Elements of Zoölogy

APPLETONS'

SCIENCE TEXT-BOOKS.

ELEMENTS OF ZOÖLOGY.

Frontispiece.

Group of Amphibious Fishes.

1 and 2. Periophthalmus (salt water). 3. Climbing perch (*Anabas scandens*), (fresh water). 4. Callichthys (fresh water).

Appletons' Science Text-Books.

ELEMENTS OF ZOÖLOGY.

BY

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PREFACE.

In the present work, that is intended as a text-book for schools and academies of all grades, the design has been to present in concise and plain language, and in the light of the latest research and investigation, the life-histories of the various groups that constitute the animal kingdom. Technical terms have only been employed where there was no simple equivalent, and the long tables of classification and formulæ, that can only be understood after a complete mastery of biological knowledge, have been omitted, as tending to divert the attention of the student from the real issue. Professor Huxley strikes the key-note of this question when he says: "That the power of repeating a classification, with all its appropriate definitions, has anything to do with genuine knowledge, is one of the commonest and most mischievous delusions of both students and their examiners. The real business of the learner is to gain a true and vivid conception of the characteristics of what may be termed the natural orders of animals. The mode of arrangement, or classification, of these into larger groups is a matter of altogether secondary importance."

While the information herein contained is expressed without technicality, the common names of orders and families are in every case followed by the scientific term, for the convenience of the instructor or advanced student. So also as regards classification: the groups of animals are arranged in an order that represents the latest knowledge of the various forms that constitute them; thus, the plan of Professor Flower has been followed in the mammals; that of Dr. Gill in the fishes; and Professor Cope, in the batrachians and reptiles. The student is first presented with the lowest forms, as being the easiest understood, and so led to others more complex; this plan being considered the most philosophical and natural.

The general characteristics of each branch or order are plainly defined, why and how they differ from preceding ones shown, and then examples are given of the individuals constituting the group that have been selected for their availability as representative forms, and for certain peculiarities that will be most readily impressed upon the memory.

It is probably the experience of every teacher in zoölogy that little or no advancement can be made unless the student can be thoroughly interested in the work, and to this end material has been introduced, in many cases in the form of notes of personal experience relating to the habits of animals, etc., as the growth of coral, the nest-building fishes, luminous animals, animal electricians, hibernation, mimicry, protection and defense—all subjects that, if enlarged upon by the teacher, will insure permanent interest. The student should be encouraged to become an investigator and collector, and available suggestions concerning the best methods of collecting and preserving specimens will be found after each branch. Object-study should be required, and dissections and drawings made, no matter how imperfect the one or crude the other.

A distinctive feature of this work is the reference to the economic value of animals. In the Smithsonian, American Museum of Natural History, Central Park, and other large institutions, collections have been formed to illustrate this subject, that is regarded as an important feature of public education. One of the commonest questions heard in museums is, "What is the animal good for?" and considering the vast interests the lower animals represent, and their relations to man's commercial dealings, the subject should at least be presented to the student. This has been done as briefly as possible, in the form of suggestions to the teacher, to be enlarged upon as occasion offers.

Collateral and supplementary reading is often necessary, and a carefully selected bibliography will be found following each principal group of animals. In the matter of illustration, representations of about five hundred animals and their parts have been given. Many of the cuts are original, and were designed especially to illustrate the habits of the animals, their economic value, etc. Others are from Buckley, Huxley, and various accurate sources already acknowledged.

The valuable assistance of S. U. Holder is cordially acknowledged, and thanks are returned to Mr. Ralph N. Monroe for photographs of the Florida crocodile and for the loan of valuable specimens; also to Professor E. L. Youmans and Professor A. S. Bickmore for pertinent suggestions and advice. Acknowledgments are also made to Dr. E. P. Wright, of the University of Dublin, for the measurements of the gigantic shark *Rhinodon*; and to W. Morey, Esq., of Colombo, Ceylon, for the original outline drawing.

C. F. H.

NEW YORK, *November* 1, 1884.

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INTRODUCTION.

ZOÖLOGY.

INTRODUCTION.

Definition of the Subject. — The science that treats of organic nature, or living things, is termed *Biology.* It is divided into *Botany*, that treats of plants; and *Zoölogy*, that relates to animals.

The Cell.—All animals are made up of one or more cells, minute globules of a jelly-like substance called protoplasm, as a rule inclosed in a delicate covering or membrane. The protoplasm of genuine cells generally contains minute moving granules, and a round transparent body termed the nucleus, that contains a dark object, called the nucleolus. The lowest animals are single cells, and are termed unicellular, but in the higher forms the cells separate by self-division, and form two layers: outer (*ectoderm*), inner (*endoderm*), while a middle layer is called *mesoderm*. From these cell-layers bone and muscular tissue are formed, and the animals are said to be many-celled.

Difference between Animals and Plants.—It is not difficult to distinguish between the higher forms of animals and plants. The trees are sightless, have no locomotive organs, and, as a rule, live upon inorganic substances; yet there are curious points of resemblance.

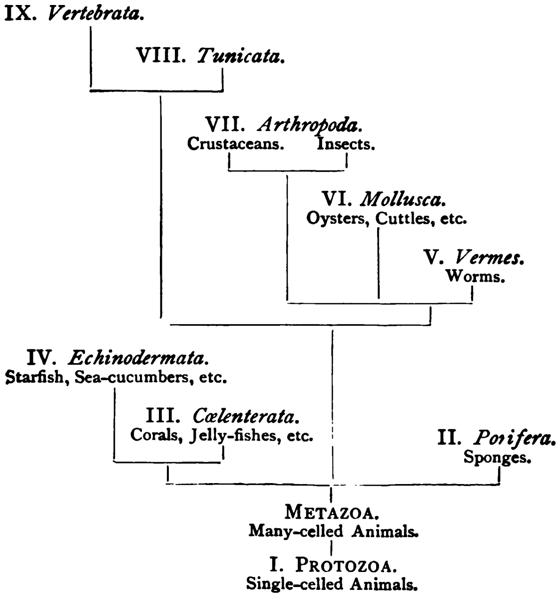
We know that a bird eats, moves, and breathes, and that its blood circulates; but plants also eat, respire through their leaves, have a circulation of sap, and some are endowed with locomotive powers. When we descend to the lower forms of animal and vegetable life, the points of similarity become almost identical; the swift-moving diatom so resembling some of the lowest animal forms that it is well-nigh impossible to distinguish between them. The plants, however, have no nervous system, no special organs of circulation or digestion that characterize the majority of animal forms, so that an animal differs mainly from a plant in possessing, as a rule, a nervous system and special organs of circulation and digestion.

Classification.—The animal kingdom, that is estimated to contain one fourth of a million species, is separated into two primary divisions: the *Protozoa*, or single-celled animals, and the *Metazoa*, or those composed of many cells. The latter are separated into eight branches: *Porifera*, *Cœlenterata*, *Echinodermata*, *Vermes*, *Mollusca*, *Arthropoda*, *Tunicata*, *Vertebrata*. These are in turn divided until the varied forms are grouped, like with like. This end is attained by comparison, and the result is termed classification. Thus the dog, as distinguished from a plant, is placed primarily in the animal *kingdom*. Possessing a backbone, it is placed in the *branch* of vertebrate animals. It differs from the fishes, reptiles, and birds, by giving milk; hence it is placed in the *class* of mammals. Continuing our comparisons, we find that, with the lions, tigers, and cats, it is a flesh-eater, and so is placed in the *order* carnivora. From its general appearance and form, it is associated with others in the *family* of dogs. With others that have a similar structure, it is given the *generic* name *canis*; then, to distinguish what kind of a dog it is, wild or domestic, it is given a *specific* or specifying name, as the common dog, *Canis domesticus.* Hence we have the following classification:

DOG.

Kingdom: of Animals.
Branch: Backboned, Vertebrates.
Class: Milk-givers, Mammalia.
Order: Flesh-eaters, Carnivora.
Family: Dogs, Canidæ.
Genus: Dog, Canis.
Species: *Canis domesticus.*
Variety: Newfoundland.

The present views of naturalists regarding the approximate relationships of the great branches may be represented by the following *provisional* table:



CHAPTER I.

FIRST BRANCH OF ANIMALS.

PROTOZOANS (*First Animals*).

General Characteristics.—The Protozoans are one-celled animals, in this differing from all others. The lowest forms resemble microscopic bits of the white of an egg. They have no definite shape, and move by a bulging out of the body-mass into root-like projections called *pseudopodia*, or false feet. In the interior are minute granules that move about (circulate), and in all, except the lowest protozoans, is seen a central oval body called the *nucleus*, and a hollow, transparent space, that contracts and enlarges with some regularity, called the "contractile vesicle." The higher forms have silicious or calcareous shells and permanent organs.

Class I.—MONERS.

These are shapeless bits of transparent matter (Fig. 1) containing merely circulating granules. By extending the body into pseudopodia, or false feet, and contracting them, they glide slowly along. Their prey is seized by surrounding it with the false feet, which fuse about it, and the victim is absorbed into the body-mass. They reproduce by simple division, or as in Fig. 1. The Moner assumes a thick covering (becomes encysted), *a*, divides into spheres, *b*, that burst out, *c*, *d*, *e*, and soon assume the parent form, *f*.

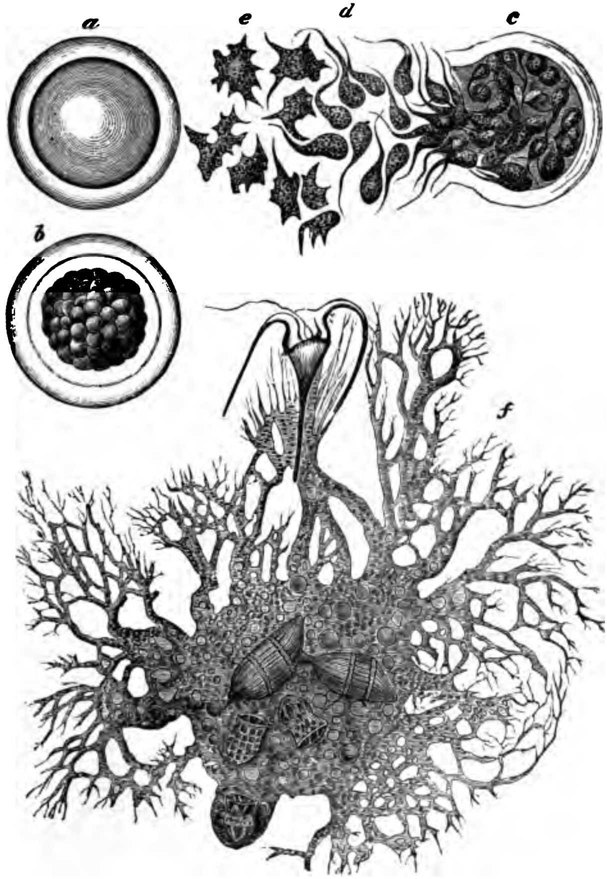


FIG. 1.—*Protomyxa aurantiaca.* *f*, eating; *a* and *b*, encysting; *c*, developing into monad-like young.

Class II.—RHIZOPODA (*Animals with Root-like Feet*).

General Characteristics.—Animals resembling the moners, but with a distinct outer and inner portion, the latter containing, as well as granules, several nuclei and contractile vesicles. They are either naked or shelled.

Order I. **Foraminifera** (*Hole-Bearers*).—In the simplest form, the *Amœba* (Fig. 2), the body is divided into a transparent outer covering, and an interior portion containing the nuclei, and circulating granules that appear to be kept in motion by the pulsation of the contracting vesicle. It moves along by throwing out *pseudopodia*, or false feet, and ingulfs its food—desmids, diatoms, and other minute forms—as does the moner. The *Amœba* reproduces by simple division.

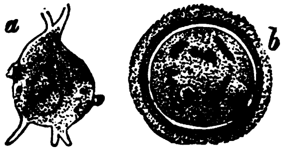


FIG. 2.—*a*, Amœba throwing out pseudopodia ; *b*, encysted.

Shelled Amœbæ.—These forms (Fig. 3) secrete rich calcareous or horny chambered shells, from which are thrown out the false feet, extending in every direction in search of prey, and fusing about it without the shell. They are generally minute, but one found off Borneo measures two inches across. They reproduce in different ways ; in one, the young resemble monads (Fig. 6), finally assuming the parent form.

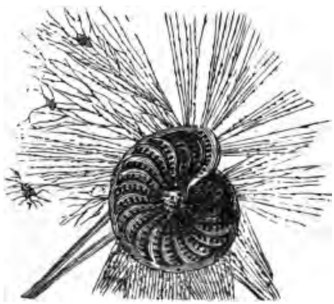


FIG. 3.—Rotalia, with extended pseudopodia.

Order II. **Radiolaria** (*Rayed Animals*).—In these animals (Fig. 4) the false feet are generally pointed, and the shells, which are formed of silica, not lime, are richly ornamented with spicules, or rays, and perforated with openings for the pseudopodia, that secure their food, as we have seen in the *Foraminifera*. They reproduce by division within the shell, the young at first resembling little oval bodies, with hair-like tails.

VALUE.—The shells of the marine forms fall in a shower upon the bottom, and form chalk-beds, as the Dover cliffs, in England, thus adding to the land of the globe. The stone of the Pyramids is made up of fossil Foraminifera.

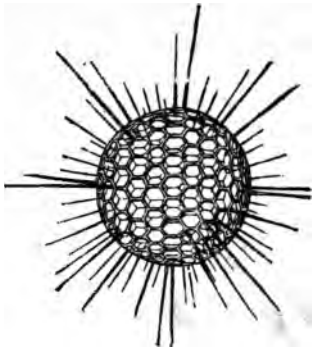


FIG. 4.—Flint-shelled Radiolarian (*Heliosphæra*).

Specimens for Study.—The *Amœbæ* can be found on leaves in fresh-water ponds. *Foraminifera* can be caught with a fine net in the ocean, or found in pools at low tide. The shells can be ground and mounted for the microscope.

Class III.—GREGARINIDA.

General Characteristics.—These (Fig. 5) are minute forms that take up their abode in lobsters, crabs, beetles, cockroaches, worms, and other animals, and lead a parasitic life, existing upon the juices of the animals they inhabit. They resemble minute worms; one, found in the European lobster, half an inch in length, is called *Gregarina gigantea,* being the largest single-celled animal known. They undergo several curious changes before reaching mature growth.

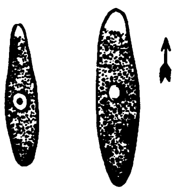


FIG. 5.—Gregarina of *Nemertes Gesseriensis*, showing nucleus and granules.

Class IV.—INFUSORIA.

General Characteristics.—Animals of permanent form with cilia, or hair-like organs, for locomotion and procuring food. They are either free or stalked.

Order I. **Flagellata** (*Monads*).—If standing water is examined with a microscope, it will be found fairly alive with numbers of minute pear- and oval-shaped creatures, having, at the place where the stem would be, a lash, that vibrates and whirls about as the animal moves along. One of the Monads, the *Noctiluca* (Fig. 6), a giant of its kind, lives in the ocean, and in appearance resembles a currant about the size of a small pin-head. On one side there is a groove, from which issues a single whip, or cilium, that is a locomotive organ, and near where this joins the body is the mouth. The outer surface of the animal is a firm membrane, beneath which is the jelly-like mass containing numerous granules, from which rises a regular network of fibers that lead over the entire body. The young are produced by a mere breaking off of a portion of the parent.

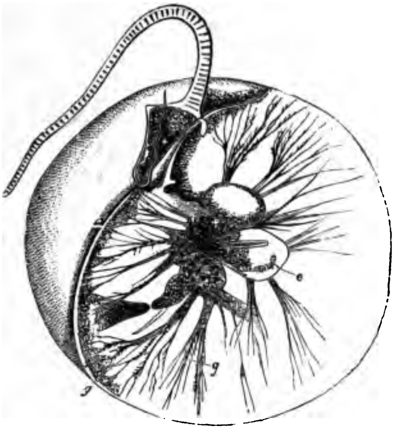


FIG. 6.—Giant monad *Noctiluca*. *e*, gastric vacuole ; *g*, radiating filaments.

NOTE.—As many as thirty thousand of these forms have been seen in the ocean in a cubic inch, moving about with great rapidity, and producing a most wonderful phosphorescent light.

Other monads are compound (several joined together), as the *Uvella*, while others are fixed, attached to the bottom by a slender stalk, as the *Codosiga*. Here the little hair-like organ is used to throw food into the mouth. Others of this order have their delicate forms protected by a hard shell, have one or several whips, or lashes, and a row of cilia, with which they lash themselves along with great velocity.

Order II. **Suctoria.**—This order is represented by the *Acinetæ* (Fig. 7), beautiful, trumpet-like animals resembling the purest glass. From the body project numerous slender tufts that are not cilia, but hollow tentacles (arms), having in some a sucker at their ends. Their prey is grasped by the arms, that contract, each at the same time sinking into the body of the victim, pumping or sucking out its juices. They multiply by self-division, while some species have free-swimming young.

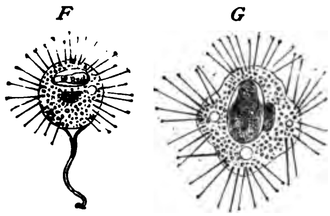


FIG. 7.—*Acinetæ*. *F*, attached by stalk; *G*, encysted.

Order III. **Ciliata.**—These are the true Infusorians, easily observed with a common microscope, a drop of standing water furnishing myriads. They are either free and covered with cilia, or stalked, with the cilia about the head. They have a mouth, a digestive cavity, or stomach, and multiply by self-division or budding. Among the free swimmers, the *Parameciums* (Fig. 8) are the giants, and easily observed if a little carmine is introduced into the drop. As they dart about, we see that they are oblong, narrowing at the head, the back rising into quite an elevation, beneath which, upon the under side, is the mouth. From the head and on all sides are minute prolongations of the body, or cilia, arranged in rows, organs of locomotion. The *Vorticellæ* (Fig. 9), or bell animalcules, are bell-shaped, and held by a long, slender, glass-like stalk, by which they contract. A colony of them presents a curious sight; the bells are continually contracting, as if jerked from behind, the stalk forming a perfect screw in the operation. They multiply by a simple division (Fig. 9, *c*) or by budding (*d*, *d*).

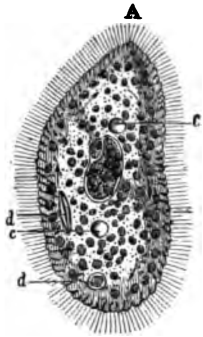


FIG. 8.—*Paramecium bursaria*, showing cilia. *c*, contractile vacuole; *d*, food.

