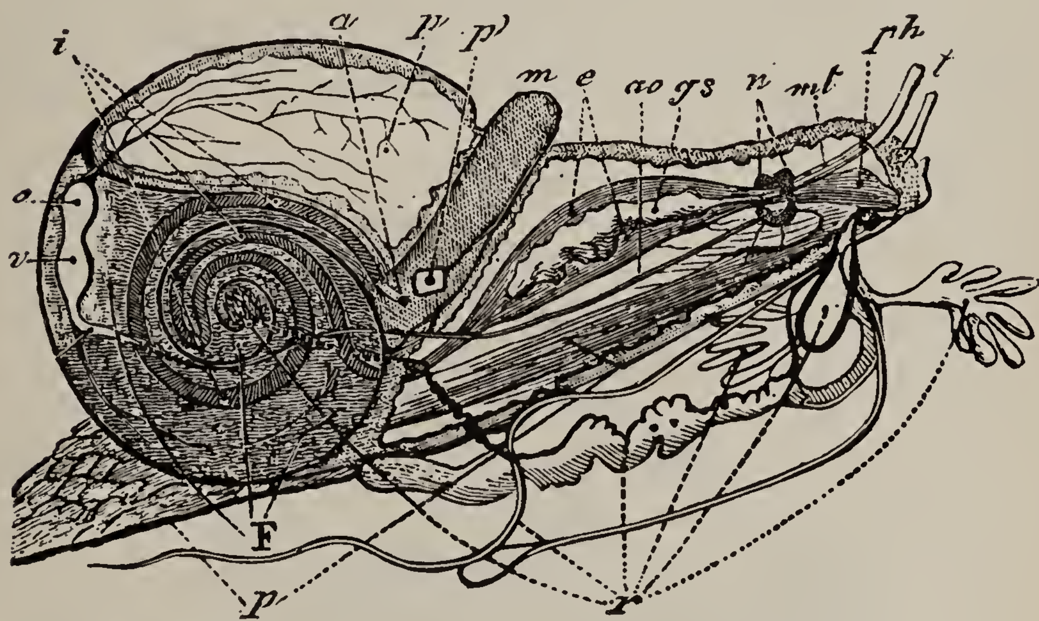
Section of triton-shell (after Owen).—*ac*, notch for siphon; *c*, axis or columella.

Among the gasteropods having lungs, the more important are the edible snails or **helixes,** the slugs or naked snails, and the various pond snails. Of the latter, two very small species, the **limnæa** and the **planorbis,** abound in stagnant waters; the former have conical shells, while those of the latter are discoid. Edible snails are found in all quarters of the globe; they live on leaves and fruits, and, although their mouth has but a single tooth, they can do great damage in vegetable gardens. Their use as food was for a long time restricted to very limited districts, but they are now much sought for the table. The most highly-esteemed species is the vineyard snail, having a russet color, with paler stripes, and commonly found in vineyards. The slugs having a viscous skin and a repulsive appearance are quite as destructive as the edible snails. The most common species are the red snail, found in the woods, the cellar snail, and the black snail.

The gasteropods having gills can only be mentioned for the varied and often very singular appearance of their shells. Among them may be named the **top,** the **bubble, pouch, boatman, hatchet, dolphin,** all named from their curious forms, and the various **limpets.** Under the name

cowry, a small species of **porcelain** shell is used in Africa and India as money. Some shells are made up of layers having different colors, and are used to make large cameos. Others, whose interiors are lined with a layer having brilliant pearly reflections, furnish the mother-of-pearl of commerce. It is probable that the famous Tyrian purple was manufactured from certain of these colored shells.

FIG. 98.



EDIBLE SNAIL (the shell has been removed, and the animal opened through the back).—*t*, tentacles; *ph*, œsophagus; *mt*, muscles of the tentacles; *n*, œsophageal ganglia; *gs*, salivary gland; *e*, stomach; *ao*, anterior aorta; *m*, mucous gland; *pp′*, lung and its orifice, *a*; *i*, intestine; *o*, auricle; *v*, ventricle; F, liver; *p*, foot; *r*, oviduct.

To study the internal organization of the gasteropods we may select the common edible snail. After having removed the shell and cut the creature open, we find a stomach with salivary glands, and a large liver occupying the posterior portion. The heart is to the left, and may be seen to beat by cutting a rather large window in the shell of a snail. The egg-passage or **oviduct** may be distinguished by its twisted condition. The respiratory apparatus is a sort of lung consisting of a respiratory chamber whose ceiling is traversed by canals filled with blood.

ACEPHALANS.

The acephalans have no distinct heads; the mouth is always hidden at the bottom of the mantle or in its folds; the gills are striated leaves; the lower part of the body is ordinarily elongated into a sort of fleshy foot. The shell consists of two valves articulated by a hinge. All these mollusks are aquatic, and most of them inhabit

FIG. 99.

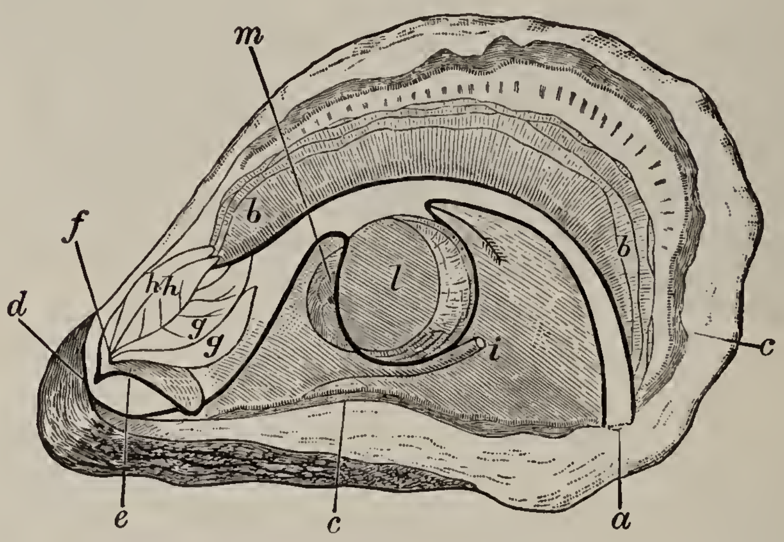


DIAGRAM OF INTERNAL STRUCTURE OF OYSTER (the dorsal surface is downward, the anterior or head end to the left).—*a*, region where water enters and leaves the animal; the dark lines indicate where one mantle-flap has been cut away to expose the other structures; *b*, gills; *c*, margin of one of the mantle-folds; *d*, anterior part of hinge; *e*, hood over mouth; *f*, position of mouth; *gh*, labial palps; *i*, end of intestine; *l*, the closing muscle of the shell; *m*, position of the heart.

the sea. Many, like the oyster, remain firmly fixed on a rocky moorage; others drag themselves over the muddy bottom. The class includes an immense variety of species, among which we will only mention the **oyster, clam, mussel,** and **teredo.**

Oysters live in salt and brackish water, not far from shore, and at but little depth. They flourish especially in calm bays and the mouths of rivers. The often very extensive colonies that they form on rocks are called oyster-beds or banks, and from these they are taken by the oyster fisherman by the aid of scoops or drags.

The **pearl oyster** is celebrated for the pearly lining of its shell and for the pearls found enclosed between the shells. The pearls are produced by the ordinary shell-excreting glands of the oyster, excited by the presence of a foreign body, usually a grain of sand. Pearl-fishing is carried on principally on the shores of Ceylon, but there are also large beds of pearl oysters in the Persian Gulf, in the Gulf of Mexico, and on the shores of Australia.

Mussels are found on rocks near the shore. They are much used as food, but some species appear to be poisonous. Some species inhabit fresh waters, both rivers and ponds, and there is a marine species whose shell is prized for its great lustre, and which often contains pearls.

The **teredos** are, unfortunately, too well known by the injuries they cause to wooden ships and naval constructions. Several times they have nearly caused the submersion of Holland by perforating the dikes that protect that country from the sea. The teredo uses its shell as an auger in driving forward its tunnel.

The name **molluscoid** is applied to certain creatures that are analogous to the acephalous mollusks; they are classified as **tunicata** and **polyzoa.**

The tunicata have no shells, but the mantle that envelops the body is thickened, sometimes being like leather. They live in the sea, and have been divided into two groups, the **salpæ** and the **ascidians.** Some of the latter are simple, some are compound,—that is, they are found singly or in numerous colonies. Their form, generally speaking, is that of a tube having two orifices corresponding to the two extremities of the alimentary canal. They respire by means of an apparatus like

Fig. 100.

Teredo in its boring.

internal gills. The salpæ have alternate generation. A single individual produces a chain-like colony, and each of these produces a single detached individual that in its turn produces a chain of successors.

The polyzoans, and ascidians, are aquatic creatures, some living in fresh water, others in the sea. They have vibratile tentacles, and usually dwell in colonies.

CHAPTER XIX.

Radiates.

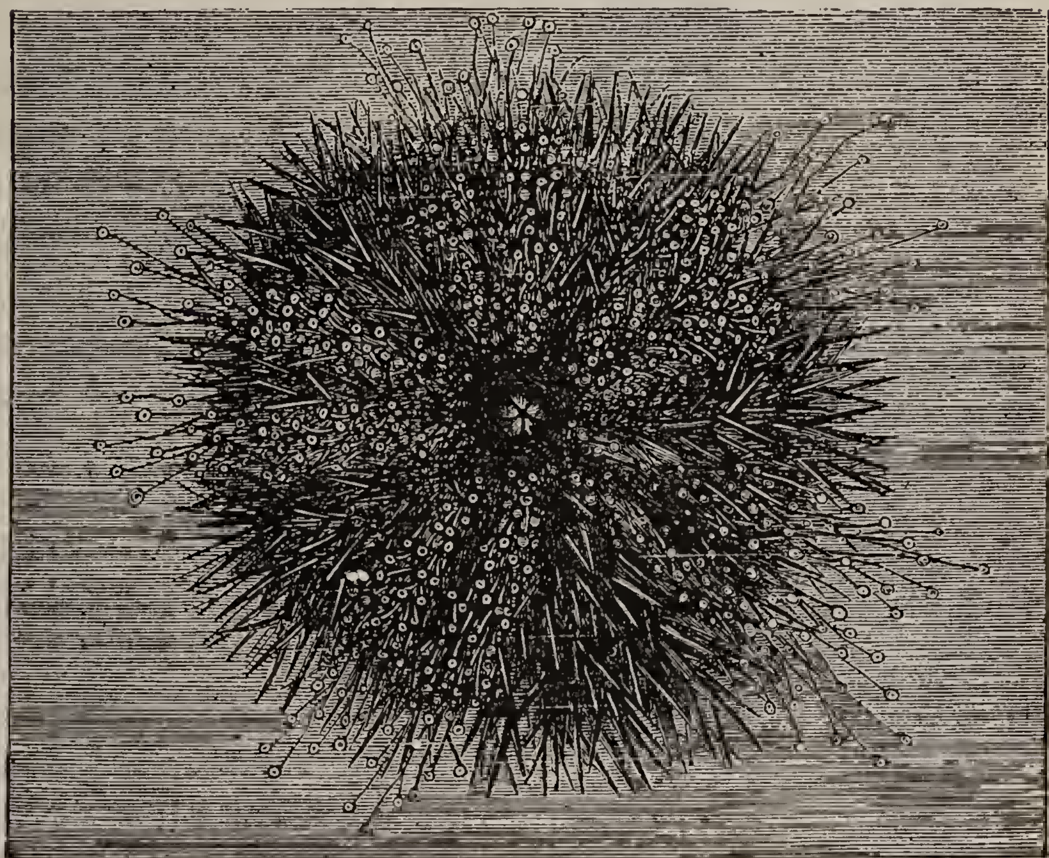
Under the name radiates are grouped a large number of lower creatures whose bodies present, in a more or less apparent manner, the form of a star; some, however, are globe-shaped, some cylindrical.

The radiates constitute the greater part of the group of beings known as zoophytes; they have been divided into several classes, the more important of which are the **echinodermata,** the **acalepha,** the **corals,** and the **sponges.**

We will examine a few types adapted to give us general ideas concerning these classes.

To the **echinodermata** belong the sea-urchins and the star-fish.

FIG. 101.

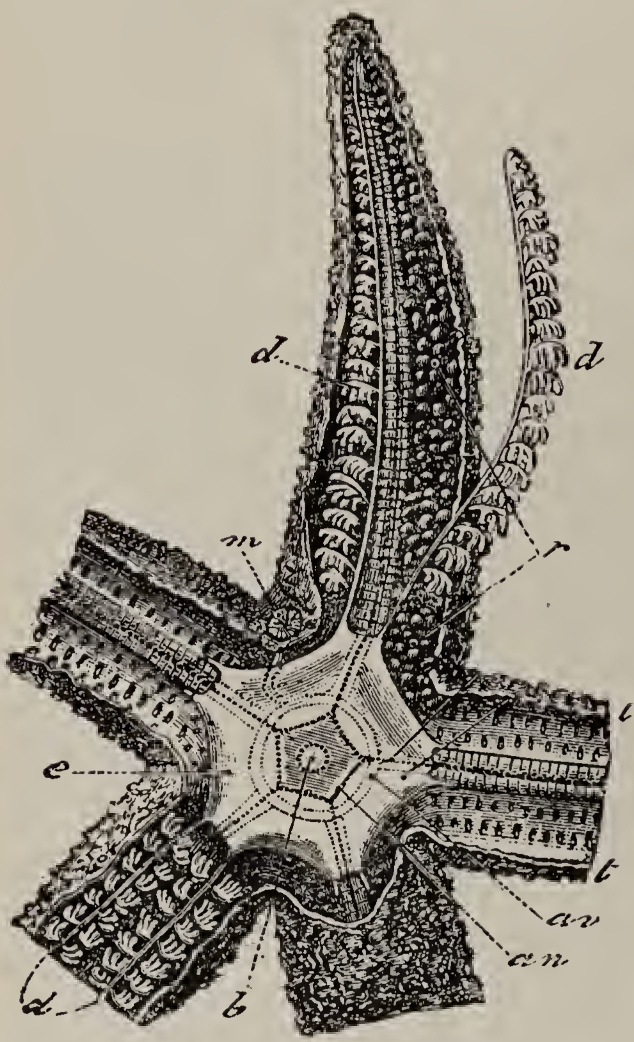


SEA-URCHIN.

The sea-urchins have a sensibly rounded form, the body being protected by a calcareous envelope that is studded with thorns. These creatures are found in all seas, and form a large number of species. The common sea-urchin is about as large as a fairly large apple; it has violet spines, is very abundant, and is used as food in some maritime localities.

The sea-urchin has a mouth provided with calcareous joints shaped like little pyramids, the summits converging to a point. These form a sort of teeth, and, being put in movement by the action of muscles, serve to tear up the food. The solid frame-work has been called Aristotle's lantern. The digestive tube is well developed and tortuous.

Fig. 102.

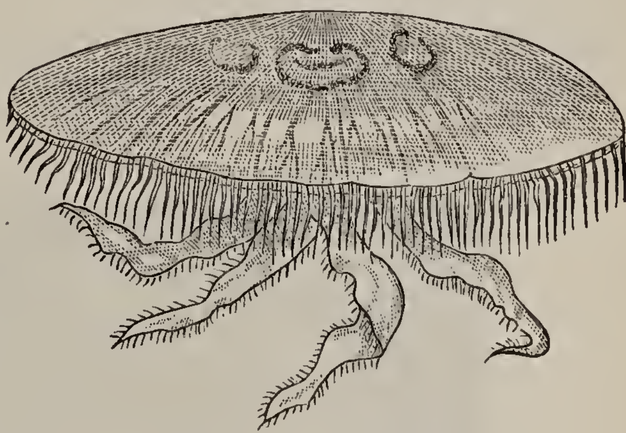


UNDER SIDE OF A STAR-FISH (the rays are cut open to show the organs).—*b*, mouth; *d*, appendages of the intestine; *e*, stomach; *an*, *œsophageal* ganglia; *av*, annular canal,—madreporic (perforated) plate; *t*, open covering.

The **asterias** or **star-fish** owes its name to the form of its body, which is divided into five or ten rays. In some species these rays are subdivided indefinitely, and form a sort of tangled hair. Sometimes these star fish are found in such numbers that they are used as manure for the fields. Like the sea-urchins, they are very voracious; the mouth is in the central portion, and leads by a short œsophagus into an annular stomach, which sends an intestinal branch into each arm. These tubes are accompanied by yellow bodies that surround them, and constitute the liver.

The acalepha include many species of **medusæ** or **jelly-fish.** These are beings of a gelatinous consistence, having various colors, and bodies formed like a flattened disk or a rounded bell. The central mouth is often surrounded by long tentacles, that float in the water. The digestive apparatus is composed of tubes more or less ramified in the centre of the gelatinous mass. This latter character is common to the acalepha and the corals, and leads to the frequent union of the two groups under the title **cœlentera.**

Fig. 103.

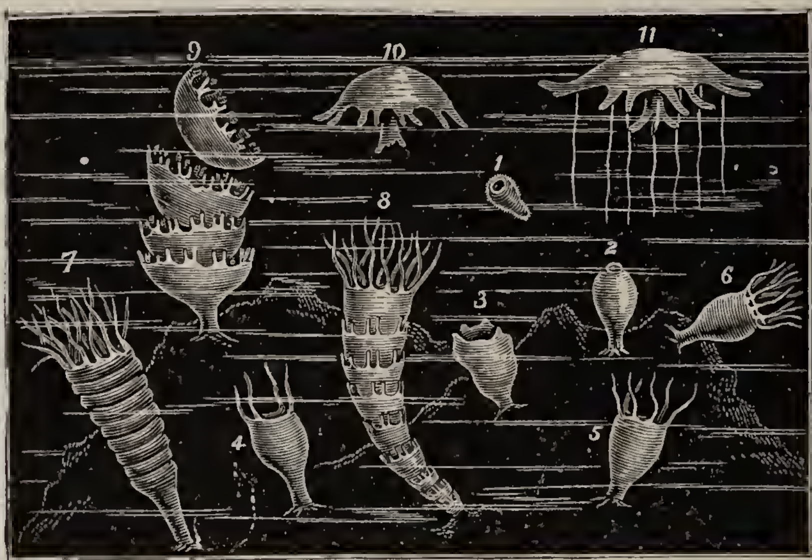


AURELIA AURITA (reduced).

The medusa present brilliant colors while floating in the sea, but soon fade when they are removed from the water. When they are touched, most of them produce on contact with the skin an itching like that caused by the sting of a nettle. For this reason they are sometimes known as sea-nettles.

In the course of their development many of the medusæ pass through a series of intermediate states, and furnish good examples of **alternate generation.** The medusa produces a ciliated larva which fixes itself, and at the same time its borders become lined with tentacles. When these latter are acquired, the young creature resembles a goblet with a fringed border. Then it undergoes new transformations; series of annular contractions appear a certain distance behind the circle of tentacles; gradually these contractions become more and more prominent, and the appearance of the animal is like that of a number of superposed disks. The borders of the disks become fringed in their turn; the contractions or strangulations between them increase, and, finally, the mass breaks up into as many little medusæ as there are

FIG. 104.



LIFE-HISTORY OF THE COMMON JELLY-FISH.—1, free-swimming embryo (*planula*); 2–6, the embryo fixed, developing into a "hydra-tuba," which (7–8) divides transversely into a pile of individuals; these in turn (9) are liberated and grow (10–11) into jelly-fish. (From Haeckel.)

disks; each of these lives freely, grows, and acquires the full and definite form, and gives birth to ciliated larvæ. Then the cycle of alternate generation recommences in the same manner and in the same order.

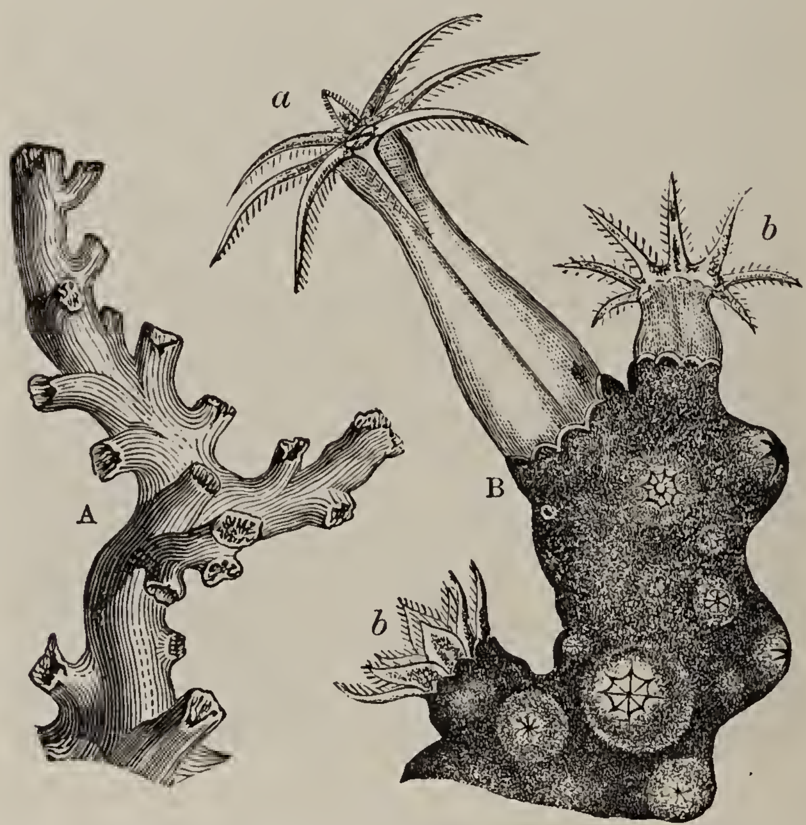
The **coralligena** include creatures that are often also called **polyps,** because of the numerous processes or tentacles that surround their mouths. Nearly all these pass their existence fixed upon some foreign body. They reproduce their species by eggs and by buds, each of the latter becoming a perfect creature, yet remaining adherent to the original polyp. There thus result **polyparies** or coral masses,—masses consisting of distinct individuals, living with a collective existence either by having one common digestive tube or by vascular intercommunication. Some of these are quite soft, such as the **sea-anemones,** so named on account of their variously-

FIG. 105.

A, Anemonia sulcata; B, Cerianthus membranaceus; C, Bunodes gemmaceus (closed); D, the same (open).

colored and numerous tentacles, that, when spread out, resemble a flower in full bloom. However, in a large number of these creatures the soft parts are sustained by a hard calcareous skeleton, constituting the polypary or coral. In the madrepores this skeleton is developed in the form of a cup, whose walls carry radiating partitions. These partitions correspond in number to the tentacles of the polyp. Since the corals multiply by breeding, and remain united in colonies, large polyparies are often found, consisting of as many little cups as there are creatures in the polypary. The form of the mass differs according to the species, but, since the breeding takes place in the same manner in each species, it follows that the form of the coral mass is also constant for each.

FIG. 106.



A, branch of dendrophyllia; B, part of a stock of red coral, with (*a*) fully extended polyp, and (*b*, *b*) two polyps partly extended.

Most of these creatures dwell in the sea, but there are a few species found in fresh water. The calcareous polyps grow only in warm seas, and there increase in such abundance that they form islands of vast extent. The well-established origin of these islands and the enormous quantities of fossil coral that are met with in calcareous rocks have led to the belief that the productions of these zoophytes form a large portion of the mass of our continents, and that these small beings may modify the outlines of the earth's crust in a rapid and remarkable manner. If we may judge by the results of investigations made during less than a century just past, we are justified in the conclusion that, in a time relatively short for geological change, the greater number of the islands of Oceanica will be united together.

Red coral is the earthy axis of a polyp that grows in abundance in the Persian Gulf, the Red Sea, and various parts of the Mediterranean, such as the Straits of Messina, off the coasts of Sardinia, Tunis, and Algeria. The stem or axis adheres to submarine rocks, generally has a beautiful red color, and the form of a little tree without leaves or small branches, and a height varying between six and twenty-five inches. A single polyp like that shown in Fig. 106 is the starting-point of the coral stem represented alongside of it. On the smaller branches of the stem are seen young individuals, whose development will produce new branchings. This method of development is quite analogous to that of vegetables.

The class of **porifera** includes the sponges, beings formed of a gelatinous mass, supported by a solid framework of variable composition. Sometimes this framework is composed of long silicious needles interlaced and resembling spun glass; sometimes it consists of calcareous spiculæ or of horny filaments. The common sponge is of the latter variety, and it is the horny skeleton that is used. The holes that run through it in all directions are the canals through which water circulates during the life of the creature.

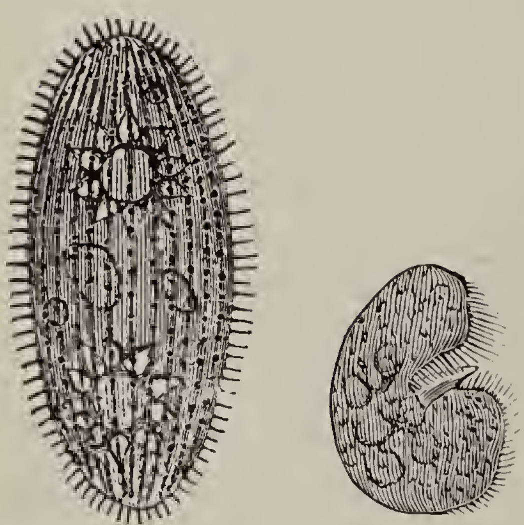
Like the corals, sponges fix themselves on submarine rocks; they are found in all seas, but those from the Mediterranean, and particularly those of the Archipelago, are most esteemed. The preparation of the sponges is very simple, consisting of washing them many times in frequently renewed fresh water. In this manner they are freed from their gelatinous envelopes and the foreign matters distributed through their tissue.

CHAPTER XX.

Protozoa—Infusoria—Microbes.

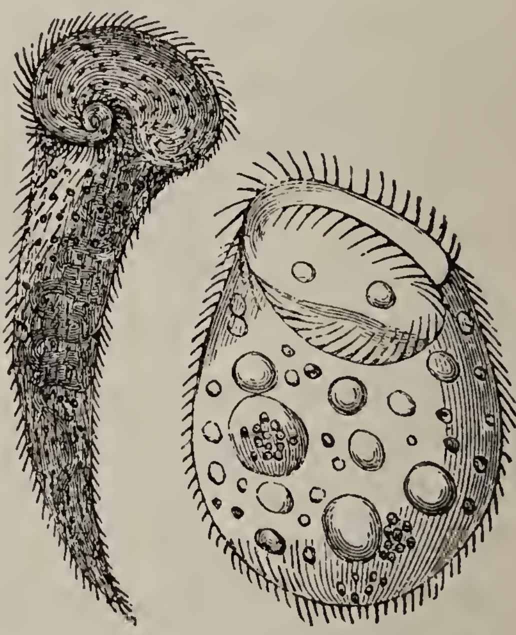
The protozoa are animals of extremely simple organization, and most generally of a microscopic size. They

Fig. 107.



Paramecium aurelia. Colpoda.

Fig. 108.



Stentor. Bursaria vorticella.

are subdivided in two principal groups, **infusoria** and **rhizopods.**

The **infusoria** are little masses of definite form, composed of protoplasm or gelatinous living matter. They are covered with an envelope carrying vibratile cilia. Of all the protozoa they are the most highly organized beings, for they possess a digestive apparatus with two orifices, and in their mass we can distinguish **vacuoles** or clear spaces, and a pulsatile vesicle which probably serves for the digestion and circulation of a nutritive liquid. These little beings have been named **infusoria** because their first observers found them in putrid infusions of vegetables; they are especially abundant in stagnant waters.

Fig. 109.

Trichodes pura. Oxytricha gibba.

Their reproduction takes place by eggs and also by *scission*, which is simply a division of the creature in two.

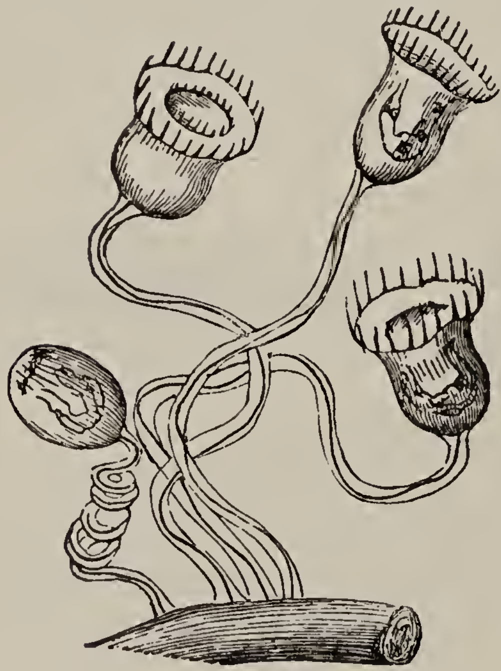
They are divided into several groups, according to the arrangement of the cilia and the general form of the body.

1. The cilia may be arranged in longitudinal lines covering the entire body excepting around the mouth. Among the forms of this kind are **paramecium** and **opalina.**

2. The body may be covered with cilia, with long rigid hairs around the mouth. The **stentor** and **bursaria** are examples.

3. The body has a convex dorsal surface and a flat ventral surface carrying cilia; the back is often hardened so that the creature much resembles a minute crustacean; examples are **euplotes** and **oxytricha.**

FIG. 110.



VORTICELLA CONVALLARIA.

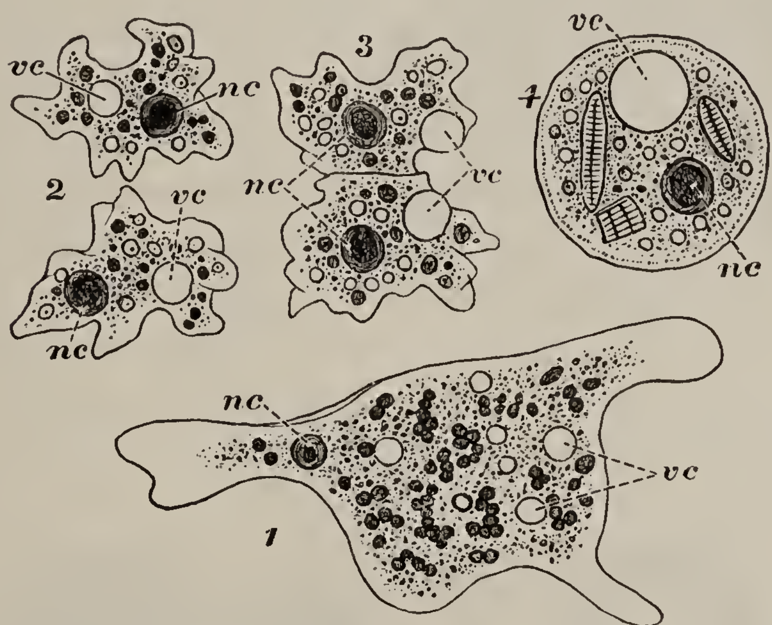
LACRYMARIA PROTEUS.

4. In this class the body is usually naked, excepting a girdle of elongated cilia, and a spiral of hairs around the mouth. Examples of these are the **ophrydium** and the **vorticella.** The bodies of all the vorticellæ are supported by a long contractile stalk. When this is contracted the creature looks like a microscopic flask; it remains attached to a plant, awaiting the passage of some desired prey; then it elongates its stalk very rapidly, like a liberated spring.

The figures on pages 180, 181, and 182 illustrate the principal forms that are found in old vegetable infusions and in stagnant water.

Closely related to the infusoria are the **foraminifera,** minute beings whose organization is still more simple than that of the former. They move around at the bottom of fresh and salt water, and their bodies consist simply of microscopic masses of protoplasm gifted with the power of movement, and called **sarcode.** Movement is accomplished by more or less numerous and lengthy expansions, which may be observed to project from the surface of the body, into which they afterwards retract and disappear.

FIG. 111.

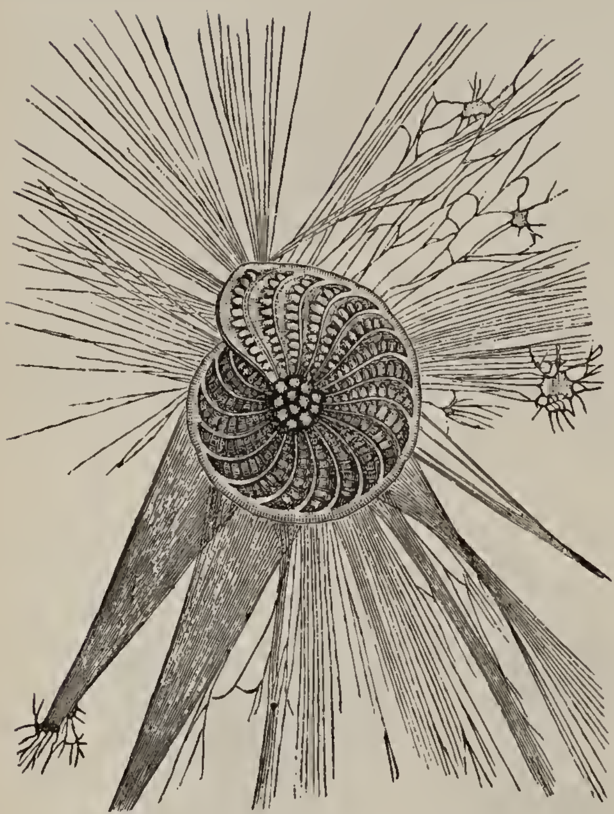


AMŒBA.—1, amœba, with blunt processes, nucleus, *nc*, contractile vacuoles, *vc*, food vacuoles, and granules; 2, two daughter-amœbæ; 3, amœba in process of dividing; 4, encysted phase, with enclosed diatoms, etc. (After Bütschli and G. B. Howes.)

Sometimes the sarcode is naked, and the forms are then the most simple, being known as amœbæ and protamœbæ.

Sometimes, however, the sarcode is covered with a calcareous envelope, a sort of carapace, pierced with nu-

Fig. 112.



A LIVING FORAMINIFER (*Polystomella strigillata*).

merous holes through which the retractile expansions may issue.

The shells of foraminifera are secreted by the sarcode, but, on account of their mineral nature, they are not destroyed with the life of the creature. The microscopic shells of innumerable beings of this kind form thick layers of sediment on the bottoms of certain seas. It has been calculated that one ounce of sand taken in front of the port of Gaeta contains about one and a half millions of such calcareous shells.

Fig. 113.

SHELLS OF VARIOUS FORAMINIFERA.

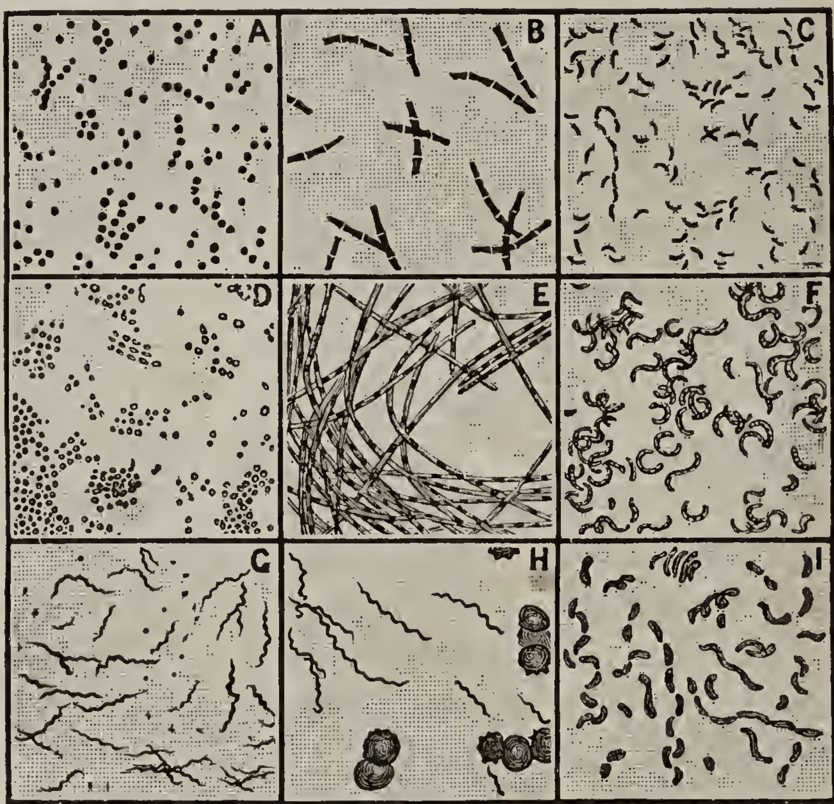
MICROBES.

By the name microbes are understood beings of exceeding smallness, that can be seen only by the aid of powerful microscopes; they are less than one-ten-thousandth of an inch in diameter, but their number is so large that it compensates for their minute size.