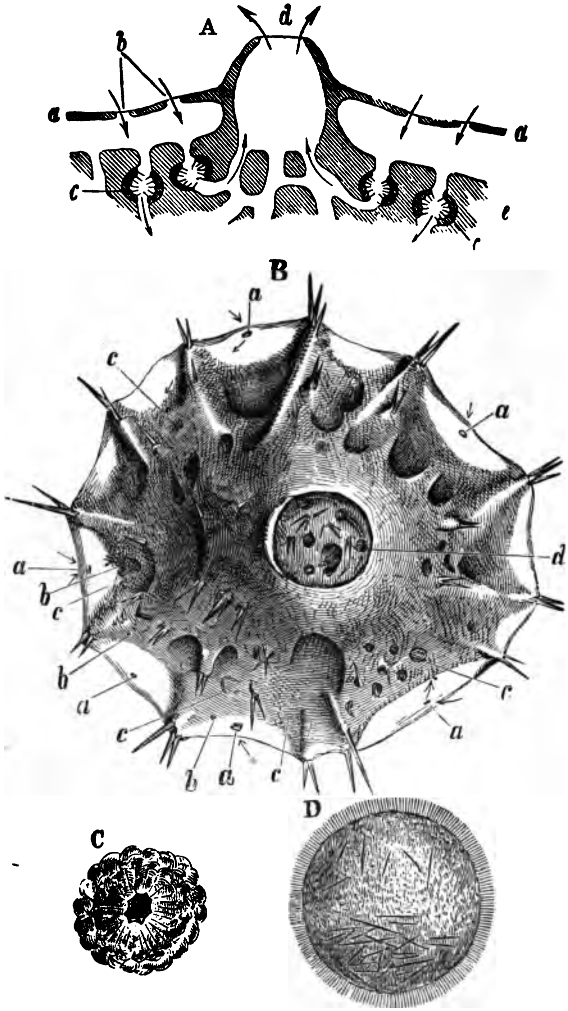
FIG. 9.—*Vorticellæ*. *a*, extended; *b*, coiled; *c*, division; *d*, *d*, free-swimming buds.

Works on Protozoans for further reference.

"The Atlantic, and Depths of the Sea," Sir Wyville Thomson; Carpenter on the Microscope; "Mind in Nature," H. J. Clark; Leidy's "Fresh-Water Rhizopods"; Pritchard's "Infusoria"; "Manual of Invertebrates," T. H. Huxley; "Challenger Reports"; "Evenings at the Microscope," Gosse; Thompson's "Monthly Microscopical Journal"; "The Quarterly Microscopical Journal"; Bastian's "Origin of Lowest Organisms, and Beginnings of Life"; "Notices of Protozoa," by Professor Leidy, in "Proceedings of Philadelphia Academy of Natural Sciences"; "Water turned to Blood by Red Infusoria," in "Popular Science Monthly," vol. iv, p. 202.

A marine sponge attached to the bottom.

PLATE II. A FRESH-WATER SPONGE.



A. Hypothetical section of a *Spongilla:* *a*, superficial layer; *b*, inhalent apertures; *c*, ciliated chambers; *d*, an exhalent aperture; *e*, deeper substance of the sponge. The arrows indicate the direction of the currents. B. A small *Spongilla* with a single exhalent aperture, seen from above: *a*, inhalent apertures; *b c*, ciliated chambers; *d*, exhalent aperture. C. A ciliated chamber. D. A free-swimming ciliated embryo.

CHAPTER II.

SECOND BRANCH OF ANIMALS.

SPONGES (*Porifera*, pore-bearing).

General Characteristics.—The sponges were for many years considered plants, but now they are known to be many-celled animals. In the *Ascetta* (Fig. 11), we have a vase-shaped cylinder, *I*, composed of cells arranged in three layers. In the second or middle layer is developed a network of delicate objects of lime, called spicules (Fig. 11), that form the skeleton, and support the cellular, jelly-like mass. The walls of the vase are everywhere perforated with pores, *p*, through which water passes, carrying food. The cells of the inner layer are provided with a cilium, or lash, *III*, and, taken individually, resemble monads. As food floats by, each cilium throws he minute bits against its cell; the soft portion is absorbed, the harder parts being rejected, and, wafted along by the cilia, find egress at the single large opening, *O*. In this

FIG. 10.—Spicules of flint-sponges, highly magnified.

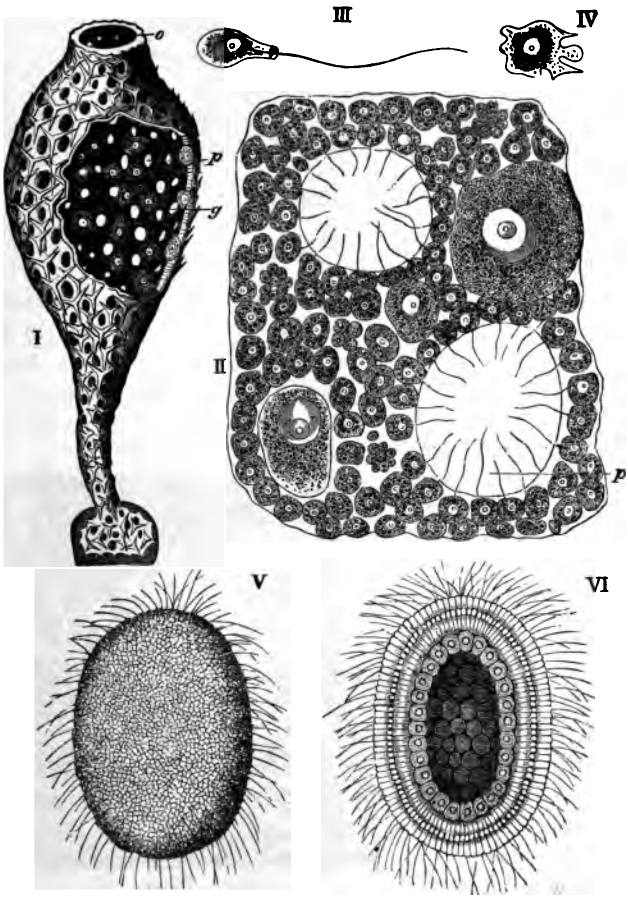


FIG. 11.—*Ascetta primordialis.* I. *o*, exhalent opening; *p*, inhalent pores; *g*, ova. Star-like spicules are seen on the outside. II. Section showing pores (*p*), with cilia of the cells extending into them. III. Cell showing lash, or cilium. IV. Same, with lash retracted. V. Embryo of *Ascetta mirabilis.* VI. Section of embryo.

way the *Ascetta* feeds. Other sponges differ from it in having a shapeless form, many large outlets instead of one, and numerous sacs lined with ciliated cells.

Development.—The young are at first free swimmers, being produced from eggs, escaping into the water as oblong little creatures, with numerous cilia, *V.* They soon become attached to the bottom, spicules appear, and they gradually assume the parent form.

FIG. 12.—Skeleton of *Euplectella speciosa.*

Order I. **Lime-Sponges** (*Calcispongiæ*). — In these, the spicules are made of lime, and the canals lined with ciliated cells. They are few in number, and may be represented by the little white sponge, *Sycon ciliatum*, and *Ascetta primordialis* (Fig. 11).

Order II. **Carneospongiæ.** — The spicules of these forms are either fibrous and horny, or silicious, and the ciliated cells are only found in little cavities, or stomachs. To this order belong a host of beautiful forms: the common sponges of commerce, the fresh-water *Spongilla*, the wondrous *Holtenia*, and the *Euplectella*, or Venus's flower-basket (Fig. 12).

Value of Sponges.—There are six species of sponges valued in commerce; three are found in America, in Key West and the Bahamas, the others coming from the Mediterranean and Red Seas. Nearly all the flints are the remains of ancient sponges.

Specimens for Study.—Sponges are difficult to keep in the aquarium. In our Northern fresh-water ponds, the *Siphydora* is common, and, in streams, the *Spongilla*, while various kinds can be found along the coast. In default of living specimens, the common toilet-sponge should be used, and sections made with a razor for examination under the microscope.

Works on Sponges for further reference.

"The Glass Sponges," by Rev. Samuel Lockwood, in "Popular Science Monthly," vol. iii, p. 529; "The Common Fresh-Water Sponge, *Spongilla*," by Professor W. C. Williamson, in "Popular Science Review," January, 1868; "North American Poriferæ," by A. Hyatt, in "Memoirs of Boston Society of Natural History"; "Life Histories of Animals," by A. S. Packard, Jr.; "The Atlantic, and Depths of the Sea," Sir Wyville Thomson.

A Syrian sponger.

CHAPTER III.

THIRD BRANCH OF ANIMALS.

HYDROIDS, ETC. (*Cœlenterata*, hollow intestine).

General Characteristics.—A simple sac, as the Hydra, composed of two-cell layers, possessing a stomach, or digestive cavity. The mouth is encircled by tentacles, which are hollow, and connect with the stomach.

Class I.—HYDROZOA.

Order I. **Hydroids.**—One of the commonest animals of the aquarium, if the water is taken from the brook or stream, is the *Hydra* (Fig. 13)—a simple, elongated stomach one quarter of an inch in length, ending in a mouth that is surrounded by from five to eight tentacles that are extensions of the body, hollow, and connecting with it. If examined closely, myriads of small cells will be seen, many of which contain delicate threads or darts, called lassoes, that are thrown out as weapons of defense (Fig. 14). By cutting a Hydra

FIG. 13.—Fresh-water *Hydra viridis*. 1. Long-armed Hydra feeding on small animals, *a*. 2. *Hydra fusca* throwing off young Hydra-buds.

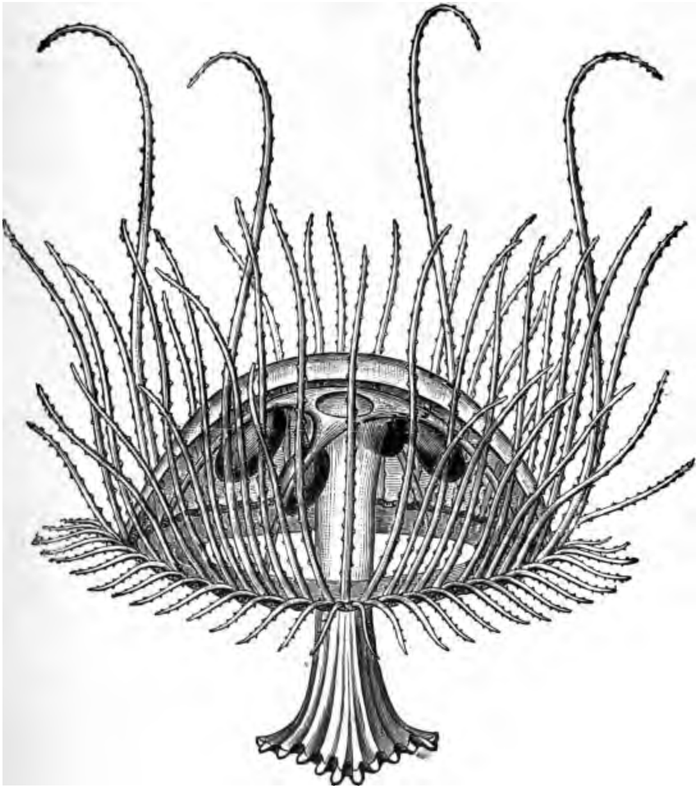
into sections, each will soon produce a crown of tentacles, and grow into a perfect animal. The Hydra can be turned inside out, and within an hour recover its natural

FIG. 14.—Lasso-cells of Hydra. 1. Arm of Hydra, containing cells. 2. Cell magnified. 3. Cell after bursting open.

position; more marvelous yet, if when so treated it is spitted with a pin or needle so that it can not turn, it will eat and reproduce its kind as if nothing had occurred. Some are solitary, while others live in colonies. They reproduce by budding (Fig. 13, *b*, *b*) and by eggs.

Lime-secreting Hydroids (*Millepora*).—Some of the Hydroids secrete lime. They resemble true corals in appearance, and were long considered as such. Under the microscope, it will be seen that the lime secreted is tunneled by numerous canals which in life are filled by the animal. The polyps are of two kinds, and, in a millepore found at Tahiti, they are in groups, the largest being stout polyps, with four tentacles, a stomach, and mouth; but the polyps about it, rising from the smaller pores, have no mouth or stomach, but many tentacles, whose duty is to capture food for the short, thick-set polyp between them. Some of the Hydroids, instead of bearing young like themselves, produce perfect jelly-fishes (*Medusæ*); such is the Campanularia (Fig. 15), that throws off, by budding, a free jelly-fish (3), that in turn produces eggs that become, not jelly-fishes, but fixed Hydroids (1). This is called alternate generations. The free-swimming young are often brilliantly luminous, presenting a wondrous appearance on dark nights.

Plumularia, greatly enlarged.



Limnocodium sorbii, a fresh-water jelly-fish, one third of an inch in diameter; produced from a hydroid. (See *Proc. Roy. Soc.*, Dec. 11, 1884.)

The *Monocaulus* is a gigantic Hydroid, seven feet high, and nine inches across the expanded tentacles, living in the Atlantic at a depth of four miles below the surface. Many of the so-called mosses that are common on the shore, and are pressed as sea-weed, are in reality compound Hydroids enclosed in horny cells, as the *Plumularia*.

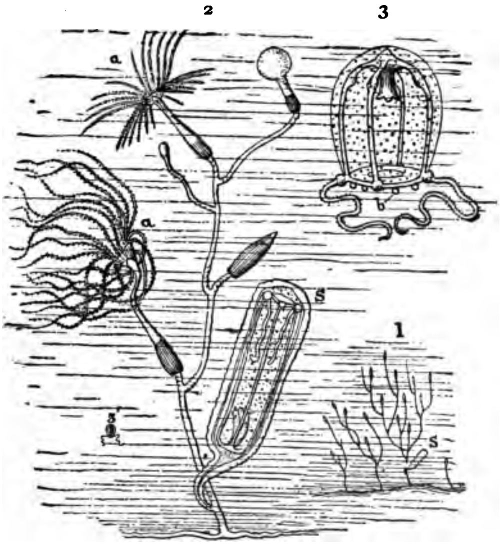


FIG. 15.—Campanularia. 1. Natural size. 2. Animal magnified: *S*, sac containing jelly-bell; *a a*, animal feeding. 3. Free-swimming young, magnified. 3′, natural size of jelly-bell.

Order II. **Discophora.**—We now come to jelly-fishes that are developed directly from eggs, as *Pelagia campanella*, or, as in *Aurelia*, produced from a Hydra form (Fig. 17, 1). They vary in size, from the little *Lucernaria* that attaches itself to weeds by a sucking disk, to the gigantic *Cyanea*, that is from two to seven feet in diameter, with tentacles over one hundred feet in length.

These jellies are disk-shaped, the tentacles in *Cyanea* hanging in eight distinct bunches from the margin, and armed with darts or lasso-cells, that form terrible

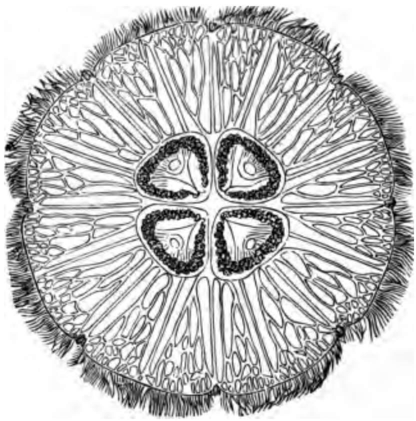


FIG. 16.—Adult Aurelia, showing the water-vascular canals.

weapons of defense. Around the fringed margin are eight protected eyes. The mouth-opening is square, leading into a large stomach, from which radiate four branching tubes (Fig. 16) called water-vascular canals. They form a network at the edge, and connect with a tube that encircles the margin of the disk. Through these branches digested food and water circulates, or finds its way over the body. A somewhat similar arrangement is found in all jelly-fishes. In swimming, the disk contracts and expands in regular time, averaging twelve or fifteen times a minute.

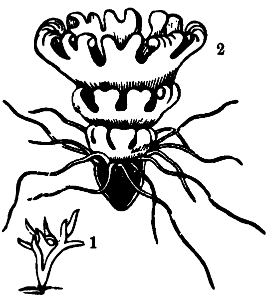


FIG. 17.—Development of Aurelia. 1. Early stage. 2. Jelly-fish ready to break off.

NOTE.—In specimens of Aurelia, 95.84 per cent of the animal is water; the solid matter in any jelly-fish is rarely over five per cent of the whole.

Fresh-Water Jelly-Fishes.—These have recently been discovered in England. They are one third of an

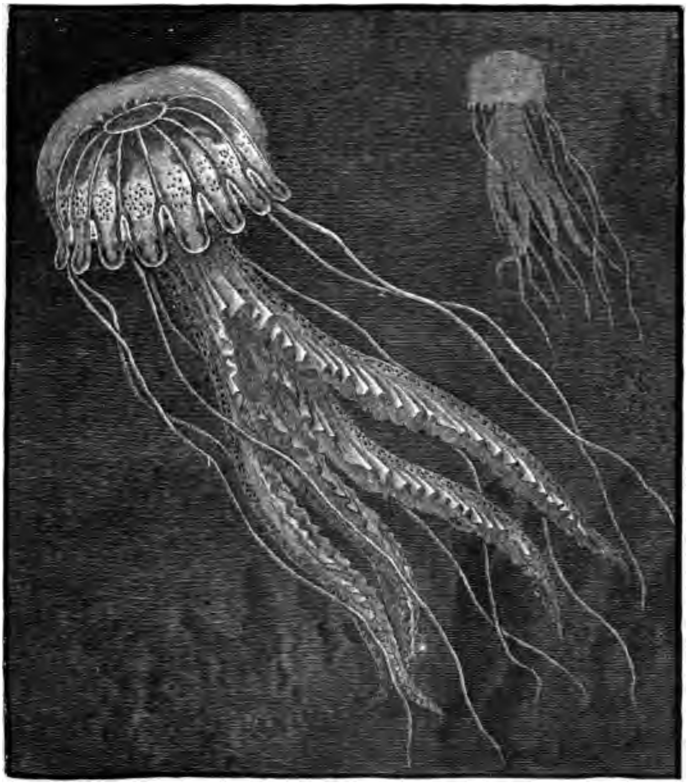


FIG. 18.—A jelly-fish swimming (*Pelagia*).

inch in diameter, and probably come from some warm climate, as they are active only when the temperature of the water is about 85°.

Development of Discophoræ.—They multiply by eggs that are deposited in the autumn, and are at first spherical, quickly changing to a pear-shape, and attaching themselves to rocks or weed. Now, tentacles appear (Fig. 17, 1), varying in number from eight to twenty-four, and after eighteen months the pear divides off into disks until we have a pile of scalloped saucers one upon another (2). The highest one dies, while all the rest break off and swim away, little jelly-fishes, that in time grow into the gigantic *Cyanea* or others, as the case may be.

FIG. 19.—Portuguese man-o'-war, *Physalia Arethusa.*

VALUE.—They form the food of some whales and fishes.

NOTE.—The gigantic *Cyanea* affords a home under its curtains for numbers of fishes and several crustaceans, while in its mouth-folds lives a long, tapering sea-anemone (*Bicidium parasiticum*), that in many cases mimics in color that of its protector.

Order III. **Siphonophora.**—These are the most beautiful of the Hydroids, and are rarely seen in the North. They are free-swimming colonies. The Portuguese man-o'-war, or *Physalia* (Fig. 19), is a mere bubble, seemingly of the finest satin, that floats upon the surface. From the upper portion rises at will a fluted membrane, colored with delicate tints of pink, that is used as a sail; from the lower portion extends a mass of tentacles of the richest blue, and, from their armament of lasso-cells, of the most dangerous character. They are called Zoöids, and are of four kinds. Some aid in locomotion, some are reproductive, while others are feeders for the entire colony. The tentacles are dragged from twenty to one hundred feet or more behind. The beautiful filaments form tempting baits when lowered, and in this way the Physalia feeds. The man-o'-war generally has several tenders, little fishes of the family *Scombridæ*, of the exact color of the death-dealing tentacles, that live under and among them, a wonderful case of mimicry.*

Allied to the Physalia are the *Porpita* and *Velella.* The latter also floats upon the surface, a raft bearing a silvery sail, while beneath is the same rich coloring of the *Physalia.*

Works on Hydroids for further reference.

"Acalephs (Jelly-Fishes) of North America, with Pictures of most of the Species in Catalogue of Museum of Comparative Zoölogy," by A. Agassiz; L. Agassiz, "Contributions to the Natural History of the United States," vol. iv; "Sea-side Studies in Natural History," Agassiz; "Sertularian Zoöphytes of the Coast of England," T. Hincks; "Popular Science Review," 1878, p. 223; Huxley's "Manual of Invertebrates"; "Challenger Reports."

Class II.—Sea-Anemones and Coral Polyps (*Actinozoa*).

Order I. **Actinaria.**—These are well represented by the sea-anemone, or Actinia (Fig. 20). In appearance

* The author once swam over the tentacles of a Physalia with an almost fatal result; the blue marks were plainly visible six or eight months after. These fishes not only mimic the color of the tentacles, but assume vertical positions, so that they seem actually a part of them. I have often lifted the man-o'-war, which can be safely done by the "sail," and the fishes that were previously unnoticed would dart about in the greatest alarm. A more remarkable case of protective mimicry is not known.

they resemble cylinders attached to the bottom, the opposite end containing the mouth, which is surrounded by numbers of hollow tentacles, armed with lasso-cells (Fig. 21), while near the base of the tentacles are the minute

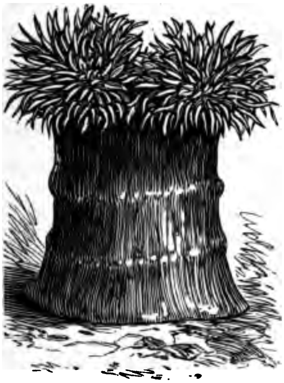


FIG. 20.—Anemone with tentacles expanded, attached by sucking disc to the bottom.

FIG. 21.—Lasso-cell of an anemone.

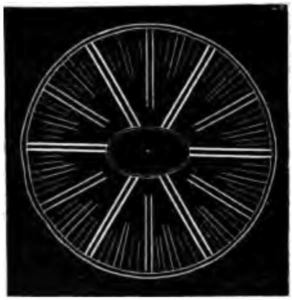


FIG. 22.—Cross-section of anemone, showing septa.

eye-spots. If a dead anemone that has become somewhat hardened is cut open horizontally, we first notice the stomach, that, divided into mouth and stomach proper, seems suspended in the body, held in place by six partitions (*Mesenteries*) (Fig. 22), that also divide the body cavity into as many distinct chambers. Each of the six principal partitions is perforated with an opening, and the chambers connect with the tentacles, so that water, and food captured by the tentacles, is taken in at the mouth, and penetrates, by the opening at the bottom of the stomach, to every part of the animal.

The anemones vary greatly in size, from delicate unattached forms that live up among the folds of the great jelly-fish *Cyanea* to enormous ones two feet across. The

Cerianthus of the Philippine Islands, with its thread-cells, builds a sheath or leathery tube one foot four inches in length, that is sunk into the mud.

Development.—Anemones multiply by budding, or, if pieces of the disk are cut or torn off, they will grow into anemones. They also deposit eggs, the young being at first free swimmers, by means of cilia, finally becoming fixed upon the bottom, and assuming the adult form.

NOTE.—In their habits they are remarkable. One observed by Dr. Collingwood in the China Sea was two feet in diameter, giving shelter in its stomach to a little fish, that, when danger approached, rushed into its protector, whose tentacles closed up like a door. A fish, known as *Premnas biaculeatus*, also lives within the stomach of the anemone, *Actinia crassicornis*. Some live a roving life, like the Adamsia, that is often found upon the back of the hermit-crab, that, upon leaving its shell, obliges its friend, the anemone, to change also. The *Urticina* is luminous.

VALUE.—The anemones are great purifiers, and are eaten in various parts of the world.

Coral-making Polyps.—The coral animal may be considered an anemone that has the power of secreting lime. In the star-coral (*Astrea*), the young is seen at the end of June—a little oblong-shaped body, swimming about by its cilia, or oars. It soon attaches itself to the bottom, and, if in a few days it should be removed, there would be found a little platform with radiating partitions of lime alternating with the soft ones that we have seen in the anemone. If allowed to grow, tentacles soon appear; other small partitions are now secreted, that extend to the outer wall, which is also being secreted; and, finally, we have a coral polyp, from which others branch, until large blocks are formed of many individuals, but all connected. So it will be seen that the polyp is not an insect, neither does it erect or build its house any more than a man builds his skeleton, but is a lime-secreting animal, pure and simple.

The corals that we are familiar with have been bleached, but when taken from the water they are of various shades of olive and brown.

Single-Polyp Corals.—The *Fungia*, or Mushroom-Coral, often attains a length of twelve inches, and is a single polyp, in which the radiating septa are plainly seen. They are the commonest forms of the greater depths; ten genera live in water a mile deep, four at nearly two miles, while the *Fungia symmetrica* has been found in from one hundred and eighty feet to three and a half miles of water. The *Caryophyllia* is a common form in the Mediterranean. Some are luminous.

Branch-Coral (*Madreporidæ*).—The Branch or Tree Coral of Florida (Fig. 23) is a familiar example, and the

FIG. 23.—Madrepore. Dead and living branch.

sides of deep channels in the reef bristle with it, the coral growing in perpendicular walls and covering the reef in vast patches, affording protection to myriads of animals. The Leaf-Coral spreads out in great leaves several feet in width. The Branch-Corals grow seven or eight inches a year, contrary to general belief.

Porites.—These polyps are extremely minute, having twelve short tentacles, and form large oval heads, weighing many thousand pounds. Many die in the center, and become hollowed out like gigantic vases, and are penetrated with worms, that, when expanded, resemble flowers

Brain-Corals (*Meandrina*).*—These corals form in great heads twelve to fifteen feet in diameter. The polyps are arranged in trenches resembling the convolutions of the brain. They grow rapidly. Fig. 24 shows a head of *Meandrina convexa* that doubled its diameter in a year, or grew at the rate of one inch a year under unfavorable

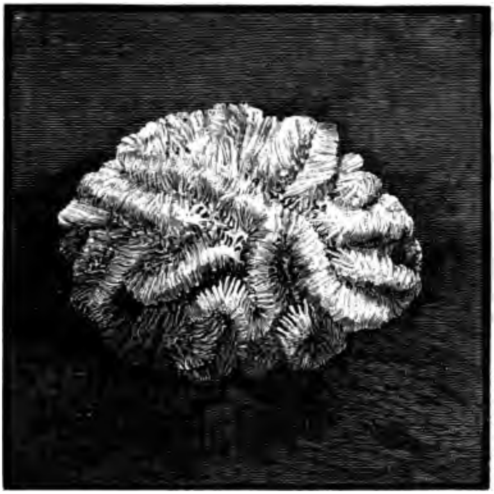


FIG. 24.—*Meandrina convexa*, Tortugas, Florida, growth of which was watched by Dr. J. B. Holder.

circumstances, being kept by the author in an aquarium, or inclosure, of dead-coral rock, through which the tide rose and fell.

Star-Corals (*Astrea*).—In the Astreas the polyps are very large, some having a diameter of two inches, almost as large as some anemones. The tentacles are of various shades—green, purple, gray, and blue tints. They attain a weight of several tons.

* *Meandrina spongiosa*, common on the Florida reef, floats upon the surface when deprived of the animal matter, and is known as floating coral.

Northern Coral (*Astrangia*).—This beautiful coral may be found in Long Island Sound, near New Haven, and on the New Jersey shore. The polyps are pure white,

FIG. 25.—*Astræa palliäa* (living).

standing high above the cells. The tentacles are covered with lasso-cells, each about $\frac{5}{1000}$ of an inch in length. It thrives well in the aquarium.

Coral Reefs.—These are banks or shoals of dead or living coral at or below the surface. The tops of submerged hills and elevations gradually approach the surface by the accumulation of organic matter, principally from the continuous falling* of shells of *Rhizopoda* and *Foraminifera* (Fig. 3), and other forms, until finally a platform of limestone is built that reaches within forty or fifty yards of the surface. Now, the reef-making corals, Madrepores, etc., that do not flourish in deeper water, become fixed, grow, and accumulate, with Gorgonias and other forms, until they reach the surface. Seeds, perhaps of the mangrove, now obtain a footing, and the reef in time becomes a coral key or island.

* It has been estimated by Murray that, if lime-secreting organisms are as numerous down to a depth of six hundred feet as they are near the surface, there would be more than sixteen tons of calcareous shells or carbonate of lime in the uppermost one hundred fathoms of every square mile of the ocean.

Barrier Reefs.—This name is given to reefs formed as above, but distant from the shore, and separated from it by deep water, as the reef, one thousand miles long and thirty miles from shore, on the Australian coast.

Fringing Reefs.—These are formed near the shore, generally in smooth water, having no great depth between them and the adjacent land.

Atolls.—When a reef reaches the surface, the waves from the side of the prevailing winds grind up the dead

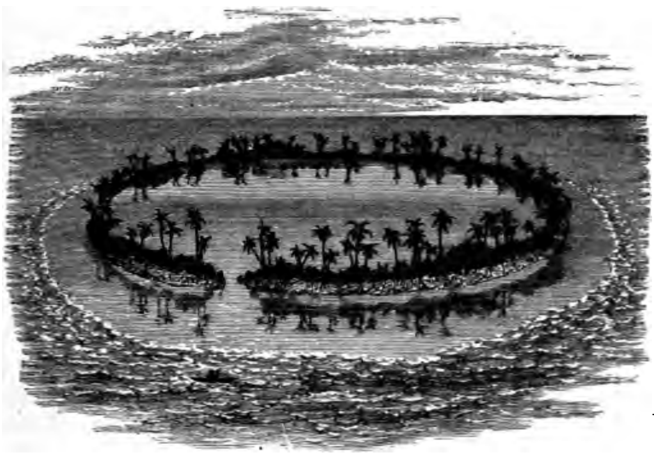


FIG. 26.—Atoll in the Pacific Ocean.

coral, and wash it over in the form of mud and sand, where it settles in smooth water. Here branching corals, that give shelter to innumerable animals, flourish, as well as lime-secreting algæ,* all continually growing and being ground up by fishes and worms, and disintegrated by the solvent action of the carbonic acid in the water, until finally a shallow lagoon or flat is formed, wholly or partly

* This is one of the most important factors of lagoon and key making. The keys of Tortugas, especially Sand Key, are made up almost entirely of these limy plates, as well as broken shells.

surrounded by the reef (Fig. 26), and cut up by currents into deep channels. Such is the atoll forming at Tortugas, Florida, where the lagoon is fast filling up, and will eventually become dry land. The shape of atolls is due to the foundation upon which they are formed, currents, winds, and the sinking or elevation of the crust.

NOTE.—An important factor in mud-making is the Holothurian. Those at St. Solomon Islands have been found to eject two fifths of a pound of mud a day, so that sixteen animals would grind up a ton a year; and as in some places the bottom is fairly covered with them, the amount of work of this kind done by a single animal can be imagined.

Works on Actinozoans for further reference.

Dana's "Corals and Coral Islands"; "Our Sea-Anemones," by A. E. Verrill; "American Naturalist," vol. ii, p. 251; "Sea-Anemones," "Popular Science Monthly," vol. vii, p. 1; "Arachnactis Brachiolata, a Floating Actinia," A. Agassiz, "Boston Journal of Natural History," vol. vii, p. 525; "Animal Life," Semper; "Sea-Side Studies," Agassiz; "Smithsonian Reports"; "Challenger Reports"; "The Atlantic, and Depths of the Sea," Sir Wyville Thomson; Darwin's "Structure of Coral Reefs"; "Fauna Americana," J. B. Holder; "Transactions American Academy," vol. xi, 1883, Agassiz; "Proceedings of Royal Society of Edinburgh, 1879–'80," Murray.

VALUE OF STONY CORALS.—The stony corals form islands. The fossil coral, *Favosites*, is polished and much used in jewelry. Fossil coral found in Cuba is much used in building. Calcined coral is used as a dentifrice and as an antacid.

Order II. **Alcyonarians.**—The animals that secrete a horny or calcareous stock without true dividing partitions or septa, are called *Alcyonarians*. Such are the sea-fans (Gorgonias), yellow, lilac, and black, sea-pens, the red coral of commerce, and many others.

Red Coral.—In the red coral, *Corallium rubrum* (Fig. 27), the axis *p* is calcareous, and composed of fused spicules, varying in color. When alive, the polyps, II, B, B, which are pure white, are connected by a series of complicated tubes, *f*. The tentacles are eight in number, and when spread out are extremely beautiful. The young are at first free swimming (III and IV). Another curious form is the organ-pipe coral, formed of upright tubes.

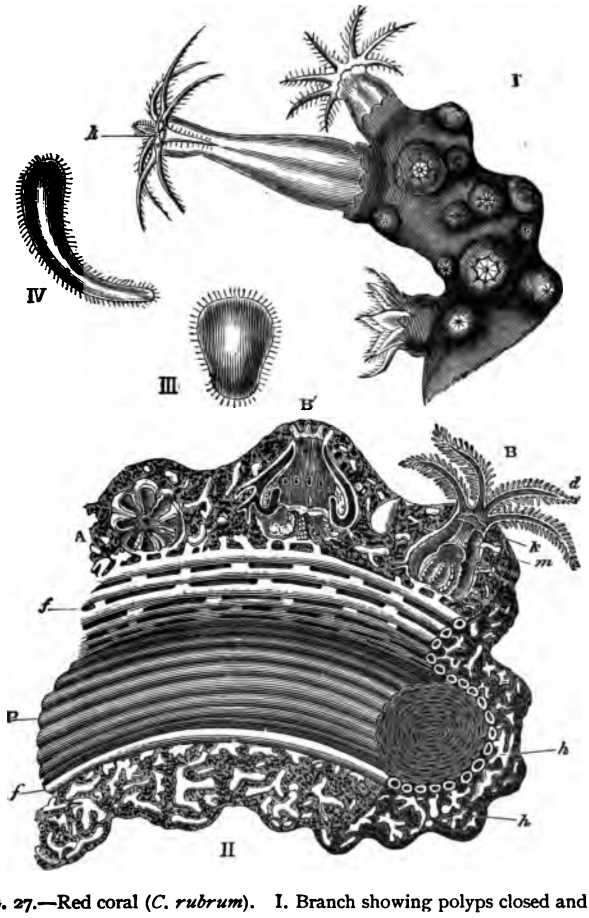


FIG. 27.—Red coral (*C. rubrum*). I. Branch showing polyps closed and expanded: *k*, mouth. II. Section of branch: *k*, mouth; *m*, stomach; *f*, canals; *h*, irregular canals; *P*, hard axis. III and IV. Free-swimming embryo, showing the cilia, or oars.

VALUE.—Eighty thousand pounds have been collected in one year. In 1873 Algeria alone employed 311 vessels and 3,150 men, realizing $565,000. The entire yearly collection is valued at over $1,000,000.

Sea-Fans (*Gorgonias*).—The Gorgonias (Fig. 28) grow in the shape of fans or plumes, branching like trees and shrubs. The stock secreted is either horny or calcareous. Those of the Florida reef are often three feet high and two wide, while the *Primnoa*, found on the Banks of New-

FIG. 28.—Sea-fan.

foundland, grows to a height of over five feet, the branches or stem being as thick as a boy's arm. Their surfaces are network, through which are delicate canals connecting the animals. On the *Gorgonia flabellum* lives a shell of the same color—a curious case of mimicry.

VALUE.—They are made into whips, canes, etc.

Sea-Pens (*Pennatulidæ*).—The sea-pens are fixed or free-swimming polyps. A gigantic one (*Umbellularia*), four feet high, lives in the Arctic regions, a mile and a half from the surface; another, ten inches long (*Veretil-*

lum), is found off the coast of Spain, and noted, as are all the Alcyonarians, for its luminous properties.*

Class III.—COMB-BEARERS (*Ctenophora*).

These are jelly-like animals, having, as organs of locomotion, vertical rows of comb-like paddles, that move up and down in exact measure as they travel along, glistening with rainbow-like hues. So vast are their numbers that in the North they often color the sea. They are not only iridescent but luminous, their very eggs and embryos giving out light. The *Bolina*, *Beroë*, *Idyia*, *Cestum*, and *Pleurobrachia* (Fig. 29), are all common on our New England shores. The eggs are deposited singly, as in *Pleurobrachia*, or in strings, as in *Bolina*, in the autumn or last of summer, the young passing through no changes, and resembling the parent as soon as hatched.

FIG. 29.—*Pleurobrachia*.