These beings take a very important part in nature. In particular, they appear to be the causes of all the putrefactions and fermentations with which we are acquainted. Besides, many of them live as parasites in the blood or in the organs of men and other animals, and by their presence occasion the most serious diseases. It is now proved that all the contagious affections are caused by microbes: thus, the **anthrax,** or carbuncle, which sometimes decimates cattle, **hydrophobia, typhoid fever, intermittent fever, scarlet fever, measles, cholera,** etc., are due to the presence of specific microbes in the blood or in some part of the organism. It is impossible for us to enter into minute details concerning these little creatures, and we can only indicate their more common forms. In this respect they may be divided into two classes: the ones called **monads** are globular; the others are filiform. The latter are sometimes straight, as the **bacterium** of carbuncle, sometimes undulating, as the **vibrios,** sometimes curled in a spiral, as the **spirillum.**

The **bacteria of malignant anthrax,** which we will take as an example, consist of rigid, straight, cylindrical filaments, at the most about one twenty-five-hundredth part of an inch in length. These filaments are immobile, which distinguishes them from ordinary bacteria and vibrios and spirilli. The bacteria of anthrax multiply so rapidly that they often render the blood of animals infected with them thick and muddy. At the same time they deprive the blood of oxygen, and it becomes black like soot, from which the French give to the disease the name **charbon** (coal).

Fig. 114.



Different kinds of bacteria (mostly after Koch).—A, micrococci in drinking-water; B, in splenic fever; C, in cholera (Koch); D, from surface of water: E, in splenic fever (in thread-form, and with incipient spores); F, spirillum, from putrefaction; G, spirochæte, from the teeth; H, in relapsing fever, from blood; I, different forms of cholera microbe (Koch).

It is a special property of microbes to develop and multiply with great rapidity. If a few individuals, either bacteria or vibrios, be placed in a clear liquid adapted for their development, in a short time it becomes clouded, and a deposit forms. This deposit is composed entirely of microbes, so great is the number produced. It can easily be understood that the presence of such a large number of these beings must modify in some manner the composition of the liquid in which they exist, for their development can take place only by the removal from the liquid of the elements required for their formation. This is the secret of animal and vegetable decomposition, of putrefactions, and of fermentations.

In the acetic fermentation, which is the conversion of wine, cider, or other alcoholic liquid into vinegar, a microbe known as the **mycoderma aceti** does the work. This is formed of straight microbes, only six one-hundred-thousandths of an inch long, and one-third or one-half as thick, a number being joined end to end, and it lives by transforming the alcohol into acetic acid by the aid of the oxygen of the air. In vinegar factories the mycoderma, which forms a whitish membrane on the surface of the wine being soured, is carefully collected and transferred to fresh wine which it is desired to convert into vinegar. It is called **mother of vinegar.**

We have already said that many contagious diseases are produced by the presence of certain microbes in the blood or in other organs. It has been found that repeated culture causes the microbes to lose their virulence,—that is, if the microbe which it is wished to cultivate be introduced into a suitable liquid, and the product of this culture be collected and submitted to a new culture, by repetition of the process an **attenuated** microbe may be obtained which occasions only slight troubles when introduced into the system. Much more, its presence or its effects will prevent the development of the virulent microbe. The attenuated microbe may constitute a **vaccine** matter which will protect the system from the attacks of the virulent microbe of the same species as itself, but which has not been attenuated by culture. An excellent example of this possible attenuation of a microbe is the **vaccine** matter employed as a preventive of small-pox. We know that it is sufficient to take a small quantity of the liquid contained in the pustules on the arm of a recently-vaccinated child for the purpose of fresh vaccinations. These pustules contain the microbes of small-pox, attenuated by culture, the culture substances being in the organism of the child. We give this example in order to help to an understanding of the mechanism of the attenuation of microbes, but we must add that while the bacteria of anthrax, of cholera, and of other diseases are known, the microbe of small-pox has not yet been isolated with certainty. In this respect it is curious to note that the use of the vaccine of variola as a protection against small-pox was known long before there were the least notions about microbes and their attenuation.

CHAPTER XXI.

Principal Orders of Mammals.

Mammals are vertebrate animals, having a constant temperature, a double and complete circulation, and an aerial, pulmonary respiration. Their skin, though it may appear perfectly naked, always has hairs, which often cover it entirely. Mammals produce living young, which they suckle.

The head is always articulated with the first cervical vertebra by a double prominence of the occipital bone. The bones of the trunk are in the same relations to one another as in man, and excepting the coccygeal vertebræ are about the same in number. In a small group the pelvis has supplementary bones, called **epipubic** or **marsupial bones,** which terminate in front among the muscles of the abdomen. The mammals belonging to this group are also mostly characterized by the existence of a sac, called the **marsupial pouch,** forming a fold in the skin of the belly. These mammals, named **didelphia,** bring into the world young ones whose development is very little advanced, and who must, before they are able to walk, remain for a considerable time suspended at the teats of the mother, these teats being located in the marsupial pouch.

All the other mammals, having no marsupial pouch and no marsupial bones, have been named **monodelphia.** Here is the first basis for a classification. The other characteristics are dependent on the number of limbs, the manner of life, the arrangement of the extremities, and the modifications of the dental system.

These characters are indicated in the table on page 190.

MAN.

The organization of man places him at the head of the great class mammalia. Anatomically, he is closely related to the monkey, and this has led to his zoological classification in the order Primates: the greatest anatomical difference between man and the anthropoid apes is found in the development of the brain. In the first chapter we have indicated the principal features of man's organism.

The population of the globe has been classified by

						Order.	Principal Suborders and Examples.	
Mammals.	No marsupial bones. MONODELPHIA.	Four limbs	Unguiculate digits	Complete dentition	More or less completely developed prehensile thumbs.	PRIMARIA	*Anthropoidea*	Man. Apes, monkeys. Marmosets.
							Lemuroidea	Lemurs.
						CHEIROPTERA	Bats and flying foxes.	
					Bristling molars.	INSECTIVORA	Moles.	
					Sharp, cutting molars.	CARNIVORA	*Fissipedia*	Lion, bear.
							Pinnipedia	Seal.
				Incomplete dentition	Incisors, no canines.	RODENTIA	*Simplicidentata*	Rats.
							Duplicidentata	Hares and rabbits.
					No incisors, sometimes no teeth.	EDENTATA	Sloth, armadillo.	
			Ungulate feet	Five digits		UNGULATA	*Proboscidia*	Elephant.
				Even toes, ruminants			*Artiodactyla*	Oxen and deer.
				Odd toes			*Perissodactyla*	Horse.
		Only two limbs, the anterior modified into fins or paddles	Rudimentary hind limbs			CETACEA	Whales.	
			No hind limbs.			SIRENIA	Manatee, dugongs.	
	Marsupial bones	DIDELPHIA, a mammary pouch; no cloaca				MARSUPIALIA	Opossums.	
		ORNITHODELPHIA, no mammary pouch; a cloaca				MONOTREMATA	Duck-billed platypus.	

naturalists in a certain number of groups that are called **races**. The distinctions between these races are principally in the physical characters and in the manners of life and languages.

Among the physical characters, the more important are the structure of the cranium, the form of the face, and the size of the facial angle. The facial angle is obtained by drawing two straight lines,—one from the auditory canal to the base of the nose, the other from the frontal protuberance to the most prominent point in front of the upper jaw. This angle is more and more open as the anterior part of the forehead is more developed and the jaws less prominent. Ordinarily there is a constant relation between the development of the anterior portion of the skull and that of the brain, and a large brain generally corresponds to highly-developed intellectual faculties; consequently a comparison of the facial angle in the different races may throw some light on the relative intelligence of these races, and some sort of comparison may be made between them and the animals most nearly related to man. There has thus been constructed for the human species a sort of progressive scale, of which the white race occupies the highest position.

The facial angle in the white race has an average between eighty and eighty-five degrees; in some individuals it is greater than a right angle. The ancients understood the value of the facial angle as an indication of intelligence, and they exaggerated it in the statues of their divinities. In the Apollo Belvedere it is nearly ninety-five, and in the Olympian Jupiter nearly one hundred degrees. In the Negro, the facial angle has an average of sixty-five to seventy degrees, and in some of the lowest African tribes it is as low as sixty-four,—that is, a little lower than the Sai monkeys, whose facial angle is sixty-five,—and almost as low as the orang-outang, which during the earlier period of its life has an angle of sixty-three, although this afterwards falls during complete development to thirty-five. The angle of the magot monkeys is not more than forty-five or fifty. In the horse and the pig it is eleven; twenty-five or twenty-six in the sheep and goat; twenty-six to thirty in the dog; thirty to thirty-six in the cat.

The study of the human family has enabled its classification into three distinct races: the Caucasian or white, the Mongolian or yellow, the Ethiopian or black.

"The Caucasian race has received its name because traditions place its birthplace in the mountains of Caucasus, whence it has spread by radiating migrations to all parts of the surface of the globe. One of these branches settling in Western Europe gave rise to the Europeans; others travelling in different directions spread over all the regions of Western Asia and Northern Africa; from these came the Chaldeans, the Hebrews, Phœnicians, Arabs, Persians, Scythians, Hindoos, and, probably, the Egyptians. The Caucasian race is distinguished by the beauty of the oval which outlines the head, by the prominent forehead, and by the large facial angle, which is about eighty degrees, as well as by the white or only slightly-tinged skin.

"The Mongolian race appears to have originated in the Altai Mountains, from which it extended into Central and Eastern Asia and the neighboring islands. The Tartars, the Chinese, and the Japanese are the principal branches; perhaps, also, the Laps, the Greenlanders, and the Esquimaux are descendants of the same race, stunted by the rigors of the climate in which they live. This race has prominent cheek-bones, a facial angle of about seventy-five degrees, oblique eyes, inclining downward at the internal angle, a yellow or olive color, and straight black hair.

"The Ethiopian race inhabits Africa south of the Atlas Mountains. It is distinguished by the black or very dark color of the skin, a small facial angle,—not much more than sixty degrees,—thick, projecting lips, flattened nose, and curled, woolly hair.

"The natives of America and Australia possess certain peculiarities which have rendered their classification uncertain. The celebrated Blumenbach made a special race of the red-man, but the natural historians consider them related to the Caucasians, while the Australians are regarded as descendants of the Ethiopian race." (Pouchet.)

Fig. 115.

Chimpanzee (after Hartmann).

MONKEYS.

Monkeys are of all animals those that most closely resemble man. They have been called **quadrumana,** from the fact that in some species the four extremities are terminated by hands, each provided with a thumb; but in many species only the posterior limbs have hands, and the name **quadrumana** is no longer used. In general, these animals have a narrow pelvis, knees loosely articulated, heels not very prominent, and these features, together with the feeble muscles of their thighs and legs, prevent them from easily standing erect. Their hands are better adapted

FIG. 116.

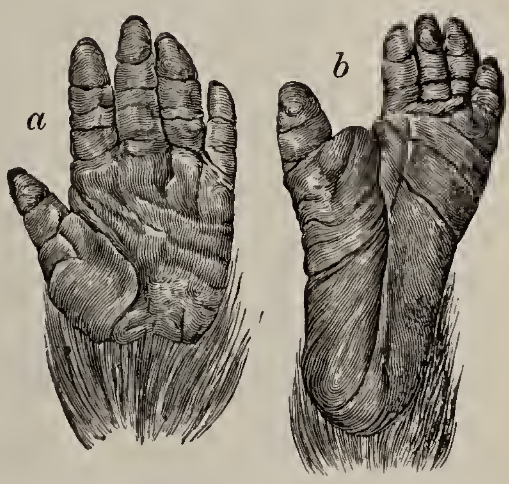
GORILLA (*Troglodytes gorilla*).

for climbing than for touch and prehension. Most of them can climb trees with wonderful agility, using their four hands in the exercise; in this some of them are aided by their tails, which are said to be prehensile, having the power of encircling and grasping objects. Monkeys live principally on vegetable food, such as fruit, young sprouts, roots, etc., to which they sometimes add shell-fish, insects, little reptiles, and birds' eggs.

Monkeys are classified in three groups: the **anthropoid apes,** tailless, semierect, and long-armed; the **catarrhini,** dog-nosed monkeys of the Eastern Continent; and the **platyrrhini,** flat-nosed monkeys of South and Central America.

Monkeys live principally in the torrid zone; those of the old continent and those of the new present great differences, corresponding to the difference in habitation. The Eastern monkeys all have twenty molar teeth, the dental formula being p$\frac{2}{2}$ m$\frac{3}{3}$; many have no tails, and none have prehensile tails; the ischial prominences are naked, and have ischial callosities, usually red in color; many have pouches in the cheeks opening into the mouth, and in these they can carry a store of provisions. Among these monkeys of the Old World are found the largest, and those most closely allied to man; of the anthropoid apes the more important are the **chimpanzee,** the **gorilla,** and the **orang-outang**; the **gibbon** and the **magot** relate them to the lower varieties.

FIG. 117.

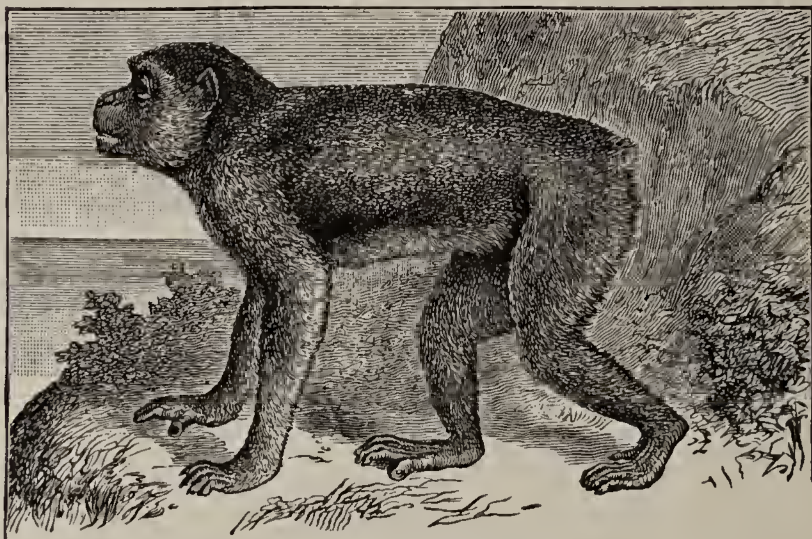


Hand (*a*) and foot (*b*) of gorilla.

The chimpanzee and the gorilla inhabit the immense swampy woods of Africa, and travellers have brought us many interesting stories of their habits and of their marvellous strength. The orang-outang and the gibbon inhabit the forests of India and the Indian Archipelago.

The magots, called also Barbary apes, are very common in Northern Africa, and are the only monkeys found

Fig. 118.



Barbary ape.

Fig. 119.

Capuchin monkey.

living wild in Europe, there being a small colony of them at Gibraltar.

The catarrhini, or Old-World monkeys, have thirty-two teeth: $p\frac{2}{2}$, $c\frac{1}{1}$, $p\frac{2}{2}$, $m\frac{3}{3}$.

All the American monkeys, excepting the family of small monkeys like the marmosets, have twenty-four molars: $p\frac{3}{3}$, $m\frac{3}{3}$. The dentition of the small monkeys is like that of the catarrhini. All the American mon-

FIG. 120.

MARMOSETS (*Hapale jacchus*).

keys have tails, and the tails are usually prehensile; the hind quarters are covered with hair, there being no ischial callosities; there is no pouch in the cheeks. Among the principal species are the **sapajous**, the **spider monkeys**, the **howlers**, the **capuchins**.

These monkeys inhabit Brazil, Paraguay, Guiana, and a part of Mexico, there being no monkeys in the temperate zone.

The **lemurs** form the lowest group of the Primates: they appear to form a connecting link between the monkeys and the insectivora. They are interesting

Fig. 121.

Ring-tailed lemur (*Lemur catta*).

little animals; many of the species are nocturnal in their habits, living almost entirely in trees, where they feed on fruit, young sprouts, birds' eggs, and even small birds and insects; they can be easily tamed. There are a number of species, most of them being found only in Madagascar; some few are found in Malaya, and others in Africa. All are adapted for climbing, and their powerful hind limbs enable them to make extraordinary leaps, one of the species passing readily from tree to tree at a distance as great as ten yards.

CHAPTER XXII.

Cheiroptera—Insectivora.

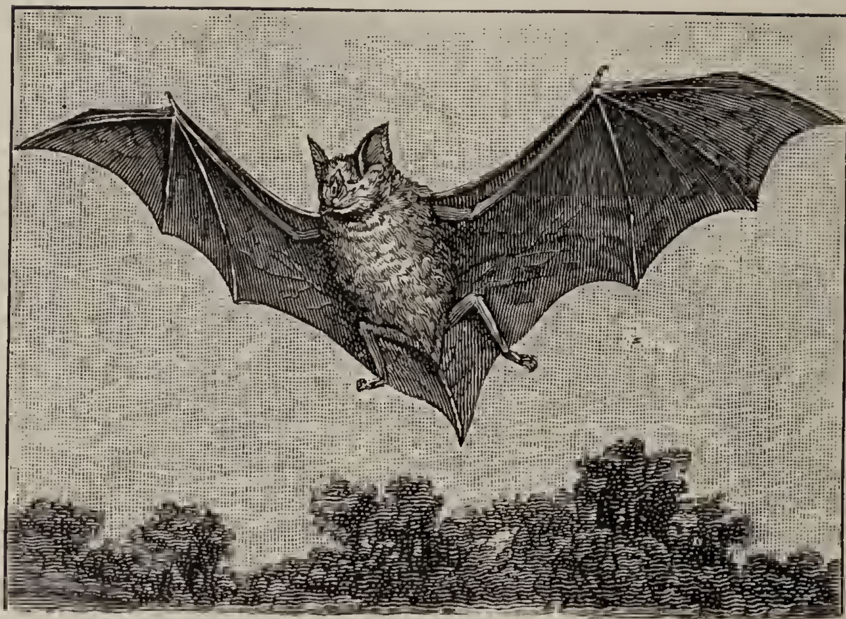
Bats form an order of mammals whose anterior limbs are organized for flying. There are many species; some of the larger ones are fruit-eaters; these are found principally in India and Africa. The bats of the temperate zones are usually small, and feed entirely on insects, especially flying insects, such as gnats, moths, and mosquitoes, which hide during the day and appear hovering in clouds in the early evening. Our bats destroy immense numbers of these troublesome creatures, and so render us a service.

Fig. 122.

Megaderma gigas, sleeping.

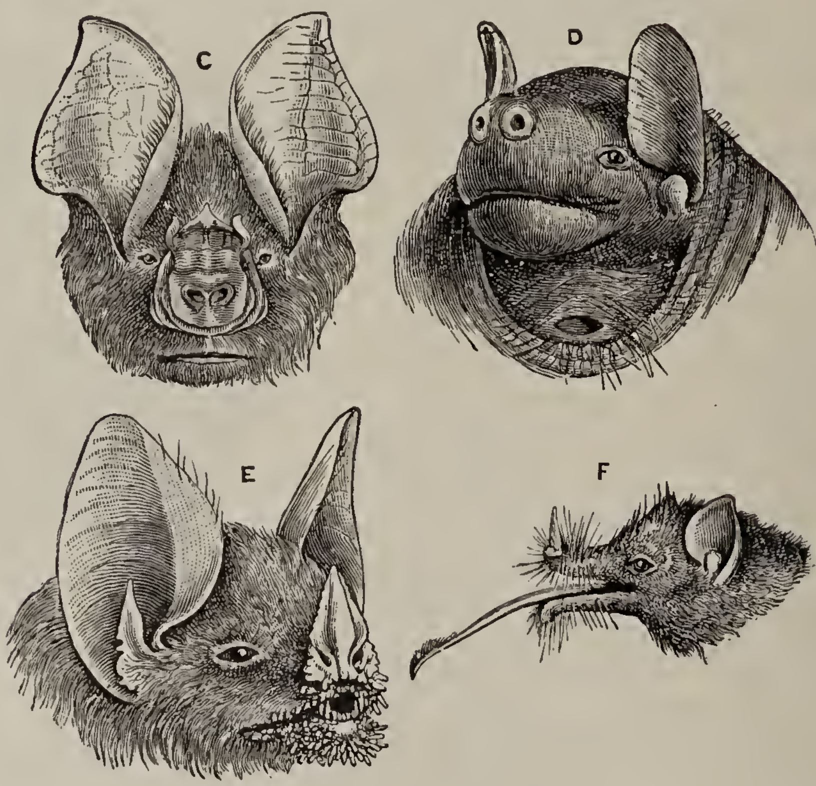
The long-eared bat is an example of enormous ear-development in these mammals, whose sight, on the other hand, appears very deficient. By hearing, smell, and touch, the last having for its organ the wing membrane which spreads over the hand, as well as the ears, face, and lips, these creatures receive impressions that nocturnal animals could not obtain by the aid of eyes.

FIG. 123.



THE GREATER HORSESHOE BAT (*Rhinolophus ferrum equinum*), flying.

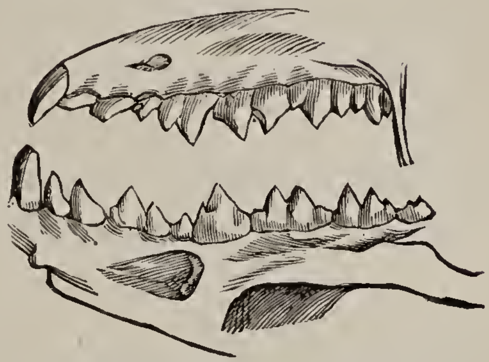
FIG. 124.



Heads of (C) Phyllorhina tridens, (D) Chiromeles torquatus (female), (E) Trachyops cirrhosus, (F) Chæronycteris mexicana.

The **insectivora** are terrestrial mammals, the four feet being provided with nails; dentition is complete, the molars bristling with conical points. They feed on earthworms, insects, snails, frogs, and even snakes, their diet being wholly or almost wholly carnivorous. The shrews, the moles, and the hedgehogs, of each of which there are several species, are examples. Some live almost entirely underground, some are terrestrial, while others are largely aquatic in their habits.

Fig. 125.



Dentition of insectivora.

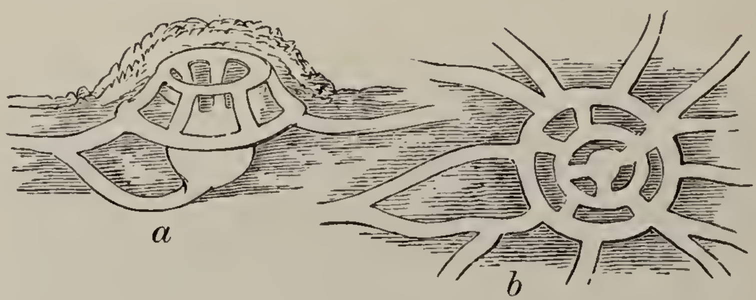
Fig. 126.

Common mole (*Talpa europæa*).

The **mole** is a small animal, whose life is almost wholly subterraneous; it is very rarely seen on the ground, for it cannot walk well, although it travels rapidly under ground. It is entirely inoffensive.

The body of the mole is cylindrical and rather short; its head, which seems set directly on the body, terminates in a snout something like a pig's, and with this the creature digs in the ground. The mole has very small eyes, but they are sufficient for the requirements of underground vision, and they are covered and hidden by long hairs, which protect them from contact with the soil that the animal throws around. The most remarkable feature in the structure of the mole is the development of the fore-limb, of which all from the wrist up is enclosed in the skin of the body, so that all that appear are two large paws lying alongside the head, the palms outside. These paws are very largely developed for the size of the animal, are naked, and each has five short, thick digits, armed with curved and solid nails. The

Fig. 127.



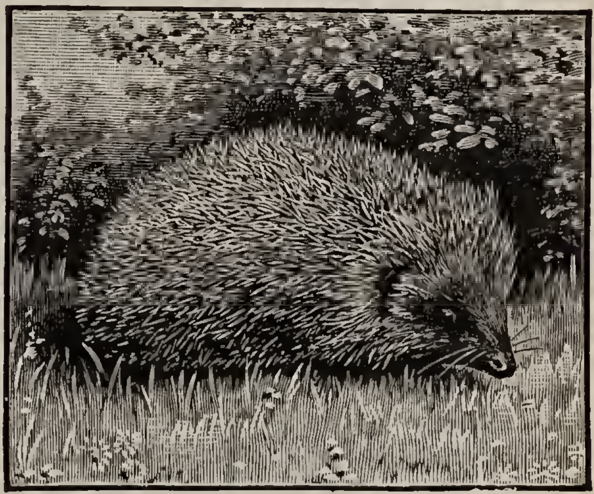
a, section of the habitation of a mole; *b*, plan of ditto.

hind limbs are much like those of a rat, but shorter and stronger. With his snout the mole digs into and hollows out the soil, and with his paws he throws behind him the loosened earth: he can travel quite rapidly in this manner, producing clean and sharply-cut cylindrical galleries, from which from time to time he removes the rubbish.

The mole feeds entirely on worms and the larvæ of insects, and in seeking such food it digs its gallery. Sometimes it may injure, by exposing them, roots which it encounters in its passage, but it does not eat these roots; it would die of hunger alongside the most juicy roots and herbs. Far from injuring agriculture, the mole aids the farmer exceedingly by destroying large quantities of injurious insects. It occasions inconvenience only by the mounds and ridges which it sometimes raises in smooth lawns.

The **hedgehog** lives principally on insects, slugs, and small reptiles, but occasionally it takes vegetable food. Its habits are nocturnal, and it hides during the day. In the winter it disappears, sleeping in some hole. The hair of the hedgehog is, on the back, modified into hard and very sharp spines, forming for the creature a defensive armor in which he can live in security. By placing his head and his limbs against his belly and rolling himself up, he forms a sort of prickly ball, in which form he fears neither weasels nor birds of prey. The fox, however, it is said, can destroy him.

FIG. 128



COMMON HEDGEHOG (*Erinaceus europæus*).

The **shrew** seems to fill a place between the mole and the mouse. It is smaller than the latter, and resembles the mole in the form of the snout, the eyes, ears, teeth, and limbs. In winter it lives in barns and stables, but in summer it lives in the fields, hidden under leaves and moss, and showing itself seldom except at night. It eats large quantities of insects, but sometimes feeds on grain. In winter it travels long distances in search of food, and burrows deep into snow seeking stumps in which it may expect to find larvæ.

CHAPTER XXIII.

Carnivora.

BEARS, DOGS, CATS, SEALS, ETC.

The carnivora are mammals whose food consists entirely or principally of flesh, and whose organization consequently conforms with the necessities of such a diet. However, these animals possess certain peculiarities of structure; not all flesh-eaters are carnivora, and

Fig. 129.

Skull of tiger.

some carnivora prefer a very mixed diet. Each jaw is armed with six pointed incisors, two strong, sharp, and curved canines, adapted for seizing and penetrating flesh, and molars capable of cutting it up. Sometimes, however, the molars are tubercled, and this is an evidence that meat is not indispensable in the creature's diet. The toes usually terminate in sharp claws.

Carnivora are classified in two suborders,—**fissipedia,** having the toes separate, and **pinnipedia,** having toes united like fins. These suborders are distinguished and divided into families as follows:

Order	Suborder	Characters	Group	Family	Example
Carnivora.	Fissipedia	Terrestrial, or only partially aquatic; cutting molar in each jaw; incisors usually $\frac{3}{3}$.	Arctoidea	*Mustelidæ*	Otter.
				Procyonidæ	Raccoon.
				Ailuridæ	Panda.
				Ursidæ	Bear.
			Cynoidea or	*Canidæ*	Wolf.
		Strong, sharp, curved claws. First and fifth toes of hind foot not longer than others.	Ailuroidea	*Felidæ*	Cat.
				Viverridæ	Civet.
				Hyænidæ	Hyena.
	Pinnipedia	Aquatic, except at birth. Very uniform molars. Incisors fewer than $\frac{3}{3}$. Webbed feet; outer and inner toe of hind foot longer and stronger than others.	Small external ears. Hind limbs flexed forward.	*Otariidæ*	Fur seals.
			Enormous canines in upper jaw.	*Trichechidæ.*	Walrus.
			No outer ear. Hind limbs flex backward only.	*Phocidæ.*	Hair seals.

ARCTOIDEA.

The word **arctoidea** signifies bear-like, and the group includes the bears and many species which at first would not seem related to the bears, but they are all similar in the structure of the skull, in the absence of the cæcum from the digestive apparatus, and in certain other peculiarities.

The **otters** have palmate feet and a tail flattened horizontally. They are organized for passing a large portion of time under water, being able to walk only with difficulty, but to swim very rapidly. They inhabit the banks of streams and ponds, living in holes close to the water's edge. They live principally on fish, of which they destroy enormous quantities. The fur is a beautiful chestnut color above, whitish-gray below, and is much prized. The otter attains a length of three or four feet.

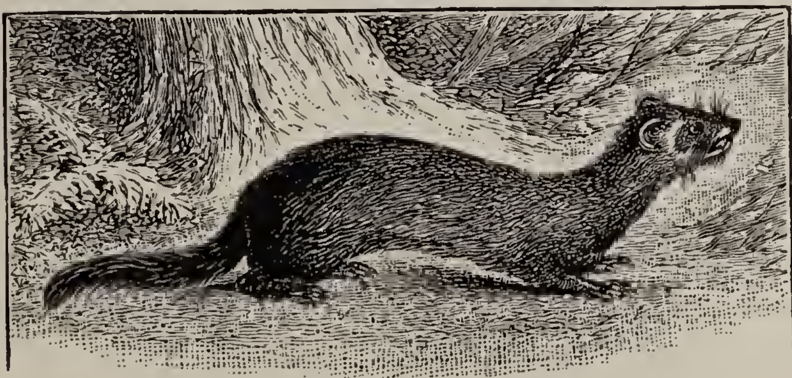
FIG. 130.

SEA-OTTER (*Enhydra lutris*).

Other members of the family mustelidæ are the **polecat,** the **pekan,** or American marten, the **ermine, ferret, sable, skunk, badger,** and other **martens,** and **weasels.**

The **polecats,** of which the ferret is one variety, are characterized by a very unpleasant odor, which they seem to be able to control to some extent. They prefer to live near farm-houses, sometimes making their homes in barns and stables; they are bold and ferocious, and often kill wantonly large numbers of barn-yard fowl, carrying off only a small fraction of their prey. The fur is brown on the back, fawn-colored on the sides, yellowish on the belly, and white on the nose; it is a soft, warm fur, but always retains a somewhat unpleasant odor. The polecat attains fifteen or sixteen inches in length, without including the tail. The name polecat

Fig. 131.



Polecat (*Mustela putorius*).

is sometimes applied to the skunk, which is an entirely different animal. The ferret, which is often employed in hunting rabbits and rats, is a sort of tamed polecat.

The **wolverene** or **glutton** of Canada is the largest of the mustelidæ, and next comes the pekan or wood-shock,

Fig. 132.

The glutton (*Gulo luscus*.)

a sort of marten, whose length from the tip of his nose to the end of his tail may be four and a half feet. The pekan is often called fisher and black-fox.

The **weasels** and **martens** are brown, but the neck of the former is white. Weasels are very destructive to poultry. The **sable** is found in Siberia, and is celebrated for the beauty of its fur, which is a dark chestnut, exceedingly fine, and lying smoothly in either direction. The **skunk** is an American animal, about as large as a common cat; its fur is almost black, more or less mixed with white. It is sold as Alaska sable. The skunk has a peculiar means of defence and offence: it has in the groin a pair of sacs with muscular walls, and these sacs secrete a fluid of most disgusting odor, that the animal can project upon its enemies or annoyers, putting them to instant flight.

Fig. 133.

Skunk.

The **badgers** walk on the whole sole of the foot, and not on the forepart of it, thus differing from the preceding species; they were, therefore, once classified with the bears as **plantigrade** carnivora, while the other families were called **digitigrade**; but this classification brought together so many unrelated species, and separated so many others which are evidently very similar, that it has been abandoned, though we may use the terms as descriptive. The head of the badger is long, its muzzle pointed; there are five toes on each foot, and

Fig. 134.

Badger (*Meles vulgaris*).

the feet are adapted for burrowing. The average length is two feet and a half. The hair is coarse, grayish-brown,

Fig. 135.

Raccoon (*Procyon lotor*).

and touches the ground as the animal walks. The badger is not entirely carnivorous; its food consists of fruits, nuts, roots, and eggs, as well as small quadrupeds, birds, frogs, etc.

The **raccoon** is a curious little animal of the family **procyonidæ.** It grows to a length of about two feet; its muzzle is very pointed, its body short and thick, its fur is brownish, its tail bushy and ringed. Its legs are rather short. It is omnivorous. It uses its forefeet with great readiness for prehension.

The **panda** is a rare animal, whose position is inter-

FIG. 136.

COMMON BROWN BEAR (*Ursus arctos*).

mediate between the raccoons and the bears. It lives at high altitudes in the Himalayas and in Thibet; it is about as large as a large cat; it has reddish-brown fur and a bushy tail almost as long as the body, and ringed with red and yellow.

Bears are found in Europe, Asia, America, and in the higher and cooler parts of hot countries. They all have bodies comparatively short for the thickness, and inhabit the most savage parts of mountains and forests, where they lead a solitary life. They have strong, curved claws, which serve them especially in digging and climbing, and are more rarely used in attack. Most of them prefer vegetable to animal food, living on fruits, nuts, roots,

Fig. 137.

Polar bear (*Ursus maritimus*).

and tender sprouts; they are particularly fond of honey. During the winter they retire to caves or sheltered spots, and sleep until spring-time: they are said to **hibernate.**

Among the better-known bears are the **brown bear** of Europe, the **black bear** of North America, the **polar bear** of the far North, the **grizzly bear** of the Rocky Mountains, and the **cinnamon bear** of the same locality. The brown and black bears are not usually disposed to attack man, but the other three species named are more carnivorous in diet, and the grizzly and polar bears are dangerous adversaries in combat. The black and brown bears, when fully grown, are about six feet long, and have at the shoulder a height of about three feet. The grizzly is larger, and the polar bear is often nine feet long.

CYNOIDEA.

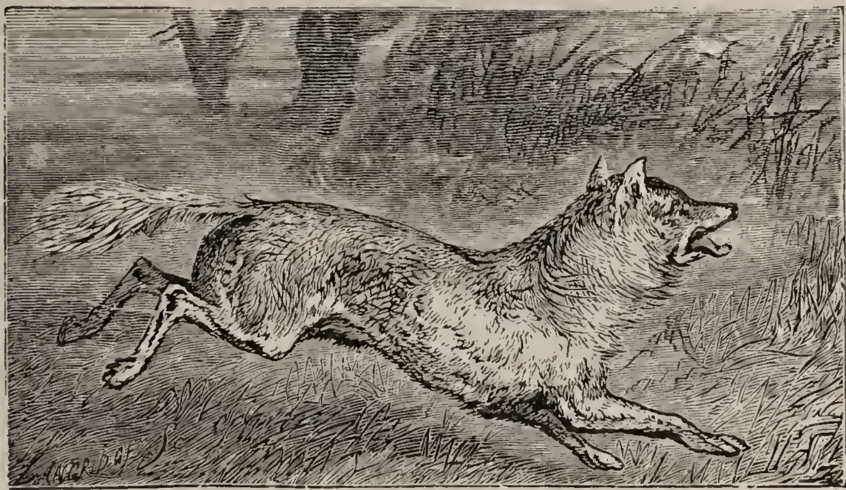
This group includes **wolves, foxes, jackals,** and **dogs.**

Fig. 138.

Wolf.

The European **wolf** is very like the gray wolf of North America. Its color is a slightly yellowish gray, with some black hairs intermingled. It is about the size of a large dog, its height at the shoulder being between two and two and a half feet. In the farming countries of Europe it frequently does great damage to the flocks, and when pressed by hunger will attack man; but it is naturally of a cowardly disposition. Some individuals are black. It prefers to live in forests. The **coyote** or **prairie-wolf** is much smaller, but similar in appearance.

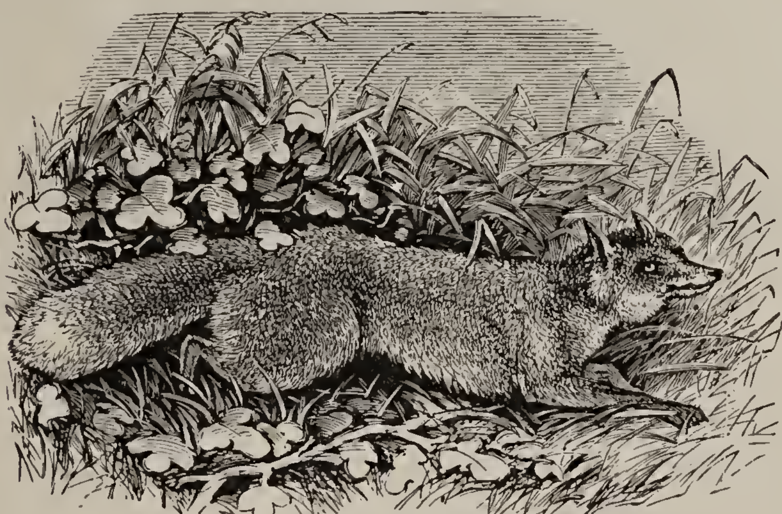
FIG. 139.



COYOTE.

The **fox** has relatively a much larger head than the dog; its ears are shorter, its tail longer, its hair longer

FIG. 140.



COMMON FOX (*Vulpes alopex*).

and thicker, its eyes more oblique. Its characteristics are much influenced by climate, and there are almost as many varieties of foxes as there are of any species of domestic animals. Most foxes are red, but many have grayish fur; in northern countries there are all colors and shades,—black, iron-gray, silver-gray, and white. The blue fox inhabits the north of both continents; its ash-gray fur is exceedingly valuable, as are also those of the silver and black foxes.

Jackals, sometimes called **golden wolves,** are found in Africa, Central Asia, Turkey, and Greece. They are troublesome destroyers of fowls in the country, and in the neighborhood of cities collect in large bands, and prowl around at night hunting animal refuse. They are smaller than wolves, and their fur is fawn-color.

FIG. 141.

COMMON JACKAL (*Canis aureus*).

The **dog** is classed with the foxes and wolves, and we need add nothing to what has been said in Chapter VIII.

AILUROIDEA.

This group includes the cat-like animals, as the name, of Greek origin, indicates.

The **lion** is distinguished from all the other species by its almost uniform fawn color, by the tuft of hairs on the end of its tail, and by the heavy mane that covers the head and shoulders of the males. It anciently existed over nearly all the Old World, but is now found only in Africa and less abundantly in Asia. It sometimes attains a length of eight or nine feet, and stands as high as four and a half feet at the shoulder.

FIG. 142.

LION (*Felis leo*).

The **tiger** lives in India, and is recognized by its fur, which is fawn-colored above, white beneath, and striped vertically with black lines. It is more slender and somewhat smaller than the lion. The **panther** inhabits Asia and Africa; it is spotted with rows of black spots, joined together in rosettes. It is probably identical with the **leopard**, which is found in the same countries. One variety is black. The **jaguar**, or American leopard, has eye-like spots, more regularly arranged than those of the leopard. It is found all over South America, and in

North America as far north as Texas and South Carolina. The **puma** of the Northern United States and Canada is

Fig. 143.

Characteristic features of the Felidæ.—*a*, tiger's head; *b*, portion of tongue; *c*, right fore-paw, showing claws; *d*, claw, showing tendons.

Fig. 144.

Jaguar (*Felis onca*).

almost as large as the tiger. Its color is a uniform gray, somewhat lighter below, and the borders of its mouth are white. The **lynxes** of Europe and America are smaller animals than those we have named, and more

Fig. 145.

The European lynx (*Lynx virgatus*).

Fig. 146.

Wild-cat.

nearly like the domestic cat. The color is grayish, with a tendency to black on the back.

All these animals are distinguished from other carnivora by the arrangement of the claws, which are retractile,—that is, capable of being thrown out and withdrawn. These curved and hooked claws constitute formidable weapons.

The domestic cats are probably descended from the wild-cat found in the forests of Europe. The **wild-cat** is yellowish gray with dark stripes, which are longitudinal on the back and transverse on the flanks. The domestic cat presents extreme variations in color, and this lack of uniformity in color is general in all animals that have become domesticated; only in the savage state does an animal possess a fixed and characteristic color.

FIG. 147.

SPOTTED HYENA (*Hyæna crocuta*).

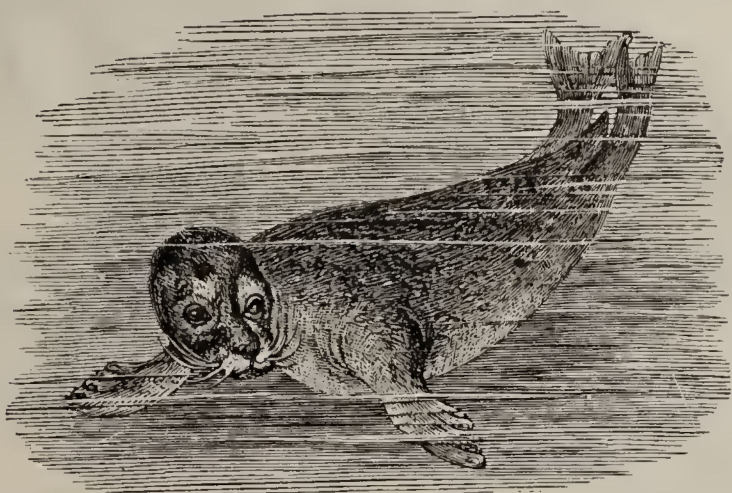
The **civet** represents a family of digitigrade carnivora having long, thin bodies, pointed heads, and short legs. The larger species are as large as foxes. The strong perfume called civet is obtained from glands situated near the anus of these animals. The **ichneumon** is another representative of the same family, called **viverridæ.**

The **hyenas** live in warm climates of the Old World; at night they infest cemeteries, disinterring the cadavers; but they are afraid of man, and attack him only when excited by the last pangs of hunger. A characteristic which enables one to recognize the hyenas when once seen is their curious oblique walk and the strange appearance presented by the hind quarters, which are always lower than the foreparts.

PINNIPEDIA.

The pinnipedia resemble the terrestrial carnivora in their complete dentition, their cutting molars, and their

Fig. 148.



Common seal (*Phocidæ vitulina*); attitude when swimming.

carnivorous diet; but they are distinguished by the form of the limbs, which are short, arranged like fins, and not adapted for terrestrial locomotion, and by their general form, which is elongated like that of a fish; the head resembles that of a dog.

The **otariidæ,** or **fur-seals,** differ from the other seals in possessing an external ear. Certain peculiarities of form have gained for the different species the names **sea-lion, sea-bear, sea-elephant,** etc. The sea-bear of the North Pacific furnishes the fur from which seal-skin garments are made.

The **phocidæ,** or common hair-seals, are found in all cold seas, and a few species even occur in the tropics. The **sea-calf,** so called on account of its peculiar cry, is the most common in temperate waters.

Seals are very intelligent, are easily tamed, and thrive well in captivity. They feed on fish and crabs, and live

Fig. 149.

Walrus.

in herds near the coasts, where they may be sometimes seen playing on the waves, sometimes resting on the sand-banks. The thick layer of fat that surrounds their bodies enables them to move through the water without exerting any apparent effort to keep afloat.

The **trichecida** or **walrus,** which is sometimes called **sea-cow** and **sea-horse,** has two enormous canines in the upper jaw, and these he uses as a means of defence and to assist in climbing on the ice. The walrus attains a length of ten or twelve feet; the seals are smaller, excepting the sea-elephant, which is said to grow as long as thirty feet.

CHAPTER XXIV.

Rodentia—Edentata.

RODENTIA.

THE rodents are mostly terrestrial mammals, having four clawed feet and incomplete dentition. They have no **canines**; the **incisors** have chisel-like edges, and are curved in a circular arc, the convexity outward; besides they grow indefinitely during life, so that they are pushed out at the base as they are worn away at the edge, and the posterior surface wears more rapidly than the anterior, whose enamel is harder. This structure indicates the diet of the animals, organized for gnawing everywhere and continually, and in whom the gnawing instinct predominates nearly all others. There is a space between the incisors and the molars.

FIG. 150.

SKULL OF COMMON PORCUPINE (*Hystrix cristata*).—The lower jaw partly in section to show the lower incisor tooth.

Rodents have the upper lip slit vertically, giving a peculiar physiognomy; this condition occurs sometimes in man as a defect, and is called harelip. Generally, rodents are herbivorous or frugivorous; some, however, such as rats, are omnivorous. Most of them are small; the limbs are organized for jumping rather than walking, the hind quarters being higher than the shoulder. The brain is not highly developed. They are timid, and only moderately intelligent, although endowed with remarkable instincts. Nearly all are nocturnal, digging galleries, and passing three-fourths of their existence underground; some are semi-aquatic, and a few live in trees. In general they have an instinct of foresight, and lay up for winter a store of provisions, consisting of grains and fruits, in quantity much greater than their real necessities require. Several hibernate during the cold season.

Fig. 151.

Common squirrel (*Sciurus vulgaris*).

Of all the orders of mammals the rodents are most widely distributed over the earth's surface, representatives being found in every country on the globe. There are more than six hundred species; many of them may be considered useful to us, because we use their skins for furs and their flesh for food; but the necessities of their diet nearly always render them injurious to agriculture, especially on account of their instinct for storing food. The most interesting species are the **squirrels, marmots, beavers, dormice, rats, mice, voles, lemmings, chinchillas, muskrats, capybaras, porcupines, agoutis, guinea-pigs, hares,** and **rabbits.** All, except the hare and rabbit, have only one pair of upper incisors, the enamel being only in front. Hares and rabbits have four upper incisors, the enamel extending around the teeth.

Squirrels are found in the forests of both continents.

Fig. 152.

Chipmunk (*Tamias striatus*).

They live on grains, fruits, and nuts, and make their homes in hollow trees. The common squirrel is bright red, with a white belly. The gray squirrel has a soft light fur, which is the object of considerable commerce. In this variety the back is a beautiful bluish gray, the hair being dark gray at the roots and silver-gray at the tips; the belly is pure white.

The **chipmunk** is a small species of squirrel, often called the ground-squirrel, common in North America. It lives in underground burrows.

Marmots are found all over Europe, Asia, and North America; they abound in the Alps. They pass the greater part of their existence in burrows, in which, on the approach of winter, they enter that lethargic sleep that characterizes hibernating animals. The **woodchuck** is our largest marmot, its length being about fourteen inches.

FIG. 153.

THE ALPINE MARMOT (*Arctomys marmotta*).

The **prairie-dogs** of the western United States are closely allied to the marmots. They construct what are called **prairie-dog villages**, and it is said that their habitations are shared with the rattlesnake and the owl. They are rather larger than rats.

The **beaver** is one of the largest rodents, attaining a length of two and a half feet. It has a flat, scaly tail, and the hind feet are webbed, all the toes having claws. It is a semi-aquatic animal, celebrated for the ingenious manner in which it constructs lodges and dams with branches of trees and mud, but aside from this instinct showing little intelligence. It is found occasionally in France and Germany, and was formerly very abundant in North America, where it lived in large colonies, and constructed lodges that excited the admiration of travellers. Under the hair of the beaver, which is usually of

Fig. 154.

Prairie-dogs (*Cynomys ludovicianus*).

a reddish color, is a fine gray down that makes the fur much esteemed.

The **rats** include a number of species, much alike in appearance and in habits. Properly, the rats may be classified as black rats and brown rats. The black rats invaded Europe at the time of the Crusades, and during several centuries ravaged the country and the cities. About a hundred years ago a few individuals of the brown species were brought from Persia; they multiplied rapidly, and waged such a terrible war on the black rats that the latter were driven from the cities.

The **field-rat** is smaller than the house-rat and larger than a mouse. It lives in the fields, where in its burrows it lays up prodigious stores of nuts and grain; a single individual will sometimes collect more than a bushel.

Fig. 155

Beavers and beaver-lodge.

The dwarf field-rat makes its home in the stubble-fields, and cuts off the stalks in order to obtain the spikes.

Mice originated in Europe, whence they have been distributed by ships to all parts of the world. They prefer the interior of dwellings, in which their omnivorous appetite and their odor render them a nuisance.

The **dormouse** is analogous to both the rat and the squirrel. It lives on trees, and often does much injury in orchards by its propensity for fruit-eating.

The following species have short tails, and are called **voles**: The **field-** or **meadow-mice,** a number of species, all more or less destructive to agriculture. The common field-mouse is especially abundant in Europe, where it sometimes multiplies so rapidly that it destroys whole crops. It is as large as a common mouse, brownish yellow on the back, and dirty white below. The **water-rat** is about as large as the ordinary black rat; it lives on the banks of streams and ponds, and feeds on roots, aquatic plants, frogs, insects, and little fish.

FIG. 156.

MUSQUASH (*Fiber zibethicus*).

The **lemmings** have still shorter ears and tail than the voles; the body is heavier and the claws stronger. They are about the size of the ordinary rat, and are found in Siberia and Northern North America. In Northern Scandinavia they multiply so rapidly that they periodically migrate in large numbers, swimming rivers, crossing mountains, devouring whatever they come across, and breeding and dying on the way.

The **musk-rat,** or more properly **musquash,** is a large rodent, its head and body measuring about fifteen inches, and its tail ten inches. It is very aquatic, rarely being found far away from the banks of the stream or pond near which it lives. It burrows under the banks, the entrance to its hole being under water. Its food is principally vegetable. Its dark-brown, downy fur is rather short, but mixed with longer and stiffer hairs, and is in considerable demand.

The **chinchilla** is best known by its soft gray fur. It inhabits high altitudes in Chili and Peru. Its body is about a foot long, and it somewhat resembles a squirrel, but its hind legs are longer.

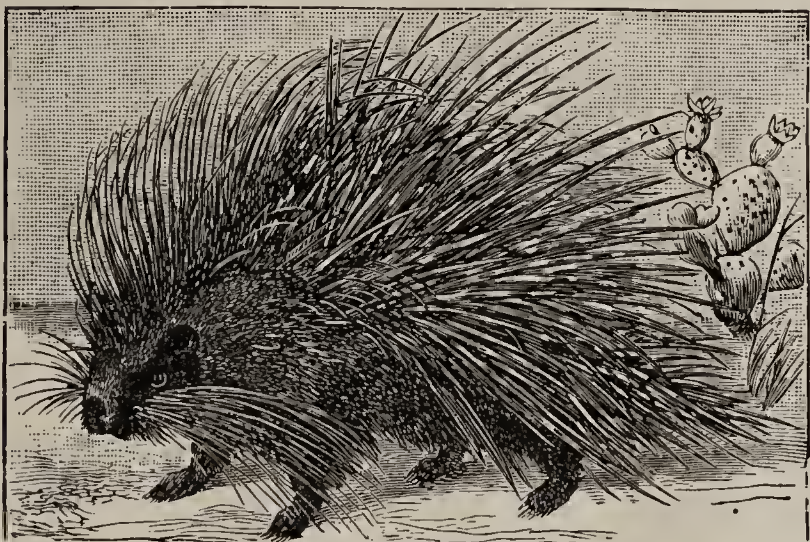
FIG. 157.

CAPYBARA (*Hydrochœrus capybara*).

The **capybara** is the largest rodent, being as large as a small pig, and much resembling in form the guinea-pig. It is aquatic in its habits and vegetarian in diet. It has thin, coarse, and brownish hair. It is found in Northern South America, where it is known as the water-hog.

The **porcupine** is quite common in the south of Europe. Like the hedgehog, it has a natural defensive armor,

FIG. 158.



COMMON PORCUPINE (*Hystrix cristata*).

formed of sharp, stiff spines, which bristle out from the body, and which may grow to a length of a foot and a half. These spines are alternately banded white and black. Porcupines are nocturnal in their habits; they live in burrows and hibernate in winter. A species of porcupine, the **urson,** is found in the Northern United States and Canada, where it is generally but erroneously called hedgehog.

FIG. 159.

AGOUTI (*Dasyprocta agouti*).

The **agouti** is a small South American rodent, having coarse brown or yellow hair. It has slender legs, with three toes on the hind feet.

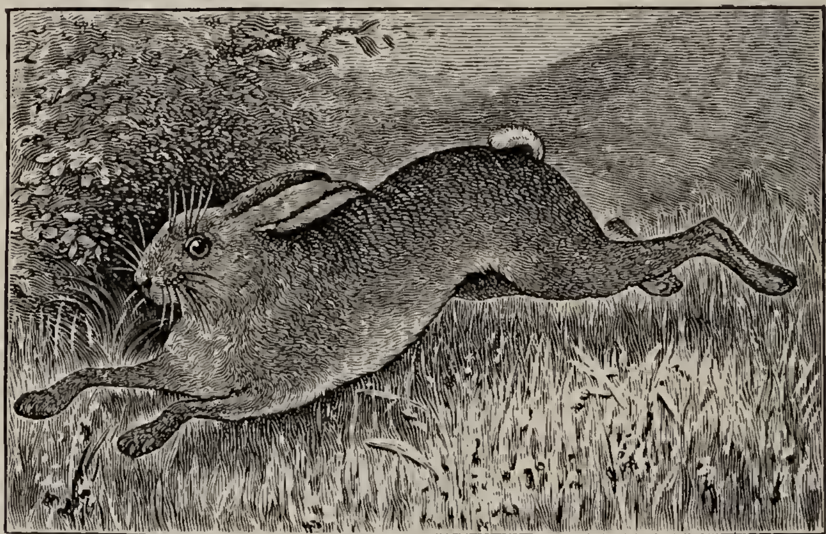
Guinea-pigs came originally from Brazil, but they are now domesticated in nearly all countries.

FIG. 160.

GUINEA-PIG.

The **hares** have very long ears; their fore legs are much shorter than the hind ones; they can consequently

FIG. 161.



COMMON HARE (*Lepus timidus*).

move only by a series of jumps, a sort of gallop. The agility of their movement is the only resource they have when they are pursued by enemies. Their fur has some commercial value, and their flesh is much esteemed.

Hares are solitary in habit, but make their abodes not far from one another. They live on herbs, roots, leaves, fruit, and grain, and even gnaw the bark off trees. They sleep during the day, and are active only at night.

Rabbits are smaller than hares, and have shorter ears and tail. Their flesh is whiter than that of the hare. They are very fecund, it having been calculated that the progeny of a single pair would in four years number twelve hundred thousand. In countries adapted to them these animals, therefore, multiply so rapidly that the soil can hardly yield crops enough for them, and they become pests to the farmer; this is now the case in certain provinces of Australia.

FIG. 162.

SLOTH.

EDENTATA.

The mammals composing this order have for a common characteristic the absence of front teeth; some have no teeth at all. By way of compensation they have very well-developed claws. None of them occur in Europe or in the United States.

As examples of edentata we will consider the **sloths,** the **armadillos,** the **pangolins,** and the **ant-eaters.**

The **sloth** is a South American animal, about the size of a cat, and looks like a deformed monkey; its limbs are not adapted for walking, and it lives suspended from the branches of trees.

The **armadillos** possess a scaly covering which envelops the body like a cuirass, and by which they are

Fig. 163.

Three-banded armadillo (*Dasypus apar*).

almost as well protected as are hedgehogs and porcupines. They are nocturnal, burrowers, and inoffensive.

Fig. 164

Great ant-eater (*Myrmecophaga jubata*).

The **pangolins** are, like the armadillos, enveloped in a scaly coat, but they are absolutely without teeth, and are compelled to live on ants that they catch by the hundred with their long, viscous tongues. They are inhabitants of the Orient and Ethiopia.

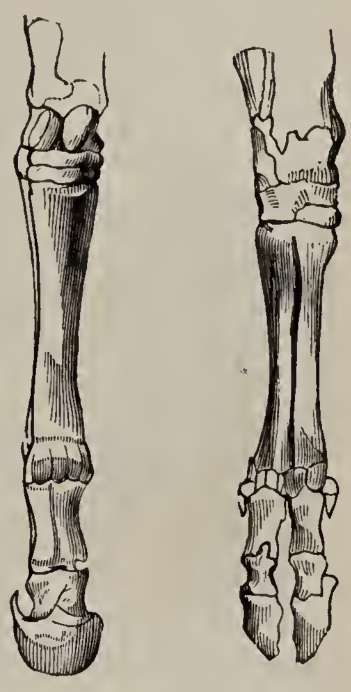
The **ant-eaters** of South America have no teeth; the muzzle is elongated like a proboscis, and by the aid of the long, viscous tongue, sometimes half a yard in length, they can lap up ants and termites (large white ants), after they have torn down the ant-hills with their powerful claws. There are several species of ant-eater.

CHAPTER XXV.

Ungulata—Artiodactyla.

THOSE mammals that have the horny extremity of the feet developed into hoofs are called **ungulata**. The order includes a great number of species; in some the number of toes is odd, in others it is even, and an excellent classification is based on this difference. Those having an even number of toes are called **artiodactyla**, and this class includes the ruminants, the hippopotami, and the swine families. The ruminants are distinguished by a complex stomach, and comprise the deer, oxen, sheep, giraffes, and camels. Those ungulates having an odd number of toes—and this number does not exceed five—are called **perissodactyla**; among these are the horse, ass, zebra, tapir, and rhinoceros. The elephant has five toes, but he is the

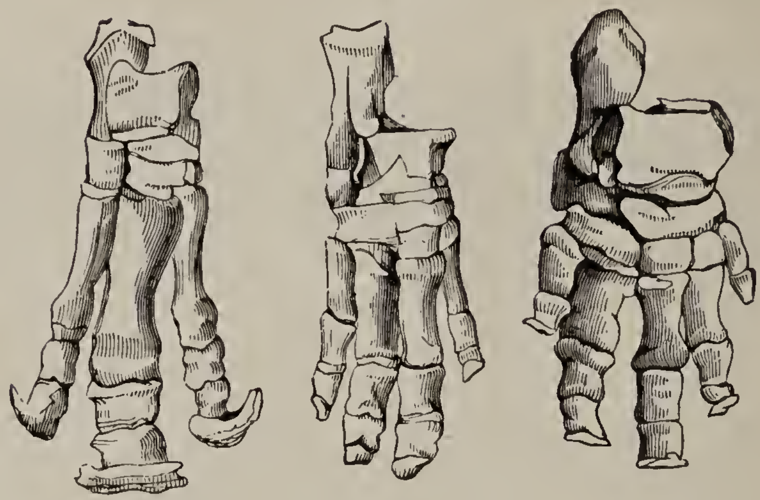
FIG. 165.



HORSE. OX.

only living representative of a suborder, called **proboscidea.**

Fig. 166.

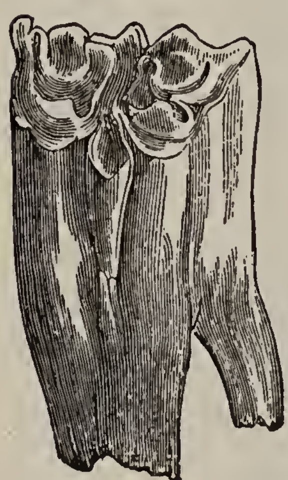


Rhinoceros. Hippopotamus. Elephant.

RUMINANTS.

The ruminants or cud-chewing mammals are herbivorous, and flesh forms no part of their food. Their teeth are not sharp-edged, but flat, and adapted for grinding; their digits do not terminate in claws, but in a horny hoof, a means of defence and not of attack. In all the ruminants this hoof is split in the median line, and so forms a bifurcated sheath for the two toes that compose the foot; ruminants are said to be **cloven-footed.** Lastly, the upper jaw is usually without incisors, and the stomach has four distinct compartments.

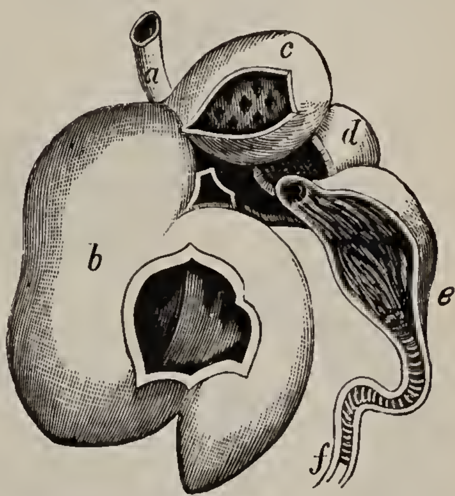
Fig. 167.



Molar of an ox.

The details of the digestive functions of ruminants are very different from those of animals whose stomachs form a simple sac. When an ox eats, he simply swallows the grass, almost without mastication, and this is stored in the first stomach, which is called the **paunch,** or **rumen,** and the second, or **reticulum,** which is lined with hexagonal cells. These first two compartments constitute the cardiac division of the stomach, and the food passes into them indifferently and from one to the other, becoming mixed and saturated with the saliva. After entering the stable, or while resting in the pasture, the ox brings up the grass in little masses and grinds it to a pulp between his powerful molars, mixing it at the same time with more saliva. He then swallows the pulpy mass, and in this deglutition the stomach walls fold together, so that the aliment passes not into either the rumen or the reticulum, but directly into the third stomach, called **psalterium,** which takes its name from the leaf-like folds of membrane that line its walls. Through these folds the broth is strained into the fourth stomach, or **rennet-bag,** where are accomplished the phenomena of digestion that are comparable to those that take place in animals having simple stomachs. At the extremity of this last compartment is the entrance to the intestinal canal. In the ruminants the total length of the intestine is more than twenty-five times that of the body.

FIG. 168.



COMPOUND STOMACH OF AN OX.—*a*, œsophagus; *b*, rumen, or paunch; *c*, reticulum, or second stomach; *d*, omasum, or third stomach; *e*, abomasum, or fourth stomach; *f*, duodenum.

Before describing the principal species of ruminants, we must insist on the importance of the form of the feet in all the species as a means of classification. There are only two digits, enclosed in a divided hoof, and the metacarpal and metatarsal bones, two each in number, are united in single bones, called the shank. That which is commonly called the leg is, therefore, only a part of the hand or foot.

Fig. 169.

Stag, hind, and fawn (*Cervus elaphus*).

The ruminants have been divided into two groups, those having horns and those having none: among the latter are the camels and llamas. In some of the first group the horns are **caducous** or deciduous, falling off every year, as in the various species of deer; in others they are persistent; in the latter case they may be hollow, consisting of a horny sheath covering an osseous prolongation of the frontal bone, as in the ox, sheep, and goat, or they may be solid and covered with skin, as in the giraffes.

Cervidæ.—The deer family includes the largest animals of our forests. The **red-deer** of Europe and Western Asia stands over four feet high at the withers, and the male has magnificent antlers. It is reddish brown in summer, and bluish gray in winter. The horns of the deer are purely osseous, the tissue being close and hard; when they have grown to a certain size, the skin which covers them becomes dry and is rubbed off, and the bone, being deprived of its covering, dies like any other bone when the periosteum is removed. This growth and fall of the horns take place every year, but each year the new growth becomes larger and gains new branches, so that it is possible to tell the age of a deer by the development of its antlers. Figure 170 shows the growth of the antlers in successive years.

Fig. 170.

Antler of stag, showing increase in number of prongs from first to sixth year.

The **wapiti** of the Northwestern United States and Canada is closely allied to the red-deer of Europe; it is frequently, but improperly, called the elk. The **fallow-deer** is a native of the Mediterranean coasts, and has been semi-domesticated in Europe, where it is found in many parks. The horns, which are possessed by the male only, are cylindrical at the base, but flattened and serrated externally in the remainder of their length. This deer is reddish brown in color, with white spots.

The **roe-deer** or **roebuck** is a small species of European deer, its horns being not largely developed.

The **cariacou,** or **Virginia deer,** is the common deer of

North America. It is smaller than the European red-deer, but is more graceful in form; its height at the shoulders is about three feet. Its color is reddish brown in summer, blue in autumn, and dull brown in winter, the under parts and internal surfaces of the legs being white. The antlers, after curving backward, spring forward, their tips being close together above the nose.

FIG. 171.

FALLOW-DEER (*Dama vulgaris*).

The coats of the fawns are spotted or even striped with white. The flesh of this deer is exceedingly palatable.

The **reindeer,** called **caribou** in the United States, is larger than the Virginia deer, and hardly as large as the stag or elk, but it is more heavily built; its legs are short and heavy and its hoofs broad, giving it a firm footing as it runs over the snow. The color is a dark grayish brown. In Lapland the reindeer has been domesticated. It occurs in the Northeastern United States and Canada and in the northern parts of Europe and Asia.

FIG. 172.

REINDEER (*Rangifer tarandus*).

The **elk** or **moose** is the largest of the deer family, standing six feet high at the shoulder. The legs are long and the neck is short, so that the animal feeds on bushes and the low branches of trees rather than on ground herbage. The horns, borne by the male only, are broad, flat, and branched exteriorly, the internal edges forming one curve. They are solitary in their habits, and prefer the wildest forests. A few are found in Northern Europe and Asia, but the species is most abundant in the colder regions of North America.

FIG. 173.

HEAD OF ELK (*Alces malchis*).

Bovidæ.—These are hollow-horned ruminants, the horns being non-deciduous. Of all animal species the bovine is, without doubt, that which renders the greatest service to man. It is used in ploughing and hauling;

Fig. 174.

Short-horn bull and cow.

its milk and flesh furnish food; its manure is of great value in agriculture. Its skin, its fat, its bones, its ten-

Fig. 175.

Hereford bull and cow.

dons, and even its intestines are made use of. The skin of the ox, the cow, and the calf are turned into leather; the hair is used by upholsterers, saddlers, etc. Buttons and other articles are made from the bones, as are also gelatin and bone-black; bone-meal is also an excellent fertilizer. Spoons, combs, etc., are made from the horns.

The blood is used for clarifying syrups, wines, etc., and in refining sugar. From the intestines are made strings for musical instruments, and the gall is used as a soap for cleaning delicate fabrics.

Fig. 176.

Jersey cow.

Cattle, like all domestic animals, are greatly modified by the influence of climate, food, and habits of life. In the temperate zones the height is greater, the flesh is more tender and juicy, and the skin is thicker. Northern cattle furnish more and better suet than those of the South. Those that live in the mountains have compact bodies, very short necks, legs,

Fig. 177.

The Cape buffalo (*Bos caffer*).

and heads, the rump large, and the horns projecting laterally; those on the plains have longer and more slender bodies, long legs and neck, and the horns are directed to the front. While variations in the species are produced by varying conditions of climate and surroundings, many of the characteristics have been intentionally developed by selected breeding. Thus, the **short-horns** or Durhams are entirely the result of man's industry.

Related to domestic cattle are the **Cape** and **Indian buffaloes,** inhabitants of Africa and Asia, and the **bison,** once roaming in vast herds over the prairies of the United States, but now with rare exceptions seen only in parks and zoological gardens.

FIG. 178.

HEAD OF THE ASIATIC BUFFALO (*Bubalus buffelus*).

The **sheep** is found wild only in certain localities, these being the lofty mountains of Central Asia and Mongolia, and the Rocky Mountains of the United States. The domestication of the sheep dates back to prehistoric eras, the first peoples of whom we have any history being pastoral races, who wandered from pasture to pasture, following their sheep. The sheep has perhaps been more modified by man's influence than any other animal.

FIG. 179.

AMERICAN BISON.

The **merino sheep**, which originated in Spain, are widely celebrated; no variety is more valuable for wool-raising.

Fig. 180.

Merino sheep.

These sheep are not large, and may be recognized by the small head and slender legs. The wool is long and curly, and becomes as white as snow when the animal is washed. The feet, the muzzle, and the forehead are often black.

In the sheep the horns, borne only by the male, are directed first backward, then curve downward and forward, forming a spiral. In the **goats**, both male and female have horns, and these are turned upward and backward; the horns of the female are small. Goats usually also have beards on the chin, while that of the sheep is never bearded. There are a number of species of goat, all of them European or Asiatic. They inhabit great heights in the wildest mountains, and are timid and wary. One of the largest is the **steinbok**, or European **ibex**.

The **antelopes** are closely allied to the goats; most of the tolerably large number of species are found only in

Africa, but some occur in India; the **chamois** is European, and the **Rocky Mountain goat** is found in the

Fig. 181.

Bezoar goat (*Capra ægagrus*).

Fig. 182.

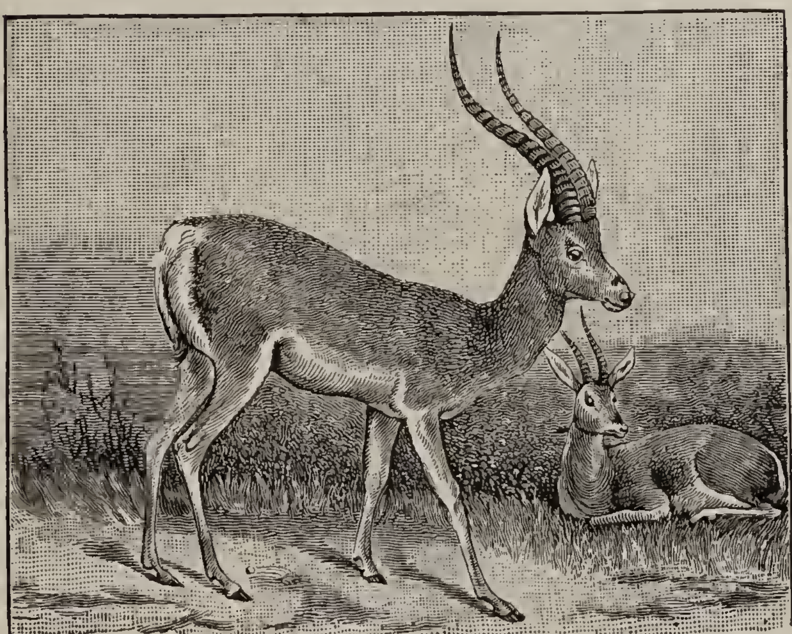
Chamois.

United States. In some species both male and female are horned, in others only the male; some are almost as large as a horse, such as the **gnu**; others, like the smaller

FIG. 183.

GNU (*Catoblepas gnu*).

FIG. 184.



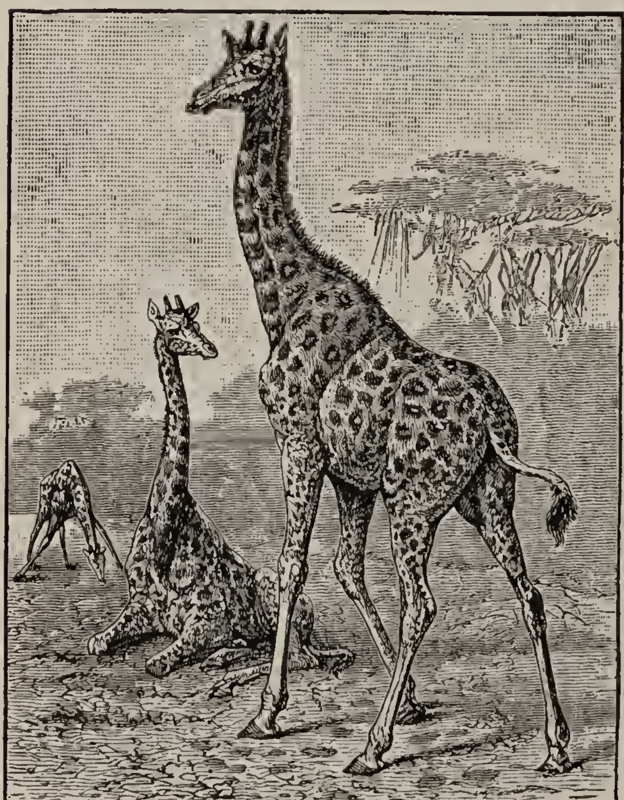
AFRICAN GAZELLE.

African **gazelles**, may not exceed two feet in height at the shoulder. The horns are of various forms, usually exceedingly graceful, and sometimes of great length; for example, the gemsbok is about four feet high at the shoulder, and its horns are two and a half feet long. These animals are all very active, very sure-footed; the chamois can leap over a chasm fifteen feet wide, or over a wall fourteen feet high.

On the prairies of Western North America is found the only known member of a family of ruminants whose horns are hollow, deciduous, and having one short branch. This is the **prong-horn,** and is generally called antelope. It seems to relate the cervidæ and the bovidæ, and the family is called **antilocapridæ.**

Giraffidæ. — The horns of the giraffes are not hollow, but solid, and consist simply of processes of the frontal bone, which are covered by the skin. These horns are persistent. The giraffes are well known by their remarkably long necks and legs, the head being eighteen feet above the ground. They are found in Africa.

FIG. 185.



GIRAFFE (*Camelopardalis giraffa*).

Camelidæ. — This family includes the camels and **llamas.** They have no horns, and they are the only ruminants having a pair of upper incisors. The upper lip of the camel is cleft and enlarged; the side of the foot is covered with a thick, indurated skin; the

Fig. 186.

Dromedary.

back bears a lump of fat which is single or double, according to the species. The digestive system of the camel differs from that of the other ruminants in that there are but three stomachs, the psalterium being absent. The interior of the paunch is lined with large cells, and it is said that the camel can store water in these cells and so go many days without drinking.

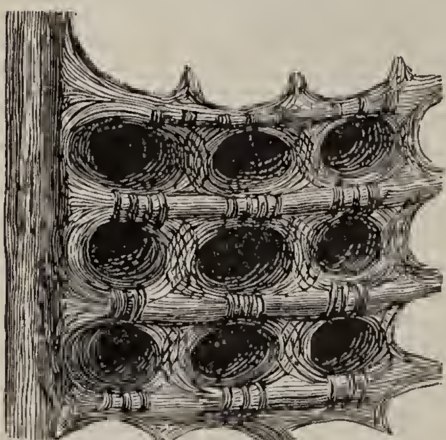
There are two species of camel: the **two-humped camel** or **Bactrian camel** of Central Asia, which is not found far from the immense plains where dwell the

FIG. 187.