Specimens for Study.—The Hydra can be found in any pond during the summer months, and the salt-water forms from old piles and rocks along the shore. Jelly-fish can be preserved in alcohol by grad-

* All the Alcyonarians dredged by the Challenger were wonderfully luminous, and the bottom of the sea is undoubtedly lighted to a more or less degree in this way. Great patches of light have been seen sixty feet below the surface, while the small forms in shoaler water vie with those of the greater depths. Professor Moseley examined the light of three Alcyonarians with the spectroscope, and found it to consist of red, yellow, and green rays only. A glass containing numbers of the *Veretillum* has given out light sufficient to read by, and was distinguishable for some distance.

ually adding it to the water they are in. Small jellies should be treated to a weak solution of osmic acid, one tenth per cent water; this hardens their tissues. To prevent animals from closing up, kill in chromic acid (one and one half per cent), and place in alcohol. Living coral (*Astrangia*) can be dredged in Long Island Sound. Specimens can be hardened for sectional examination in osmic acid.

A ship sailing at night through phosphorescent animals, as noctiluca (Fig. 6), jelly-fishes, ascidians, etc.

CHAPTER IV.

FOURTH BRANCH OF ANIMALS.

STAR-FISHES, SEA-URCHINS, ETC. (*Echinodermata*).

General Characteristics.—Marine radiate animals, having a calcareous skeleton made up of many plates. They possess a nervous system, and are distinguished, especially from the former groups, in having a tube-like digestive canal, distinct and separate from the cavity of the body.

Skeleton.—By making a vertical section of the common star-fish (Fig. 30), we find that the skeleton is made up

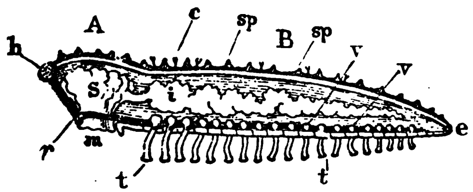


FIG. 30.—Section of one ray of star-fish. *A*, central body; *S*, stomach; *m*, mouth; *h*, madreporic plate; *r*, ring about the mouth; *B*, ray; *sp*, spines set in leathery coat; *c*, pedicellariæ; *e*, eye; *t*, *t*, tubular feet; *v*, *v*, vesicles for supplying feet with water; *i*, liver.

of calcareous plates, connected by a leathery integument, and covered by the skin, having spaces between them to allow the ingress of water. The plates increase by additions to their edges; thus their shape is preserved. The spines, or defensive organs, *sp* (Fig. 30), work on a ball-and-socket plan, and among them occur worm-like appendages called *pedicellariæ*, *c*, having two calcareous jaws. Between the arms, on the upper surface, is a hard, flat, pinkish body, perforated with holes, called "the madreporic plate," *h*. The under surface of the rays is channeled, the plates being pierced with four rows of minute holes.

Internal Organs.—The mouth, *m*, is on the under surface, and leads into the stomach, *s*, which is seen extending into the rays, ending in a short intestine, to which is attached the green, branching liver, *i*. About the mouth extends a ring, that throws off a delicate nerve to the eye, *e*, at the tip of each ray; other cords also extend to each sucker, *t t*, this constituting the *nervous system*.

Circulation.—There is a system of blood-vessels, but

FIG. 31.—*Pentacrinus caput medusæ.*

what is called the water-vascular system is most important, aiding in both locomotion and respiration. Water is taken in at the sieve-like madreporic plate *h*, flows down a tube, called the "stone canal," into the circular canal, *r*, that encircles the mouth; here it flows into tubes that branch into each ray, then into numerous sacs, or ampullæ, *v v*, that have long extensions provided with suckers. By the contraction of the sacs, water fills the extensions that penetrate the four rows of holes, and they appear as feet, suckers, or locomotive organs, *t t*.

Class I.—Crinoids (*Lily-form*).

Eight living genera of these forms are known. One of the most beautiful, the *Pentacrinus*, is found in deep water off the West India Islands. They may be described as inverted star-fishes growing on stems. Some are always fastened to the bottom (Fig. 31), while others break off when attaining a mature growth and lead a wandering life, as the *Antedon*. In the *Pentacrinus* the stem is about a foot long, resembling pentagonal buttons piled one upon another, sending off at intervals short whorls of branches that are jointed in a similar way. The stem is rooted in the mud, while the animal is cup-shaped, presenting the appearance of a bunch of rich, waving plumes. These are the arms, arranged about the mouth, closing over it, or spreading out at will. The Crinoid (*Antedon*) is found in the Gulf of Maine. They multiply by eggs, that pass through several complex changes before assuming the parent form.

Fig. 32.—Sand-star.

Class II.—STAR-FISHES (*Asteroidea*).

The star-fishes assume the most varied and curious shapes. In Sand-stars (Fig. 32), the body is a mere flattened disk, the arms branching out suddenly, often round and snake-like, while the feet have no suckers, and appear from the sides of the rays instead of the bottom. The *Ophiacantha spinulosa* is not merely a star in shape, but is highly luminous. Some, as the *Ophiothela*, divide themselves spontaneously, the body looking as if it had been chopped in two; the two halves become separate individuals, new arms growing from the severed parts. In one of the brittle stars, known as the basket-fish, the arms are divided into many branches of twos—bifurcating, as it is called—and resemble, when coiled, a ball of snakes. They live in the coral reefs of the South, and are often found off the New England coast.

Development.—The young are produced from eggs, some, as *Ophiocoma vivipara*, appearing at once in adult form,

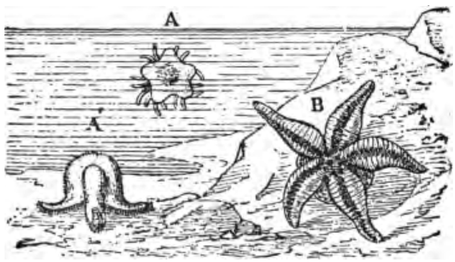


FIG. 33.—Development of common star-fish. A, free-swimming form; A', later stage settling on the bottom; B, same assuming star-shape.

while others (Fig. 33) are at first minute sacs swimming by aid of cilia, undergoing many changes, finally in two or three years assuming the adult shape. The common star-fish (Fig. 34) preys upon the oyster.

FIG. 34.—The star-fish at home (*Asterias Forbsii*), showing upper and under sides.

NOTE.—Not all star-fishes have five rays. The *Brisinga* has from nine to twenty, the *Solaster*, found on the New England coast, eleven; while others have thirteen or fourteen. The great star-fish *Asterias discoida* is often inhabited by a living fish (*Oxybeles lumbricoides*).

Class III.—Sea-Urchins (*Echinoidea*).

General Characteristics.—The egg-shaped skeleton (Fig. 35) is made up of about six hundred hard, six-sided plates in double rows, containing perhaps 3,720 pores for the emission of the tube-like feet. The star-fish is a sucker, but the Echinus a biter, having five long calcareous teeth that meet at a point, *m* (Fig. 35), and are renewed as they wear away. They are moved by a complicated system of muscles, and held in place by a leathery skin. The body is covered with about 4,000 spines, each of which is made up of hollow tubes, and works on a ball-and-socket plan, *s*.

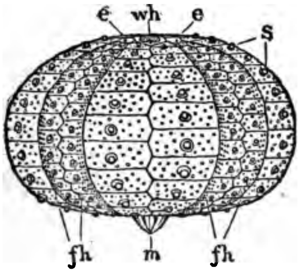


FIG. 35.—Skeleton of sea-urchin without spines. *m*, mouth; *fh*, foot-holes; *wh*, madreporic plate; *e*, eyes; *s*, sockets of large spines.

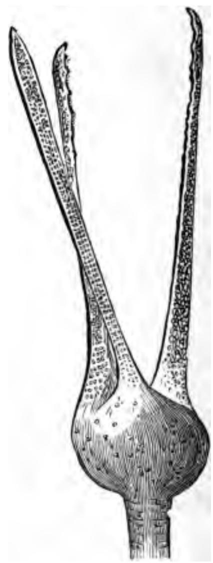
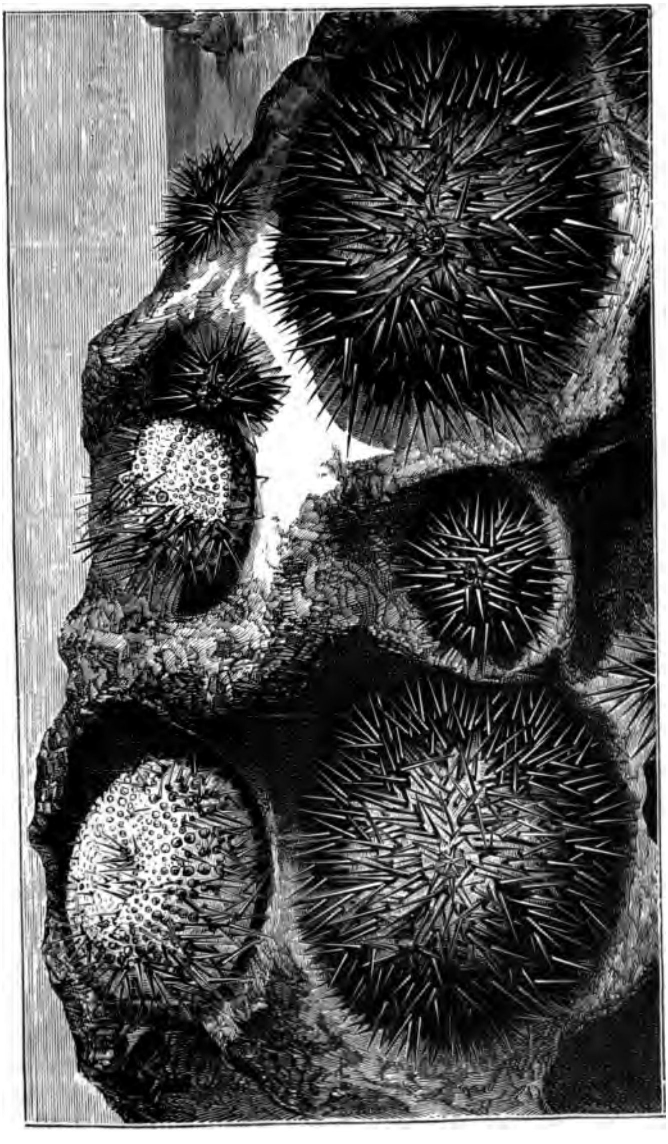


FIG. 36.—Jaws of Pedicellaria. Highly magnified.

Among these spines are over 2,000 suckers, or feet, of three different kinds: 1, suckers proper; 2, and most frequently found near the mouth, pedicellariæ (Fig. 36), whose calcareous jaws are continually opening and shutting in locomotion and defense; and 3, stalked button-like bodies called *sphæridia*, probably organs of taste. The same



A group of Echini, showing the burrows they form.

PLATE VI. ECHINODERMS.

1. Echinus righting itself on perpendicular surface, showing how the suckers are used. 2. Teeth of Echinus. 3. Natural movements of a star-fish on reaching the surface of water.

madreporic plate, *w h*, and a similar circulatory system are found as in the star-fishes.

Development.—They are produced from eggs, the free-swimming young passing through many changes (Fig. 37). In some Echini the young are produced without changes. The *Hermiaster* holds its young in a regular sac, while the eggs and young in others are held in place by the spines that fold about them like so many protective arms.

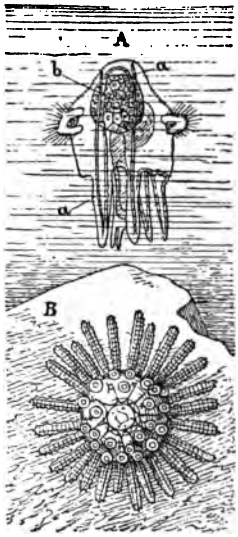


FIG. 37.—Development of sea-urchin. A, free-swimming young; *a*, *a*, lime rods; *b*, urchin forming within. B, later form, showing spines.

Class IV.—SEA-CUCUMBERS (*Holothuroidea*).

In these animals (Fig. 38) the body is long and worm-like, and resembles a rough-skinned cucumber. Looking down upon the mouth, that is surrounded by tentacle-like gills, their radiate character is seen, and by laying open the body a similar disposition of muscles may be noticed. The madreporic plate or strainer is internal. The feet are in five series, each consisting of five rows, by which they move slowly along. The skin of Holothurians is leathery, and contains numbers of curious bodies resembling dumb-bells, wheels, and anchors (Fig. 39). The *Holothuria Floridiana* is inhabited by a fish, the *Fierasfer.** In the *Holothuria sca-*

* In many observed by the author on the Florida reef they invariably died as soon as taken from the Holothurians; but in the aquarium at Naples they have been seen to leave their home and return tail first, the action of the Holothurian in taking in water helping them in.

bra of Zamboanga lives an entirely different fish (*Enchely-ophis vermicularis*).

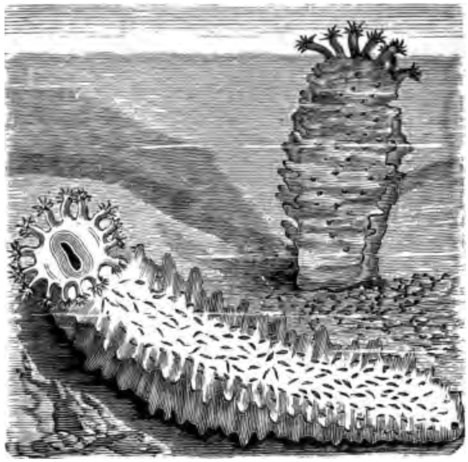


FIG. 38.—Sea-cucumber (*Holothuria lutea*), showing tentacle-like gills.

NOTE.—The common *Pentactes* of the North lies buried in the sand, the tentacle-like gills resembling mosses of various kinds. In some species they look like toadstools ; others resemble broad leaves or short, delicate shrubs, and, when concealed in the sand, these mimicking mouth-parts are thrust up, and wave to and fro in the current, deceiving the shrewdest of their enemies.

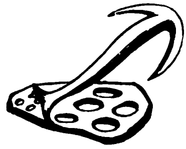


FIG. 39.—Anchor-plate in Synapta, magnified.

Development.—The young are developed much as in the star-fishes ; some are at first free swimmers by means of cilia, and pass through change of forms as curious and distinct as in many insects (Fig. 40), while others appear at first in the adult form, and are protected in nurseries called marsupiums.

VALUE.—Over 1,000 vessels are engaged in the trepang-fisheries of the East. The yearly shipment of them from Macassar alone amounts to $600,000. Spines of certain Echini are used as slate-pencils in some countries.

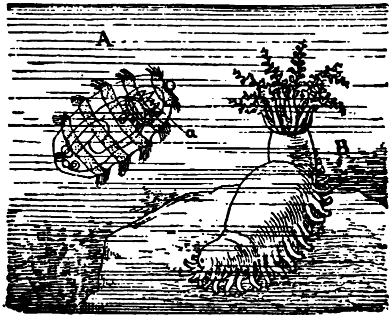


FIG. 40.—Development of sea-cucumber. A, jelly-like animal swimming; *a*, sea-cucumber forming within. B, later form, showing tentacles and feet.

Specimens for Study.—Living crinoids are not generally obtainable, but the fossil stems are to be found in various localities (see "Geology"). The stomachs of cod and other fishes often yield brittle stars not found near shore. The anchors, dumb-bells, etc., of Holothurians can be seen by treating the skin to a solution of potash, and should be mounted for the microscope.

Works on Echinoderms for further reference.

"Challenger Reports"; "Depths of the Sea," Sir Wyville Thomson; "Smithsonian Reports"; Moseley's "Notes of a Naturalist"; "Natural History of the Star-Fish," A. Agassiz, in "Memoirs of Museum of Comparative Zoölogy"; "Echinoderms of New England," A. E. Verrill, in "Boston Journal of Natural History," vol. x; "Invertebrata of Vineyard Sound," Verrill; "Seaside Studies in Natural History," Agassiz; "Homologies of the Pedicellariæ," "American Naturalist," vol. vii, Agassiz; "Reports of the United States Commissioner of Fisheries."

CHAPTER V.

FIFTH BRANCH OF ANIMALS.

THE WORMS (*Vermes*).

General Characteristics.—Animals that as a rule have a head, tail, upper and lower surfaces (dorsal and ventral), and generally made up of an indefinite number of joints or segments. An idea of the internal structure can be obtained from the section of a leech (Fig. 48). The digestive organ is tubular, extending from the mouth to the vent. The heart is a small pulsating organ above it, and a system of vessels containing a clear red or green fluid lead into the respiratory organs when present; many worms, however, breathe through the body-wall. The nervous system consists of a white double chain of ganglia extending along the ventral surface. The brain is small, and situated in the upper part of the head. In some, the eyes are in different parts of the body—the head, tail, etc.; in others, they are absent. In the leech, they are confined to the first three segments. In some, as the worms of the first class, two branching tubes are found that constitute a water vascular system similar to that of the Echinoderms. All the worms are developed from eggs, and many pass through remarkable changes before assuming the adult form. The worms include many animals that, though varying greatly in appearance, all possess certain characteristics in common.

Class I.—FLAT-WORMS, etc. (*Platyhelminthes*).

FIG. 41.— Liver-fluke of sheep twice the natural size. *a*, mouth ; *c*, digestive tube ; *d*, abdominal sucker.

The Planarian worms are the common forms of brooks and streams, found clinging to the floating twigs and leaves, resembling slugs. Some are brown, with from two to thirty black eye-spots. The marine forms attain a large size. Many are covered with delicate cilia and protective bristles, either spiral or straight rods held in cells and shot out like so many arrows as a defense. They multiply in several ways, that of self-division being the most curious: if divided into several pieces, each one becomes a perfect worm. The flat-worms are remarkable for their changes during growth, some passing through as many as seven. Many are parasitic, infesting other animals, as the liver-fluke of the sheep (Fig. 41).

The metamorphosis of an allied form, *Monostomum mutabile*, is as follows: When the embryo escapes from the egg, it is a ciliated form (Fig. 42, A). It swims about, soon entering the body of some animal—in the case of Fig. 41, the snail (*Limax agrestis*). It now produces a sac-like larva called the nurse ; later, this is called the *Redia*, then having a tadpole-shape, C, in which are seen germs, *a*. The animal grows until it assumes the appearance of D, when the young burst out as tadpole-like creatures called *Cercariæ*, E. They now leave their host, swim about, are swallowed by some animal, as the sheep, and make their way to the liver. Here the tail is lost, and they become encysted, in time appearing as a perfect fluke-worm, F, that finally escapes through the intestine, and lays eggs in pools or ponds, thus completing the transformation, that varies in different genera. The tape-worm that comes from pork belongs in this class.