CAMEL (*Camelus bactrianus*).

Tartars, and the **single-humped camel,** or **dromedary,** originally of Western Asia, but now domesticated in Asia and Africa; this latter is the species employed as a beast of burden.

FIG. 188.



PART OF THE INSIDE OF STOMACH-PAUNCH OF CAMEL, showing the water-cells.

The **llamas** are the American representatives of the Camelidæ, true camels being found only in the Old World. Several species of llama occur in the mountainous regions of Western South America, and some of them have been domesticated by the natives, both for service as beasts of burden and for the long, woolly hair obtained from them. They are much smaller than camels, and have no humps on the back.

FIG. 189.

LLAMA.

SUINA.

This section of the artiodactyla includes the hippopotamus and the various species of suidæ. They are not ruminants.

The **hippopotamus** lives on the borders of the large rivers of Central Africa and in the neighboring marshes and swamps. It is a large animal, attaining a length of twelve feet or more; though it does not walk well, it is an agile swimmer. Its diet is exclusively vegetable, and its stomach has the enormous capacity of five or six bushels. The feet have four toes, all of which have short, rounded hoofs that touch the ground in walking. The incisors and canines grow continuously, like the incisors of rodents.

The **suidæ**, or swine family, has a number of representatives, among which the more important are the **wild**

Fig. 190.

Hippopotamus amphibius.

Fig. 191.

Wild boar.

boar of Europe, Asia Minor, and Northern Africa, the **wart-hog** of Southeastern Africa, and the **peccary**, which is found from Arkansas to South America. These animals live either solitarily or in families in forests and swamps. The canines of the wild boar are developed enormously, being curved forward and upward, and forming tusks that are powerful weapons. All the members of this family have elongated mobile snouts, which are used in digging in the soil for the roots that constitute their food. There are four toes on each foot, only three of which touch the ground in walking.

Fig. 192.

Improved Yorkshire pigs.

The **domestic hogs** are descendants of the wild boar; there are a large number of varieties, all developed by careful breeding, some of which become very fat, while others are valued for their lean meat. Among them we may name the Essex, Sussex, Berkshire, Yorkshire, and Victoria varieties; from these mainly the American hogs are descended.

CHAPTER XXVI.

Proboscidia—Perissodactyla.

The **elephants** are the largest terrestrial mammals. There are two species, the Indian and the African. The Indian or Asiatic elephant is usually taller than the

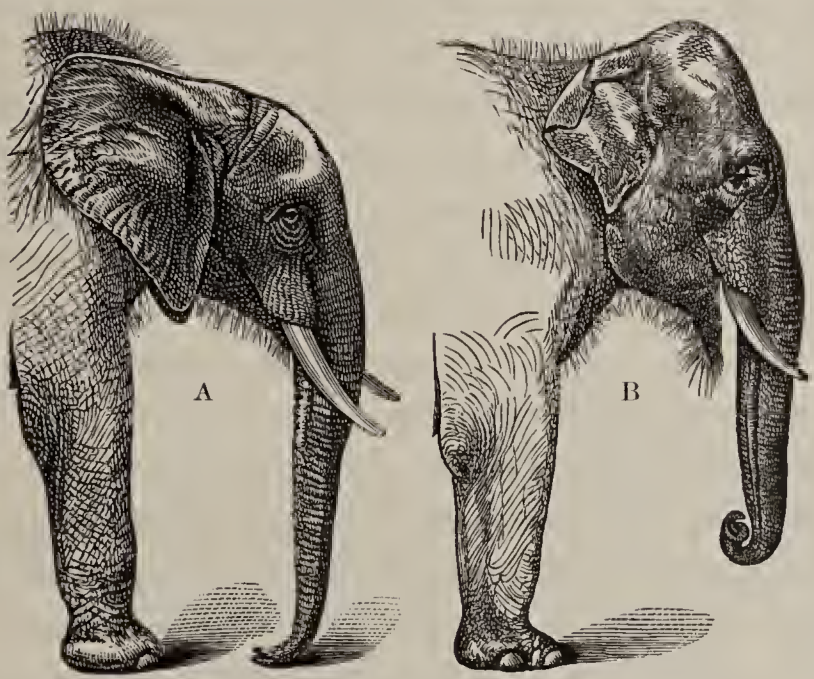
Fig. 193.

African elephant ("Jumbo").

African, and has smaller ears and tusks, and a concave forehead. It inhabits the forests of continental India and of Ceylon, Sumatra, and Borneo. It is domesticated, and trained to do many kinds of work. The

African elephant has a convex forehead; it is not now

FIG. 194.



Heads of (A) African and (B) Indian Elephants.

domesticated, and has not been for many centuries. This animal is destructively hunted for its tusks, which furnish the valuable ivory of commerce.

FIG. 195.

Tips of trunks of (*a*) African and (*b*) Indian elephants.

The two enormous species of fossil mammals known as **mammoth** and **mastodon** belonged to the class proboscidia, and differed but little from the elephants in organization and in habit.

PERISSODACTYLA.

The perissodactyla are classified in three families, represented by the horse, the tapir, and the rhinoceros.

The **horse, asses, zebras,** and **quagga** make up the family **equidæ;** their feet terminate in single toes protected by but one hoof. They are all herbivorous, and the digestive apparatus is simple; they do not ruminate.

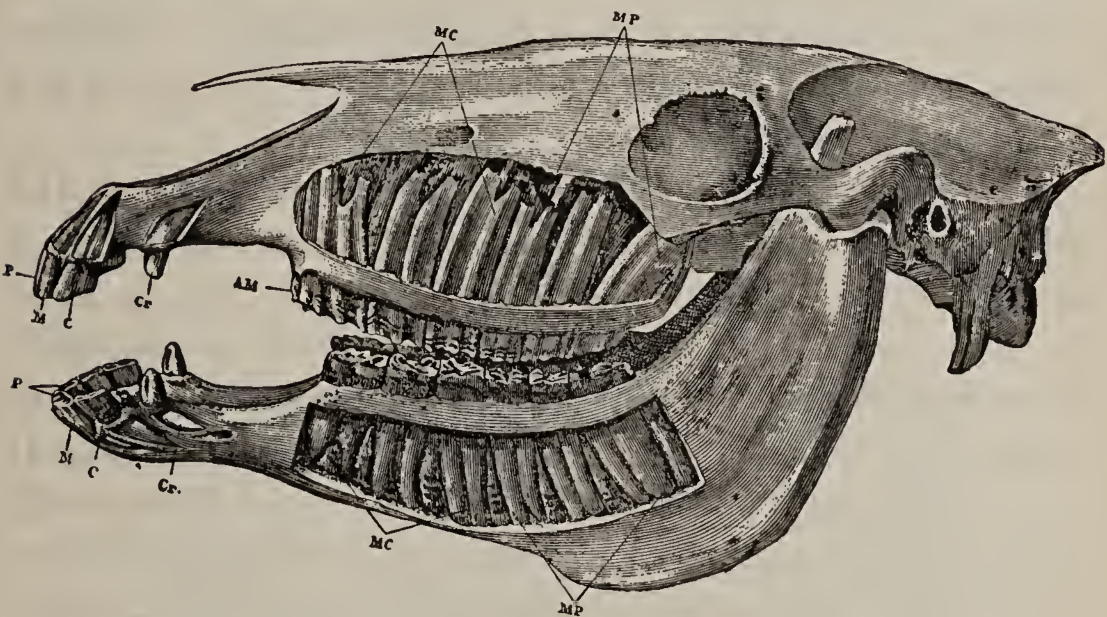
As we know the horse, he is the result of intelligent breeding, continued for centuries, and directed to render this valuable servant better adapted to fulfil the functions for which man designs him. The wild horse—that is, in a natural state and neither raised nor broken by man—is smaller than the domestic horse; it has long, coarse hair, a large strong head, projecting bones; but delicate, well-formed limbs.

The jaws of the horse are provided with teeth which are worthy of study: at the back of the mouth are the large square molars which are used to crush and grind grains, straw, and fodder; they are twenty-four in number, twelve on each side, six above and six below. In front are flat teeth with sharp edges, used in cropping herbage; they are the incisors, and number twelve, six above and six below. Between the molars and incisors, above and below and on each side, is a space without teeth, and where the gums are naked. This is the space in which lies the **bit,** and it is called the **bar.** Usually, each jaw of the male has two **dog-teeth,** which represent the canines of the carnivora, and are placed in front of and at a little distance from the molars.

In our days the true wild horse seems to have disappeared; nevertheless in those parts of both continents known as steppes, savannas, pampas, and prairies are found horses that have been untamed and independent for several generations, being descendants of domestic horses that have escaped or become lost; these wild horses may be considered as representative of the original wild race.

There are many varieties of horse, some characterized by strength, others by swiftness. The large, short, and heavily-built horses are adapted for slow work that requires sustained effort. The **Flemish** and **Norman** horses are such, and are greatly valued for heavy work; so, also, are the **Percherons**. The **Andalusian** horses of

FIG. 196.



DENTITION OF THE HORSE, AS A WHOLE.—P, pincers; M, intermediates; C, corners; Cr, canines; AM, supplementary premolars; MC, deciduous molars or premolars; MP, permanent molars.

Spain have long been celebrated for their grace and fleetness. The **Arabian horses** have in the Orient preserved all their purity and their primitive excellence. Among the tribes that inhabit the desert the horse is more than a servant, it is a companion, and to this necessity must be attributed the superiority of the Arabian horses. There is a very similar variety in Algeria, direct descendants of the Numidian horses, which anciently had great celebrity. These horses are docile, gentle, patient, and courageous, sure-footed on difficult ground, indefatigable; they combine all the characters required in army horses.

In agriculture the horse is the most active and most valuable aid to man. Even when it is dead its carcass has a considerable value; the hide, flesh, blood, fat, bones, hair, mane and tail, hoofs,—all can be utilized. In certain countries horse-meat is eaten, and there is no possible objection to the use of this meat as food if the animal be killed when in a healthy condition. Horses killed by accident might well be eaten, but it would not be profitable to raise horses for food.

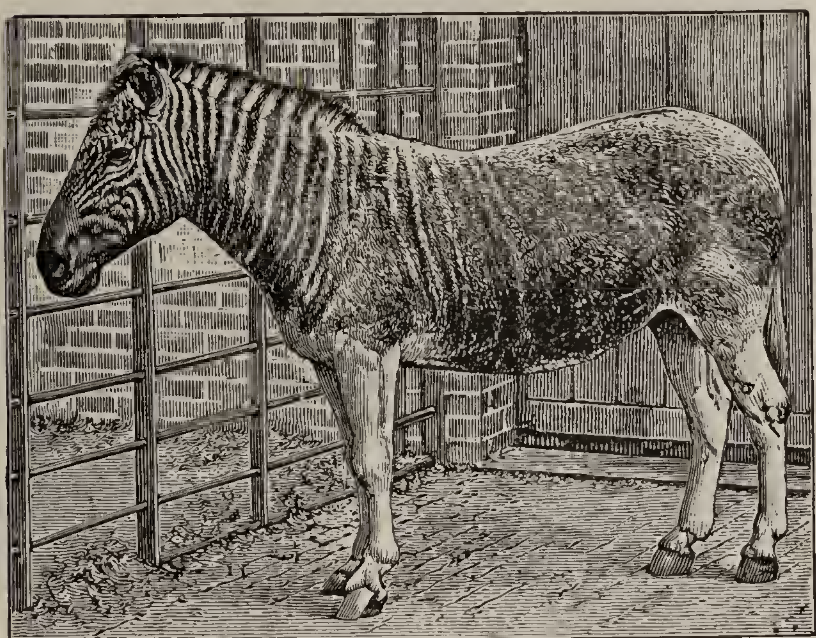
The species of **ass** include the domestic ass and the African and Asiatic wild asses. The domestic ass is a descendant of the African; the Asiatic species is light in color, and has a dark stripe in the middle of the back, extending from neck to tail. "On comparing the ass to the horse, both in form and general aspect, we notice at once," says Daubenton, "that the ass's head is larger in proportion to the body than that of the horse; the ears are much longer, the forehead and temples furnished with longer hair, the eyes less prominent, and the lower eyelid flatter; the upper lip is more pointed and overhanging, the neck and shoulders are thicker, the withers are higher, the chest is narrower and blended with the throat. The back is convex, and usually the spinal column is prominent from its origin to the base of the tail; the haunches are higher than the withers; the rump is flat and hanging; the long hairs of the tail are confined to the last quarter of its length." The mane of the ass is erect, not flowing like that of the horse.

The mule is the result of crossing the horse and the ass, and preserves some of the features of each. To the

Fig. 197.

Zebra.

Fig. 198.



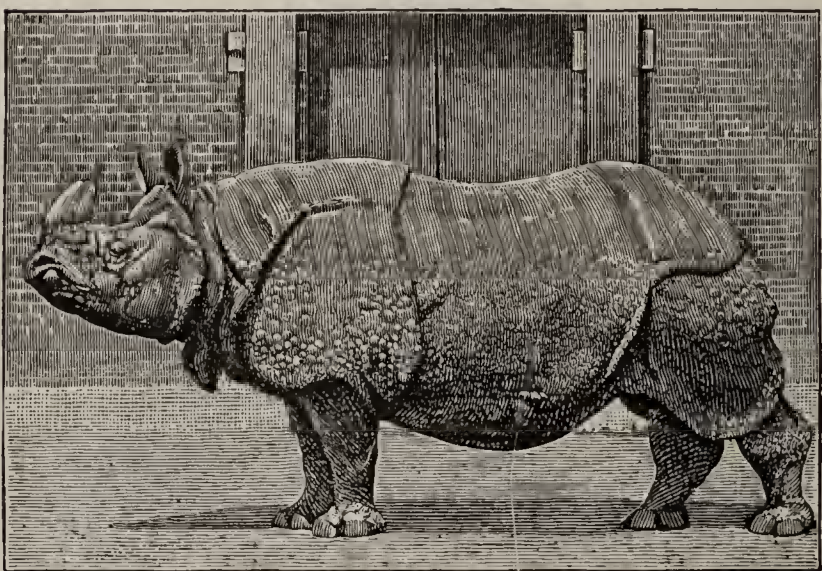
Asinus quagga (from a photograph by Messrs. York & Son, London).

ass it owes its large head, long ears, and vigorous temperament; to the horse its height, its elegant outlines, and its greater activity. The mule is more sedate than the horse and stronger than the ass; it supports heat better than the first, and cold better than the second, and is a

Fig. 199.

Tapir.

Fig. 200.



Rhinoceros unicornis (from a photograph by Gambier Bolton, F.Z.S.).

valuable animal in mountainous countries on account of its firmness of foot.

The **zebras** are smaller than the horse and larger than the ass, resembling the latter in outline and proportions.

Their entire bodies are very regularly striped with alternate white and black or brown bands. They are found in South Africa, as is also the **quagga,** which resembles the ass still more closely than does the zebra.

The **tapir** has a long, pointed head, the nose being elongated into a sort of trunk. It is a semi-aquatic animal, of peaceful disposition, living in herds in India and South America.

The **rhinoceros** is heavy and compact in form, the body being covered with an almost impenetrable skin, which forms folds having the appearance of jointed armor. They possess enormous force, and are brutal and fierce without intelligence. They are herbivorous. There are several species found in Asia and Africa, some having two horns, some only one.

CHAPTER XXVII.

Cetacea and Sirenia.

The cetacea are classified in two suborders, the **odontoceti,** or toothed whales, including the dolphins, porpoises, and cachalots, and the **mystacoceti,** which have no teeth in the adult state, but whose palates are provided with plates of **whalebone**. Both are carnivorous.

Odontoceti.—Dolphins are very carnivorous; they follow, in large schools, transatlantic steamers, devouring the fish that are attracted by the *débris* continually thrown overboard. They may attain a length of ten feet.

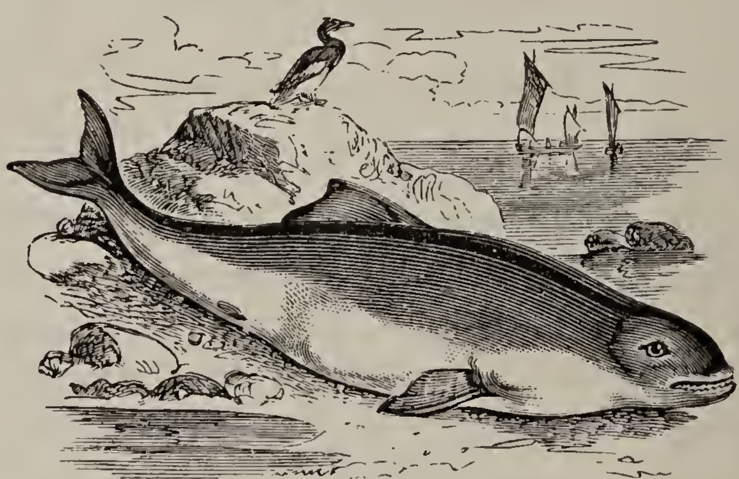
The **porpoise** has a shorter snout than the dolphin, and is much smaller. It is gregarious, and many are often seen swimming in file, their backs appearing alternately

Fig. 201.

Common dolphin (*Delphinus delphis*).

above the water. Its teeth, like those of the dolphin, are admirably adapted for catching fish.

Fig. 202.



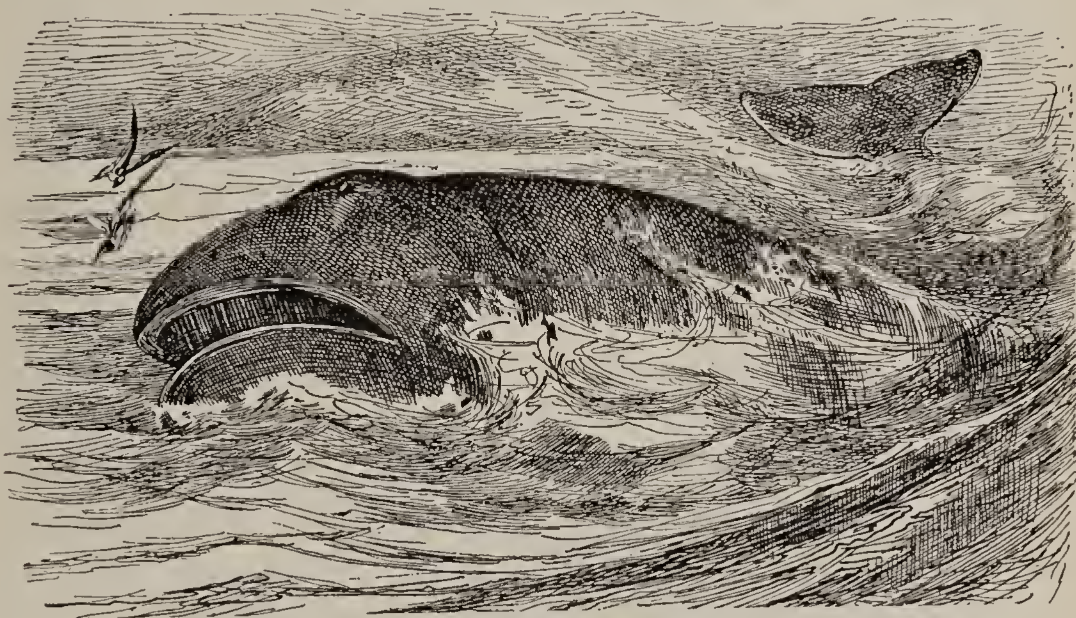
Porpoise (*Phocæna communis*).

The **cachalot,** or **sperm whale,** grows as long as fifty or sixty feet; it has teeth only in the lower jaw. Its head is enormous, forming one-third the length of the body.

From these animals is obtained **spermaceti,** a white, crystalline substance, that is found in the right nostril under the skin, and in front of the cranial bones, and in such large quantity that a single whale will furnish several hogsheads. The **cachalot** also yields **ambergris,** an odorous substance used in perfumery. It appears to be produced from the bile. The oil of the sperm whale is highly prized.

Mystacoceti.—The true whales are gigantic animals, measuring eighty or eighty-five feet in length, and

FIG. 203.



WHALE.

weighing as much as one hundred and fifty tons. The general form is like that of a fish, the body being long and cylindrical, tapering towards the tail and joined directly to the head without any appearance of a neck. The head is very large, the mouth opening exceedingly wide, being carried back under the eyes, which are very small in proportion to the size of the body, and placed very low, near the commissure of the lips. The jaws have no teeth, those organs being replaced by fibrous plates, with which each side of the mouth is provided, and formed of the blackish elastic substance commonly called **whalebone.** These plates, from eight to ten inches wide and as much as ten feet long, are rooted in the upper jaw, and have together the appearance of an enormous comb. Whales have two anterior limbs, composed of the same bones that form the corresponding limbs of large terrestrial animals, but only the hand is outside of the body, and the phalanges, instead of being free, are blended into a fin. There are no posterior limbs, and the body terminates in a crescent-shaped tail, which is horizontal, instead of being vertical, like a fish's tail.

The respiration of whales is aerial; they have lungs, and respire the air itself, so that although they live entirely in the water, they are obliged to come frequently to the surface to breathe. Like other mammals, they are warm-blooded. They bring their young into the world alive,—not by eggs, like fish,—and they suckle their young. Their skin is not scaly, but a hard hide, more than an inch thick, under which is a layer of fatty tissue. This skin is black on the back, and grayish or silver below. Whales feed on crustaceans, mollusks, and small fish; when they open their enormous mouths, the mass of water that enters necessarily contains myriads of small creatures; in order to collect them and get rid of the water, this latter is filtered out through the comb formed by the whalebones.

Whales do not leave the water, and only rarely the deep sea; their organization does not allow them to come on land, and their weight and size prevent them from approaching the shores. When they are driven on shore by storm, they are stranded just like ships, and enormous specimens of this and allied species are sometimes so thrown on our coasts.

The substances obtained from the whale are, first, the oil which is obtained by melting the fat or blubber, and a single whale may yield eight or ten tons; then the whalebone, which is used for many purposes.

The **arctic right whale** is forty-five or fifty feet long, as is also the **humpback**, so called from the shape of the dorsal fin. The name **balænoptera** is given to the **razorbacks, fin-backs,** and **rorquals,** which latter are the largest species. The balænoptera have folds in the skin of the throat, and very distinct dorsal fins.

SIRENIA.

This order contains but two living families, the **manatees,** or sea-cows, and the **dugongs.** They are found in

Fig. 204.

Dugong (*Halicore dugong*).

warm Southern seas and estuaries; they are inoffensive, gregarious, and herbivorous. Like the cetacea, they have no hind limbs, but the phalanges of the fore limbs are perfect in sirenia, and there are rudimentary nails.

The dugongs attain a length of about ten feet; the manatees are somewhat longer. In both families the female displays a remarkable affection for her young, carrying it around under the flippers, with the head out of water. The tail of the manatee is rounded at the end; that of the dugong is fluked. The manatee partly leaves the water, even feeding on shore plants; the dugong keeps to the water, grazing on algæ.

CHAPTER XXVIII.

Marsupials—Monotremes.

THE females of the marsupials have the mammæ placed in a sac or pocket (Latin **marsupium**), in which the young are placed after birth. This organization is necessary, because the young are born in a very imperfect condition, and must remain suspended at the mammæ during a certain term. The sac is supported by special bones, called marsupial bones, which are processes from the anterior portion of the pelvis; they exist in the male as well as in the female. The only species that we need study are the kangaroos and opossums.

The **kangaroos** live in herds on the borders of the great forests of Australia. There are several species of different sizes, the largest sometimes attaining a height of eight feet. The fore limbs are much shorter than the posterior, and the latter, protected by a sort of hoof, are the only ones used in locomotion, which in these animals is very curious, consisting of a series of jumps. The long tail, whose bones are very strong, acts as a sort of spring assisting in the jumping. These animals are peaceable and inoffensive, entirely herbivorous; they are hunted

FIG. 205.

THE GREAT KANGAROO (*Macropus giganteus*).

both for their skins, which make excellent leather, and for their flesh.

The **opossums** are the American representatives of the marsupials; there are several species, some of the South American being scarcely larger than a mouse. That of North America, the Virginia opossum, is larger than a cat; it has a scaly prehensile tail, and is nocturnal in its habits, which are those of a scavenger.

There are many other marsupials, and we may mention as among the most curious the **flying phalangers,** which have a membrane stretching from the outer digit of the

Fig. 206.

Virginian opossum (*Didelphys virginiana*).

Fig. 207.

1, Flying phalanger (*Petaurus taguanoides*).
2, Flying mouse (*Petaurus pygmæus*).

fore paw to the foot; by the aid of this membrane they can make enormous leaps from tree to tree.

MONOTREMATA.

This order contains but few species, mostly limited to Australia ; and in it we find a sort of transition from mammals to birds. In fact, the shoulder of the monotremes has the same structure as that of birds and reptiles ; their urinary system is like that of birds, and their teeth are either shed early in life or entirely absent. There are no mammæ, the mammary glands opening directly on the surface of the skin ; and the female lays

Fig. 208.

Ornithorhynchus paradoxus.

eggs, from which the young are hatched, thus differing from all other mammals.

The **ornithorhynchus** is the most interesting of this order. By the Australian colonists it is called water-mole. Its teeth drop out before it reaches adult life, leaving on each side of the jaw two horny prominences, which serve the purposes of mastication in the adult. The mouth is surrounded with naked skin, which forms folds at its base, and looks much like the bill of a duck. The length is eighteen to twenty inches from tip to tip, and the body is covered with short, soft fur. The animal is aquatic in its habits; its food consists of worms, crustaceans, and water insects.

The **echidna** is sometimes called spiny ant-eater, for it lives mainly on ants. It has a long-pointed muzzle, and the fur of the back is interspersed with strong spines about two inches long. It can burrow very rapidly in soft earth. There are several varieties of this creature found in the rocky and mountainous regions of New Guinea, Tasmania, and Australia.

Fig. 209.

Echidna aculeata.

CHAPTER XXIX.

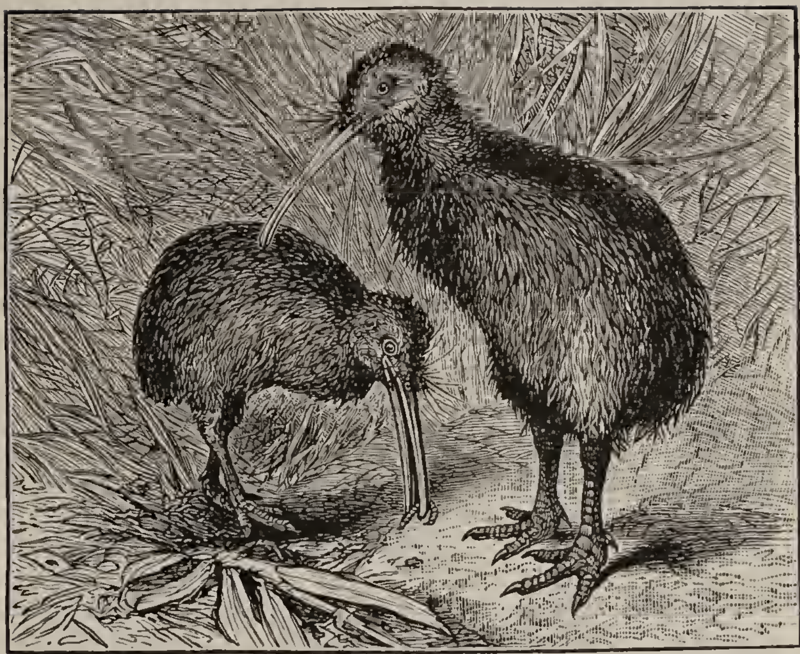
Birds.

The classification of birds does not rest on a satisfactory basis like that of mammals. All living birds are divided into two subclasses, the **ratitæ**, or flat-breasted (raft-breasted) birds, which is small in number, and the **carinatæ**, or keel-breasted birds, which includes all the others.

RATITÆ.

The wings of these birds are short or rudimentary, and are not adapted for flying; the breastbone is flat,

FIG. 210.



APTERYX.

FIG. 211.

OSTRICH (*Struthio camelus*).

not requiring large surfaces for muscles of flight, as in the carinatæ. There are no shafted feathers.

The smallest representative is the **apteryx** or **kiwi** of New Zealand,—usually not much larger than a good-sized hen. The largest is the **ostrich**, which is also the largest living bird, being six or seven feet high. The plumage of the males is black mixed with white, and there are

FIG. 212.

CASSOWARY (*Casuarius galeatus*).

large white feathers on the wings and tail; that of the female is uniform gray. The ostrich is now found wild only in the sandy portions of Africa, Arabia, and Syria, but it is tamed and reared on **ostrich farms** for the feathers, which have great value. The ostrich can run with great rapidity, and can travel over the desert, passing rapidly from one oasis to another in search of food. The **rhea** of South America is closely related to the ostrich, but is not as large, and its grayish feathers have no commercial value. The **emu** and the **cassowary** are found in Australia and the South Sea Islands; they are three or four feet high. The cassowary has a horny crest on the forehead; the emu has none; otherwise the birds are very similar.

CARINATÆ.

The following classification of the **carinatæ**, the birds with a keeled breastbone, is mainly that of Ridgway's "North American Birds:"

Swimmers and Divers.

1. Pygopodes.—Divers: loon, penguin, auk.
2. Longipennes.—Gulls and terns.
3. Tubinares.—Nostrils open at end of nasal bones: albatross, petrels.
4. Steganopodes.—Toes all webbed completely: cormorant, pelican.
5. Anseres.—Ducks, geese, swans.

Waders.

6. Odontoglossæ.—Flamingoes.
7. Herodiones.—Herons, ibis, storks.
8. Paludicolæ.—Cranes, rails, coots.
9. Limicolæ.—Plover, snipe, woodcock.

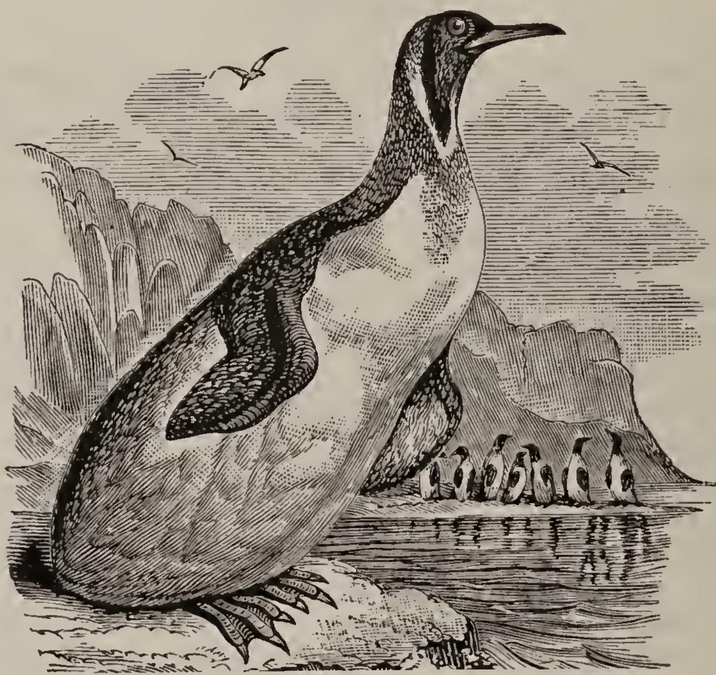
10. Gallinæ.—Chickens, partridge, quail, turkey, pheasant.
11. Columbæ.—Pigeons and doves.
12. Raptores.—Eagles, hawks, vultures, buzzards.
13. Psittaci.—Cockatoos, parrots, paroquets.
14. Coccyges.—Cuckoo.
15. Pici.—Woodpeckers, flicker.
16. Macrochires.—Goat-suckers, whippoorwill, humming-birds.
17. Passeres.—Perching birds.

SWIMMING AND DIVING BIRDS.

The orders of swimming and diving birds are related only by the aquatic habits common to all. The feet are webbed or **palmated** more or less perfectly, according to the order. The plumage is covered with a sort of fatty varnish that makes it impermeable to water; under the feathers is an exceedingly soft and thick down that protects the body from cold; the neck is more or less elongated; the legs, on the contrary, are short. Some, such as the albatross, have powerful wings, adapted for rapid flight; others, like the penguin, cannot fly at all, but the rudimentary wing is used as an aid in swimming.

Pygopodes.—The legs are inserted far behind, giving

FIG. 213.



KING PENGUIN (*Aptenodytes pennantii*).

the body a vertical position when standing, and the bird cannot walk well; the tail-feathers are absent or very short. The **penguins** are the largest of this order, standing as high as four feet. They are found in Antarctic and South-Temperate regions, and pass more than six months of the year on the sea, approaching the shores only at the breeding season, and remaining there during the incubation of the eggs and the rearing of the young. The wings are only a sort of flippers covered with scale-like feathers, and they are often considered as a distinct order called "**Impennes.**" They are very awkward on land. The **auks** now living are small and confined to the arctic regions. The **great auk,** which was three feet high, much resembled the penguin, but is believed to be extinct since the middle of the present century. The **loons** or **divers** are common in the northern parts of both continents. They have a peculiar wild, shrill, and howling cry.

Fig. 214.

Great northern diver (*Colymbus glacialis*).

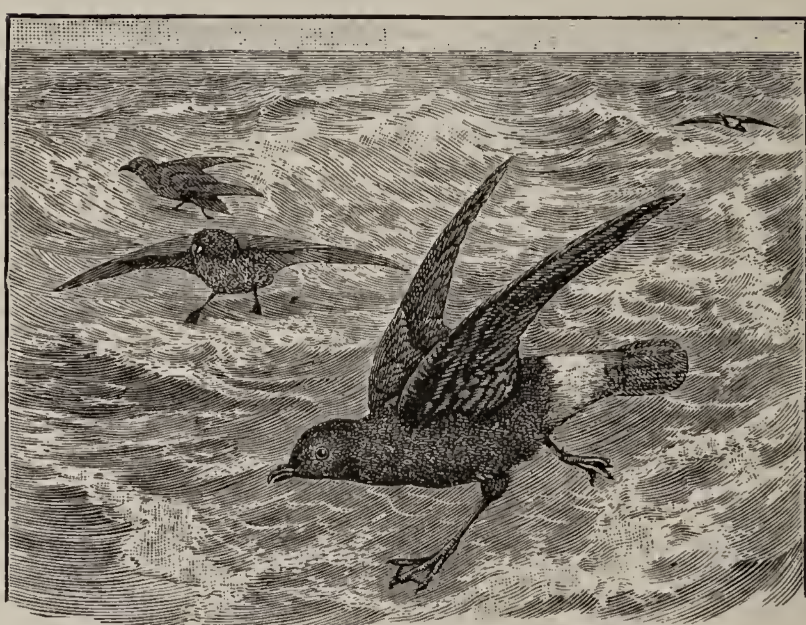
Longipennæ. — The birds of this group, the **gulls** and **terns,** have long and powerful wings, which form when spread a narrow flexible band. The legs are set in about the middle of the body, which is horizontal when standing. All pass a great part of the time suspended between the sky and the sea, and they are found hundreds of miles from any land. They follow ships in large numbers, seeking either the *débris* of food thrown overboard or the fishes attracted by this *débris.* There are many species.

Tubinares.—This order includes the species of albatross and petrel. The **albatross** is three or four feet in total length, and is found principally in Southern seas, though the **black-footed albatross** is abundant on our Pacific coasts. It frequently follows ships far out at sea, as does also the **stormy petrel,** or Mother Carey's chicken, which is the best known of the petrel family, and is the

Fig. 215.

Albatross.

Fig. 216.



Stormy petrel (*Procellaria pelagica*).

smallest web-footed bird known, being not much larger than a lark. Sailors consider the appearance of the

FIG. 217.

CORMORANT.

FIG. 218.

PELICAN (*Pelecanus onocrotalus*).

stormy petrel as an omen of storm, for they are seldom seen unless disturbed by high seas.