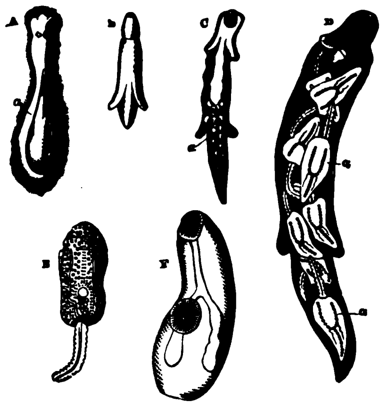


FIG. 42.—*A*, *Monostomum mutabile*. *A*, the ciliated embryo; *a*, the nurse; *b*, nurse free; *C*, *Redia* of *Distoma pacificum*, containing germs of other *Rediæ*; *D*, *Redia* containing *Cercariæ* (*a*); *E*, *Cercaria*; *F*, *Distoma*, which results from the metamorphosis of the *Cercaria*. (After Steenstrup.)

FIG. 43.—Trichina.

Class II.—ROUND OR THREAD-WORM (*Nematelminthes*).

The pin-worm and Trichina are examples. The *Trichina spiralis* (Fig. 43), one twelfth of an inch long, is the most dangerous, becoming encysted in the human muscles. The eggs are eaten by rats, that in turn are perhaps eaten by pigs, so finding their way into the human system. The *Gordius* *aquaticus* is the thread-worm, common in many insects and in pools. They are the so-called horse-hairs that do not turn to snakes.

Class III.—Wheel-Animalcules (*Rotifers*).

The Rotifers (Fig. 44) are microscopic worms, some being only $\frac{3}{100}$ of an inch in length, having a membranous covering. Upon the anterior portion they have one or two disks, surrounded by cilia (Fig. 44, A), whose constant motion creates the optical illusion of wheels revolving. They abound in the ocean, and in standing fresh water, and are so tenacious of life that they recover after having been dried for years, their sudden appearance after continued droughts being attributed to what is called spontaneous generation. Under the microscope they assume remarkable shapes: now oval, caused by the upper and lower segments shutting together; then leech-like, moving along seemingly by suckers, or darting off swiftly, propelled by cilia. They are oviparous, and Ehrenberg found that one species produced 16,000,000 young in twelve days.

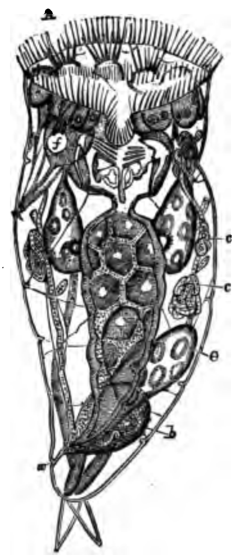


Fig. 44.—A Rotifer, highly magnified (*Hydatina senta*). *A*, cilia; *a*, anus; *b*, contractile vesicle; *c*, water-vessels; *e*, ovary; *f*, ganglion.

Class IV.—Moss Animals (*Polyzoa*).

These animals form a moss or coral-like growth, composed of cells (Fig. 45), each of which contains a minute, worm-like polyzoan. They are the commonest objects of the sea-shore, and are often pressed under the name of sea-mosses. Some occur in fresh water. They multiply by budding and by summer and winter eggs, the young of the latter being at first free swimmers.

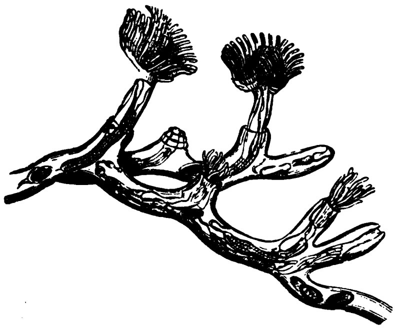


FIG. 45.—A moss animal (*Plumatella repens*), zoöids expanded and retracted.

FIG. 46.—Brachiopod showing arms.

Class V.—LAMP SHELLS (*Brachiopoda*).

The Brachiopods (Fig. 46) are worms that secrete unequivalved shells with or without hinges. The arms are on each side of the mouth, and in some appear in spirals supported by loops. By the motion of the fringes of the arms, food is thrown into the mouth ; they are also respiratory organs. The *Lingula* (Fig. 47) is an example

FIG. 47.—Lingula anatina.

common in the sand south of Cape Charles, where they make sand-tubes about their peduncles or stems. The young are at first free swimmers by means of cilia. Allied to them are the Nemertian worms, acorn-tongue, and star-worms, that form Classes VI, VII, and VIII.

NOTE.—Lingulæ, quite similar to those of to-day, are found in the Trenton limestone; 2,090 species are known, of which 2,000 are extinct.

Class IX.—LEECHES, EARTH AND SEA-WORMS (*Annulata*).

The leech (Fig. 48) is a common form of the higher worms. The body is flat and divided by numerous segments; the head small, with ten small and simple eyes; the mouth bears three teeth, arranged so that the wounds they inflict appear as gashes radiating from the center. Some swim readily, while others move by the use of their suckers, that are one or two in number. The eggs are laid in sacs in the fish-leech, *Clepsine*, and when hatched the young cling to the mother; others are laid in small oval sacs (Fig. 49), and deposited upon the stems and leaves of water-plants.

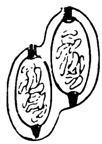


FIG. 49.—Egg-capsules of leech.

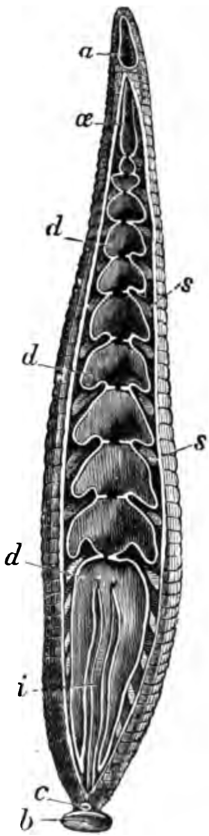


FIG. 48.—Section of a leech. *a*, anterior sucker; *b*, posterior sucker; *c*, anus; *d*, *d*, *d*, stomach; *æ*, œsophagus; *i*, intestine: *s*, *s*, glands of the skin.

NOTE.—Land-leeches are greatly dreaded in the forests of India (Fig. 50), and in the East India islands they exist in such vast numbers that Semper, the naturalist, was driven from the woods at Luzon by them, the animals falling upon him like dew from the shrubs and trees. According to the same authority, during the Sikh rebellion an entire English regiment was forced to retreat before the myriads of blood-suckers.

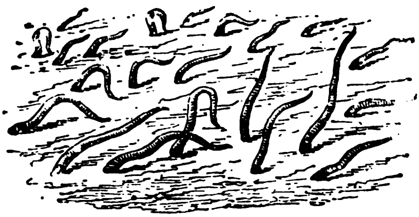


FIG. 50.—Land-leeches of India, racing to attack some animal.

VALUE.—Leeches, from their extreme sensitiveness to atmospheric changes, are sometimes used as barometers, but their principal value is in medicine. In one year 7,000,000 were used in London, at $10 per 1,000.

Earth-Worms.—The earth or angle-worms (Fig. 51) are cylindrical, and composed of numerous joints or segments, each divided by a thin muscular partition. Upon examination, the lower portion of the segments will be

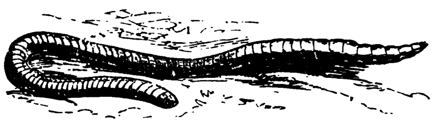


FIG. 51.—Earth-worm (*Lumbricus terrestris*).

found perforated with four rows of minute holes, through which extend bristles that are really the feet. These curve backward, and, by extending the head and throwing them out, the remainder of the body is pulled along, a fresh hold taken, and so on. They multiply by eggs that are protected by capsules, those of some kinds containing fifty eggs.

VALUE. — Eaten by the Indians, and valuable as preparing the earth for the reception of seeds.*

* The amount of vegetable mold thus brought to the surface in a single year by worms amounts, according to Darwin, in some places to ten tons in a single acre ; they rarely go below six feet, and it has

Marine Worms.—A common form on the sea-shore is *Nereis* (Fig. 52); the body is composed of from one to two hundred joints, each of which bears a pair of paddles; upon the head are four eyes, while the mouth is armed with a powerful proboscis and two large cimeter-like teeth.

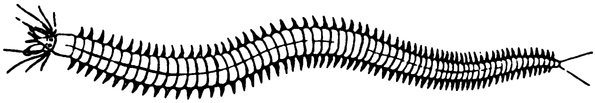


FIG. 52.—Sea-worm (*Nereis*). (After Morse.)

They live in holes in the sand, lined with a fluid secretion. They multiply by eggs. The *Cirratulus* also lives in a tube. In the South some of these forms arrange a leaf of sea-weed in the structure so that it falls over the mouth, forming a door, and giving the entire tube the appearance of sea-weed. The *Serpulæ* (Fig. 53), that build stony houses, have radiating coronets, dashed with rich coloring, for breathing organs. The *Pectinaria* bears upon its head a pair of combs of burnished gold, while with very few exceptions all the worms are luminous — green, blue, white, and yellow lights marking their movements under the sea.

been estimated that they average about 100,000 to the acre. In New Zealand 348,480 have been found in an acre of rich ground; so it will be seen that the upper crust is continually being eaten and ejected by them, their myriads of holes conveying water to the interior as well as air. The worms also drag vast masses of leaves under ground, that enrich the soil. They cover up seeds, undermine rocks, burying them up, and to their work is due the preservation of many ruins and ancient works of art. Some of their casts found in India are over a foot in length. In England, numbers of ancient Roman villas have been discovered beneath the ground, their entombment, according to Darwin, undoubtedly caused by the worms that undermined them and deposited their casts upon the floors, until finally, aided by other causes, they disappeared from sight.

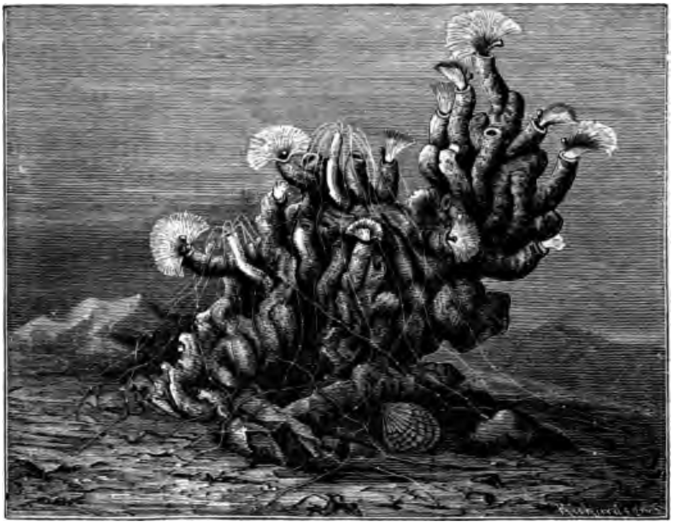


FIG. 53.—Fixed tube-making marine worms (*Serpulæ*).

VALUE.—Food and bait.

NOTE.—The most brilliant light-givers are found in the families *Polynoidæ*, *Syllidæ*, *Chætopteridæ*, and *Polycirrus*. If the first named is watched in the aquarium, gleams of greenish light will be seen at the attachment of each scale, and the separate organ glistens with pulsations of light at the ruptured surface. In the second worm the under surfaces of the feet are the only luminous spots. In the third the light is confined to the dorsum of the tenth segment or joint, while the *Polycirrus* is phosphorescent over its entire surface, emitting a vivid pale bluish light.

Works on Worms for further reference.

Verrill, "Invertebrata of Vineyard Sound," in "Report of United States Commissioner of Fisheries," 1874; Verrill, "Parasites of Man and Domestic Animals"; "Planariæ of our Ponds and Streams," E. R. Lankester, in "Popular Science Review," October, 1867; "Alternate Generation and Embryology of *Antolytus cornutus*," A. Agassiz, "Boston Journal of Natural History," vol. vii; "North American Fresh-Water Leeches," A. E. Verrill, in "American Journal of Science," 1872, vol. iii, page 126; "Animal Parasites and Messmates," Van Beneden; "Formation of Vegetable Mold," Darwin.

CHAPTER VI.

SIXTH BRANCH OF ANIMALS.

MOLLUSCA.

General Characteristics.—Mollusks are soft, unjointed animals enveloped by a muscular cloak or mantle, generally protected by a shell. They have a well-defined nervous system, a heart, arteries, and veins through which passes colorless blood, a foot for locomotion, and eyes more or less developed ; 20,000 living species are known, and 19,000 fossil. Those with two valves, as the oyster, are called bivalves, and those with one, as the snail, univalves. The former are called Lamellibranchs, from the folded plate-like appearance of their gills.

Class I.—OYSTERS, etc. (*Lamellibranchiata*).

General Characteristics—THE SHELL.—The shell (Fig. 54) is formed of carbonate of lime, secreted by the edges of the mantle, which is divided into two halves on the right and left sides, each one secreting a valve. The part of the shell where growth commences is called the beak (Fig. 54, *a*) ; that where the shell opens, the base, *k*. The portion indicated by the direction of the beaks is the anterior side ; the opposite, the posterior. Near the beaks is the hinge *b*, and here the valves join by teeth, *c*, *d d*, that fit into cavities on the opposite valve. A horny ligament, *h*, connects the valves, always tending to throw them apart ; thus, dead clams are always found open. In the interior of dead shells several scars are seen, some oval and others mere lines; the former are the marks of the adductor muscles, *e*, *e*, that move the valves, opening and shutting them. Near by are smaller scars, showing the position of the pedal muscles that moved the foot. The line running parallel with the margin of the shell is called the pallial line, *f*, and shows where the mantle was attached to the shell.

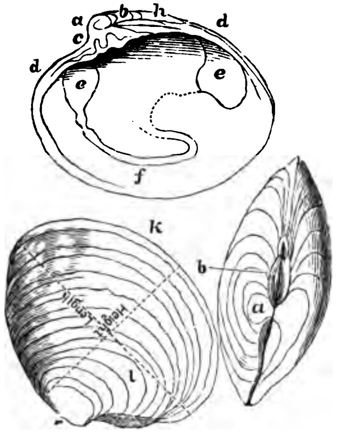


FIG. 54.—Bivalve shell. *a*, beak; *k*, base; *b*, *b*, hinges; *c*, *d*, *d*, principal teeth; *h*, ligament; *e*, *e*, adductor muscles; *l*, lines of growth; *f*, pallial line.

FIG. 55.—Mollusk, without siphon. *S*, shell; *m*, lower half of mantle; *m'*, a piece of the upper half; *g*, breathing-gills; *h*, heart; *lv*, liver; *lp*, lips; *o*, opening of mouth; *a*, anus, where refuse is thrown out; *ms*, muscle holding shells together; *c*, elastic cushion forcing them apart.

Internal Organs.—Opening the valves, we note the two leaves of the mantle, or body-wall, whose function is to secrete and repair the shell. Removing these, we see the gills (Fig. 55, *g*) or branchiæ that are open in front and joined at the back. They appear made up of minute rods covered by a maze of veins, and are provided with cilia. The siphon (Fig. 56, *s*), or so-called blackhead, when present, projects through the mantle, and in the clam is capable of great distention. It is divided into two parts, either double or single, and the orifices are surrounded by tentacles.

Circulation.—The blood is purified (aërated) and food obtained by the same action. Water is drawn into the siphon opening farthest from the valve (Fig. 56, *in*), and, wafted along by the cilia, is thus brought in contact with the gills. The food-particles in the water are carried along to the toothless mouth (Fig. 55, *o*), that, guarded by two pairs of sense organs (palpi), is placed at the end of the shell opposite the siphon. They then pass into the stomach and intestine that winds about and passing through

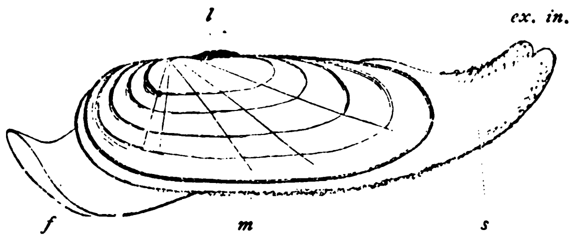


FIG. 56.—Bivalve with siphon, showing the foot. *l*, ligament; F, foot; *m*, mantle; *s*, siphon; *ex.*, excurrent orifice; *in.*, incurrent orifice. Except the siphon and the large foot, the arrangement of organs is similar to that of the oyster. (After Morse.)

the heart finally connects with the siphon nearest the valve (Fig. 56, *ex.*), out of which all *rejectementa* passes. Extending through the body is a glass-like rod, that is possibly a brace or support. The heart lies near the hinge (Fig. 55, *h*), and is composed of one ventricle and one auricle in the oyster. In other species the heart is three-chambered, or there may be two hearts of two chambers each. Arteries lead from the ventricle over the body, and veins carry blood to the gills *g*, where it is purified by the air in the water—then passing back to the auricle. The nervous system consists of three pairs of ganglia—cerebral, pedal, and a pair that send nerves to the internal organs, gills, etc. The eyes, when present, are in the borders of the mantle, and often resemble gems. The foot is a muscular organ that projects from the mantle nearly opposite the siphon, by which the animal leaps, moves, or glues itself to the rock, as the case may be. The ear is in the foot—a transparent sac containing a clear fluid in which floats a glassy globule.

BIVALVES WITHOUT SIPHONS.

Oysters (*Ostreidæ*).—The oyster is found in great beds upon the coasts of many countries. About 425 different living species are known, and over 1,400 fossil, some of the latter being of gigantic size. A single oyster will deposit during July and September over 1,000,000 yellow eggs. At first they remain in the gills, but finally leave the parent, and, after swimming about for a while by means of cilia, during which their numbers are greatly diminished, they finally settle upon the bottom, and in five or six weeks are as large as a grain of corn, three years, however, being required to attain full growth. They generally lie upon their sides, and are often inhabited by one or more small crabs (*Pinnotheres*).

VALUE.—Seven hundred and sixty-five million oysters are handled yearly in New York alone, representing a capital of $1,577,000, the industry giving employment to thousands.