Steganopodes.—In this order the toes are completely webbed. The **cormorant** lives on islands in most parts

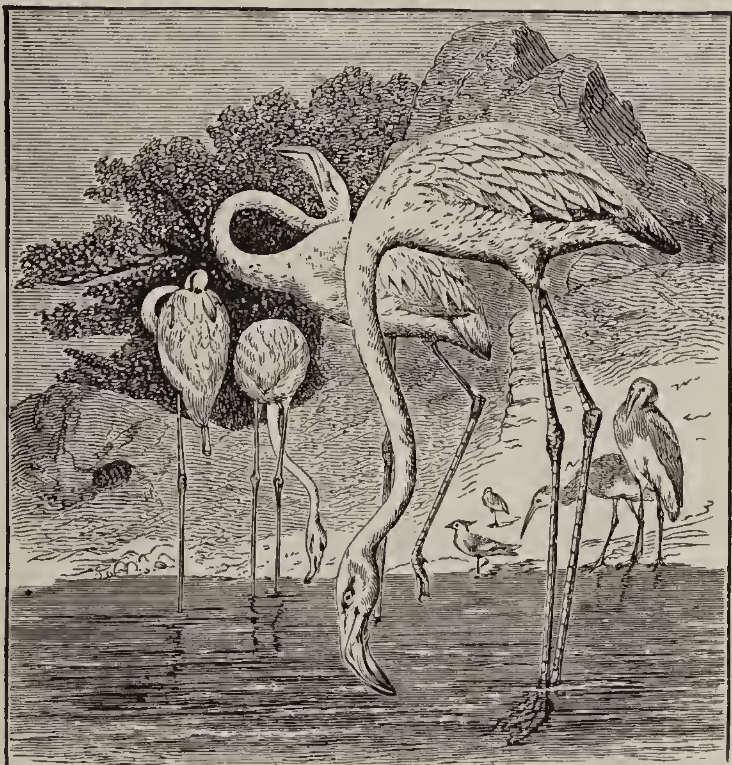
FIG. 219.

SWAN.

of the world. Its head is rather small, and is naked below the eyes and at the root of the beak. The **pelicans** have under their enormous beak a membranous pouch in which they can store their prey until at liberty to swallow it leisurely. They are found principally in warm countries, and frequent both fresh and salt waters, where they unite in flocks for fishing. The cormorants also have a pouch, much less developed than that of the pelicans. Among the steganopodes are the **tropic birds** and the **man o' war**, or **frigate bird,** frequently seen in the Gulf of Mexico and in the tropical oceans.

Anseres.—This order has short legs, and the cutting edges of the bill are more or less fringed or serrated.

FIG. 220.



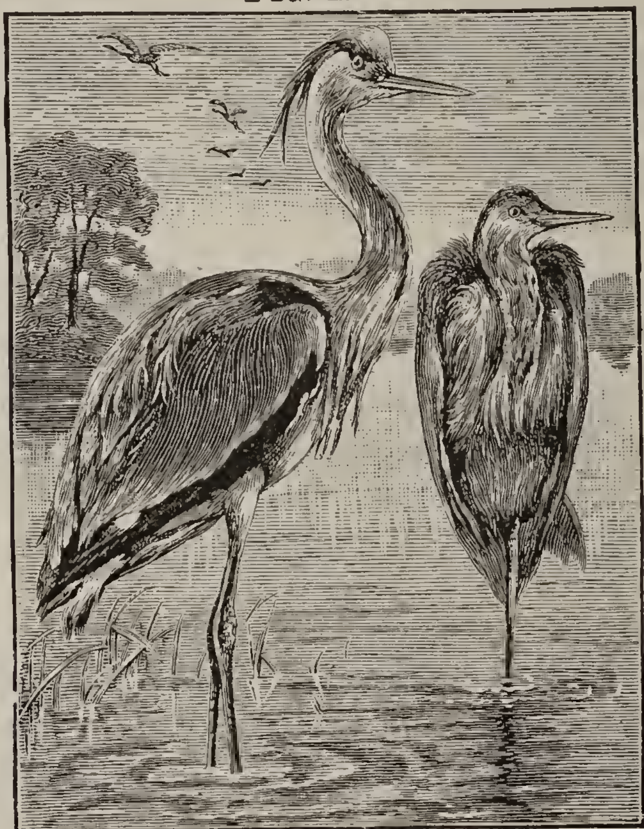
FLAMINGO (*Phœnicopterus ruber*).

The species are exceedingly numerous; among the **ducks** we may cite the **teal, wood duck, black duck, mallard, red-head,** and **canvas-back.** They all have wide, flat beaks, and the legs are placed back of the centre of the body; the neck is long, but not as long as that of the **goose,** while that of the **swan** is very long. The **eider** is a northern species that rarely descends as far south as our coasts. Its body is protected by a very close and very soft down, which is highly prized for stuffing pillows, etc. The general characters of the goose are well known. It swims little, and does not dive. The larger wild-geese are almost three feet long. The **swans** are remarkable for their elegance of form and grace of movement.

Odontoglossæ.—The **flamingo** has a tongue whose sides and base are covered with horny spines. They can swim in deep water, but the legs are rather adapted for wading than for swimming. One European species, when erect, stands about six feet high.

Herodiones.—Like the flamingoes, most of the birds of

FIG. 221.



COMMON HERON (*Ardea cinerea*).

this order have very long legs, and the lower parts of the thighs are without feathers. The length of leg is compensated for by the great length of the neck and bill, by which, without stooping, the bird can pick up from the level of its feet the reptiles, insects, and fish on which it feeds. Usually the toes are very long, and partially joined by a membrane, so that the weight of the bird can be supported by soft and muddy bottoms. There are a number of species of **heron**, distinguished principally by their size and color. Their long bill opens almost up to the eyes, is sometimes serrated, and is used for catching the fish and frogs which form their habitual

Fig. 222.

Boat-bill (*Cancroma cochlearia*).

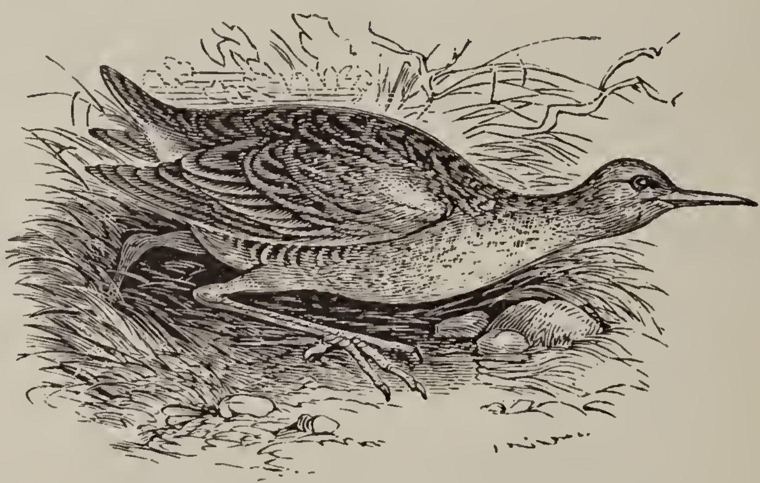
Fig. 223.

Crane (*Grus cinerea*).

food. When, however, the fishing is poor, the heron eats worms, mollusks, and reptiles. The **ibis** and **stork** were considered sacred by the Egyptians. A species of stork found in India carries on its neck an immense pouch, much larger than that of the pelican. The **boat-bill** differs from the herons by its curious boat-shaped bill.

Paludicolæ.—The **cranes, rails,** and **coots** are not as aquatic as the preceding birds; a considerable proportion of their food consists of vegetable substances. The **Virginia rail** and the **water-rail** are esteemed as food.

Fig. 224.



Water-rail (*Rallus aquaticus*).

The **moor-hen** and the **corn-crake** are closely allied to the water-rail. These birds, though comparatively small, are rapid runners.

Limicolæ.—The various species of **plovers, woodcocks, snipes, sand-pipers,** and the **stilts, curlews,** and **willets** belong to this order. These birds frequent low, moist grounds, and feed on worms, insects, larvæ, and mollusks. They have long bills with which to seek their food in the mud and marshes, and the sand-pipers, curlews, and several species of snipe feed on the small insects left on the sea-shore at the ebb of the tide.

Gallinæ. — This order includes the more important birds used as food; they are heavy birds, and do not fly easily. Their toes are not adapted for grasping branches nor for swimming nor wading, but for flat surfaces, and they live almost entirely on the ground, ordinarily in little flocks, composed of one male and several females. Most of the varieties are of foreign origin, but they readily acclimate themselves in all

FIG. 225.

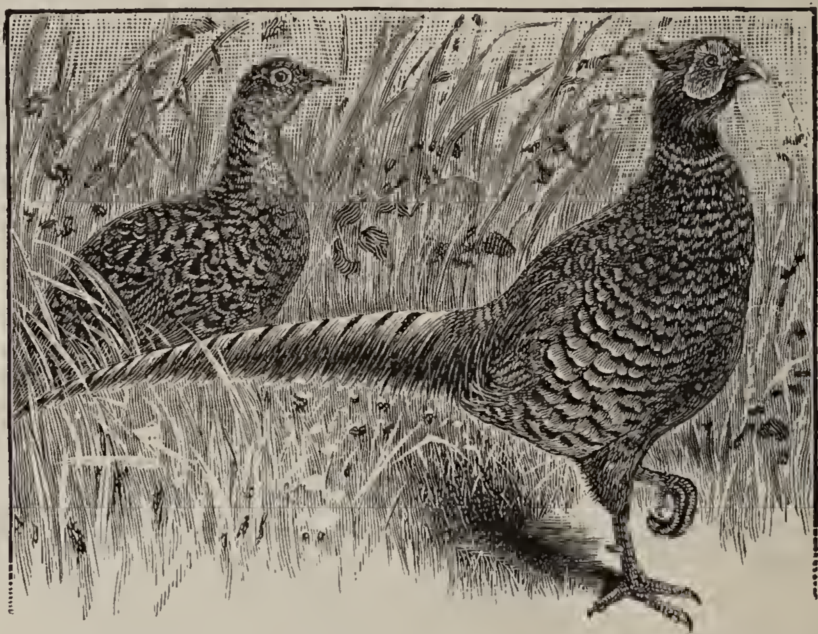
1, RINGED PLOVER; 2, GRAY PLOVER; 3, GOLDEN PLOVER.

FIG. 226.

FEET OF VARIOUS BIRDS.—*a*, swift; *b*, stilt; *c*, black stork; *d*, wryneck; *e*, falcon; *f*, raven; *g*, kingfisher; *h*, pelican; *i*, grebe; *k*, coot; *l*, smew-duck.

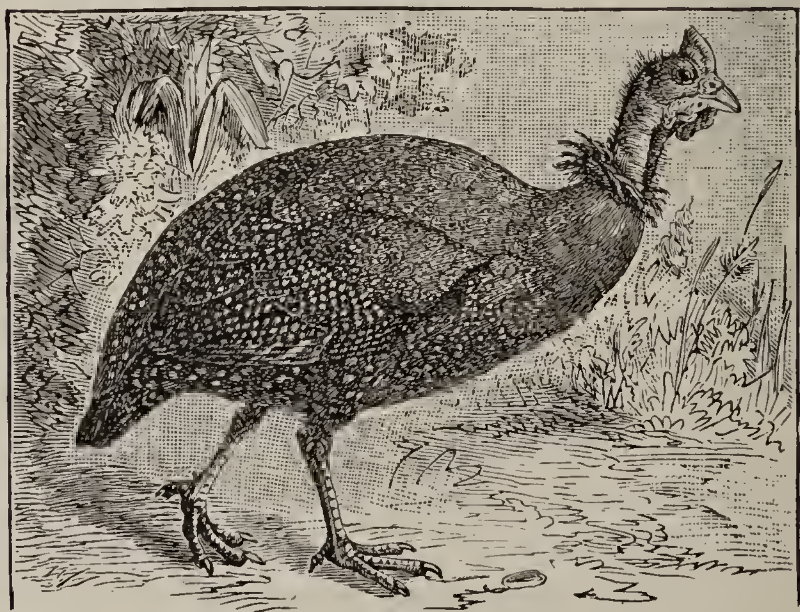
countries. The most important of all is the **chicken**, which we have sufficiently described in a previous chapter. The chickens of our rural districts are usually so mixed in form, plumage, and size that no distinct race is determinable; when pure races are to be bred they must be kept apart. The **turkey** is a native of North America. The **pheasants** are natives of Asia, and have been introduced and acclimated in all the temperate regions of Europe, and attempts have been made to in-

Fig. 227.



Common pheasant (*Phasianus colchicus*), male and female.

Fig. 228.



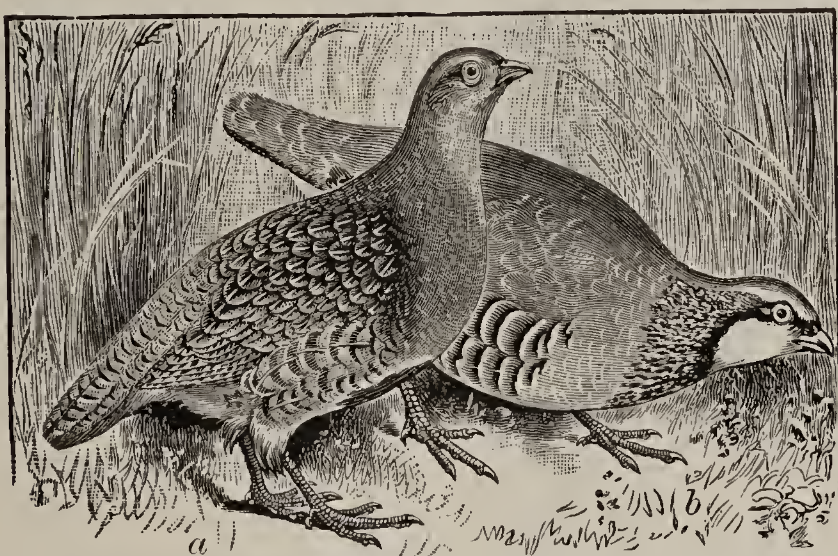
Common Guinea-fowl (*Numida meleagris*).

troduce them into the United States. The **guinea-fowl** is a species of pheasant that has been domesticated all over the civilized globe. **Quail** of various species are found in nearly all temperate regions. In some portions of the United States the quail is erroneously called the partridge, and this name is also applied to the **ruffed grouse,** a large gallinaceous bird found in the mountainous regions of the United States. The **prairie-hen** is a grouse. Partridges are not found in the United States excepting in the extreme western parts.

Fig. 229.

Common quail (*Coturnix vulgaris*).

Fig. 230.



a, common partridge (*Perdix cinerea*); *b*, red-legged partridge (*Perdix rufa*).

Columbæ.—Pigeons fly heavily, but with great power, and can prolong their flight for a considerable time. They usually build their nests in trees and live in pairs, although sometimes uniting together in immense flocks. Among our wild pigeons are the **band-tailed,** the **red-billed,** the **white-crowned,** and the **passenger.** The common wild dove of the United States is the **mourning dove,** so called from its plaintive cry. The species of domestic pigeon are exceedingly numerous ; one of them, the **carrier pigeon,** has been employed for ages for carrying messages ; when taken hundreds of miles from its home it is able to find its way through the air, and quickly returns to its nest.

Raptores.—In their habits the raptores correspond to carnivorous mammals. Some live on small birds and quadrupeds, others on fish, reptiles, and insects. Their toes are armed with strong, hooked claws, called **talons ;** the beak is straight at the base, but curved towards the end, and terminates in a sharp point. The wings generally have a wide spread, and most of the order are rapid in flight. The nests or eyries are placed on high trees or inaccessible rocks.

FIG. 231.

HEAD AND FOOT OF BRAZILIAN EAGLE.

We may distinguish in the order the **nocturnal** family of owls from the other families, which are **diurnal.** The latter have the eyes in the sides of the head ; they fly and hunt during the daytime. Among them are the **vultures, kites, hawks, buzzards, eagles,** and **sparrow-hawks.**

The **eagles** inhabit mountains and steep cliffs. There are a large number of species, among which we may mention our **bald eagle,** so called from its white-feathered head, and the **golden eagle,** which is distributed all over

FIG. 232.

GOLDEN EAGLE (*Aquila chrysaëtus*), ADULT MALE.—From E. T. Booth's "Birds of the British Islands" (Porter, London, 1881).

Europe and North America, and attains a length of nearly three feet. The **osprey** is variously called the fish-hawk and the fishing eagle; it feeds entirely on fish. **Falcons** and **kites** are found principally in Europe, the former feeding on even large birds, while the kite is a scavenger, though he sometimes robs the barn-yard. The true **buzzards** are an inferior sort of eagles; one of them is commonly called the **hen-hawk.** The **vultures** are distinguished from the preceding species by their naked head and neck, and the relatively inferior strength of

FIG. 233.

COMMON KITE, OR GLEDE (*Milvus ictinus*).

FIG. 234.

CONDOR.

the talons. They feed on dead animals, and act as scavengers, being the hyenas of the class of birds. The true vultures are found only in Europe, there being a brown species and a yellow one. The **turkey buzzard,** more properly called **turkey vulture,** is the most common American vulture. The **condor** is an enormous species of vulture, living among the highest Alps; its wings have a spread of four yards, and of all birds it is the most powerful in flight.

The **owls** are nocturnal birds, of which there are many species, all having strong resemblance between them. The eyes are very large, and placed in the front of the head; they do not like the light, and remain hidden during the day, beginning to hunt at dusk. They are carnivorous, living on insects, small reptiles, birds, and little mammals, all of which they swallow whole. Generally they do not construct nests, placing their eggs in holes in trees or rocks, or in abandoned nests of other birds. These birds are very useful to the farmer, destroying large numbers of injurious creatures. Among the species may be mentioned the **barn-owl, screech-owl, great snowy owl,** and **burrowing owl,**—the latter being the species that shares the burrows of the prairie-dog.

Fig. 235.

Barn-owl (*Strix flammea*).

FIG. 236.

Heads of *a*, short-eared owl; *b*, long-eared owl; and *c*, snowy owl.

Psittaci.—The **parrots, paroquets,** and **cockatoos** are very numerous. They have thick, short bills, and large, fleshy tongues. They do not fly well, but climb with great ease, using for this purpose both the beak and the feet. They carry their food to the mouth with one foot, standing on the other. They live on nuts and seeds, which they are able to extract from the shell, however hard that may be.

FIG. 237.

GRAY PARROT.

The **cockatoos** are found in Australia and the Indian Archipelago, the largest species being two feet in length. They are white, with yellow crests, but there is a black species. **Parrots** are found in nearly all tropical countries; a large species occurs in Mexico; and **paroquets**, which are smaller, are found as far north as the Carolinas.

Coccyges.—We need mention but two members of this order, the **cuckoos** and the **kingfishers**. The former live in the fields, and are well known for their habit of placing their eggs in the nests of other insectivorous birds which are smaller than themselves, and the young cuckoo, when hatched, manages to get the greater part of the food, and frequently pushes the rightful heirs of the nest over its borders. The **belted kingfisher** is the common species in the North. It has a most curious aspect, the head appearing as large as the body. It makes its nest at the extremity of a horizontal burrow in the earthy bank of a stream or lake.

Fig. 238.

Kingfisher (*Alcedo ispida*).

Pici.—Woodpeckers are of all sizes, from nineteen inches in length down. They are expert climbers, sinking their strong, hooked claws into the bark of trees and supporting themselves by the aid of their stiff and inflexible tail-feathers; they are thus able to climb perpendicular surfaces with great ease. The beak is straight and chisel-edged, and cuts through the bark, while the very long tongue, covered with a sticky saliva, penetrates the hole, seeking the larvæ of insects. Their nests are in the trunks of trees, and they are found all over the world. Some are very plain in color; others are crested

FIG. 239.

WOODPECKER.

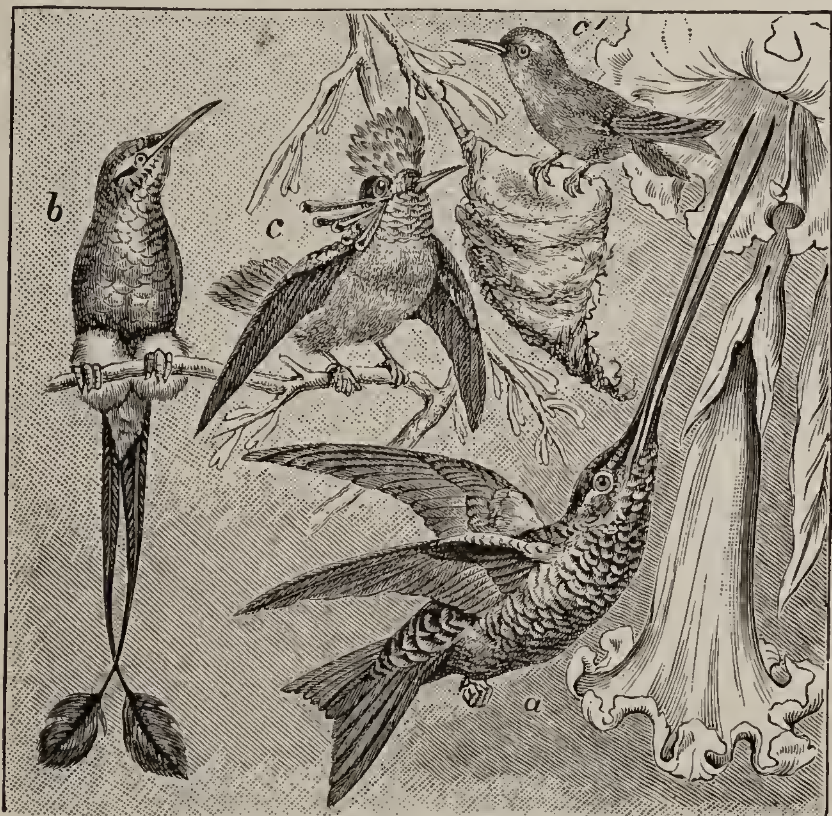
FIG. 240.

THE NIGHT-JAR (*Caprimulgus europæus*).

or marked with brilliant red. The common **flicker** is an insectivorous bird closely allied to the woodpecker.

Macrochires.—The **goatsuckers,** so called because it was formerly imagined that they suck the milk of herds, and the closely-allied **whippoorwill** are birds with sober-mottled plumage. The nests are made among dead leaves on the ground. The **night-hawk,** which is not a

FIG. 241.



a, sword-bill humming-bird (*Docimastes ensifer*); *b*, white-booted racket-tail (*Steganurus Underwoodi*); *c*, *c*′, male and female tufted coquette (*Lophornis ornata*).

hawk at all, is of this order. The **humming-birds,** exceedingly small, of which there are many species, are often very beautiful, the minute feathers appearing as brilliant scales, having lustrous metallic reflections. They have long beaks and very long tongues, which they thrust into flowers for the purpose of feeding on small insects, and probably, also, on the nectar.

CHAPTER XXX.

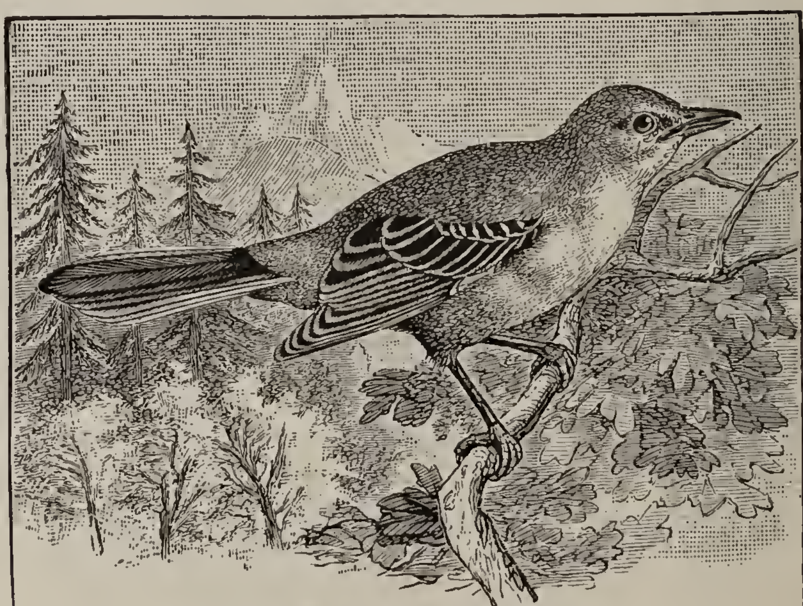
Birds (*continued*)—Passeres.

THE order **passeres** includes a number of families, and the species are exceedingly numerous, usually comparatively small in size, but having few common characteristics. They all have the toes adapted for perching.

The **fly-catchers,** of which the **kingbird** or **bee martin** is a type, have short, strong bills, and destroy millions of insects. They have no song, the cry being a sort of chirp.

The **mocking-bird** of America and the **nightingale** of

FIG. 242.



MOCKING-BIRD (*Mimus polyglottus*).

Europe are very plain in plumage, but are remarkable songsters, and make the groves melodious at night. These and the **bluebird** belong to the **thrush** family, as does the **robin redbreast.** Both these birds are very familiar, and make their nests very near country houses.

FIG. 243.

BLUEBIRD (*Sylvia sialis*).

FIG. 244.

COMMON CREEPER (*Certhia familiaris*).

The **creepers** are common all over the northern hemisphere; their feet are adapted to tree-climbing, and in this they are aided by the stiff feathers of the tail. The

FIG. 245.

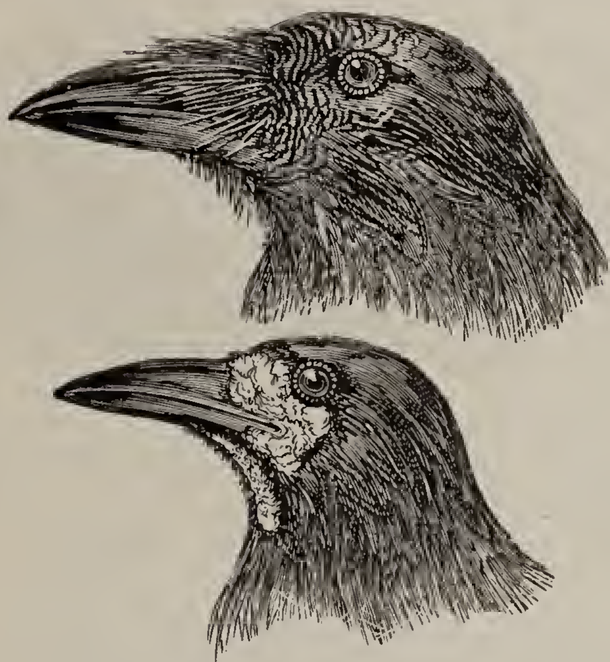
LARK (*Alauda arvensis*).

FIG. 246.

RAVEN (*Corvus corax*).

wrens, chickadees, tits, wagtails, and **sparrows** are pas seres, and, indeed, the order is named from the latter species. There are several species of **larks**, those found

FIG. 247.



RAVEN AND ROOK HEADS.

FIG. 248.

COMMON MAGPIE (*Pica rustica*).

in America being the **horned larks**, having little horn-like tufts of black feathers on each side of the head.

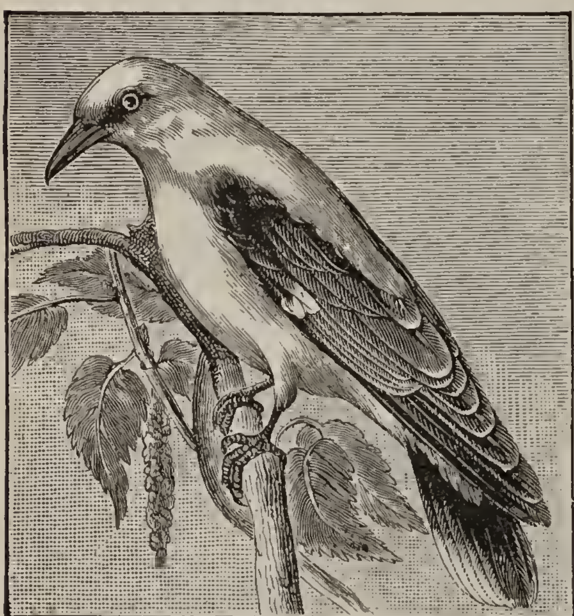
The **skylark** is a European bird. The **crows, ravens, jays,** and **magpies** belong to the crow family. There is

FIG. 249.

BLACKBIRD.

but little difference between the crow, the raven, and the rook, these birds being the largest of the passeres, and the whole family being omnivorous. The rook has a bare space about the margins of the bill. In some countries the crow acts as a scavenger, street-cleaning being left to it entirely. It likes to follow the sower in the field and eats large quantities of grain, but at the same time it destroys innumerable insects. The raven and magpie can be easily tamed, but are very mischievous. The crows and ravens are black; the magpies have rich metallic re-

FIG. 250.



GOLDEN ORIOLE (*Oriolus galbula*).

FIG. 251.

BOBOLINK.

FIG. 252.

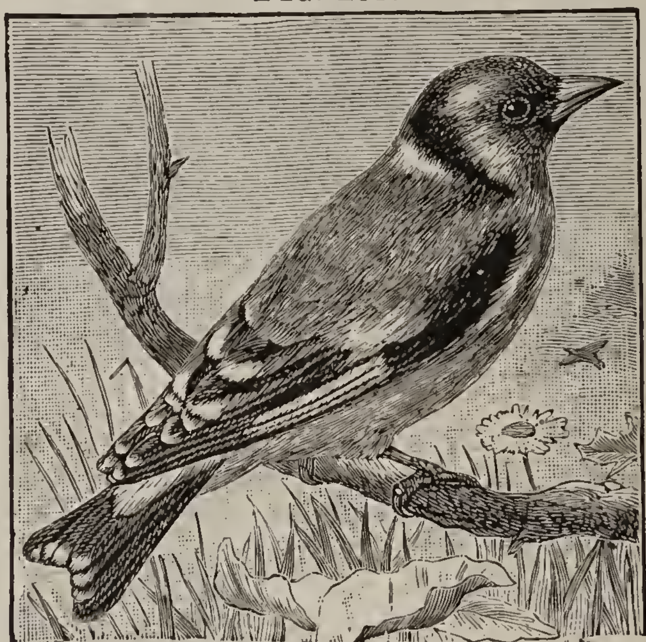
BULLFINCH.

flections, purple, green, and brown; the jays are of many colors, the **blue jay** being one of the most common.

The **blackbird** family includes the **orioles,** one of the most beautiful of which is the **Baltimore oriole,** rich orange in color. Some of the blackbirds have beautiful red wings. The **meadow-larks** are of this family, as is also the **bobolink, reed-bird,** or **rice-bird,** as it is variously called.

The **wrens, chickadees, tits, wagtails, sparrows,** and

Fig. 253.



Goldfinch (*Carduelis elegans*).

finches are passeres, but of different families. They are of various colors, usually sober, but some of the finches are brightly tinted. The **swallows** and **martins** prefer to build their nests under the eaves of houses, in chimneys, or in the crevices of walls. All the **warblers, honey-creepers, cat-birds, tanagers,** and **buntings** are passeres, and the order includes about half the known birds. Most of the species are migratory, preferring temperate climates, and flying northward in the spring, again to return south on the approach of winter.

CHAPTER XXXI.

Reptiles and Batrachians.

THE reptiles are classified in five orders, as follows:

1. **Chelonia**: having limbs and bodies usually covered with horny scales; the jaws terminate in a horny beak: tortoises and turtles.

2. **Rhyncocephalia**: only one representative, New Zealand sphenodon.

3. **Lacertilia**: bodies having limbs and covered with scales; teeth: lizards, chameleons, etc.

4. **Ophidia**: no limbs. scales, teeth: snakes.

5. **Crocodilia**: much like the lacertilia, but the heart has four cavities as in the birds: crocodiles and alligators.

CHELONIA.

Tortoises have a horny beak, analogous to that of birds. The body is covered by a carapace. which forms a sort of double shield protecting the entire trunk, and within which the head, tail, and limbs can be drawn when necessary. The upper shield is formed by the union of the ribs and dorsal vertebræ, and is known as the **carapace.** It is joined to the lower shield, called **plastron,** by bands of bony pieces. The motor muscles of the limbs and shoulder and the pelvis are enclosed in the carapace.

FIG. 254.

TORTOISE.—Its body is enveloped in a solid box, called a shell.

The union of the ribs renders the mechanism of respiration of the tortoise very different from that of animals whose ribs are mobile, and tortoises take in air by an act of swallowing. This air enters the mouth by the nostrils, and the tongue acts as a valve, which forces it into the pharynx and towards the lungs.

According to the form and habits, the chelonia may be arranged in three groups: **sea tortoises, fresh-water tortoises,** and **land tortoises.** The aquatic species are generally called **turtles.**

The **land tortoises** have large feet, terminating in a sort of stump, and usually a very arched carapace, which completely protects all parts of the animal. The largest American species is the **gopher tortoise,** found in the Southern States; its length is about fourteen inches, its shell very convex, brownish yellow, tinged with dark brown. The **box tortoise** is our common land tortoise, and grows to a length of about six inches. The **Greek tortoise,** found on the borders of the Mediterranean, is much esteemed as food. All the land tortoises bury themselves in the soil during the winter, sleeping there until spring.

The **fresh-water turtles** have palmate feet and a flattened carapace, sometimes without plates and covered with a soft skin. One of the smaller species is the **mud-turtle,** about six inches long; it is found all over North America; the skin of its limbs is orange-colored, and it is edible. Larger species are the **alligator terrapin,** found in Southern waters, and the **snapping-turtle,** well known for its strength and ferocity.

The tide-water turtles are usually called **terrapin,** and are much sought for their flesh; among them the **diamond-back,** which attains a length of six or seven inches, is most prized.

The **sea-turtles** have limbs terminating in a sort of fins, and the carapace is not large enough to receive the head and limbs. They are found in warm seas and grow to a great size, specimens having been taken that weighed seventeen hundred pounds. The flesh of the **green turtle** is highly esteemed. The **hawksbill** or **caret** furnishes tortoise-shell, each individual having thirteen large plates in the centre of the carapace, and twenty-five smaller ones on the borders.

RHYNCOCEPHALIA—LACERTILIA.

The order of **rhyncocephalia** is represented by but one living species, the New Zealand lizard or **sphenodon,** remarkable in having a third eye.

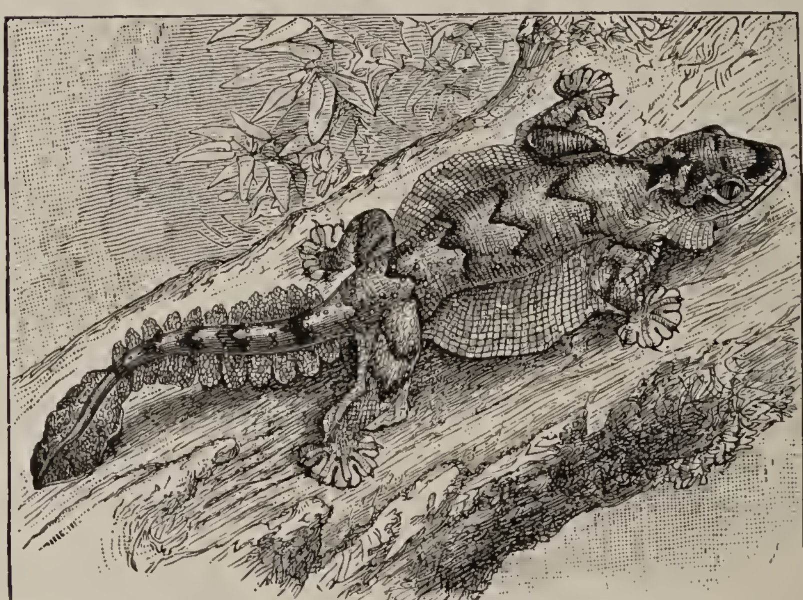
The general characteristics of the **lizards** have been given in Chapter X., and we need not reconsider them. The species of **lacertilia** are very numerous; some very small, others exceedingly large. The largest is the **monitor** of the Nile, an aquatic lizard that grows to a length of six or seven feet. Then come the **iguanas,** a large family, the species being variously and brilliantly colored; they occur in South America and the West Indies, and attain a length of from three to five feet. The **geckos** are dull in color, inhabitants of Southern Europe, India, and Egypt, attaining a length of more than two feet. The poisonous **Gila monster,** found in the sandy deserts of New Mexico, Arizona, and Texas, has brilliant black and orange scales; it is more than a foot long, and is the only venomous lizard, excepting the closely-allied **Mexican lizard.** The **horned toads** of the Southern United States are lizards, as are also the **glass-snake** of the United States and the **slow-worm** of Europe.

The **chameleons** have the power of changing color

FIG. 255.

COMMON IGUANA (*Iguana tuberculatus*).

FIG. 256.