Comb Shells (*Pectens*).—The Pectens are generally round, with radiating ribs from the valves, and are noted for their locomotive powers, and the luster and brilliancy of their gem-like eyes that dot the mantle. They have also numbers of filaments that extend

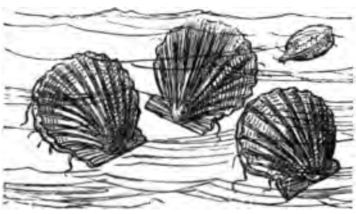


FIG. 57.—Pecten swimming, by violently opening and closing its valves.

from the shell—in the *Lima hians* to more than its entire length—and, by a vigorous opening and shutting of its valves, this shell flies through the water, its long, golden-red tentacles streaming behind. It also constructs a nest by covering itself with stones, shells, etc., connected by its byssus. The common Pecten is called the dancing-scallop (Fig. 57), from its curious movements, darting through the water and above it with the greatest ease.

VALUE.—Indian ornaments and articles of food.

Wing Shells (*Aviculidæ*).—The Meleagrina or pearl-oysters have obtained great prominence from their pearl-bearing properties. They come from Madagascar, Ceylon, Panama, etc. The pearls are formed of a pearly matter called nacre, secreted by the animal. If a grain of sand falls into the shell, the oyster envelops it with a pearly coating to smooth off the edges, and layer by layer the pearl grows. Imperfect pearls grow upon the sides of the valves, and are generally the attempts of the oyster to repel the advance of some boring parasite.

NOTE.—One fishery in Ceylon recently produced $80,000 worth of pearls, to obtain which 17,000,000 oysters were brought ashore. The fisheries are under the government control. Mother-of-pearl is the pearly shell of certain oysters, and valued in decoration. In one year twenty tons of silver-tipped shells have been received at Liverpool from the Society Islands, thirty tons of black-tipped from Manila, and 340 tons of a smaller kind from Panama.

Pinna.—These shells, common on many shores, are wedge-shaped and horny, the hinge delicate, the beaks forming a sharp peak. The foot is long and grooved. Over thirty species are known, and are found buried in the sand off shore. They attain a length of two feet.

VALUE.—The Pinna has long been noted for its silk, which is the cable or byssus by which the shell attaches itself to the bottom. Gloves and stockings of Pinna-silk can be seen in the British Museum. Gloves so made cost $1.50 a pair, and stockings $2.75.

Mussels (*Mytilidæ*).—The black mussels with their silvery interiors are the common forms on the rocks of the Eastern Shore. They are covered with a thick leathery skin, the hinge being without teeth. They are remarkable for their climbing powers (Fig. 58, *M*). By means of their foot, *f*, they fasten a silken cord to the rocks, then another, and by continually stretching out cables ahead or upward.

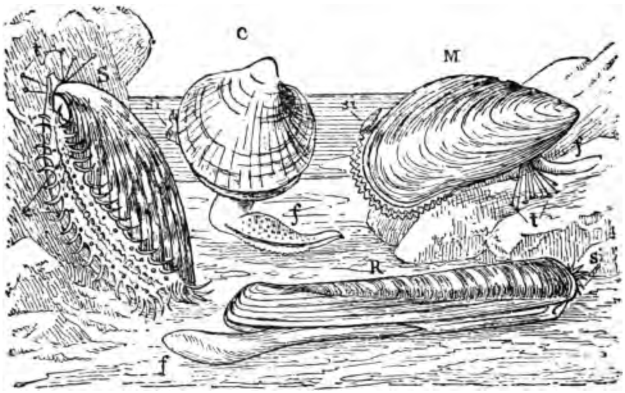


FIG. 58.—Group of headless mollusks. *c*, cardium springing; *M*, mytilus; *s*, pecten; *R*, razor-fish, solen; *f*, foot; *t*, anchoring-threads; *si*, breathing-siphons; *e*, eyes of scallop.

and lifting and breaking off those below, they climb or warp themselves along very much as does a ship on a lee-shore; 217 living and 350 fossil species are known.

VALUE.—The edible-mussel fisheries afford employment to many persons in Europe.

Fresh-Water Mussels (*Unionidæ*).—These are pond, river, and lake mussels, resembling in appearance the edible mussel, black without and pearly within, tinted with iridescent hues. About 550 living species are known throughout the world, and 60 fossil. The sexes are distinct. The young are held in the gills of the mother in the winter and early spring. They live for ten or fifteen years.

VALUE.—Unios produce pearls, and in St. Clair County, Illinois, and Rutherford County, Tennessee, their collection is a profitable business. In Scotland, $50,000 worth of fresh-water pearls have been taken from unios during the summer. A pearl was taken from a unio near Salem, New Jersey, a few years ago, that sold in Paris for $2,000.

BIVALVES WITH SIPHONS.

Tridacna (*Tridacnidæ*).—In the *Tridacna gigas* (Fig. 59), the largest living bivalve, the shells are often five feet

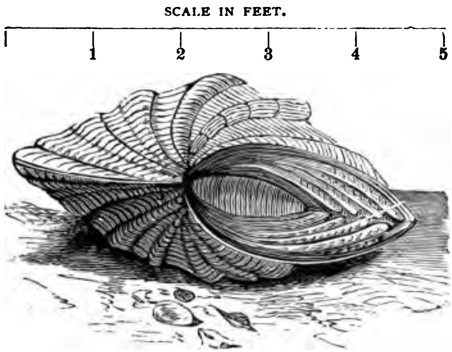


FIG. 59.—Giant clam (*Tridacna gigas*).

long; each valve weighing over 250 pounds, the animal itself frequently 30 pounds, one serving as a meal for fifty men. The shell is trigonal, with deep radiations. They are common in the Torres Straits, where they are sunk into the coral rock, presenting the appearance of huge elongated sea-anemones, the mantle being of brilliant blue and green. So securely are they imbedded that they have to be quarried out at low

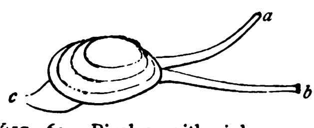


FIG. 60.—Bivalve, with siphons. *a*, excurrent; *b*, incurrent; *c*, foot. (After Morse.)

tide with axe and chisel. According to Moseley, they attain an age of one hundred years.

NOTE.—So powerful are they that large sharks and rays that have accidentally crossed them have been seized and held. The Tridacna always harbors within its shell several crabs. The byssus is so large that it can only be cut with a hatchet. Eight species are known.

VALUE.—The Tridacnæ are often used as *benetiers* for holding holy water. The natives cut the shell up into knives.

Razor-Shells (*Solenidæ*).—This shell (Fig. 58, *R*) is long, thin, and slightly curved, with two or three teeth in each valve. They have a powerful club-shaped foot, do not secrete a byssus, but lie concealed upright in the sand. When placed upon the sand, they use the foot like an auger, and rapidly disappear; 60 or more living species are known, and 350 fossil.

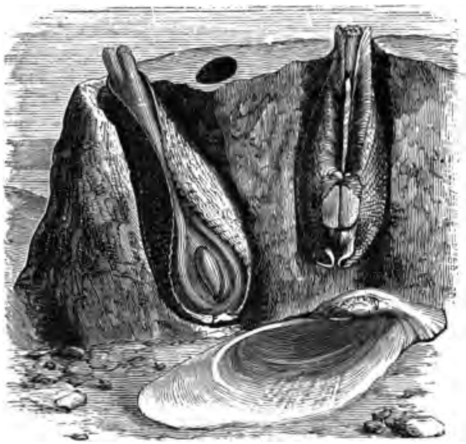


FIG. 61.—Pholas imbedded in a block of granite, showing section.

Boring Shells (*Pholadidæ*).—These have a thin, brittle, and very hard shell, open at both ends, and armed with file-like markings. The siphons are very long, and united except at the tips. They are found in nearly all oceans, about 80 living species and 50 fossil being known. They are noted for their boring powers (Fig. 61), making their way into the hardest rock.

NOTE.—The shells contain aragonite in their composition, and are supposed by continual friction to wear away the hardest rock. Having entered a block of gneiss, they grow and enlarge their hole, and so imprison themselves. The pillars of the temple of Serapis, in Italy, are pierced by them, showing that the land was submerged long enough for them to obtain a foot-hold. The Pholas emits a bluish-white light when dead or alive, and they may be compared to miners with their lamps. A single one placed in seven ounces of milk has been used as a lamp; faces near it were illumined, and the milk appeared transparent. Another, placed in honey, retained its light over a year.

Ship-Worm (*Teredo*).—The shell is composed of two curved equal valves, open at both ends (Fig. 62). The animal is worm-like, and not entirely covered by the shell.

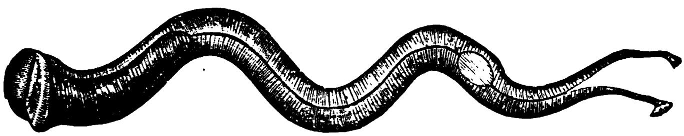


FIG. 62.—Ship-Worm (*Teredo navalis*).

They bore into wood, incasing the tunnel with a limy ceiling. The siphons are long, and where they separate are protected with small calcareous bodies, called palettes, which close the mouth of the tube. The foot forms a sucker. The common teredo is at first free swimming, passing through several changes before it assumes the adult form. The *Teredo gigantea*, found at Sumatra buried in the mud, is from four to six feet in length, the tube three to four inches in diameter, and when covered with other shells is extremely bulky and heavy.

NOTE.—The destruction they cause seems incredible. A large portion of a wreck stranded on the Florida reef, and examined by the author several years ago, has now disappeared, having crumbled away under their tunneling. Hulls that appear solid may be crushed by the hand—completely honey-combed. In 1731 they nearly destroyed the piles in Holland, threatening the country with destruction. They attack floating wood, and so are carried all over the world. Docks at Tortugas, Fla., were rendered unsafe in twelve months. Palmetto is the most successful resistant.

Watering-pot Shells (*Aspergillum*).—In these shells the two valves are imbedded in the lower part of the tube, the beaks only being visible externally. The tube which incloses the siphon ends in shelly expansions or ruffles; at the other or anterior end it is club-shaped, and covered by a disk like the nose or sprinkler of a watering-pot, and perforated with numerous holes in exactly the same way. They are found in tropical countries, buried in the mud or sand, the ruffled end containing the siphon exposed.

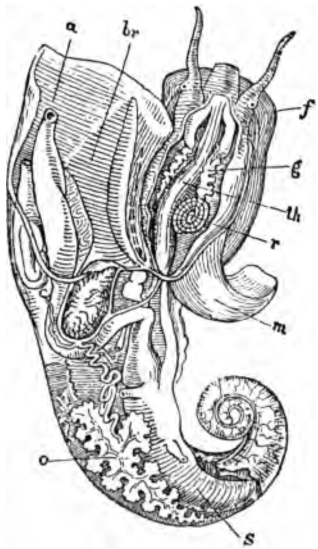


FIG. 63.—The interior of a univalve (*Periwinkle*). *f*, foot; *m*, muscle for drawing back into the shell; *g*, spittle glands; the glands for giving out slime are near the anus tube; *th*, throat leading to *s*, stomach; *r*, tooth-bearer rolled up; *br*, branchiæ or breathing-gills, which, when the mantle is folded back in its place, lie over the throat; *a*, anus; *o*, ovary carrying eggs.

SINGLE-SHELLED MOLLUSKS.

Class I.—SNAILS, etc. (*Gasteropoda*, belly-footed).

General Characteristics.—Mollusks that secrete a single shell. They have ears and eyes upon a distinct head. The foot is now a flat, creeping disk

(Fig. 63, *f*). They also have an *odontophore* or tooth-bearer, and the shell is often closed by a plate or door called the operculum; 22,000 species are known, 7,000 of which are extinct or fossil.

Sea Wood-Lice (*Chitonidæ*).—In these (Fig. 64) the shell is composed of eight transverse plates. The young

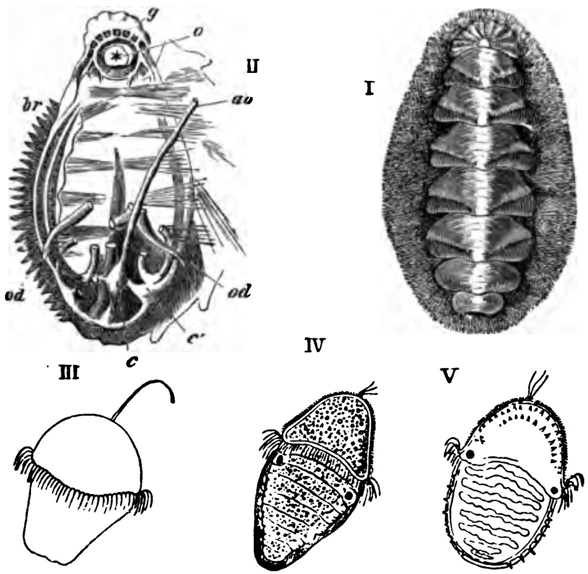


FIG. 64.—A gasteropod (*Chiton*). I. Adult, showing plates. II. *Chiton* dissected: *o*, mouth; *g*, nervous ring; *ao*, great artery from the heart, aorta; *c*, ventricle; *c'*, an auricle; *br*, left branchiæ; *od*, oviducts. III, IV, V. Development of free-swimming young.

(Fig. 64, III) at first have no shells, swimming about by the aid of minute cilia; 250 living species are known, and 125 fossil. In the West Indies they are eaten by the natives.

Ear-Shells (*Haliotidæ*).—The Haliotis is a pearly ear-shaped shell, with the outer lip perforated with holes:

they have no operculum. They are found in many seas, 196 living and 150 fossil species being known.

VALUE.—In California they are eaten. In 1880, 6,372 sacks of Albalones, or Haliotis, valued at $46,179, were shipped from that State, and probably as many more by rail. They find a market in New York and Boston, where they are either cut or powdered and made into buttons, etc.

Violet Snails (*Ianthinidæ*).—These shells (Fig. 65, I) float upon the surface of Southern waters, and are tinted with purple and violet, the animal when pressed emitting

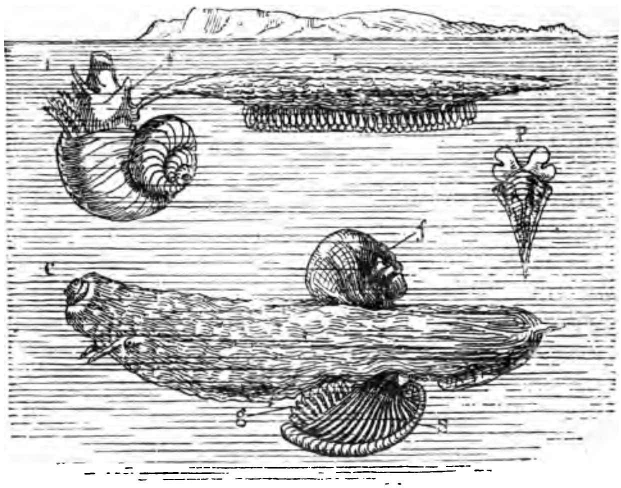


FIG. 65.—I, *Ianthina*, the ocean-snail : *f*, foot ; *r*, raft of air-bubbles, with egg-bags hanging down. C, *Carinaria* : *f*, foot ; *s*, shell covering the breathing-gills, *g*. Both these forms float upside down. P, *Pteropod.*

a rich purple indelible ink. They secrete by their foot a curious raft, composed seemingly of bubbles of air in transparent sacs. This buoys them up, and is also a nursery, the eggs being attached to the under portion, the entire family being at the mercy of the wind.

Cowries, or Egg-Shells (*Cypræadæ*).—The Cowries (Fig. 66, C), called in Florida micramocs, have richly enameled and marked shells; the spire is not seen, and the opening is small. When living they throw out a coating that completely covers the shell, protecting it from damage.

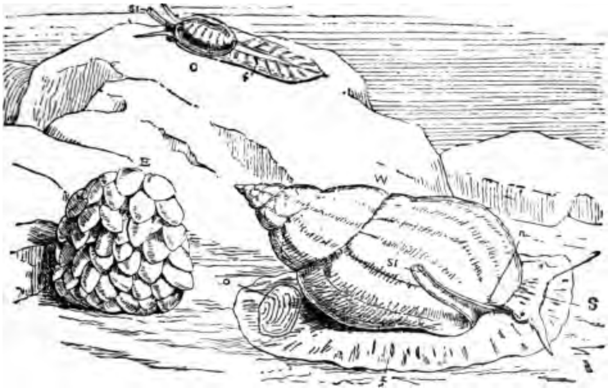


FIG. 66.—Flesh-feeding mollusks. W, whelk; E, whelk-eggs; C, cowry; *o*, operculum; *n*, notch in shell; *si*, siphon; *f*, foot; *s*, head.

VALUE.—The *Cypræa moneta* is used as money in some parts of Africa. In 1848 60 tons of this money was sent out.

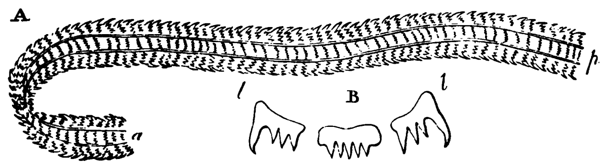


FIG. 67.—Toothed tongue of *Buccinum undatum*. B, one of the transverse rows enlarged; *l*, lateral teeth.

Whelks (*Buccinidæ*). — Nearly 1,100 living species have been found; many are common on our shores. The shell has few whorls, and the operculum is long or ovate (Fig. 66, W, *o*). In some the tongue is long and contains

100 rows of teeth (Fig. 67). Some bore into shells, and all are scavengers.

VALUE.—Many of the whelks afford a rich crimson dye, which in 1684 was used in Ireland for dyeing linen.

NOTE.—Some of the Southern species, as *Magilus*, burrow into coral, throwing out a tunnel as fast as the coral surrounds them, and filling it up with shelly matter.

Diverse-footed Mollusks (*Heteropoda*).—These Gasteropods are all marine, and float upon the sea in transparent shells of delicate and glass-like construction. In some the foot forms in part a curious fin-like organ. The eggs are deposited in long threads, the young passing through many changes. The *Carinaria* (Fig. 65, C) and *Atalanta* are the best known.

Gasteropods with Exposed Gills (*Opisthobranchiata*).—We now come to the shelled or shell-less mollusks that have gills more or less upon the outside.

Sea-Pigeons (*Aplysiadæ*).—These are also called sea-slugs and hares. One, common on the Florida reef, is as large as the closed fist, and somewhat resembles a plucked pigeon. They are green or olive in color, and when touched throw out as a defense a cloud of rich purple ink that completely surrounds them. They are found crawling among the sea-weed, not in the coral. The skin appears to cover the body in two folds lapping over the back, and when the animal is lifted from the bottom is vigorously flapped.

Sea-Slugs (*Eolis, Doris, etc.*).—These curiously formed mollusks are found on sea-weed and in other localities. In many the gills resemble plumes and leaves, so that the animals are almost perfect mimics of the weed, even in color. Such is the luminous *Scyllæa pelagica*. The gills of the Doris (Fig. 68, *d*) resemble a plant; the Eolis (Fig. 68, *e*) seems covered with grass; while the Glaucus resembles a lizard with three branching feet on each side. They are shell-less except when very young. Eolis and Tritonia have been heard to make audible sounds. The eggs of Doris

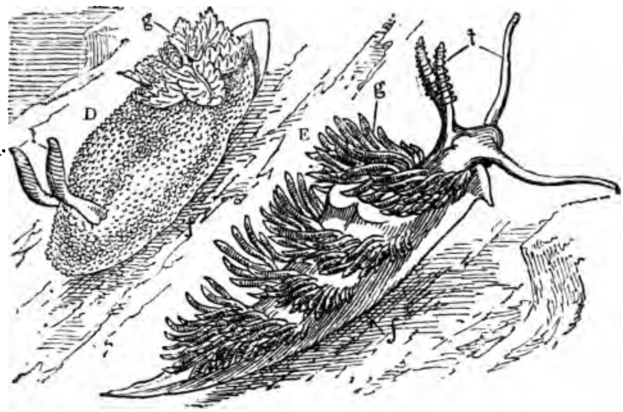


FIG. 68.—Naked-gilled mollusca, commonly called sea-slugs. D, *Doris pilosa ;* E, *Eolis coronata ;* *f*, foot ; *g*, breathing-gills ; *t*, tentacles.

are incased in a ribbon and rolled up like a watch-spring; 360,000 young are often produced, that are at first free swimmers.

AIR-BREATHING GASTEROPODS (*Pulmonata*).

General Characteristics.—Mollusks possessing a single lung, a chamber on the right side of the body near the head, lined with a membrane containing blood-vessels. The cavity is closed by a valve. The shell, when present, is generally thin and delicate, and often highly colored.

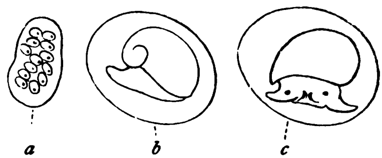


FIG. 69.—*a*, egg capsule of a fresh-water snail ; *b*, *c*, eggs, highly magnified, showing the young snail. (After Morse.)

Pond-Snails (*Limnæidæ*). — These are the common pond-snails, interesting from the great variations of the shell. The eggs are laid in capsules (Fig. 69), in a jelly-like mass, late in the spring. In the winter they hibernate in the mud; 320 species are known.

Land-Snails (*Helicidæ*).—Three thousand three hundred and thirty-two species of these are known in various

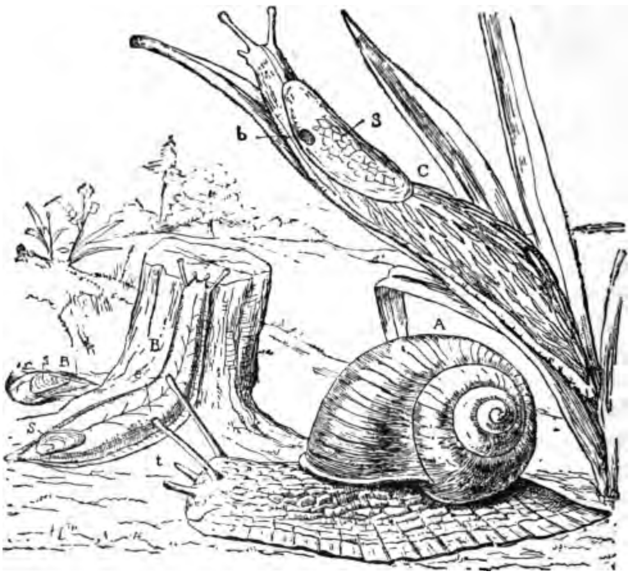


FIG. 70.—Air-breathing gasteropods: Snails and slugs. A, garden snail (*Helix*); B, B, slug *Testacella*—one disappearing into the ground, and only the tail showing; C, the great gray slug (*Limax*); *s*, shell; *t*, tentacles; *e*, eyes; *b*, breathing-hole.

parts of the world. They are easily kept in a fernery and their habits watched. Many of the snails (Fig. 70, A) deposit large white or yellow eggs with a calcareous covering. The Bulimus (Fig. 71), an ally, rolls two leaves together and fastens the eggs between. Some of their eggs are as large as a pigeon's.

A GROUP OF UNIVALVES.

1. Land mollusk of Philippines (*Rhysota Antonii*). 2. *Eulima*, that lives in Holothurians. 3. *Chlorœa*. 4. *Lymnea*. 5. *Chlorœa*. 6. *Cochlostyla stabilis*. 7. *Planorbis*. 8. *Succinea*. 9. *Amphidromous* (Malay). 10. *Xesta*. 11. *Physa*. 12. *Cochlostyla* (Philippines).

VALUE.—Cultivated for food—an important industry in France.

NOTE.—Most of the snails hibernate in the cold seasons, and will live for years without food. The largest are the agate shells of Africa, eight inches across; the eggs an inch in length, with a hard covering. The *Helicarion gutta* of the Philippine Islands, according to Semper, when caught by the tail, throws it off and so escapes, the tail in time growing again. This is also the case with a West Indian snail (*Stenopus*). *Helix hortensis*, common in New England, was introduced years ago from England. *Helix fidelis* is an albino, found in Washington Territory.

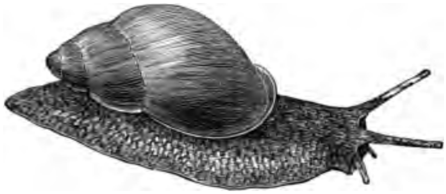


FIG. 71.—Bulimus rosaceus.

Land-Slugs (*Limcidæ*).—These slugs (Fig. 70, C), of which 116 different species are known, are common in every garden, and their bright-yellow eggs found under old boards or buried in the ground. They have, as a rule, a rudimentary scale-like shell (Fig. 70, S), long tentacles, and are carnivorous, eating worms and other animals. They have a curious secretion by which they lower themselves from twigs and leaves. It is also a defense, and when applied to many animals, as moles, is often fatal. *Limax noctiluca*, from Teneriffe, has a luminous

FIG. 72.—*Onchidium tonganum*, a mollusk with dorsal eyes; natural size.

pore on the mantle, while the eggs of *Arion* are luminous for the first fifteen days.

Marine Pulmonata.—The *Peronia* frequents the sea-coast. The most remarkable form is the *Onchidium* (Fig. 72), that, according to Semper, has numerous eyes upon its back (Fig. 73) in addition to the usual pair upon the head. They form the principal food of a fish, the *Periopthalmus*, that leaves the water and hops along the shore to obtain them.

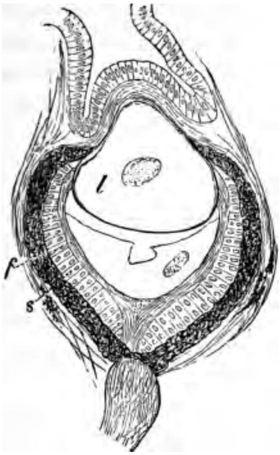


FIG. 73.—Section of dorsal or back eye of *Onchidium verruculatum*. *f*, fibrous layer of retina; *s*, layer of rods and cones inclosed in retina.

VALUE.—All slugs are scavengers. Several kinds are dried and eaten by the Indians.

Class III.—SCAPHOPODA.

Tooth-Shells (*Dentaliadæ*).—These headless mollusks have a tooth- or tusk-shaped shell (Fig. 74), open

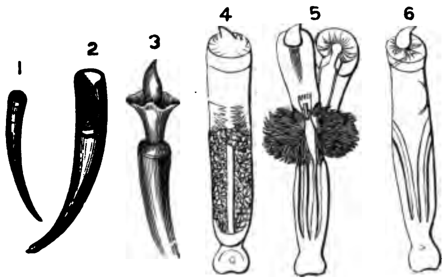


FIG. 74.—1, *Dentalium entalis*, natural size; 2, shell magnified, and broken to show animal within; 3, animal projecting from the shell; 4, animal from below, magnified; 6, same from above; 5, same, showing internal structure.

at both ends, with a foot greatly elongated and adapted for boring in the sand, in which they live in from 60 to 600 feet of water on the sea-coast. The sexes are distinct. The young pass through several changes before assuming the adult form. The shells form the wampum of the Indians.

Class IV.—SQUIDS, etc. (*Cephalopoda*, head-footed).

General Characteristics. — The Cephalopods are the highest forms of mollusks. They are marine, and either swim or crawl; have long arms or tentacles arranged about the mouth, armed with suckers or hooks, two parrot-like beaks, and a toothed tongue. They generally possess ink-bags; have highly developed eyes, and a large brain protected by a cartilaginous covering, calling to mind the cranium of vertebrates.

Wing-footed Cephalopods (*Pteropoda*). — These, the lowest and perhaps degenerate Cephalopods, are free-swimmers, moving by two broad fins or wings upon each side of the neck (Fig. 65, P). In Northern waters they are found in vast swarms. The *Cleodora* emits a soft, clear, phosphorescent light that gleams through the delicate shell. The *Clio*, in swimming, almost touches its fins above and below. It has a wonderful arrangement for seizing prey. Each tentacle bears about 3,000 transparent cylinders, each containing twenty stalked suckers; and, as there are six tentacles, the *Clio* can grasp its prey with 360,000 hands. They have also a pair of many-toothed jaws, and a tongue armed with recurved teeth—a terrible array for so small a creature. They are eaten by whales. The young pass through several changes.

Order I. **Four-gilled Cephalopods** (*Tetrabranchiata*); **Nautilus** (*Nautilidæ*).—Of 1,500 species that have lived in past ages, only two are extant. The shell (Fig. 75) is pearly, and divided into cells or rooms that are formed as the animal grows, the last one occupied always being walled up or divided off by a partition called a *septum*. The center of all the divisions is penetrated by a tube; so, though living in the last chamber, the animal is still connected with the first by a long, delicate, fleshy pedicle that extends through it. The different air-chambers are filled with gas, and by them the specific gravity of the animal may be increased or diminished. Beneath the mouth is a siphon through which water is ejected, thus forcing them along. On the bottom they crawl with the shell upward. They have *no* ink-bag, and in the female the tentacles or arms number ninety-four. The great fossil Ammonites, three feet across, are extinct relatives of the nautilus.

FIG. 75.—Section of *Nautilus pompilius*, showing the chambers and connecting tube containing the fleshy pedicle.

VALUE.—Shell in ornamental work.

NOTE.—The eye of the nautilus is remarkable in having no dioptric apparatus, being merely an elevation bearing a minute hole that leads into the globe of the eye, which during life is filled with sea-water, and thus, according to Hensen, in place of a refracting lense and cornea, there is an arrangement for forming an image on the principle of the pin-hole camera.

Order II. **Two-gilled Cephalopods** (*Dibranchiata*); **Spirula** (*Spirulidæ*).—These small Cephalopods resemble squids, but contain within their bodies a delicate chambered pearly shell with separate whorls, the various rooms or cells all connected by a tube or siphuncle, as in the nautilus. The animal is rarely seen alive, though, after a storm, the keys of the outer Florida reef are often lined with their empty shells.

Giant Squids, etc.—Small squids (Fig. 76) are common in nearly all waters, but within a few years specimens have been discovered of gigantic size in the fiords of Newfoundland and other parts of the world. The largest found was fifty-five feet long, the body from the tip of the tail to the beak twenty feet, and the long tentacles thirty-five feet. The body is bag-shaped, terminating in an arrow-shaped tail; the head is distinct from the body, with large, staring eyes; about the mouth are eight short and two long arms, the former with suckers on their entire length, the latter having them principally at the ends. Beneath the mouth is the siphon through which they eject water and ink—the latter when alarmed. The long arms are used to secure prey, drawing it within the reach of the smaller ones and the beaks, that resemble those of a parrot, with the exception that the upper fits into the lower. The body is supported internally by a long and extremely delicate pen. They are carnivorous, living on fish. The *Loligo pallida* is common on our coast. The *Cranchia* has been seen to emit a faint phosphorescent light. The large squids are extremely powerful, often

FIG. 76.—*A*, squid (*Sepia officinalis*); *B*, horny ring of sucker, showing saw-like edge.

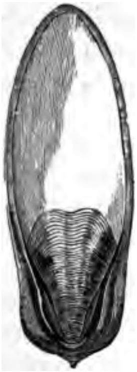


FIG. 77.—Pen of *Sepia officinalis.*

weighing 2,000 pounds or more, and have been known to attack boats. Each egg of the *Sepia* is inclosed in a thick envelope resembling India-rubber; those of the *Loligo* in rows in a tough jelly, and glued to the bottom in strings.

VALUE.—As codfish-bait. The sepia of the artist comes from their ink-bags, and the cuttle-fish bone of commerce is the pen of a certain species. The pen of *Sepia officinalis* (Fig. 77) is made into pounce, dentifrice, and polishing-powder.

Eight-footed Cephalopods (*Octopoda* *).—These, as well as the squids, are commonly called devil-fishes. They live

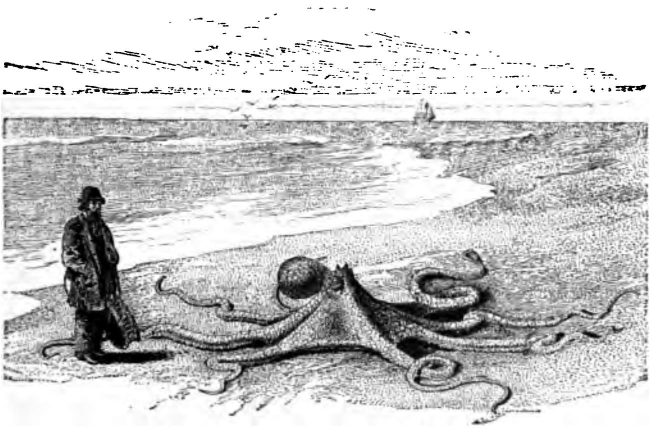


FIG. 78.—*Octopus punctatus*, showing the relative size,and the position when crawling on the bottom. From the Emerton model at Yale College.

* A small one, speared by the author, lifted over twenty pounds of coral when hauled in, throwing out ink that permeated the water in all directions. In 1877 an Indian woman is said to have been drowned by one at Vancouver Island. At Sitka the *Octopus punctatus* (Fig. 78) is caught having, according to Dall, a total radial spread of nearly twenty-eight feet.

upon the bottom among the rocks. The body (Fig. 78) is a simple sac, from which radiate eight sucker-lined arms. They are very powerful, and when enraged waves of color pass over the skin in rapid succession. When attacked they eject a cloud of ink, and under its cover crawl away, passing through incredibly small holes, and so mimicking the colors of the bottom that an experienced eye is necessary to detect them. They feed upon crabs and other animals, and are mainly bottom animals, though some species have web-like membranes between their eight arms enabling them to swim. Each egg of the octopus is inclosed in a thin, transparent, oval case, and attached by a stalk with several hundred others to the bottom; sixty species are known.

VALUE.—The fisheries are important to the Chinese.

Argonaut (*Argonautidæ*).—The Cephalopods of this family are often incorrectly figured with sails raised in the air. The shell is symmetrical and of great delicacy and beauty. The animal rests in it, the upper or dorsal pair of arms being developed at their tips into membranes that are thrown back over the shell (Fig. 79), holding the

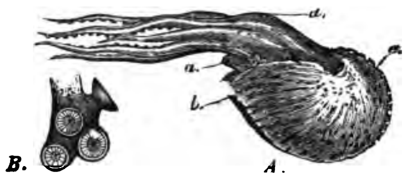


FIG. 79.—*Argonauta argo.*—*A*, female with the expanded arms in their natural position, embracing the shell, *b*; *d*, the other six arms; *a*, the funnel. *B*, suckers.

Argonaut in. The broad tentacles also contain the shell-secreting glands. The shell is likewise the nursery, the eggs being attached within it and carried about. The male secretes no shell, and is extremely small. They are deep-water animals, and crawl about upon the bottom

(Fig. 80), but are occasionally cast ashore on the New Jersey and New England coasts; nine species are known.

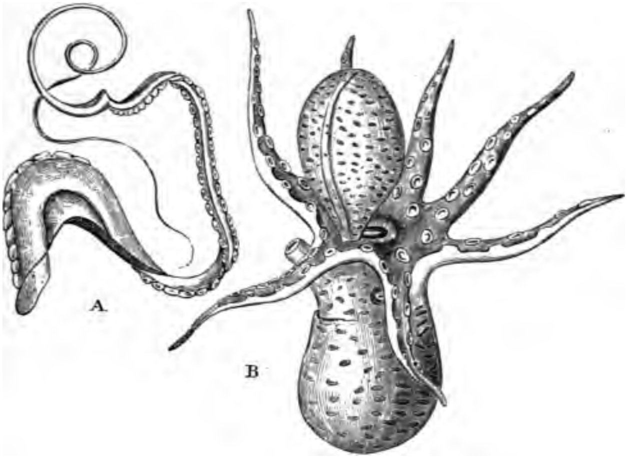


FIG. 80.—*Argonauta argo.*—*B*, shell-less male; *A*, the hectocotylus detached.

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CHAPTER VII.

SEVENTH BRANCH OF ANIMALS.

CRABS AND INSECTS (*Arthropoda*).

General Characteristics.—Animals having jointed feelers, jaws, and legs, arranged in pairs ; skin hard, and body made up of rings or segments. The Arthropods are divided into two classes : first, crustaceans, crabs, etc. ; second, insects.

Class I.—CRABS, etc. (*Crustaceans*).

General Characteristics.—Arthropods that breathe by means of gills attached to the feet, or in some cases respiring through the body-walls, as in the *Entomostraca.* The body is covered with a hard skin, composed principally of carbonate and phosphate of lime. This forms an external skeleton, protecting the soft body parts within.