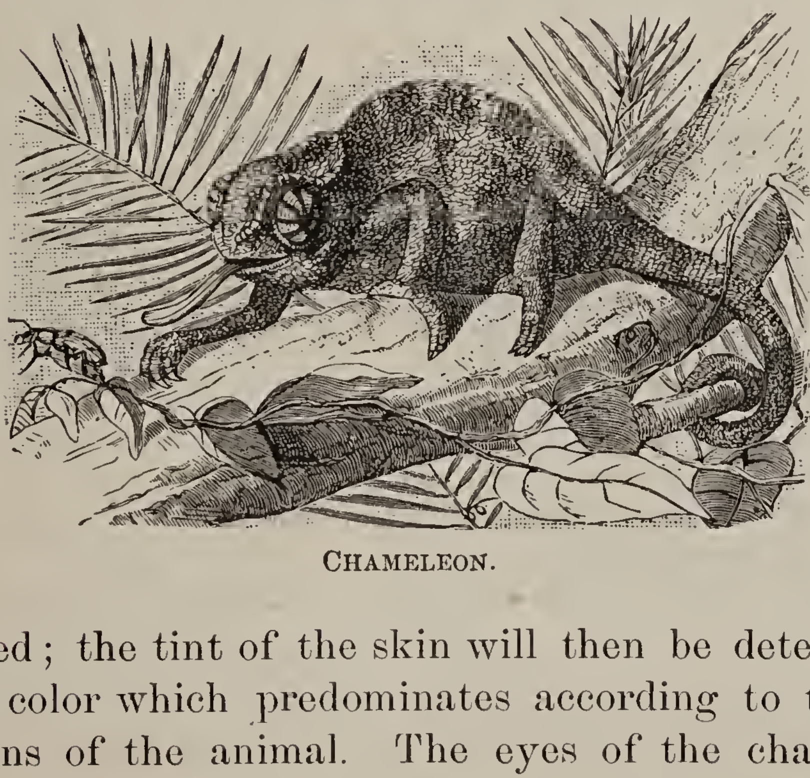
FRINGED GECKO (*Ptychozoon homalocephalum*).

according to their surroundings; this faculty appears to be owing to the fact that the skin contains two different layers of pigment, one yellowish gray, the other

Fig. 257.

Gila monster (*Heloderma suspectum*).

Fig. 258.



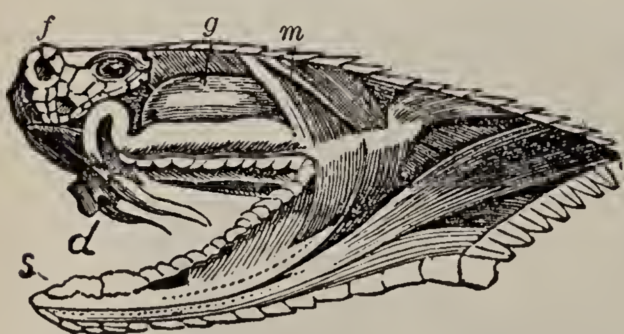
Chameleon.

dark red; the tint of the skin will then be determined by the color which predominates according to the impressions of the animal. The eyes of the chameleon are very prominent and very mobile, and they can be turned in opposite directions; the long tongue can be thrust far out to seize insects, and the round and prehensile tail can grasp tree-branches, etc. The digits, like those of parrots, are arranged in two opposing pairs on each limb. The lungs are large, and when fully inflated nearly double the bulk of the body. The common chameleon rarely exceeds fifteen inches in length.

OPHIDIA.

Serpents have no limbs; their extremely elongated bodies are moved by a series of lateral flexures. The vertebræ and the ribs alone constitute almost the entire skeleton. The water-adder has more than three hundred vertebræ; the viper about two hundred. The eyes of serpents have a fixed appearance, caused by the existence of but one eyelid; this eyelid is fixed and transparent, and covers the eyeball as would a watch-crystal. The tongue is long, slender, and ordinarily bifurcated; it is frequently thrust out, and this has given rise to the erroneous notion that it could be used as a sting.

Fig. 259



Poison apparatus of the rattlesnake.—*g*, poison-gland, having a duct opening into a canal in the fang; *m*, muscles that compress the gland and close the jaws; *d*, poison-fangs; *s*, salivary glands; *f*, nostril.

The mouth is always armed with teeth, but these organs are of little service excepting to retain the prey, which is swallowed entire, after a process of softening and crushing that sometimes lasts several days. The extreme extensibility of the jaws, which are readily dislocated, allows serpents to swallow animals much larger than themselves. Many of these reptiles inject into the wounds made by their teeth an exceedingly poisonous liquid; the **venom** is secreted by glands located behind the eye, and communicating by a duct with the **fangs**. These teeth are rooted in the upper jaw, and have either a tubular canal or a simple groove by which the venom descends when the poison-bag is compressed by muscular contraction as the serpent strikes; serpents do not bite. It has been recently found that venomous serpents suffer no ill effects from self-inflicted wounds, and that the poison is not dangerous to other individuals of the same species, nor to other ophidia generally.

We may classify serpents as venomous and non-venomous.

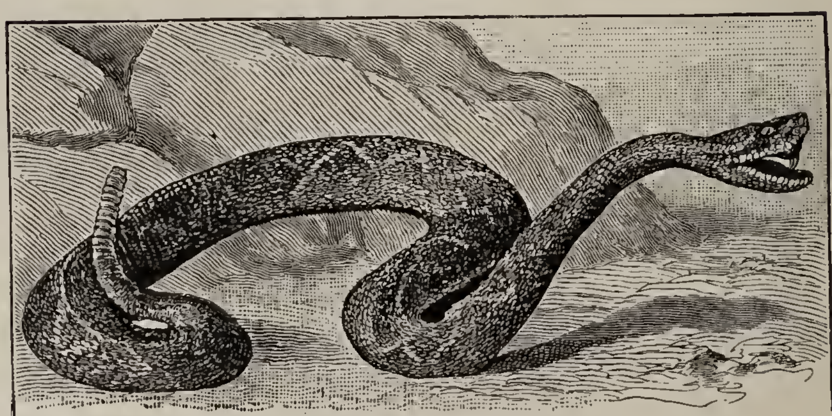
The largest of the non-venomous serpents are the **pythons** of Asia and Africa, and the **anacondas** and **boas** of South America. The first two may attain a length of twenty or thirty feet, and they have great crushing power, being able to seize even large animals, and strangle and crush them in their folds. The largest animals that they can swallow do not, however, exceed the size of a small dog.

Among the non-venomous snakes of the United States, the more common are the **black snake**, the **pine-snake**, which is mottled white and black or brown, and is sometimes more than six feet long, the **scarlet snake** of the South, the **garter-snakes**, the small **green snakes**, the common **water-snakes** of a dark greenish color, and the **banded** and **striped water-snakes**. These snakes are more useful than noxious to man, for they destroy for their food large numbers of snails and insects, field rats and mice, etc., as well as frogs and toads. Their bites are not at all dangerous.

FIG. 260.

PYTHON (*Python sebæ*) swallowing a bird.

FIG. 261.



RATTLESNAKE (*Crotalus horridus*) in act of striking.

The most dreaded of our venomous serpents are the species of **crotalus** or **rattlesnake**. In these the end of the tail carries a curious apparatus, consisting of a number of articulated horny rings, and terminating in a sort of button. By agitating this the rattlesnake produces a noise much like that of the locust, this noise being usually made when the snake is excited. The number of rings is increased with successive sloughings or castings of the skin, but does not indicate the age of the animal. There are three other poisonous serpents in the United States: the **water moccason** and the small **harlequin snake** of the South, and the **copperhead,** so called from its coppery color, of the North.

Among the poisonous snakes of other countries the better known are the **cobra** of India, whose bite causes large numbers of deaths annually, the **puff adder** of Southern Africa, and the **fer de lance** of Martinique. The stings of venomous serpents rapidly paralyze the nerve-centres, and depress the circulatory and respiratory functions; at the same time there is great local and general swelling of the affected part and its vicinity.

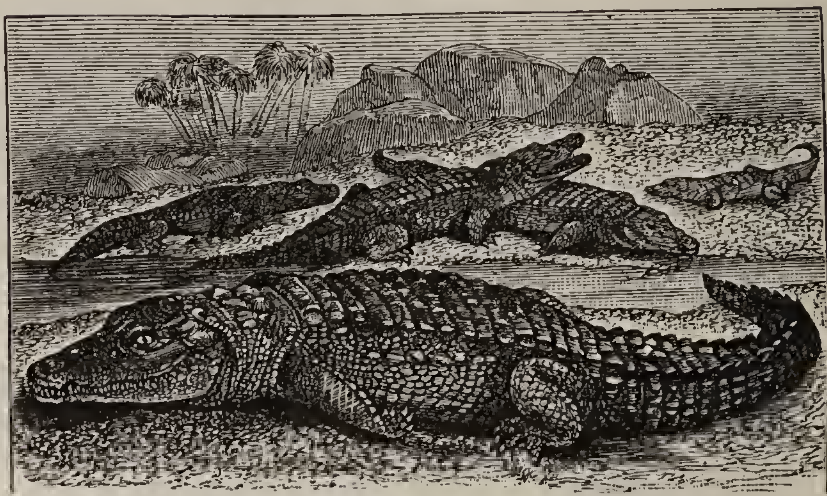
CROCODILIA.

Crocodiles grow to a large size. Their bodies are protected by a hard scaly hide, which is almost impenetrable by bullets. Their diet is carnivorous, their life aquatic; they cannot walk well on shore, their bodies being too heavy for the legs, but they swim very rapidly. The larger species are dangerous to man, the crocodile of the Nile being said to attain a length of thirty feet, although those seen are not often more than half that long. The ancient Egyptians worshipped them.

The **alligators** have shorter and broader heads than the crocodiles, and are not so large, the greatest length being about twenty feet. They are found in the waters of South America, Mexico, and the Southern United

States. They rarely attack man, especially when on land.

FIG. 262.



CROCODILE.

The **gavials** are of the crocodile order, but differ from the crocodiles and the alligators in having a long, slender

FIG. 263.

PIKE-HEADED ALLIGATOR (*Alligator lucius*).

snout. They occur in India, Java, and Borneo, and the most common species is that of the Ganges, whose length is about twenty-four feet.

BATRACHIANS.

The general characters of the batrachians have been considered in the chapter on the frog.

They are classified as (1) **anura,** those having no tails, like the frogs and toads; (2) **urodela,** those having tails, such as the newt and salamander; (3) **cæcilia,** which have no limbs.

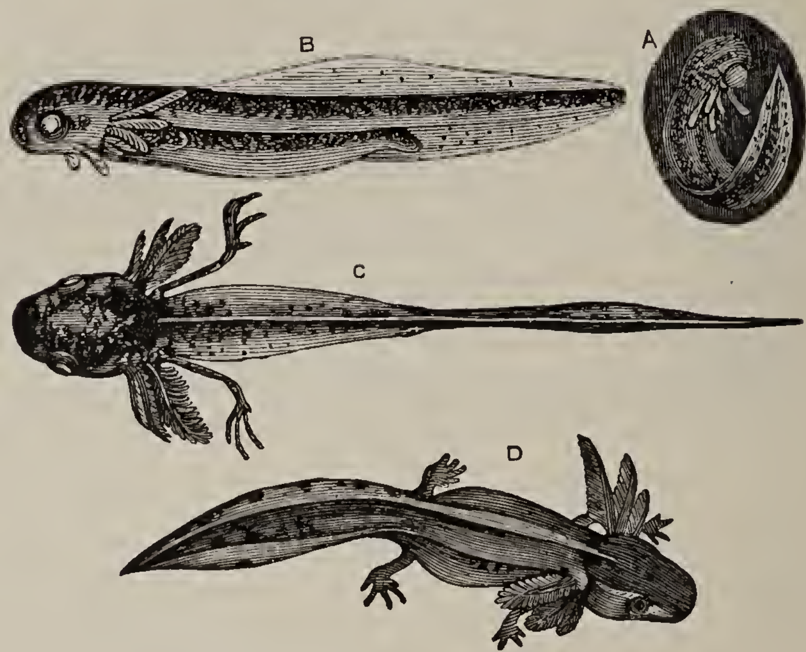
We need not repeat what has been said of frogs, but may add that some toads are the most repulsive in aspect of the batrachians. Their skin secretes an acrid liquid, which exudes when the creature is irritated. Tales are often told of toads discovered in rocks or trunks of trees, where they must have remained many years imprisoned; exact experiments have shown that batrachians of this kind may live rather more than a year in an envelope permeable by air, such as plaster, or porous calcareous formations, but that when inclosed in an impermeable envelope, like metal or clay, they perish in about a month.

Fig. 264.

Great water newt (*Triton cristatus*).

The **newts,** or **tritons,** and **salamanders,** retain throughout life the tail which is present in the tadpole stage of the frog. The salamanders are terrestrial, being found in moist places; the newts are aquatic, being able to crawl only slowly on land. All are usually small, inoffensive creatures, but the giant salamander of Japan attains a length of three feet. Like the lizards, the urodela have the singular property of replacing lost parts.

FIG. 265.



LARVÆ OF TRITON CRISTATUS.—A, condition before leaving the egg; B, tadpole shortly after it is hatched; C, at about the twenty-second day; D, at about the forty-second day.

CHAPTER XXXII.

Fishes.

THE general characters of fish as a class have been studied in Chapter XI., the example being the carp.

The classification of fish is based first on the nature of the skeleton; those having an osseous skeleton are called **teleostei,** and are by far the more numerous; those in which the skeleton is cartilaginous constitute the subclass **chondropterygii.** The first subclass is divided into orders according to the condition of the premaxillary

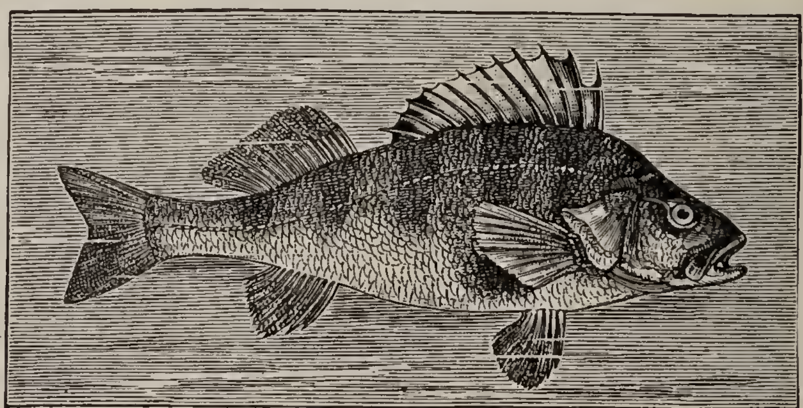
BONY FISHES, TELEOSTEI	Gills comb-like	Premaxilla and upper jaw mobile	Spinous rays, on dorsal, ventral, and anal fins	Lower pharyngeal bones separate.	Acanthopterygii	Perch, mullet, mackerel, bass, rock-fish, stickleback.
				Lower pharyngeal bones united.	Acanthopterygii pharyngognathi	Wrass.
			No spinous rays on dorsal fin	Ventral fin (if present) on throat or breast. No duct to swimming-bladder.	Anacanthini	Cod, haddock, turbot, flounder.
				Ventral fins posterior. A duct to swimming-bladder.	Physostomi	Carp, minnow, pike, salmon, trout, smelt, chub, eel, herring.
		Premaxilla and upper jaw fixed to one another and to skull			Lophobranchii	Pipe-fishes, sea-horse.
	Gills composed of rounded lobes				Plectognathi	Sun-fish, file-fish, globe-fish.
CARTILAGINOUS FISHES					Chondropterygii	Shark, skate, sturgeon.

bones, the presence or absence of spinous rays on the dorsal fins, the position of the ventral fins, and the existence or absence of a duct connected with the swimming-bladder. This classification is shown in the table on page 311.

BONY FISHES (TELEOSTEI).

Acanthopterygii (spine-finned). — The fresh-water **perches** are of medium size, eight to twelve inches long, very carnivorous, and very destructive to other fish. The flesh is white or pale-yellow, and is excellent and wholesome food. The **black bass** and **striped bass,** or

FIG. 266.

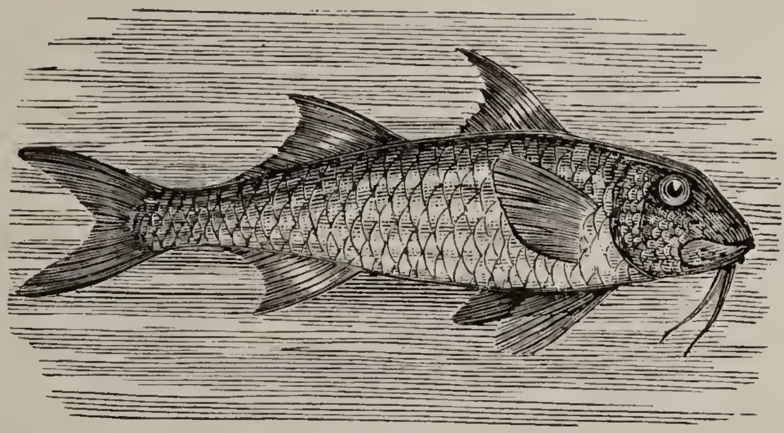


PERCH (*Perca fluviatilis*).

rock-fish, are game fishes; they prefer cold and rapid waters; the spines in the dorsal fin are very sharp, and the head of the first is large. The **mullet** and **red-mullet** have delicate flesh; they feed on the organic matter found in muddy bottoms,—the mullet being a fresh-water and the red-mullet a marine fish.

The **mackerel** is ordinarily between twelve and sixteen inches long, and is found in almost all temperate and tropical seas, excepting on the American coasts of the South Atlantic. They move in shoals, approaching the shores for feeding or spawning. The mackerel is highly esteemed as food, but its flesh spoils rapidly.

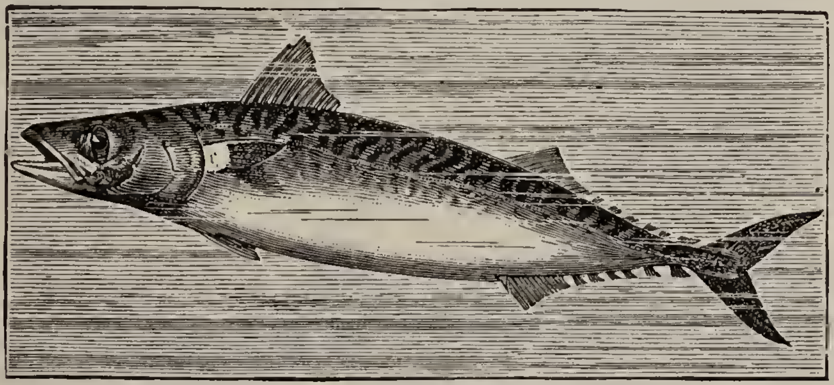
FIG. 267.



SURMULLET.

The **Spanish mackerel,** or **tunny fish,** has bright-yellow spots on the sides, and grows much larger than the common mackerel. It is an excellent food-fish, and is generally preserved in oil.

FIG. 268.



COMMON MACKEREL (*Scomber scomber*).

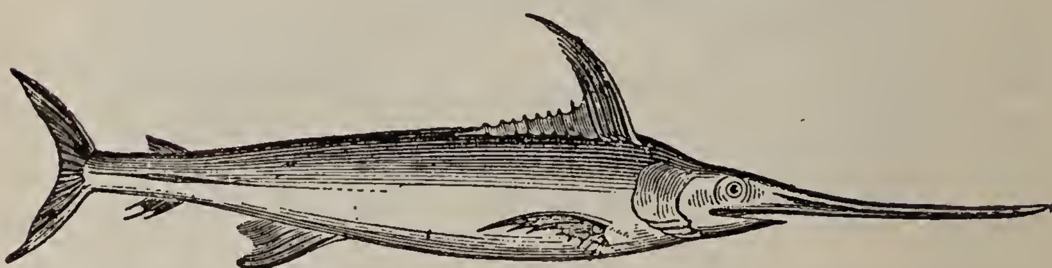
The **blue-fish** is one of the finest fishes of the Atlantic coasts of the United States; it is very rapacious, and it furnishes excellent sport. Some have been caught five feet long, but those usually taken average about two feet in length.

The flying-fish of the Gulf of Mexico and the tropical Atlantic is the **flying-gurnard**; its pectoral fins are so

Fig. 269.

Sapphirine gurnard (*Trigla hirundo*).

Fig. 270.



Sword-fish.

largely developed that the fish can leave the water, continuing its course in the air for a distance as great as five hundred yards.

The **sword-fish** is remarkable for the extensive bony prolongation of its upper jaw, called its sword, which it uses as a weapon, and with which it can even pierce the planking of ships. It has no teeth.

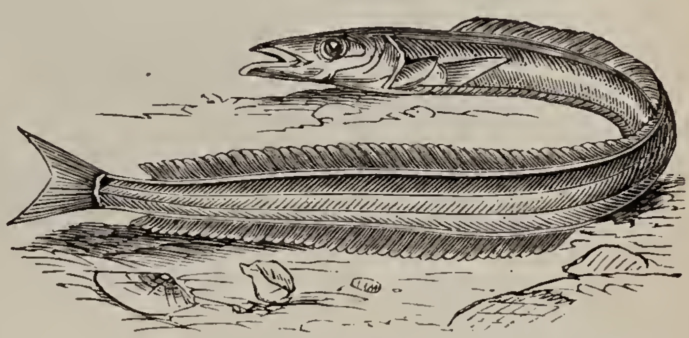
Acanthopterygii pharyngognathi.—The species of wrass, among which is the **parrot-fish,** belong to this order. They have strong, bony jaws, the teeth being firmly united together.

FIG. 271.

CODFISH.

Anacanthini.—This order has no spinous rays in the dorsal or ventral fins, and if an air-bladder be present it has no duct. The family of **codfishes** form the most important members, constituting the means of life and the food of whole cities and tribes on the North Atlantic coasts. Cod-liver oil is made from the livers of these fish. The **haddock** and the **hake** belong to this family. The **sand-eel,** much used as bait in sea-fishing, belongs to another family of the same order.

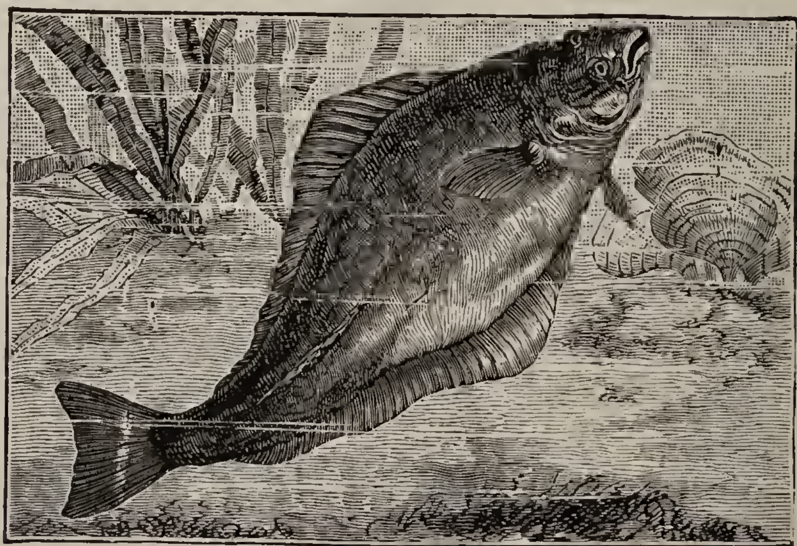
FIG. 272.



SAND-EEL OR SAND-LANCE (*Ammodytes lancea*).

The **flat-fishes** constitute an interesting family, called **pleuronectidæ**; among all the vertebrates they are the only ones that are not symmetrical. They have no swimming-bladder, and, on account of the arrangement of their fins, they can rest and move only on one side of the body, which is flat. The two eyes are on one side, and this is always the darkest, the other being white or very light in color. The two sides of the mouth are unequal; swimming is accomplished by an undulating movement of the whole body, and the darker side is always uppermost. They prefer sandy bottoms, and are not found at great depths; some live only in the sea, others frequent fresh water; they are all carnivorous.

Fig. 273.



Halibut (*Hippoglossus vulgaris*).

Among the important species are the **halibut,** the **sole,** not found in American waters, the **turbot,** the **flounder,** and the **plaice.**

Physostomi.—In this order all the fin rays are articulated, excepting the first ray of the dorsal and pectoral fins, which is sometimes ossified. The ventral fins have no spines, and are abdominal if present; excepting in one family, the air-bladder has a duct.

The order includes the common **catfish,** frequently called **bull-head,** the **minnow, chub, sucker, carp, gold-fish, trout, salmon, pike, muskallunge, smelt, herring, shad, sardine, anchovy, menhaden, electric eel, common eel,** and **conger eel.**

The **catfish** sometimes attains a great length. It has, as have several others of this order, barbels on the upper and lower jaws, and it is well armed with sharp rays on the dorsal and pectoral fins, which require great care in handling. The **minnow** and **chub** are common in nearly all our streams and lakes. **Carp** are beautiful fish in the water, their scales reflecting a silvery light; some species have barbels, some have none; their ordinary length is one or two feet, but they have been caught as long as five. The **sucker** is a sort of carp, and so is the **gold-fish.**

FIG. 274.

CHUB.

Of all fresh-water fish none are more highly esteemed for the table, for their beauty, and for the sport of taking them than the **trout** and the **salmon,** but the salmon is not really a fresh-water fish; it leaves the deep ocean in spring and ascends rivers almost to their sources for the purpose of spawning; during this season it is fished for. The flesh of both the salmon and trout is reddish and very palatable. Trout seek the coldest and most rapid waters.

The **pike** and **pickerel** have beak-shaped noses, and are exceedingly voracious, devouring nearly all other fish that are found in the same waters. The **muskallunge** of the St. Lawrence and of the large northern lakes is a fish of the same family; it attains a very large size.

Fig. 275.

Teeth of the pike (carnivorous).

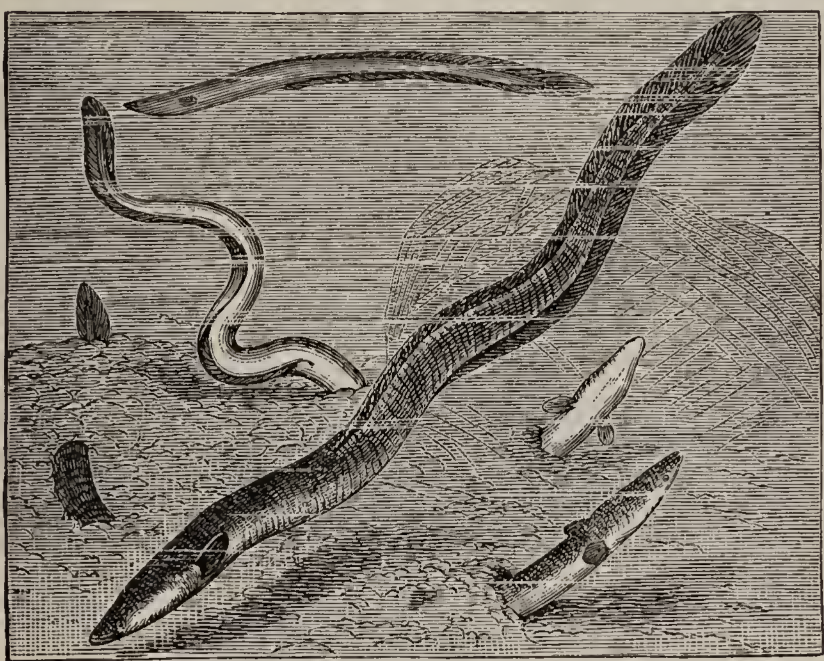
Herring have been supposed to migrate annually, and their appearance in certain parts is so uniform that the direction of their voyages was considered known; starting from the Northern Atlantic, they appear to form two immense shoals, one of which takes a westerly direction towards America, while the other descends towards the European seas and breaks up into three divisions; one of these proceeds towards the British Isles, another towards Norway and the Baltic, and the third enters the North Sea, crosses the English Channel, and advances as far as the mouth of the Loire. Recent investigations, however, seem to show that the migration is only apparent, and that during the greater part of the year the herring live at considerable depths in the ocean where the nets cannot reach them; at the beginning of the spawning season they ascend all at once, and appear from place to place on the coast; thus, there is no travelling from north to south, but a change from deep to superficial water. The herrings place their eggs in a froth which they blow up on the surface of the water.

Sardines are taken principally in the Mediterranean and on the coasts of Brittany; more than six hundred million are caught every year, and as soon as caught they are salted, for they spoil very quickly. Some are sent to market in salt, the rest are preserved in oil.

Anchovies, taken principally in the Mediterranean, are prepared in the same manner.

Vast shoals of **shad** run up our rivers in the early spring for the purpose of spawning, and large numbers are taken in nets. Only at this season is their flesh a palatable food. The **menhaden** or **mossbunker** is exceedingly numerous on our Atlantic coasts, and enormous numbers are taken annually for the manufacture of fish-oil, the refuse of the oil-factories being used in the preparation of manures.

FIG. 276.



COMMON EEL (*Anguilla vulgaris*).

Ordinary **eels** live alternately in fresh and in salt waters, but they readily become accustomed to a permanent life in ponds and streams. They sometimes leave the water for a time, either in search of insects on bushes or in order to reach a neighboring piece of water, and in the latter case they can travel quite a distance.

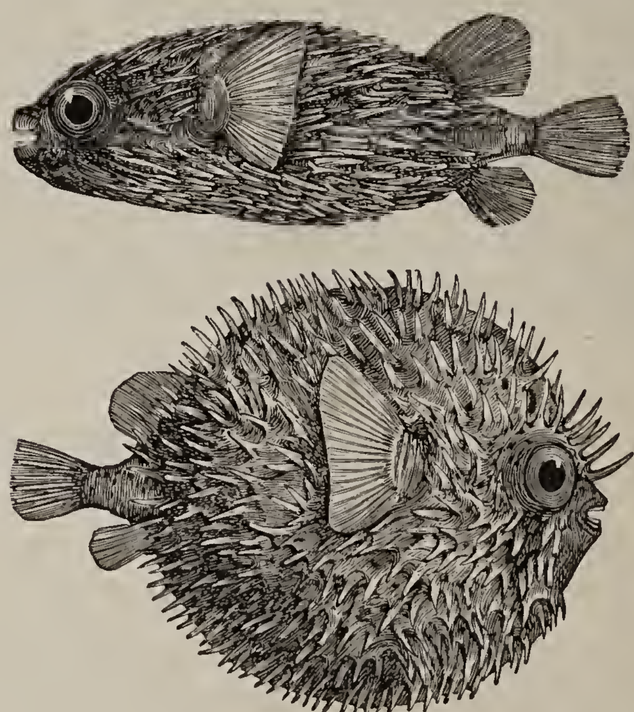
FIG. 277.

HIPPOCAMPUS ANTIQUORUM.

The **conger eel** is commonly called the sea-eel; it attains a length of from three to six feet and is sometimes much longer. The **gymnotus,** or electric eel, has the general form of ordinary eels. It is about six feet long, and possesses a powerful electrical apparatus, capable of communicating a violent shock to very large animals. It is found in the rivers and marshes of South America.

Lophobranchii and **plectognathi.**—These two orders are interesting to us chiefly on account of the strange forms

FIG. 278.



A, globe-fish (*Diodon maculatus*); B, the same inflated.

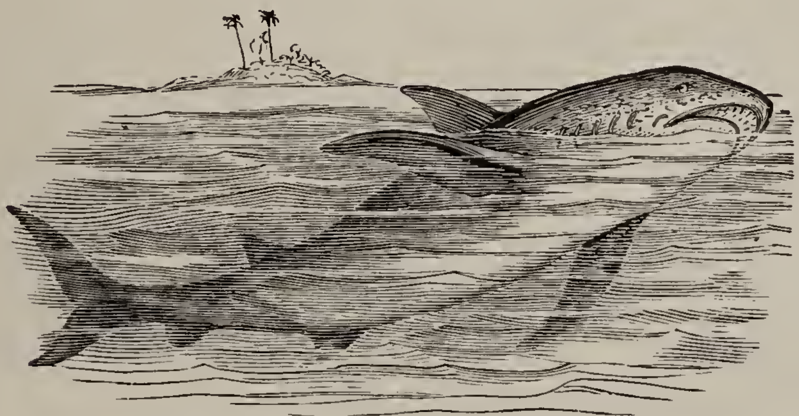
of some of their members. Of the first we will cite only the **hippocampus** or **sea-horse,** sometimes caught in our bays and rivers, and of the second, the **globe-fish,** which has a curious power of inflating itself.

CARTILAGINOUS FISHES (CHONDROPTERYGII).

We may subdivide the cartilaginous fishes into **selachoids,** including the sharks, sea-fish, rays, and torpedos, and **ganoids,** composed of the sturgeon family. The selachoids have no air-bladder; the ganoids have an air-bladder provided with a duct.

Selachoids.—Sharks are found in all seas, and grow to an enormous size; some as long as thirty feet having

FIG. 279.



WHITE SHARK (*Carcharias vulgaris*).

been taken, and these are small compared to extinct species, which measured seventy-five feet or more in length. The mouth of a large shark is sometimes two yards in circumference, and its borders are covered with four or six rows of teeth as sharp and cutting as the teeth of a saw. The voracity of the shark is proverbial; they swallow everything they come across floating in the water. Ships are often followed by schools of them.

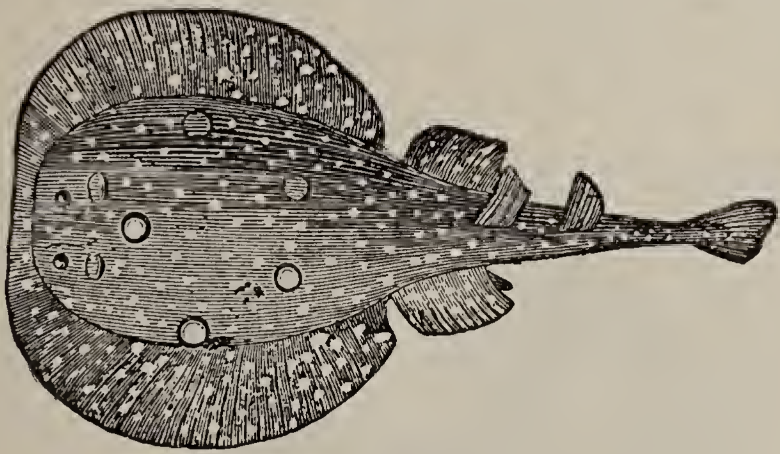
Dog-fish belong to the same class as sharks; they grow as long as three feet, and the flesh of some species is eaten. The skin of the **sea-dog** is prepared and used as "rub-skin," for polishing wood and ivory. The muzzle

FIG. 280.

SAW-FISH.

of the **saw-fish** terminates in a strong bony plate armed on the edges with sharp, pointed teeth. **Rays** and **skates** have a rhomboidal body, a slender, cylindrical tail, the eyes and gill-holes in the upper portion of the head, the mouth below and armed with thin, obtusely-pointed teeth. Some of the skates attain a large size, measuring more than six feet across. They are edible, and some species are much esteemed. The **torpedo,** or electric ray, has a smooth, naked, almost circular body, and a long, fleshy tail; it possesses a powerful electric battery, the discharge from which can disable a strong man. It is found in the Atlantic and Indian Oceans and in the Mediterranean.

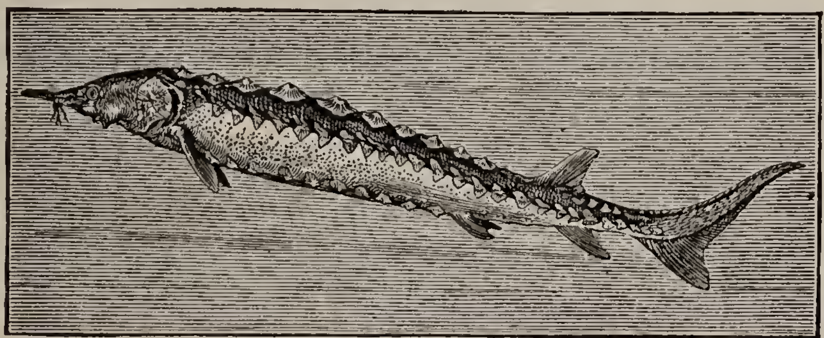
Fig. 281.



Electric ray.

Ganoids.—The sturgeon lives in nearly all seas, and at certain seasons ascends large rivers, where it is taken in nets. It has no teeth, and feeds on small fish, and even larvæ, which it digs out of the mud with its tough nose.

Fig. 282.



Sturgeon (*Acipenser sturio*).

Its body is protected by several rows of osseous bucklers, arranged longitudinally on the surface of the skin. It grows to a length as great as ten feet. The flesh is used as food, **caviare** is prepared from the eggs, while the interior of the swimming-bladder furnishes **isinglass.**

CYCLOSTOMATA.

The members of this group differ from the true fishes in having no jaws, no paired fins, no scales, and they possess gill-pouches that act like lungs. The **lamprey**

Fig. 283.

Lamprey (*Petromyzon marinus*).

and the **hag-fish** are examples; the first a marine, the second a fresh-water species. They have round mouths, in which the tongue works like a piston, so that they can attach themselves to the skin of fishes and suck not only blood but flesh.

CHAPTER XXXIII.

Insects.

THE general organization of insects has been explained in Chapter XV., in the description of the may-bug. The structure of the wings and of the mouth is the basis of the classification in orders shown on page 326.

Before studying some of the more important representatives of the class insecta it is well that we should recall the fact that, while a few insects assume their final forms on leaving the egg, most of them pass through several distinct phases between the egg and the perfect creature.

The egg gives birth to a sort of worm, either with or without legs, and these creatures are called **larvæ**; when they have legs they are commonly called caterpillars. The larvæ of some species closely resemble the perfect insects, the wings only being absent, and these appendages are developed after the last casting of the skin; in such cases the metamorphosis is said to be incomplete. We have an example in the **cockchafer.** In a much larger number of species the changes at the various stages of existence are more remarkable, and it is difficult to find any resemblance between the larvæ and the perfect insect; metamorphosis is complete, and the butterflies furnish us an example.

The state of **chrysalis, pupa,** or **nymph,** as it is variously called, succeeds that of the larva. During this period most insects abstain from all nourishment, and are apparently dead. To protect themselves from the

INSECTA.	Winged	Two pair of wings	Different	Entire elytra. Masticating mouth. Second wings folded transversely	COLEOPTERA	Beetles. May-bugs. Cantharides. Wevils. Goat-chafer. Lady-bug. Potato-bug.
				Entire elytra. Masticating mouth. Second wings folded transversely and longitudinally	DERMAPTERA	Earwig.
				Entire elytra. Masticating mouth. Second wings folded longitudinally	ORTHOPTERA	Cockroach. Grasshopper. Migratory locust. Cricket.
				Half elytra; sucking mouth or beak.	HEMIPTERA	Bedbug. Common locust. Plant louse. Cochineal.
			Alike	Wings naked. Masticating mouth.	NEUROPTERA	Dragon-fly. Termites. Ant-lion.
				Wings naked. Mandibles and a sucking mouth.	HYMENOPTERA	Ichneumon. Ants. Wasps. Humble-bees. Bees.
				Wings covered with scales; a soft coiled proboscis	LEPIDOPTERA	Bombyx (silk-worm). Hawk-moth. Moths. Butterflies.
		Two wings; sucking mouth			DIPTERA	Mosquito. House-fly. Gad-fly. Cattle-flies. Gnats.
	No wings. Apterous.	No tail		Legs adapted for jumping	APHANIPTERA.	Fleas.
		A long tail		Legs adapted for running	THYSANURA.	Silverfish.

weather and from their enemies during this stage, many of them prepare in advance a silky envelope, some cover themselves with clay, others wrap themselves in leaves, and still others hide themselves under the

Fig. 284.

Caterpillar, chrysalis, and imago of the goat-moth (*Cossus ligniperda*).

bark of trees or in the soil. If a chrysalis be examined after short intervals of time, the gradual development of the organs of life may be seen through the thin exterior envelope. At last, after an interval that depends on the species and the external conditions,—sometimes more than a year,—the fully developed perfect insect, or imago, bursts its prison walls. This last state is ordinarily of short duration: in most cases it does not last longer than a few weeks, in many it is limited to several days, while in some it is ended in an hour or so. and the insect dies. The occupation of the perfect insects is limited almost entirely to the perpetuation of the species; when the eggs are laid in places most favorable for their development, the life of the insect is ended.

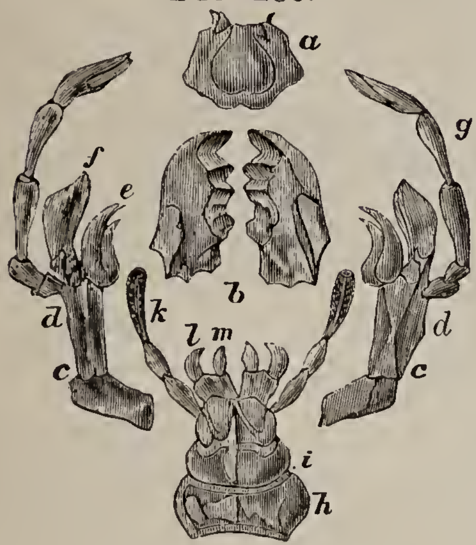
The arrangement of the mouth varies according to the diet. Masticating insects (coleoptera, orthoptera, etc.) possess, as we have seen in the cockchafer, organs adapted for mastication. In the hymenoptera these or-

Fig. 285.

Various forms of chrysalis.—*a*, orange-tip butterfly; *b*, black-veined white butterfly; *c*, swallow-tailed butterfly; *d*, purple emperor; *e*, silver-washed fritillary; *f*, Duke of Burgundy fritillary.

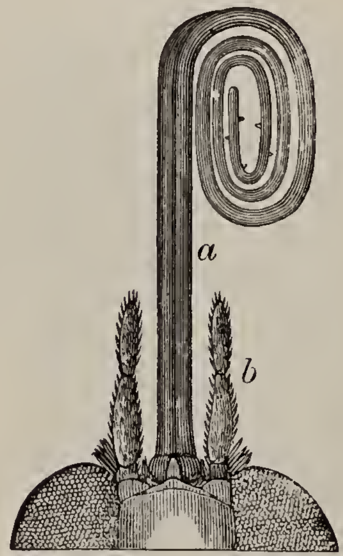
gans are modified for sucking or lapping soft substances or liquids; the lower lip is elongated into a membranous tongue, which accompanies the palps, and the jaws form a bivalve sheath, which constitutes the **proboscis**. In blood-sucking insects (diptera) the mandibles are modified into sharp lancets, which are capable of penetrating the skin of animals, and these are enveloped by a sheath formed of the jaws and the labra.

FIG. 286.



MOUTH PARTS OF COCKROACH (after Savigny).—*a*, labrum; *b*, mandibles; *c*, first pair of maxillæ, with, *d*, stipes; *e*, lacinia; *f*, galea; *g*, maxillary palps; *h*, submentum of second pair of maxillæ or labium; *i*, mentum; *k*, labial palps; *l*, paraglossa; *m*, lacinia; the last two together forming the ligula.

FIG. 287.



MOUTH PARTS OF CABBAGE BUTTERFLY (after Leunis).—*a*, suctorial tube, formed from first pair of maxillæ; *b*, the labial palps, belonging to the second pair of maxillæ. At the base of the former, hints of upper lip, mandibles, and second maxillæ can be seen.

The **coleoptera** include the **cockchafer, stag-beetle, church-yard beetle, Colorado beetle,** or potato-bug, **fire-fly, glow-worm, lady-bug, meal-bug, water-beetle, cantharides,** and the whole beetle order. The Colorado beetle is too well known by the damage it does the potato crop, and the only protection from it appears to be the

FIG. 288.

COLORADO BEETLE.—*a*, beetle, natural size; *b*, caterpillar; *c*, eggs. (From Miss Ormerod's "Injurious Insects.")

sprinkling of the plants with the arsenical compound Paris green. It is about a third of an inch long, light-brown, with dark spots. The fire-fly produces its brilliant light by two spots on the thorax. The glow-worm has its phosphorescent organs on the abdomen, and only the males are winged; the cause of the phosphorescence is not known.

Fig. 289.

Brazilian fire-fly (*Pyrophorus noctilucus*) in burrow of mole-cricket, showing the two oval phosphorescent organs on the thorax.

Among **orthoptera,** the better known are the **grasshopper,** the **cockroach,** the **migratory locust,** and the **cricket.** Many of this order are jumping insects, and in these the males can produce a peculiar rasping sound by rubbing the wing-cases against spinous projections on the posterior legs. This faculty has often occasioned confusion of the grasshoppers with the common locust. The migratory locust is a great destroyer of crops; sometimes these insects appear in vast clouds that alight and devour every green thing before them, leaving fields naked.

Fig. 290.

Green-faced locust (*Tragocephala viridifasciata*).

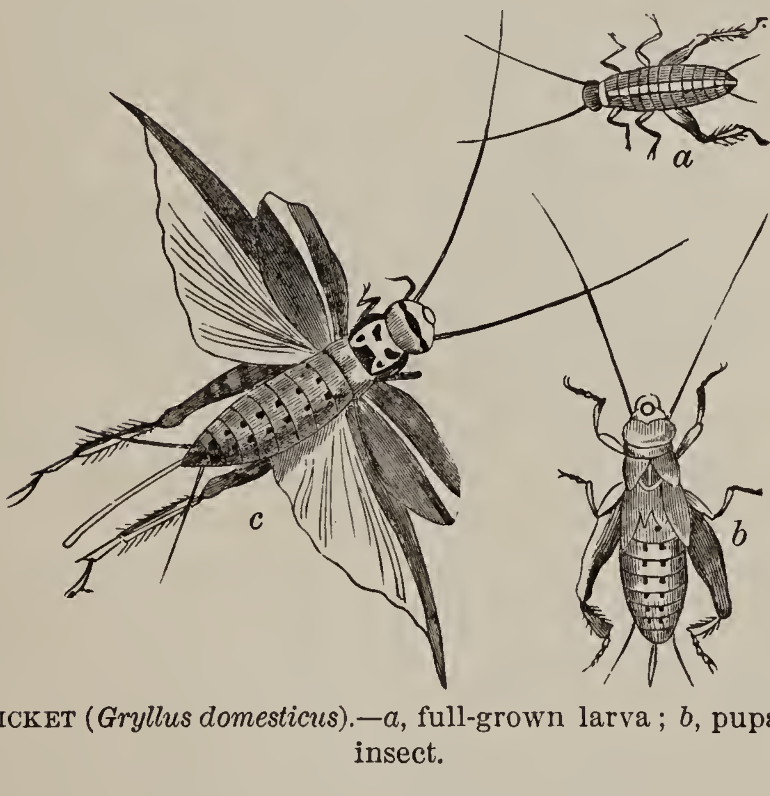
The **cicada—common locust**—belongs to the order of

hemiptera by its general features, but it lacks the very peculiarities which give the name to the order; its upper

FIG. 291.

LOCUST (*Pachytylus migratorius*).

FIG. 292.



HOUSE CRICKET (*Gryllus domesticus*).—*a*, full-grown larva; *b*, pupa; *c*, perfect insect.

wings are as delicate and transparent as the lower ones. The female has at the extremity of the abdomen a borer, which is used in piercing the bark of trees, in order to prepare a place for the eggs. At the base of the abdomen of the male is an apparatus by which he can produce the monotonous sound so well known in summer, and that some species continue day and night. The larvæ of the cicada drop to the ground and bore their way into the soil, remaining a long number of years, sucking the juices of roots. This insect is commonly known in the United States as the seventeen-year locust.

Fig. 293.

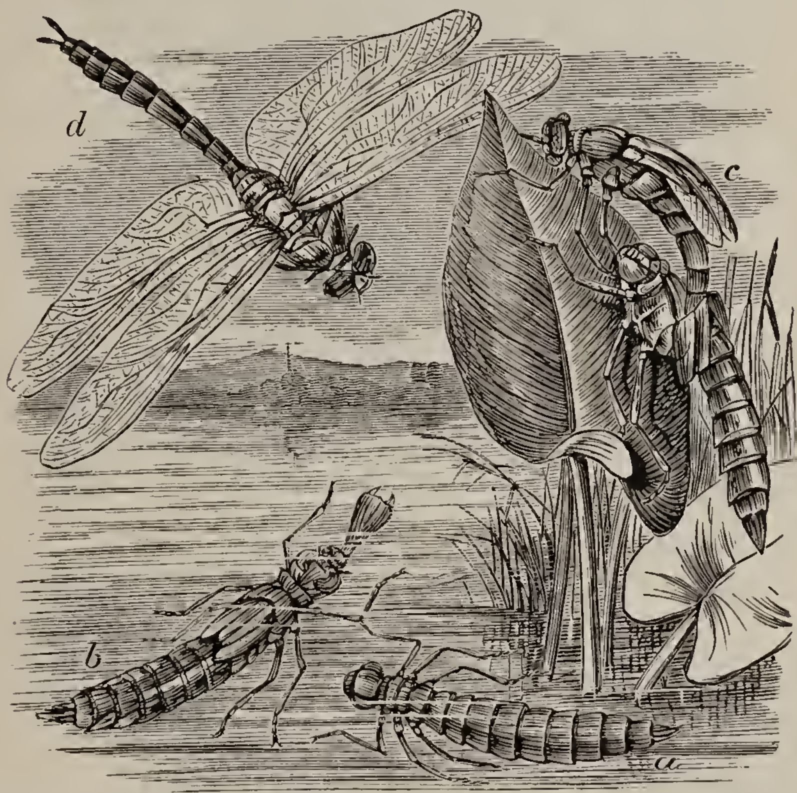
Cicada.

The **neuroptera** have four membranous wings, whose nervures form a net-work somewhat resembling the veins of a leaf. They are sometimes made a suborder of orthoptera. Prominent among them are the **dragon-fly,** whose larvæ are aquatic and very voracious, feeding even on newly-hatched fish; there are a large number of species. The **ephemera** constitute a genus of neuroptera whose perfect insect-life lasts but a day: the best example is the **May-fly,** whose pupa leaves the water with wings, but still enveloped in a delicate robe, of which the insect disencumbers itself on some stem of grass or twig.

The coloring matter called **cochineal** consists of the bodies of a species of hemiptera; we will study the insect in the next chapter. Ordinary **lice** belong to the hemiptera.

The **hymenoptera** include **bees, humble-bees, wasps,** and **ants.** We will defer the study of bees until we consider the useful invertebrates. The humble-bees form a distinct genus, and comprise several species, some making their nests underground, some on the surface, and others being borers. They are all social, constructing nests, gathering wax and honey, raising the larvæ in common, and carrying on in a less perfect manner than the honey-bees the industrious work for which this whole order is celebrated.

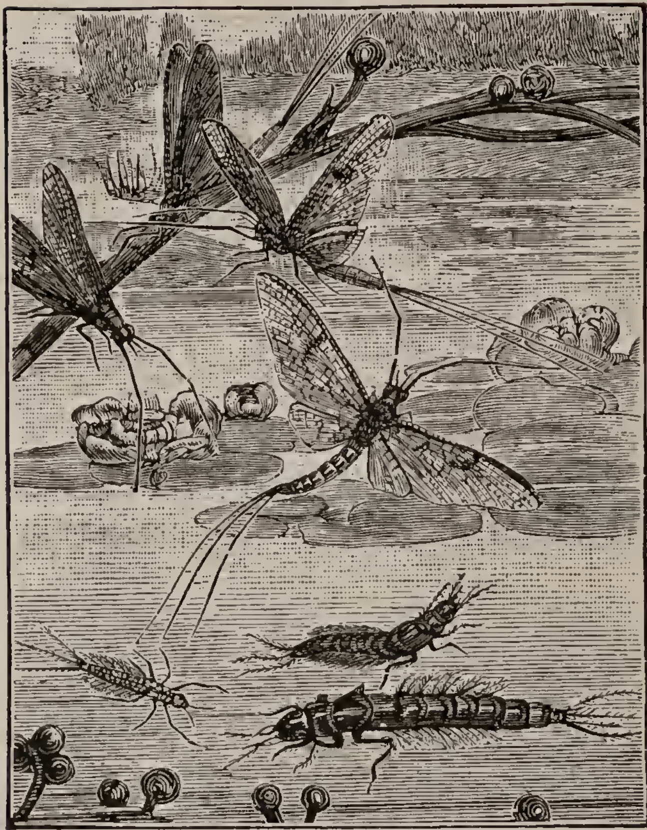
Fig. 294.



Metamorphoses of dragon-fly (*Aeschna grandis*).—*a*, larva; *b*, pupa; *c*, perfect insect issuing from pupa case; *d*, perfect insect, with wings fully developed.

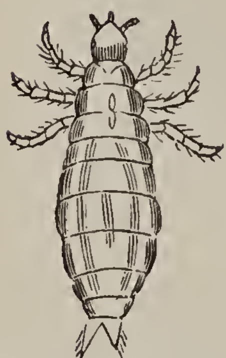
Wasps form societies sometimes not less numerous than those of the bees. They also manifest great industry in constructing their nests, which certain species make underground, while others prefer hollow trees or the branches of bushes. The nests are made of a substance very analogous to paper, that the insects prepare from particles of old wood moistened with their saliva;

FIG. 295.



METAMORPHOSES OF THE MAY-FLY.

FIG. 296.



LOUSE (*Pediculus capitis*) (magnified).

FIG. 297.

HORNET (*Vespa crabro*).

the interior contains a large number of regular cells, in which the eggs are deposited. Wasps take great care of the young larvæ, feeding them on the *débris* of fruit, and on honey which is but little inferior to that of bees. The adults live as foragers in orchards, where their depredations often occasion serious loss. Their stings are painful, and sometimes not without danger.

Ants are social in their habits, like the preceding species; there are several thousand species, distributed all over temperate and tropical countries: the **termite,** or white ant, belongs to an entirely different order. They

FIG. 298.

A COMMON ANT (*Lasius flavus*).—*a*, queen; *b*, worker; *c*, male; *d*, larva; *e*, pupa. (After Lubbock.)

occur, as we shall see do also the bees, in three different forms,—males, females, and workers, and the latter are without wings. The workers feed the larvæ and take care of the pupæ, carrying them into the sunshine, or moving them from place to place when danger threatens. The various species construct their nests of different materials and in different manners; most live in chambered galleries; some simply burrow under stones. The giant black ant prefers a hollow tree or a stump; the yellow and brown ants raise conical **ant-hills** of sand or earth sometimes a foot high, chambered and traversed by innumerable galleries. Some species of ants reduce others to slavery, compelling them to bring food and to nurse the larvæ.

FIG. 299.

PART OF A GALLERY, WITH ANT WORKING ON TIPTOE, — *Pogonomyrmex molifaciens*, the agricultural ant of Texas. (From McCook.)

The **lepidoptera** are classified in three families, different in their habits and their forms; they are the **diurnal,** generally called **butterflies,** the **crepuscular,** and the **nocturnal,** the latter two being commonly called **moths.**

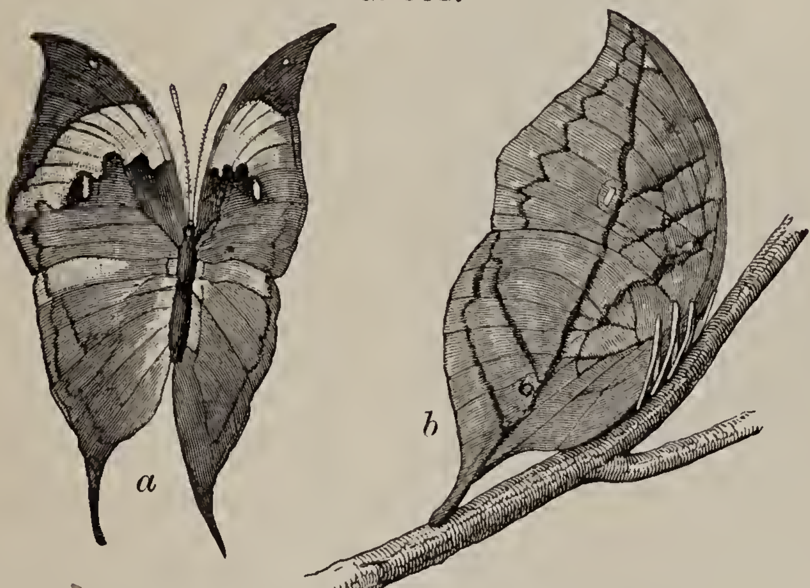
The diurnal lepidoptera may be recognized by the erect position of their wings when at rest. They fly only during the day; their colors are usually brilliant; the chrysalis is usually naked and attached by the posterior extremity of its body. There are very many species.

The crepuscular lepidoptera do not fly all the evening, as their name would indicate; some are even diurnal in their habits. However, the wings of all are held horizontally during repose, and their movements produce a humming sound when flying. The chrysalis is usually enclosed in a cocoon, and attached to a tree or wall or hidden in the earth. Some of the species are very large, one of the South American measuring a foot across the extended wings. The colors are usually sober. The nocturnal lepidoptera fly only at night or at evening

FIG. 300.

EMPEROR MOTH, WITH CATERPILLAR, PUPA, AND COCOON.

FIG. 301.



KALLIMA INACHIS (from Carus Sterne).—*a*, flying; *b*, at rest.

after sunset. Some of them have no proboscis, and a few have no wings. When wings are present they are held horizontally at rest, or even folded around the body. The color is generally dark, and the chrysalis is enclosed in a cocoon. This group is numerous, and some species do much damage, the larvæ eating woollen and other fabrics.

Mimicry, or imitation of surrounding objects, is often exhibited to a remarkable degree in the lepidoptera; the leaf-butterfly (Fig. 301) is almost indistinguishable from a brown leaf as it rests upon a branch or twig.

The **diptera** have only one pair of wings, the missing pair being usually replaced by two movable appendages, called **balancers.** The mouth is organized for suction; sometimes, as in the fly, it consists of a simple fleshy and retractile proboscis, whose free extremity acts as a sucker; sometimes, as in the mosquito, there is a cylindrical sheath containing five scaly darts, each of which ends in a sharp point flattened like a lance. The metamorphosis of the diptera is generally complete. The larvæ are usually without limbs, and are commonly called worms. They are born and pass the first stage of their life in stagnant waters or moist soil or among rotten matters. Many species are ovoviviparous.

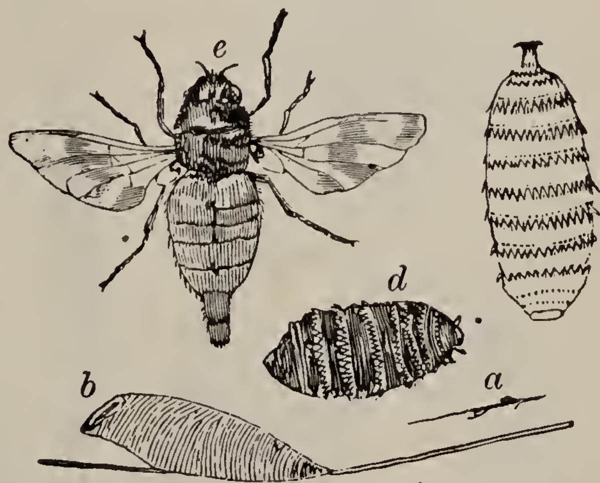
FIG. 302.

LIFE-HISTORY OF THE GNAT (*Culex pipiens*).—*a*, larva; *b*, pupa; *c*, perfect insect emerging; *d*, male, and *e*, female gnat.

The diptera are almost as numerous as the coleoptera; there are more than twenty thousand species of flies, most of which are without special interest, excepting that they frequently become pests.

Mosquitoes and gnats abound in all parts of the world, —as well in the frozen regions of the North as at the equator. They prefer marshy localities, and sometimes render such neighborhoods almost uninhabitable. They deposit their eggs on the surface of water, and the larvæ are aquatic.

Fig. 303.



Horse bot-fly.—*a*, a horse-hair with eggs of bot-fly; *b*, one egg magnified; *c*, larva; *d*, pupa; *e*, perfect insect, female, a little larger than life.

The **horse-fly** and **ox-fly** are common during the summer in woods and pastures, where they torment cattle to such an extent by their bites as sometimes to drive them nearly mad. The **gad-fly** or **bot-fly**, of which there are several species, have no organs for perforation, but deposit their eggs on the skin or in the nostrils of large mammals, especially the ox, horse, and sheep. The larvæ may develop in the nostrils, or the eggs, taken into the mouth by the tongue of the animal, are introduced into the digestive canal, where they develop, and which the insects leave at the period of their last transformation, allowing themselves to fall on the ground.

CHAPTER XXXIV.

Some Useful Invertebrates—Pisciculture.

MANY invertebrates are used as food; among the crustacea, such are the lobster, crab, and crayfish; among

FIG. 304.

MOUTH-ORGANS OF HONEY-BEE (*Apis mellifica*) (largely magnified).—*a*, tongue; *b*, *b*, labial palps; *c*, *c*, first maxillæ.

mollusks, the oyster, clam, mussel, and scallop. Others are used in medicine, such as the leech and the cantharides. In studying the various species, we have already noticed this utility, and in the present chapter we will consider a few insects that have a considerable interest from an industrial point of view; they are bees, silk-worms, and cochineals.

Bees are hymenoptera in whose buccal apparatus we may distinguish an upper lip, mandibles, and a proboscis. We will particularly study the honey-bee, and we find in one of their small republics three classes of individuals: **drones** or males, **females,** and **workers,**—the last being sexless. A swarm or hive contains one female, called the **queen,** six or seven hundred drones, and twenty or twenty-five thousand workers. The workers procure food, construct the hive, and take care of the eggs, larvæ, and pupæ; the queen does nothing but eat and lay eggs; the drones are killed or driven from the hive as soon as there are a sufficient number of larvæ to insure a full, new, young swarm. The females and workers have a sting connected with a poison-bag containing formic acid and other irritating substances; this sting is barbed so that it cannot easily be withdrawn, and its use as a weapon is usually followed by the death of the bee.

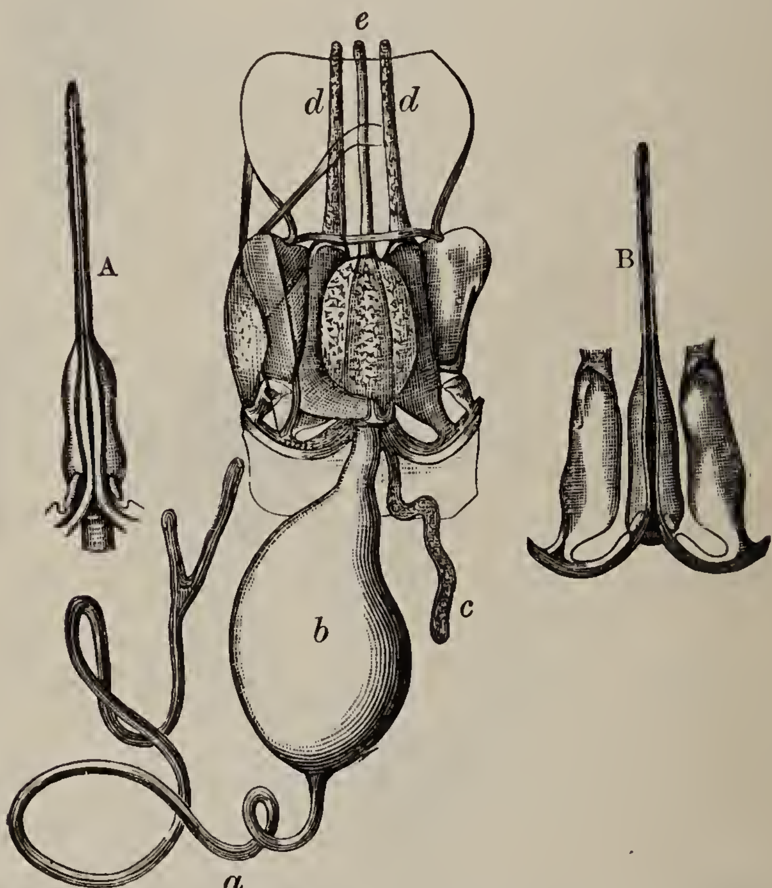
Fig. 305.

Honey-bee (*Apis mellifica*). — A, queen; B, drone; C, worker.

Wild bees usually make their nests in hollow trees or in sheltered cavities in rocks, but for convenience in removing the honey various forms of box-hives are made.

The storing of honey is done exclusively by the workers, and the organs with which they are provided are admirably adapted for the purpose. The posterior legs are furnished on the interior sides with stiff hairs that form a brush, which collects the pollen of flowers and the gummy matters that cover buds. At the sides

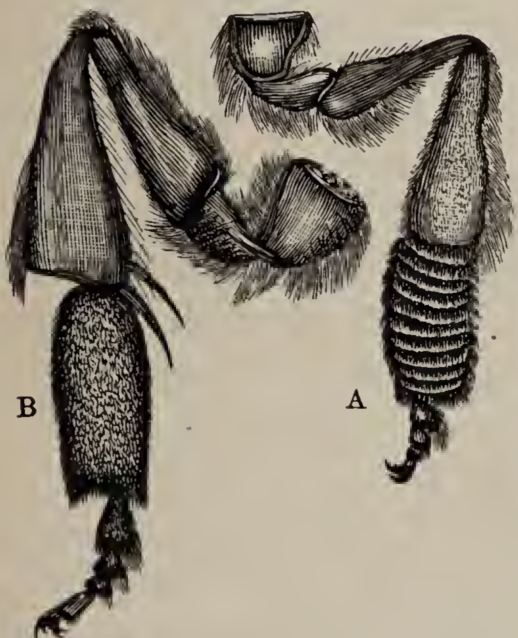
FIG. 306.



STING OF WORKER-BEE (*Apis mellifica*) (after Kraepelin).—*a*, poison gland; *b*, poison bag; *c*, accessory gland; *d,d*, outer supporting pieces; *e*, inner sheath enclosing sting proper: A, sting proper; B, sheath in which sting works, seen from below.

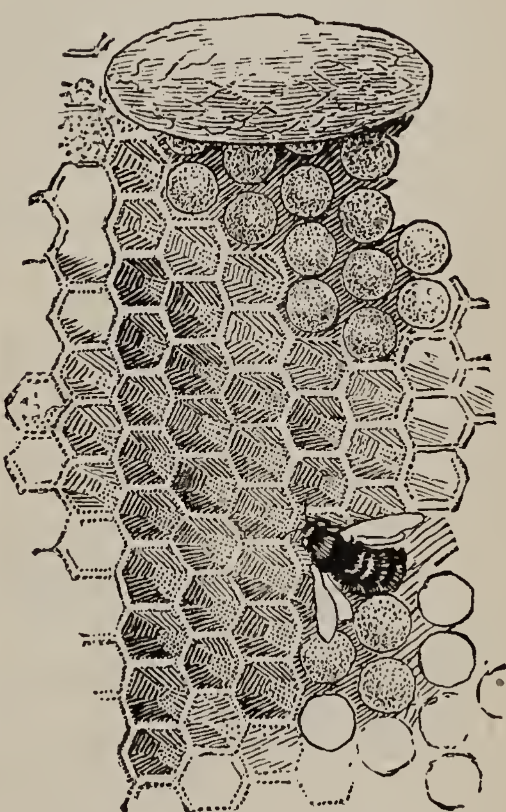
under the wings are little hollows or **baskets**, in which the spoil is carried home. The long proboscis penetrates easily into the corolla of flowers and pumps or licks up the nectar secreted there. With these different materials the bees produce **honey, wax,** and **propolis.** **Honey** is nothing but the nectar of flowers, which the bees disgorge from their honey-bags, retaining what is needed for their individual food. **Propolis** is a resinous and odorous substance, taken directly from plants, and used for lining the hive or stopping up holes in it, and occasionally for building a prison around some intruding slug. Wax is secreted by the bees themselves; they can produce it when fed on honey alone. It is secreted by the walls of the abdomen in the space between the segments, and is used for the construction of the cells or **comb**. Each of these cells is a sort of hexagonal cup; the comb is composed of two layers of such cups placed bottom to bottom, and in them are placed not only the eggs and larvæ, but the provisions of honey and pollen necessary for the life

Fig. 307.



Hind leg of honey-bee, A; of humble-bee (*Bombus lapidarius*), B.

Fig. 308.



Fragment of honey-comb, showing empty six-sided cells, full cells with opening closed, and one large queen's cell.

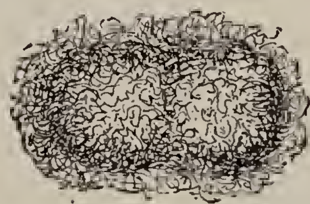
of the swarm. The hatching of the eggs brings forth larvæ that have no limbs; these are cared for by the workers in the cells in which they are born: by appropriate care and nourishment of honey and pollen, either queens, drones, or workers are produced, and the cells are differently shaped, so that the intended sex of the inmate cannot be mistaken. After a certain number of days these larvæ change into pupæ, and the latter into perfect bees. There cannot be at the same time two queens in the same hive. So soon as a young queen prepares to leave her cell at the close of her metamorphosis, the old queen attempts to kill her; the workers prevent this, and the old queen leaves the hive, taking with her a part of the population, and forming a new swarm. The new queen, who is left in the hive, soon emigrates in the same manner, abandoning the hive to a still younger one, and there may be in this manner four **swarms** each season; the departing swarm usually alights on the branch of a tree not far from the old hive, and the bees allow themselves to be transferred to a new hive without resistance.

The swarming usually occurs late in the spring, and the honey is gathered at the beginning of summer, so that the bees are able to renew their provisions before winter; besides, the workers being away nearly all day on fine days, the honey and comb may be removed without sacrificing the bees and without danger of being stung. Sometimes before removing the honey the bees are stupefied with smoke or with ether vapor; but this is entirely unnecessary where modern frame hives are used.

During the winter, bees live on the provisions that they have collected during the season of flowers. When too large a proportion of honey has been taken from them, or when the winter is very long, they are usually fed a mixture of sugar, water, and honey.

The **silk-worm** is the larva or caterpillar of the mulberry silk-worm, a species of lepidoptera whose scientific name is **sericaria mori.** It is a nocturnal moth, having white wings with a few black rays; the body is velvety, covered with a white fur; the antennæ have the form of foliated palm branches. The larva is at first a little

Fig. 309.



Cocoon of silk-worm.

Moth and eggs of the silk-worm (*Sericaria mori*).

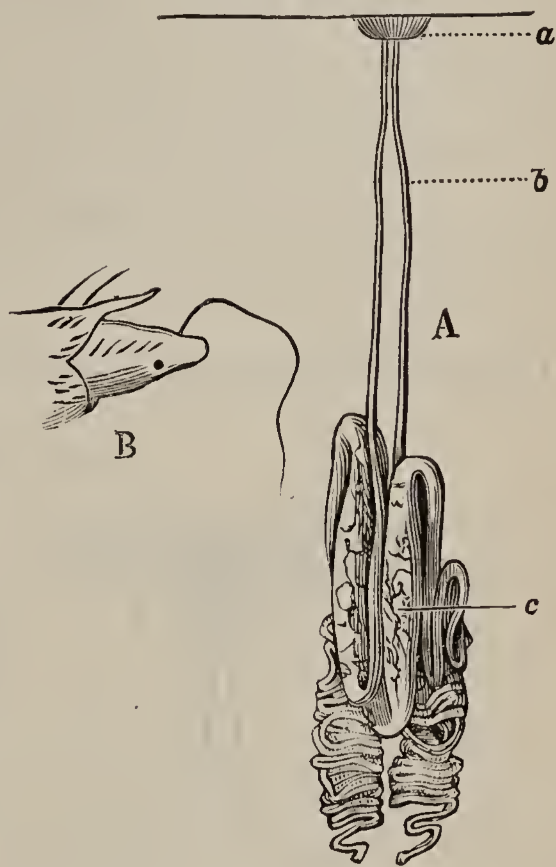
Silk-worm (*Sericaria mori*) (about twice natural size).

black worm somewhat over a quarter of an inch long, but towards the end of its development it may attain a length of three-quarters of an inch. Its skin is almost without hairs, of a light lead-gray color with black spots on the dorsal surface. There are eight pair of legs. The head is scaly and armed with jaws. The glands that secrete the substance of silk are placed in the interior of the body on each side of the median line, and communicate with a tubercle on the lower lip by means of two very narrow canals. The silky matter flows from the two glands, assumes the form of thread in the canals, and dries in the air as it is drawn from the minute orifices in the tubercles. The finest fibres that are used in industry are formed by the twisting together of three or four natural fibres. With these fibres, of which some are white and some yellow, the larva rolls up an entirely closed oval cocoon, in which it shuts itself up during the last metamorphosis, and which it leaves as a perfect moth, after having dissolved, by a peculiar liquid secretion, the gummy matter that holds the fibres together, and prevents them from separating from one another.

The rearing of silk-worms is an exceedingly important industry in certain countries. It is conducted in **silk-worm nurseries,** where all the operations are conducted on a scientific basis, in order that the products may have the greatest superiority. However, the accumulation of enormous quantities of silk-worms in a limited space is accompanied by great danger of loss in case of epidemic diseases among them, and the rearing of the worms must not be undertaken on too large a scale.

To form an idea of the series of operations conducted in an ordinarily large nursery, we must start with the worms in the eggs. An ounce of these contains about forty-four thousand, and an ordinary nursery employs about ten ounces, while the smaller cultivators cannot use over two or three ounces. In France, where silk culture has reached a high stage of development, the hatching is undertaken when the buds of the mulberry begin to put forth little leaves. The eggs are then maintained at a temperature between 68° and 77°, and the worms appear in five or six days. The rearing occupies about a month; although this time may be shortened by keeping the temperature high and furnishing more food, the results are not satisfactory. During their short lives the worms cast their skins several times—usually four—and the time between each casting is called an **age.** At each age there is a moment when the appetite of the worms appears insatiable. The worms hatched from an ounce of eggs consume nearly a ton of mulberry leaves before they reach maturity; they then quit the nests filled with leaves in which they are kept, and crawl on to bundles of branches arranged for them, and there begin to spin. This work lasts three days, after which the cocoons may be detached. An ounce of eggs produces a hundred or a hundred and fifty pounds of cocoons.

FIG. 310.



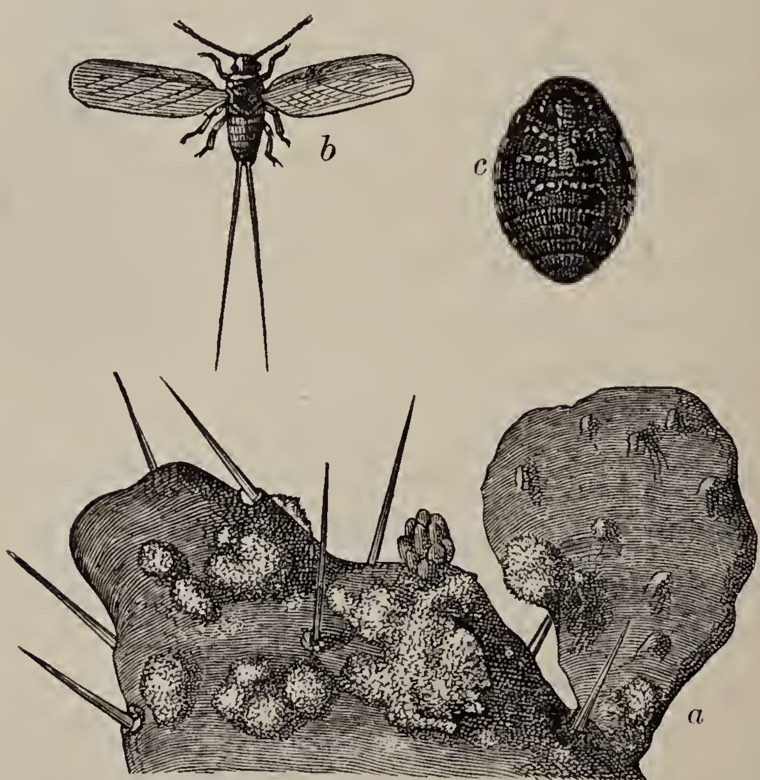
SILK-SECRETING APPARATUS.—A, organs that secrete the silky matter in the silk-worm: *a*, posterior part of the head; *b*, canals for the exit of the silky matter; *c*, reservoir and silk gland; B, nipple on the lower lip from the tip of which the silk-fibre issues.

When the cocoons have been collected, the best specimens are set aside for future rearings, and from these the moths are liberated in two or three weeks; they produce other eggs, which are preserved until the following season. Twenty ounces of cocoons yield about an ounce of eggs. The cocoons from which silk is to be made are exposed to steam; the pupa are thus killed, and the silk is unrolled and reeled.

The **sericaria mori,** or **bombyx mori,** which produces the best silk, can be reared only where the mulberry flourishes, but there are other silk-producing worms, species of bombyx, that feed on oak-leaves, rice-leaves, and on the leaves of poplar, elm, white thorn, and castor-oil bean.

The **cochineal** insects are species of **hemiptera** in which

Fig. 311.



Cochineal (*Coccus cacti*).—*a*, living on cactus (*Opuntia*); *b*, male; *c*, female.

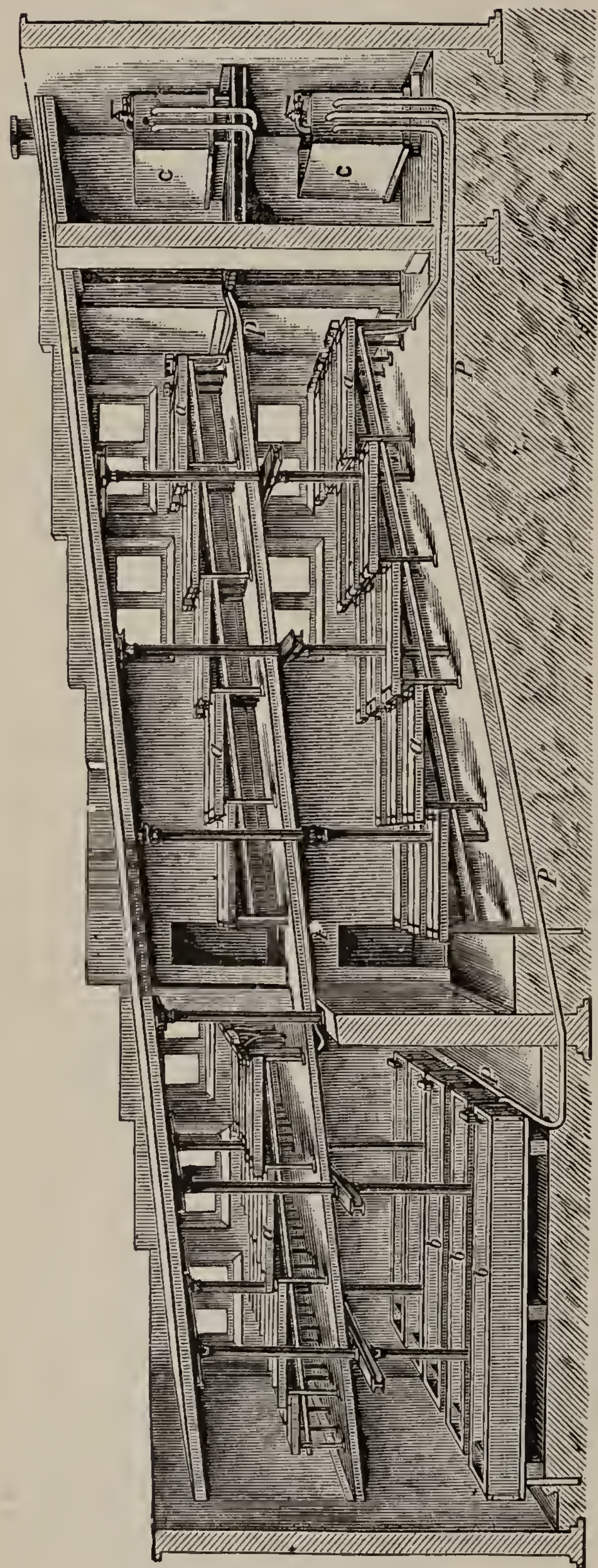
the female lives flattened out on the leaves of certain plants; as soon as the eggs are laid she swells up and dies, protecting the eggs with her dried body. The ordinary cochineal lives in Mexico, on the leaves of a cactus called nopal, and is largely cultivated. Little nests containing the females ready to lay eggs are suspended on the spines of the nopal, and the larvæ soon appear on the leaves and spread over the plant. The males have wings, but the females are apterous, and remain on the plant, from which they are collected, killed by heat, and dried in the sun. They contain the coloring matter called **carmine.**

Lac, which is ordinarily known as shell-lac, is a resin produced on certain varieties of fig-trees in Asia by a species of hemiptera, called the **coccus lacca.**

PISCICULTURE.

Since we have from time to time spoken of useful animals, we should not pass in silence the efforts that have been made to preserve certain species and to enable them to multiply. Fish, in particular, are important from an alimentary point of view ; the entire population of certain towns consists of fishermen, and it is not astonishing that the art of breeding and protecting fish, called pisciculture, has been practised from very remote epochs. It was known to the Chinese and to the ancients, has long been carried on in Europe, and is now successfully conducted on a large scale in the United States. There is no difficulty in understanding the interest that attaches to the preservation in our lakes and watercourses of useful species, such as the carp, perch, bass, trout, and salmon. Artificial hatcheries have been invented, and the habits of the fish have been closely studied; for, in order to ascertain the best conditions for reproduction, we must know how and in

Fig. 312.



A FISH-HATCHERY.

what surroundings the eggs are laid, and what nourishment must be furnished the young fish or **spawn.**

Some species, such as the trout and salmon, deposit their eggs in little cavities in sand or gravel, or in the interstices of rocks; others, such as the perch, carp, and roach, attach the eggs to aquatic plants or stones by the aid of a viscid, glue-like matter. These conditions being known, it is easy to establish an artificial hatchery. For the perch tribe a frame of wood, supporting a net-work of branches and aquatic plants, may be sunk in the water by means of stones; while for the salmon species a bed of gravel in running water would be required.

Remy, a poor French fisherman, was the first to introduce artificial hatching into Europe, being led to his invention by observing the immense destruction of the eggs and young by various enemies in nature. He simply enclosed the eggs, mixed with the milt, in zinc boxes perforated with holes, which were then sunk in the river until the eggs were hatched. At present a number of shallow troughs are usually employed, arranged side by side, and at gradually-increasing elevations; water flows through the whole series; this arrangement permits the hatching of eggs of different dates to be conducted simultaneously, and the separation of spawn of different ages.

When the eggs are hatched, the spawn must be carefully fed, the food, of course, depending on the species; young trout and salmon thrive well on the larvæ of insects and on smaller fish.

Pisciculture consists not only in supplying streams and lakes with eggs and young fish under the most favorable conditions; it includes also the precautions which must be observed to fully populate large rivers. At certain seasons of the year various fish ascend the rivers for **spawning**, and everything that may prevent or interfere with their free **running** up and down must be carefully avoided. Dams in rivers are effective barriers to the running, and laws usually require that **fish-ways** or **fish-ladders** shall be provided by which the fish may ascend, jumping, as they easily do, from one step to the next.

Among the fish that run up the rivers we may mention shad, salmon, sea-trout, sturgeons, and eels. During the months of March and April millions of young eels, hardly larger than threads, ascend the rivers in compact masses; under suitable conditions these grow rapidly, and in a few years will weigh as many pounds. Towards autumn the young fish have grown large enough to take care of themselves, and they go down to the sea.

In conclusion, pisciculture consists in the care given to the breeding of fish. "If fish be hatched in the hope of increasing them, the method of the agriculturist must be followed; he sows his grain in the most favorable ground, and especially in a soil carefully prepared for the seed; to place young fish in a lifeless river is like planting wheat in chalk or in sand" (Blanchard).

CHAPTER XXXV.

Obnoxious Invertebrates.

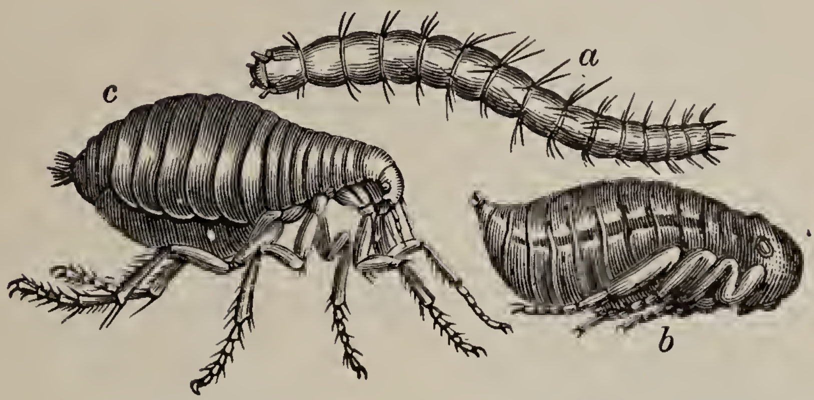
WHILE studying worms we came across a certain number of **parasites.** Besides these there are among the invertebrates, and especially among insects and arachnides, a large number of species injurious because of their parasitic habits.

FIG. 313.

BLOW-FLY.

We have already mentioned the cattle-flies and the bot-flies; there are certain species that attack man. One of these is a Mexican fly, of which the female deposits her eggs in the nostrils of those who sleep out; these eggs pro-

FIG. 314.



METAMORPHOSES OF COMMON FLEA (*Pulex irritans*) (magnified).—*a*, larva; *b*, pupa or nymph; *c*, perfect insect.

FIG. 315.

MOUTH APPARATUS OF THE FLEA.—The long serrated mandibles are on each side of a median needle which represents the labrum. Exterior to these mandibles two grooved joints represent the lower lip. The maxillary palps are still further out.

FIG. 316.

BEDBUG (*Cimex lectularia*), magnified.

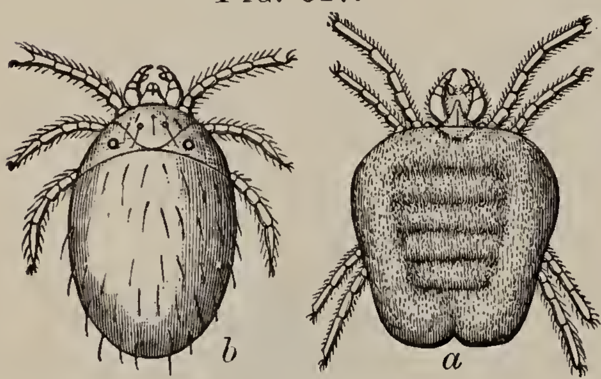
duce carnivorous larvæ that penetrate profoundly, and occasion terrible suffering and frequently death.

Fleas are apterous (wingless) insects, organized for jumping, and having a mouth armed with small lancets that are modified mandibles; these lancets are enclosed in a sheath formed by the union of the jaws. The bite is painful because the insect secretes an irritating saliva.

The **bedbug** is a hemiptera, and is still more objectionable than the flea. It has one pair of rudimentary wings, and when it is at rest the short beak is hidden in a fold of the abdomen. The mandibles and the jaws are modified into bearded needles, enclosed in a sheath formed by the upper and lower lips.

Among the parasitic arachnides may be classed the **acarids** or mites, creatures having a discoid or globular body, and a mouth ordinarily adapted for sucking. Among these are the **ticks**, which attach themselves firmly to the skin of mammals by means of a serrated mouth formed by the union of the jaws.

FIG. 317.

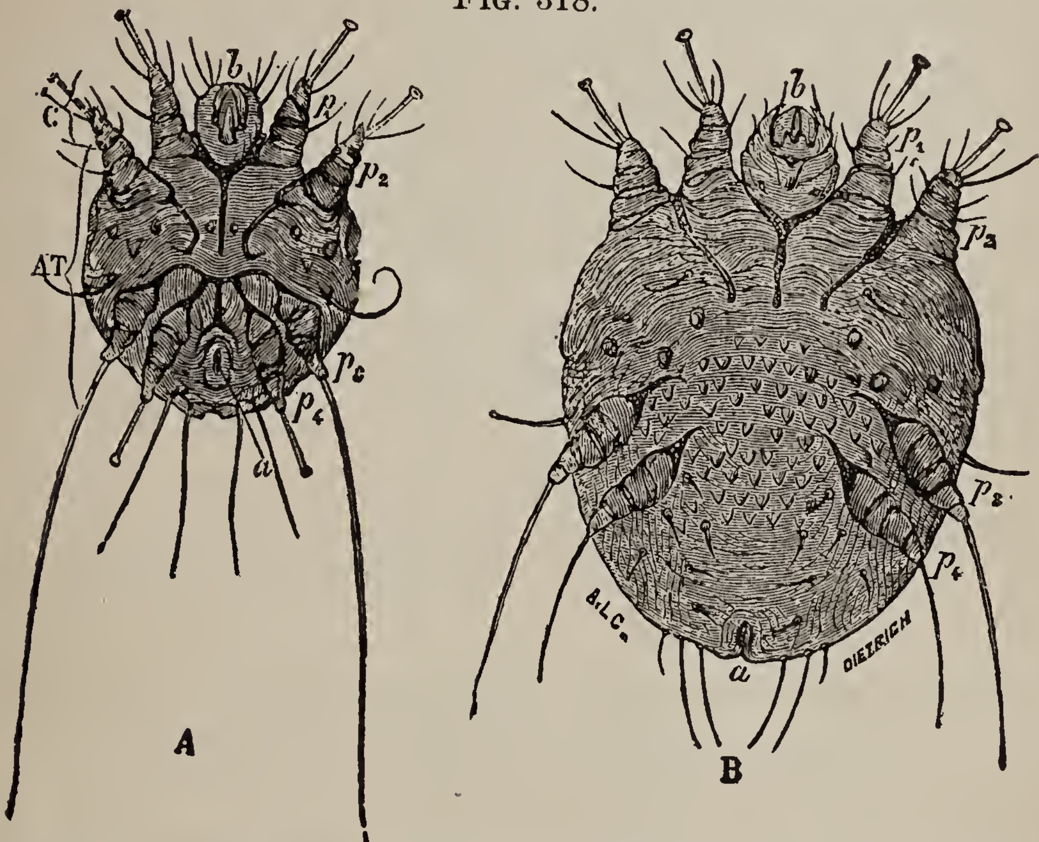


a, *Trombidium holosericeum*, female (magnified 9 diameters); *b*, larva, full grown (harvest-bug).

The **harvest-bug** or **harvest-tick** is the larva of an acarid called **trombidium.** It has six feet, like the larvæ of most acarids, and is found in the woods and fields in July and August. It often occasions great inconvenience to men, its presence in the skin producing violent itching.

The **itch-insect,** or **sarcoptes scabiei,** is hardly visible to the naked eye; the female lives in the skin of man and of various animals, such as the ox, sheep, dog, etc., and burrows out galleries, where it feeds on the juices secreted because of the irritation it occasions. These burrows appear on the surface of the skin like the sinuous scratches of a pin; the larvæ crawl out of them and hide themselves under a neighboring epidermic pellicle.

FIG. 318.



ITCH-INSECTS.—A, male; B, female; p_1, p_2, p_3, p_4, the four pair of feet; *b*, mouth; *a*, anus.

SOME INSECTS INJURIOUS TO AGRICULTURE AND TO INDUSTRY.

Coleoptera.—We have already spoken of the ravages committed by beetles of various kinds and in their various forms. Both the larvæ and the perfect insect are exceedingly destructive. There are about a hundred species of beetle that live at the expense of the pine-tree; different species attack different kinds of tree, some eating leaves, others preferring twigs, while some bore into the wood. The **rose beetle,** the **asparagus beetle, sugar-cane beetle,** and **carpet beetle**—the latter being exceedingly destructive to woollens of all kinds—are only too well known.

Of the **dermiptera,** the **earwigs** destroy fruits and flowers.

Orthoptera.—The **cockroaches** eat and soil our food; **grasshoppers** and **locusts** devour roots and young sprouts.

Hemiptera.—Plant lice live socially on most plants; they cause a more or less rapid destruction by absorbing all the nutritive juices. The **phylloxera,** so fatal to the grape-vine, is closely related to the plant lice. The harlequin cabbage-bug and tree-hoppers are hemiptera.

Neuroptera.—The **termites,** which will presently be described, are particularly injurious to wooden constructions.

Hymenoptera.—The damage caused by ants and wasps has already received notice. Certain of these insects are very injurious to trees.

Lepidoptera.—In the state of larva or caterpillar nearly all this order are destructive to certain vegetable or animal matters. We may cite all the varieties of silk-worm, the cabbage-worm, larch-lappet, hemlock-worm, corn-worm, and the peach- and apple-twig moths.

We will terminate with a few details concerning some species whose history is of particular interest.

Grasshoppers have very long hind legs and a powerful masticating apparatus. But they are not nearly as much dreaded as their near relatives, the **migratory locusts.** At certain epochs innumerable legions of these insects start from desert regions of the Rocky Mountains, of Arabia and Tartary, and rise high in the atmosphere, until they encounter winds that carry them great distances. The light of the sun is darkened as they pass, and the air is filled with a dull sound, caused by the striking of their wings. At last, carried by the wind, they fall like a rain-storm ; trees are stripped of leaves, and the branches break under the weight of the insects ; all vegetable life disappears ; harvests are devoured. Then, to complete the desolation, the bodies of the insects that are crushed in the mass, exhausted by hunger or by fatigue, form on the naked ground a thick layer of decomposing matter that serves as a hot-bed of disease. Russia, Poland, and Hungary have been several times plague-stricken from this cause.

The **phylloxera** lives as a parasite on the roots of the grape-vine, and increases with frightful rapidity. It is rendered still more destructive by the fact that, besides the apterous individuals that remain fixed on the roots, there is a winged form that carries the pest in all directions. The winged insect lives on the leaves, and lays eggs that produce apterous individuals. The latter penetrate under the skin of the root, and by their sucking apparatus kill the vine by pumping all the juices of the plant.

During the warm season the apterous individuals produce, by a sort of budding, large numbers of young, among which some develop into winged insects. The latter migrate, and, as we have seen, lay eggs, from which wingless and less injurious individuals are hatched, but from these are produced the destructive and the winged forms.

The **termites,** or white ants, are of many species ; they have multiplied to such an extent in certain towns of France that attempts to destroy them have proved almost useless. At La Rochelle they invaded the public buildings, destroyed all woodwork, and devoured the archives. The damage wrought by the termites is much greater by the fact that it is never apparent from the exterior. Indeed, the creatures dread the light, and are very careful to leave absolutely intact the surface of the wood they are destroying; joists and supports, apparently perfect, thus give way when the interior is galleried in all directions.

FIG. 319.

HOUSE-MOTH.

The clothing and carpet **moths** are injurious only in the state of larvæ. They are then veritable plagues for all matters composed of wool, feathers, hair, horn, tortoise-shell, skin, and for collections of natural history.

Generally they seek dark, quiet places and uniform temperature, so that the best way to prevent their ravages is to shake frequently and expose to bright light and sudden changes of temperature all articles that might be subjected to their attacks. It is sometimes quite difficult to recognize the presence of these creatures, even by close examination; for sometimes the larvæ make a covered gallery, leaving the outside fibres in position; sometimes the sheath or cocoon which it makes for itself is covered with the *débris* of the material on which it rests, and the colors are so arranged that no difference is detected on first inspection.

Most of these house-moths belong to the family called tineidæ, each species of which prefers fabrics of special material, but, unfortunately, many of them seem able to adapt themselves to whatever matter of animal origin they can get.

GLOSSARY.

Acanthoceph′ala (pl.) ("thorny-heads"), a small group, or phylum, of worm-like organisms, living within the bodies of other animals; they have hooks, or spines, upon the head.

Acar′ida (pl.) ("atoms," "indivisibles"), mites; insects of low type.

Aceph′ala ("headless"), an order of mollusks, to which the oyster and clam belong.

Actinozo′a (pl.) ("rayed animals"), a class of marine animals, including corals, etc.

Æpyor′nis ("tall bird"), a huge extinct bird of Madagascar.

Æstiva′tion ("summering"), the torpid state of certain animals in the hottest season.

Albi′nism, abnormal whiteness in the skin, hair, or feathers.

Amblyp′oda (pl.) ("clumsy-footed"), a group of huge extinct mammals that probably had some of the characters of the elephant.

Amœ′ba ("changing"), a minute animal organism capable of changing its form at will.

Amphib′ia (pl.) ("double living"), an order of vertebrate animals, living at first in the water, and later capable of living in either air or water, as frogs, newts, etc.

Amphip′oda (pl.) ("having feet in either direction"), an order of crustaceans which have feet partly directed forwards and partly backwards.

Anat′omy ("cutting up"), the science of organic structure.

Anten′na ("a sail-yard"), a horn-like process on the head of certain insects and crustaceous animals; a feeler.

A′phid. See Aphis.

A′phis ("unsparing" or "profuse"), a genus of minute insects called plant-lice; they are exceedingly destructive to vegetation.

Appendicula′ta (pl.) ("appendaged"), a great phylum, including the Rotifera, Chætopoda, and Arthropoda.

Ap′tera (pl.) ("no wings"), a class of wingless insects.

Arach′nida (pl.) ("spiders"), a group of articulate animals, including spiders, scorpions, and mites.

Arthrop′oda (pl.) ("jointed feet"). See Articulata. A division of the animal kingdom nearly equivalent to Articulata. But the term *Arthropoda* is the wider in its signification, and is now more often employed than *Articulata*.

Articula′ta (pl.) ("jointed"), a division of the animal kingdom, including animals whose bodies are composed of joints or rings. See Arthropoda.

Artiodac′tyla (pl.) ("even-toed"), a suborder of ungulate animals having an even number of toes on each foot, as swine, camels, and ruminants.

Ascid'ians ("pouched"), a class of tunicates showing marked vertebrate characters.

A'ves ("birds"), a class of oviparous vertebrates having feathers and warm blood; the birds.

Avifau'na ("bird fauna"), the birds of a region collectively.

Batra'chia (pl.) ("frogs"). See AMPHIBIA.

Biol'ogy ("discourse on life"), the science of life and living things.

Brachiop'oda ("arm-footed"), an order of headless bivalve molluscoids having two fleshy spiral arms.

Branchiop'oda (pl.) ("gill-footed"), a division of crustaceans having gills upon the feet.

Bryozo'a (pl.) ("moss-animals"). The same as POLYZOA.

Bunodon'ta (pl.) ("mound-toothed"), a group of artiodactyl mammals, so called from the tubercles on the crowns of the molar teeth. Here belong the pig and the hippopotamus.

Carina'tæ (pl.) ("keeled"), an order of birds having the breast-bone provided with a keel. By far the largest number of existing species of birds belong to this order.

Cen'tipedes ("hundred-footed"), a group of myriapodous animals.

Cephalop'oda ("head-footed"), a class of mollusks having a circle of tentacles around the mouth, as the cuttle-fish and squid.

Ceta'cea ("a sea-animal"), an order of mammals living in the sea, as dolphins and whales.

Chætop'oda ("bristle-footed"), a group of worms, including earth-worms.

Chilog'natha (pl.) ("lip-jawed"), a group, or order, of Myriapoda having the two lower jaws united to form a lip.

Chirop'tera (pl.) ("hand-winged"), an order of mammals having the fore limbs adapted for flight; the bats.

Cirripe'dia ("curl-footed"), a group of crustaceans having a number of long curled processes like feet; barnacles.

Cœlentera'ta (pl.) ("hollow entrails"), a large group, or phylum, of radiated animals, including the Actinozoa, Hydrozoa, and Ctenophora.

Cœ'lom, or **Cœlo'ma** ("hollow"), the body-cavity; the cavity within the animal body.

Cœlo'mata (pl.) ("hollows"), properly, the plural of CŒLOMA; used also as the designation of those animals which have a cœloma, including vertebrates and many of the inferior animals.

Coleop'tera (pl.) ("sheath-winged"), an order of insects with two pairs of wings, the outer serving as a sheath or covering, like the beetle.

Collem'bola (pl.) ("tail-leapers"), the spring-tails, or snow-fleas; a small group of insect-like creatures generally classed as insects of a low type.

Copep'oda (pl.) ("oar-footed"), an order of crustaceans with oar-like feet. Many of the low organisms called fish-lice belong here.

Crania'ta ("having a skull"), those vertebrates that have a brain enclosed in a bony or cartilaginous case or skull.

Crusta'cea (pl.) ("having a crust or shell"), a class of articulated animals having a shelly coating, like the lobster and crab.

Ctenoph'ora (pl.) ("comb-bearing"), an order of Cœlenterata, comprising many small gelatinous, pellucid, marine forms, characterized by comb-shaped swimming organs.

Decap'oda (pl.) ("ten-footed"), the highest order of living crustaceans, including the crabs, lobsters, and prawns.

Dimor'phism ("double form"), the

property possessed by certain low animals of producing different forms of offspring.

Dinor'nis ("terrible bird"), an extinct genus of birds found in New Zealand.

Dip'noi (pl.) ("double breathing"), a small class of fish-like animals (by many regarded as fishes of a primitive type) which have lungs as well as gills.

Dip'tera (pl.) ("double-wing"), an order of insects which have two wings only, as the house-fly.

Echinoder'mata (pl.) ("hedgehog-skinned"), a class of sea-animals which have a covering of tough skin.

Edenta'ta (pl) ("deprived of teeth"), an order of mammals having no front teeth, as the sloth and ant-eater.

Entozo'a (pl.) ("within animals"), animals which live within the bodies of other animals.

Fau'na ("goddess, or nymph, of cattle"), the various kinds of animals found in a country.

Foraminif'era (pl.) ("having an opening"), an order of minute animals having shells the chambers of which communicate by means of small perforations.

Galli'næ (pl.) ("hens"), an order of birds represented by the domestic fowl.

Gan'oids ("splendid appearance"), fishes distinguished by the angular form of their bony, enamelled scales.

Gasterop'oda ("belly-footed"), an order of mollusks having under the belly a fleshy disk which serves instead of feet, as the snail.

Gastrot'richa (pl.) ("hairy-bellied"), a small phylum of worm-like animals, having cilia on the ventral surface.

Gemma'tion ("budding"), a process of reproduction by which a part of the parent is detached to form the offspring.

Gephyr'ea (pl.) ("bridge-like"), a class of worm-like Podaxonia, by some writers regarded as true worms, but according to a later view placed near the Polyzoa.

Hemip'tera (pl.) ("half a wing"), an order of insects whose wings are partly membranous and partly like those of a beetle.

Histol'ogy ("discourse on webs or tissues"), the minute anatomy of the tissues.

Hy'brid ("an outrage"), the offspring of parents which belong to different species.

Hydrozo'a ("water-animals"), a division of the animal kingdom containing aquatic animal organisms of a low order of development, including jelly-fishes.

Hymenop'tera (pl.) ("membrane-winged"), an order of insects having four membranous wings, as wasps and bees.

Hyracoi'dea (pl.) ("hyrax-like animals"), a suborder or group of subungulate mammals, including the hyrax (coney, or daman), the klipdas, and a few other remarkable forms.

Ichthyol'ogy ("discourse about fish"), the branch of natural history treating of fishes.

Infuso'ria ("decoction - animals"), microscopic animalcules (protozoa) found in water, and especially in infusions of plants, etc.

Insectiv'ora (pl.) ("insect-eaters"), an order of small mammals, such as the mole, shrew, and true hedgehog, living chiefly upon insects.

Isop'oda (pl.) ("equal-footed"), an order of crustaceans having the legs alike in size and position; it includes the sow-bugs, etc.

Lar'va ("a mask"), an insect in a caterpillar state; an undeveloped animal.

Lepidop'tera (pl.) ("scale-winged"), the order of insects which consists of butterflies, moths, etc.

Mamma'lia (pl.) ("pertaining to the breast"), the class of animals that suckle their young.

Marsupia'lia (pl.) ("pouched"), an order of mammals the female of which carries her young in a pouch, as the kangaroo and opossum.

Maxil'la ("a jawbone"), the jaw in animals and insects.

Metamor'phosis ("change across"), a change of form.

Mollus'ca (pl.) ("soft"), a division of animals having soft bodies and no internal skeleton, as snails.

Mollus'coids ("mollusk-like"), animals (like polyzoa, brachiopods, and tunicates) that somewhat resemble mollusks.

Monotrem'ata ("one vent"), an order of mammals that lay eggs.

Morphol'ogy ("a discourse on form"), the department of science treating of the organs and structure of animals.

Myriop'oda (pl.) ("ten - thousand-footed"), a class of articulate animals having many-jointed feet.

Nematoi'dea ("thread-like"), a group or class of slender worm-like animals; thread-worms.

Neurop'tera (pl.) ("nerve-winged"), an order of insects having transparent nerved wings, as the dragon-fly.

Nidifica'tion ("making a nest"), the act of building nests.

O'cydrome ("swift runner"), a rare bird of New Zealand, that cannot fly, but runs very swiftly; there are several species.

Ornithol'ogy ("discourse on birds"), that part of zoology which treats of birds.

Orthop'tera (pl.) ("straight-winged"), that order of insects which includes grasshoppers, etc.

O'vum (pl. **O'va**), the egg.

Par'asite ("a guest"), an animal that lives upon or within another animal.

Perissodac'tyla (pl.) ("odd-toed"), a suborder of ungulate mammals having an odd number of toes, as the tapir, rhinoceros, and horse.

Phyllop'oda (pl.) ("leaf-footed"), an order of branchiopod crustaceans having flattened feet, like the brine-shrimps.

Phylloxe'ra ("leaf-drier"), a genus of aphids, or plant-lice, one species of which (*P. vastatrix*, the "devastating phylloxera") is exceedingly destructive to the grape-vine in certain regions.

Phy'lum ("a tribe"), any sub-kingdom or primary division of the animal kingdom, such as the vertebrata.

Pinnipe'dia (pl.) ("fin-footed"), a suborder of carnivorous mammals, including the seals and walrus.

Pis'ces (pl.) ("fishes"), that class of the vertebrata which includes the fishes.

Plana'rians ("flat"), a group of flattened fresh-water worms.

Platyhel'mia (pl.) ("flat-worms"), an extensive phylum, including tapeworms, leeches, and many other worm-like forms.

Podaxo'nia (pl.) ("axis - footed"), a phylum of animals, including the Gephyrea and the Polyzoa.

Pol'yps ("many-footed"), animals having no organs of locomotion, and provided with a circle of tentacles round the mouth.

Polyzo'a (pl.) ("many animals"), a

class of low polyp-like animals that form colonies, or compound animals composed of a great number of individuals.

Porif'era ("pore-bearing"), a class of protozoan animals, including the sponges.

Prima'tes (pl.) ("first" or "highest"), an order of mammals, including the most highly developed species, such as the lemurs, apes, and man.

Proboscid'ea (pl.) ("having a trunk"), a group of subungulate mammals having a long prehensile nose (trunk or proboscis), as the elephant.

Protozo'a (pl.) ("first animals"), the name of the lowest forms of animal life.

Pter'opods ("wing-footed"), an order of mollusks that have wing-like expansions of the foot, which serve as swimming organs.

Pu'pa, the third stage of existence of an insect.

Quadru'mana (pl.) ("four-handed"), four-handed mammals, as apes.

Quad'ruped ("four-footed"), an animal having four feet.

Radia'ta (pl.) ("rayed"), marine animals whose structure is radiate. The term is now used as a descriptive one, and many authorities do not recognize it as the name of any group of animals.

Radiola'ria (pl.) ("small-rayed"), a class of minute oceanic protozoa having flinty skeletons. In some places there are large masses of rock made up mainly of the flinty remains of fossil Radiolaria.

Rati'tæ (pl.) ("raft-like"), an order of birds which have no keel upon the breast-bone, including the ostrich, rhea, apteryx, cassowary, emeu, and several extinct birds, many of them very large.

Reptil'ia (pl.) ("crawlers"), the class of vertebrata that includes crocodiles, lizards, frogs, and snakes.

Reticula'ria (pl.) ("netted"), nearly the same as Foraminifera.

Rhizop'oda (pl.) ("root-footed"), a class of protozoans of very low and primitive type, so named from the root-like processes by which some of the species are attached, or by which they move about.

Roden'tia (pl.) ("gnawing animals"), an order of mammals with chisel-shaped incisors (front teeth) adapted for gnawing, as rabbits, rats, mice, squirrels, gophers, beavers, porcupines.

Rotif'era (pl.) ("wheel-bearers"), a class of animalcules with disk-like bodies.

Sau'ria (pl.) ("lizards"), a group of reptiles that includes lizards, crocodiles, etc.

Sire'nia ("sea-nymphs," "mermaids"), an order of herbivorous marine mammals, including the dugong, the manatee, and the extinct stellerine.

Stomap'oda (pl.) ("mouth-footed"), an order of crustaceans having the feet placed around or near the mouth.

Subungula'ta (pl.) ("slightly hoofed"), a group of mammals usually placed among the Ungulata, but not having complete hoofs, including the hyrax, elephant, etc., most of the species being extinct.

Tax'idermy ("arrangement of skins"), the art of preparing, stuffing, and mounting the skins of animals and birds.

Taxon'omy ("law of arrangement"), the classification of organisms; the systematic and natural arrangement of animals and plants.

Teleos'teans (pl.) ("completely boned"), a subclass of fishes having a complete bony skeleton; true or typical fishes.

Tere′do ("borer"), one of the so-called ship-worms or wood-worms. The teredo is a mollusk that bores holes in wooden ships, and in piles and other timbers placed in the sea-water.

Ter′mites (pl.) ("wood-worms"), a group or family of insects known as white ants; but they are not true ants. Their destructive ravages are noticed in the body of this work.

Thysanu′ra (pl.) ("tassel-tails"), a group of low insect-like forms, generally considered as insects of a low type. The so-called "silver-fish," common in kitchens and closets, is a well-known example.

Tin′amou, a South American bird of several species, generally classed as one of the Carinatæ, and as related to the domestic fowl. But it has many of the structural features of the ostrich-like birds, or Ratitæ, which it also resembles in its habits.

Traguli′na (pl.) ("goat-like"), a group of small tropical artiodactyl mammals resembling deer, but not very closely related to them nor to any true ruminant, including the chevrotains, or deerlets.

Tunica′ta (pl.) ("wearing a tunic"), a class of molluscoids (by some classed as vertebrates) which are protected by a leather-like covering instead of a shell.

Tylop′oda (pl.) ("pad-footed"), a group of artiodactyl mammals having pads under the soles of the feet; the camel, llama, and alpaca are examples.

Ungula′ta (pl.) ("hoofed animals"), an order or group of mammals provided with hoofs or strong nails on the toes, including the horse, ox, deer, elephant, etc.

Ver′mes (pl.) ("worms"), the name given to the class of worms; but the class is not a well-defined one, and is to be regarded as made up of several distinct groups.

Vertebra′ta (pl.), the division of animals which have vertebræ and a bony skeleton.

Zoöl′ogy ("discourse on animals"), the science of animals.

Zo′ophyte ("plant-animal"), any animal that is fixed in its place by a stem and in other respects resembles a plant. The name is not much used at present by zoologists.

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