Skeleton.—Taking the fresh-water cray-fish as an example (Fig. 81), the body is seen to be divided into two general regions : the cephalo-thorax (head and thorax) and the abdomen, and as a rule made up of twenty distinct rings or segments often difficult to define. Upon these the organs or appendages are arranged in pairs, being modified for various purposes, as cutting and crushing claws, paddles, stalked eyes, antennæ, swimmerets, etc. To the first segment of the head the movable and stalked eyes are attached (Fig. 81, *e*). The next segment bears the small and large *antennæ* or feelers ; then follow six pairs of jointed organs, fitting closely together, their office being to take the food from the claws and prepare it for the stomach. The first pair are the jaws proper, or *mandibles*,

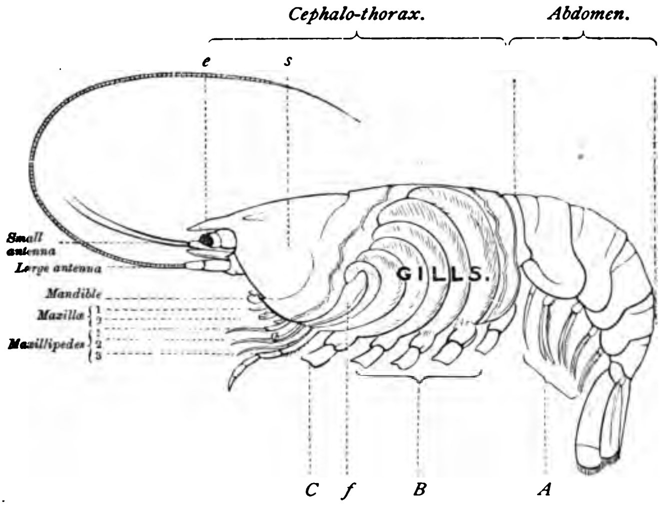


FIG. 81.—Cray-fish seen from the side, with that portion of the carapace removed which covers the branchiæ, or gills. The appendages of the left side only shown. *s*, region of stomach ; *A*, abdominal appendages ; *B*, bases of the four small legs ; *C*, base of large claw ; *f*, "gill-bailer," or flabellum, attached to the second maxilliped ; *e*, eye. (After Morse.)

that cut and grind the food ; the next two pairs, 1 and 2, are assistant jaws, or *maxillæ*. Below these are three pairs of appendages called foot-jaws, or *maxillipedes*. These belong to the thorax, while the *mandibles* and pairs of *maxillæ* belong to the head proper. The segments of the abdomen fit loosely together, so that the "tail" can be bent beneath the body, and by flapping it vigorously the crayfish swims, the five flattened appendages (Fig. 82) at the end serving as fins. From the under portion of the *cephalo-thorax* extend five pairs of legs : the first pair are the large claws prominent in the lobster, where one is a crusher and the other a cutter; the other four pairs (Fig. 81, B) are long and slender, the first two ending in nippers, the hinder ones being provided with points or claws; these are the true organs of locomotion on the bottom. Each segment of the abdomen except the last bears a pair of flat appendages or swimmerets (Fig. 81, *a*), by which the cray-fish can swim ahead, and to these the eggs are attached.

Digestion.—The digestive organs, seen in Fig. 83, consist of the mouth, surrounded by the mandibles, that leads

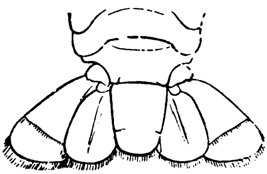


FIG. 82.—Tail of a cray-fish, showing flattened appendages for swimming. (After Morse.)

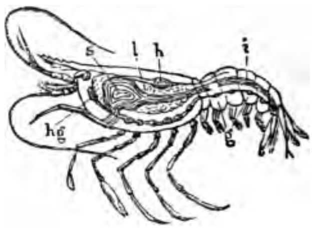


FIG. 83.—Ideal section of prawn, showing: *s*, stomach, below this the mouth; *l*, liver; *i*, intestine; *h*, heart; *g*, chain of ganglia or nerve-masses; *hg*, head-ganglia.

by the œsophagus into the large stomach *s*; the latter is provided with crushing teeth, by which food is still further masticated, then passing through a strainer at the posterior end, and so into the intestine *i*, that leads into the telson. The liver *l* is very large and of a dark-green hue.

Respiration.—The higher crustaceans breathe by gills, the plume-like object in Fig. 81. They are attached to the base of the legs, and are protected by the carapace or shelly covering of the *cephalo-thorax*. Water containing air reaches the gills by flowing under the edge of the carapace back of the great claws. In the oyster (Fig. 55), we saw that cilia kept up a current over the gills, but here there is a curious appendage attached to the base of the second pair of maxillipeds (Fig. 81, *f*), called the "gill-bailer," that moves back and forth, creating a current over the gills that finds its way out through an opening near the mouth. The colorless blood is pumped by the heart (Fig. 83, *h*) to the gills, where it takes up oxygen, returning to the heart by numerous venous channels.

Nervous System.—The brain or head ganglia is seen in Fig. 83, *h g*. Nerves pass to each eye, and others to the four antennæ, while a chain of nerve-masses extend through the body (Fig. 83, *g*), having branches to the principal parts.

Organs of Touch, Hearing, etc.—The ears are at the base of the smaller or first antennæ (Fig. 81), and are little sacs in the upper side, containing a thick fluid, in which float grains of sand. On a ridge projecting into the interior of the sac are numerous hairs, not over $\frac{1}{60}$ of an inch in length, that are connected by nerves with the brain. The sound-wave sets the sand-grains in motion, the vibration in turn affects the hairs, and the sound is carried to the brain.

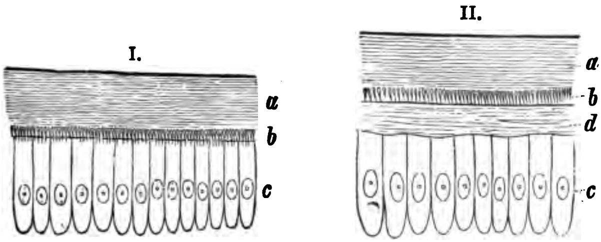


FIG. 84.—Stages of casting in the carapace of the freshwater cray-fish, from Braun. I. First stage: *a*, the two old cuticular layers; *b*, the layer of casting hairs; *c*, the epidermis cells. II. Second stage: *a*, *b*, *c*, as in I; between *b* and *c* the new cuticle *d* has intervened.

The organs of touch are the delicate hairs about the mouth-parts and legs. The organs of smell are supposed to be on the under side of the outer branch of the small antennæ. Crustaceans moult or cast their shell at different periods. The old shell is pushed up by what are called

7

"casting hairs" (Fig. 84). The soft-shelled crab is a result of the casting. They also have the faculty of throwing off their limbs and renewing them again.

Development. — The young of most crustaceans pass through many changes before assuming the parent form.* The eggs resemble at first minute currants (Fig. 86), that attach themselves by glutinous threads to the appendages

* The Australian *Dromia* is an exception, the young leaving the egg in the adult form, and clinging to the mother. A similar case is seen in the fresh-water cray-fish (Fig. 85), *Astacus fluviatilis;* the young of some crustaceans (Balanus) appear at first in the Nauplius form, with three pairs of legs.

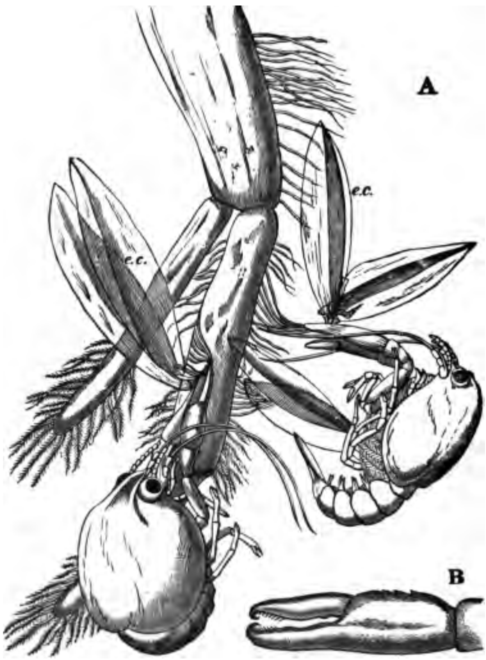


FIG. 85.—*Astacus fluviatilis.* A, two recently hatched cray-fish attached to one of the swimmerets of the mother; *e c*, ruptured egg-cases; B, chela of a recently hatched cray-fish, × 10.

of the abdomen (Fig. 85), and are carried about by the mother. When first hatched they are generally in the zoæa stage. The eyes of the zoæa (Fig. 87, *a*) are large and black. From the carapace extends upward a long horn, another projecting downward like a tusk. They moult several times, gradually changing to the megalops form (Fig. 87, *b*), and finally, after successive moults, seek the bottom and assume the adult shape (Fig. 87, *c*).

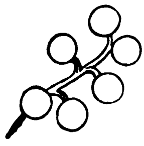


FIG. 86.—A few eggs from a common crab, enlarged. (After Morse.)

Order I. **Barnacles** (*Cirripoda*).—The barnacles are fixed crustaceans, and partly from this circumstance were long considered mollusks. The adult

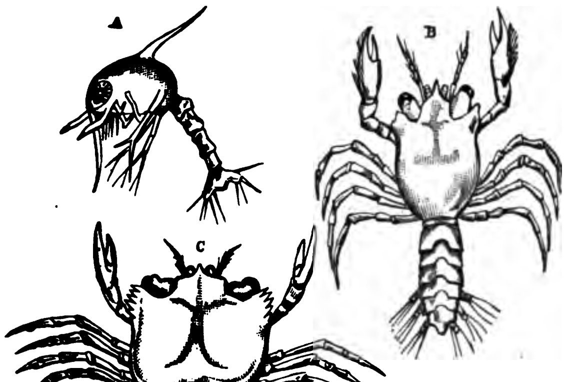


FIG. 87.—Metamorphosis of the crab (*Carcinus mænas*). *A*, zoæa stage; *B*, megalops stage; *C*, ready to seek the bottom.

Balanus (Fig. 88) is round, with a broad base, and attaches itself to shells or rocks. The newly hatched young are free-swimmers (Fig. 89, *A*), but soon acquire a bivalve shell, *B*, and attach themselves to the bottom by their antennæ, that secrete a glutinous substance for the purpose. *C*, *D*, *E* show the successive stages to the adult form, in which the shell is multivalve, the animal anchored by its head, and its feet modified into cirri, that waft food into the shell and mouth. Goose barnacles are connected with the bottom or floating objects by long, leathery pedicles. They have no gills, breathing through their skin.

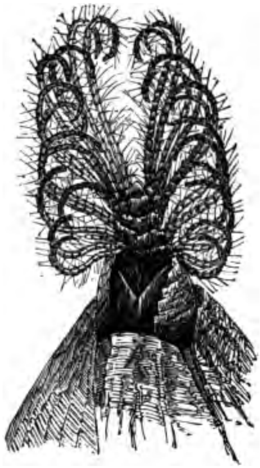


FIG. 88.—Upper part of adult barnacle, showing appearance of cirri under the microscope.

NOTE.—Barnacles grow on whales, turtles, and floating objects of all kinds. Goose-barnacles have been found six inches long growing in the mouth of a large sun-fish (*mola*), and a barnacle is found on the feathers of penguins in the South Atlantic.

Order II. **Water-Fleas** (*Entomostraca*).—A common example is seen in the *Cyclops*, found in fresh water, that may be distinguished by its single eye and egg-sacs. It is just visible to the naked eye. Most of this order are parasites upon fishes. The *Lernæans* (Fig. 90) live upon the gills of various fishes; the *Caligus* preys upon holibut, rays, etc., the *Argulus* upon the alewife, the *Penella* upon the sword-fish and sun-fish, while the *Nogatus* preys upon the man-eater shark. They have no gills, breathing through the body-walls or skin.

Order III. **Leaf-footed Crustaceans** (*Branchiopoda*).—These animals breathe by broad, leaf-like gills upon their feet, and secrete a bivalve shell. The *Artemia*,* or

* *Artemia salina* (Fig. 91, *b*) has been made to acquire the characteristics of *Branchipus* (Fig. 91, *a*) by gradually diluting the water until it was fresh.

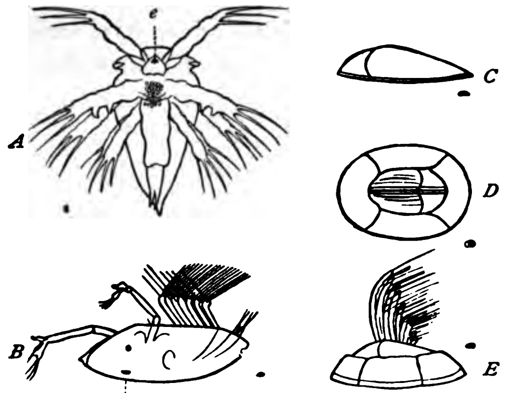


FIG. 89.—Early stages of a barnacle. *A*, shortly after leaving the egg; *e*, eyes. *B*, having acquired a bivalve shell, and just before becoming attached, represented upside down. *C*, appearance after becoming attached—side-view. *D*, top-view of still later stage, with the shell forming around it. *E*, side-view of later stage, showing appendages protruded. (The little marks at the sides of the figure indicate the natural size of the object. *A*, *B*, highly magnified; all of these views are magnified, and, with the exception of *D*, are reduced from figures of C. Spence Bate.)

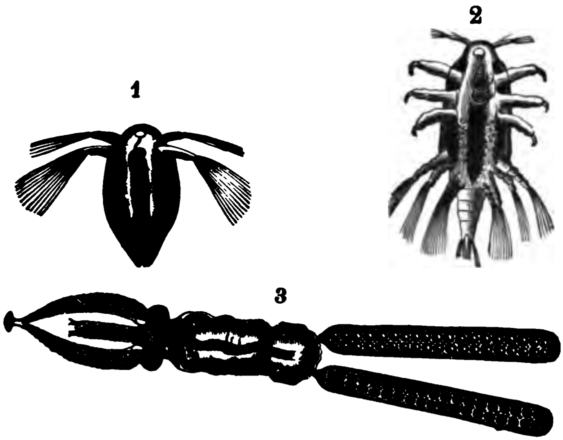


FIG. 90.—A Lernæan (*Tracheliastes*) of a fresh-water fish (*Cyprinæ*). 1, larva, as it leaves the egg. 2, larva, more advanced. 3, adult female, showing the egg-sacs. (Nordmann.)

brine-shrimp (Fig. 91), live in the brine-vats of various countries, the amount of salt sometimes determining the form

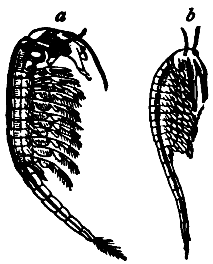


FIG. 91.—Brine-shrimps. *a*, *Branchipus stagnalis*. *b*, *Artemia salina* whose form depends upon the saltness of the water.

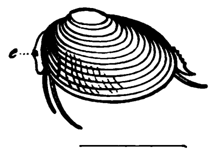


FIG. 92.—Fresh-water crustacean, with bivalve shell. *e*, eye. (After Morse.)

of the animal. They multiply by budding and by eggs. The *Estheria* (Fig. 92) secretes a bivalve shell, microscopic rings upon it indicating the various moults, the cast-off coat being cemented to the new shell which forms beneath. *Sida* and *Daphnia* are called water-fleas from their activity. The latter carries its eggs upon its back. The *Apus* (Fig. 93) is an interesting form, having forty-seven segments and as many as sixty pairs of limbs. They withstand remarkable extremes of heat and cold, the eggs hatching in snow-water after being frozen for two weeks. The *Nebalia*, representing Order IV, *Phyllocardia*, has leaf-like feet, and

FIG. 93.—*Apus*.

passes through no metamorphosis. The body is compressed, the rostrum distinct from the carapace.

Order V. **Fourteen-footed Crustaceans** (*Tetradecapoda*). In this order are the beach-fleas (Fig. 94), so common among the weeds; the pill-bugs and others living in salt and fresh water. The *Idotea phosphorea* has an acute tail-piece, and mimics the eel-grass and fucus with its green, gray, and yellow colors, at night gleaming with vivid phosphorescence. They live under stones and rock-weed, and when touched curl into a ball. The eggs are held in a little brooding cavity under the thorax between the legs. Many species of *Podocerus* and others build curious nests in which they take shelter. A gigantic amphipod has

FIG. 94.—Sand-hopper (*Talitrus saltator*).

FIG. 95.—Mantis shrimp (*Squilla mantis*).

two enormous faceted eyes that entirely cover the head. The *Arcturus*, from Arctic seas, mimics sea-weed with its long antennæ, and carries its young about on its back or feelers. The *Squilla*, or mantis shrimp (Fig. 95), representing Order VI, *Stomapoda*, is an interesting form; the gills are attached to the base of the under abdominal feet. They burrow in the sand below tide-water.

Order VII. **Ten-footed Crustaceans** (*Decapoda*); **Long-tailed Crustaceans** (*Macrura*).— The shrimps (Fig. 96) are common on nearly all shores. Some possess

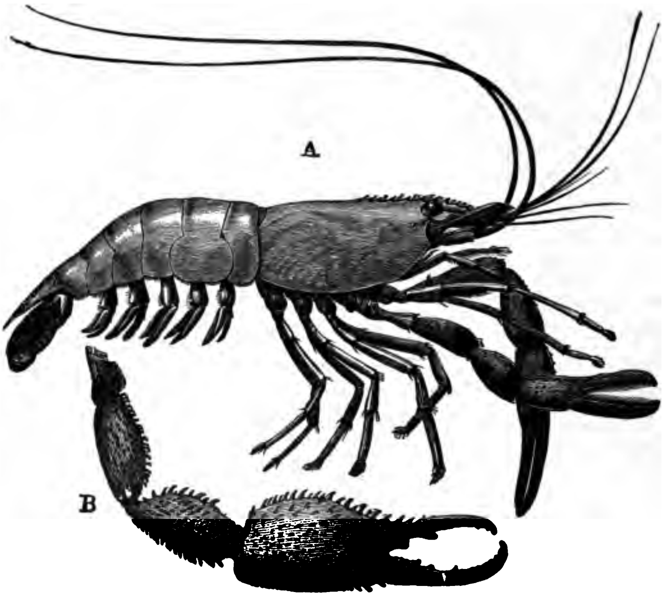


FIG. 96.—Prawn (*Palæmon jamaicensis*), about $\frac{5}{7}$ natural size. A, female. B, fifth thoracic appendage of male. (After Huxley.)

the faculty of mimicry to a wonderful degree. The chameleon shrimp changes to green and brown, even becoming transparent under certain conditions. Deep-red-colored ones have been found in the Atlantic, and others from great depths have remarkably developed eyes. Cray-fish in the Mammoth Cave are blind, and the eyes of *Willemœsia*, from the deep Atlantic, are rudimentary. Lobsters (Fig. 98) that are familiar on Northern coasts are in Florida replaced by the whip-lobster (Fig. 99), that has long whips instead of the large claws.

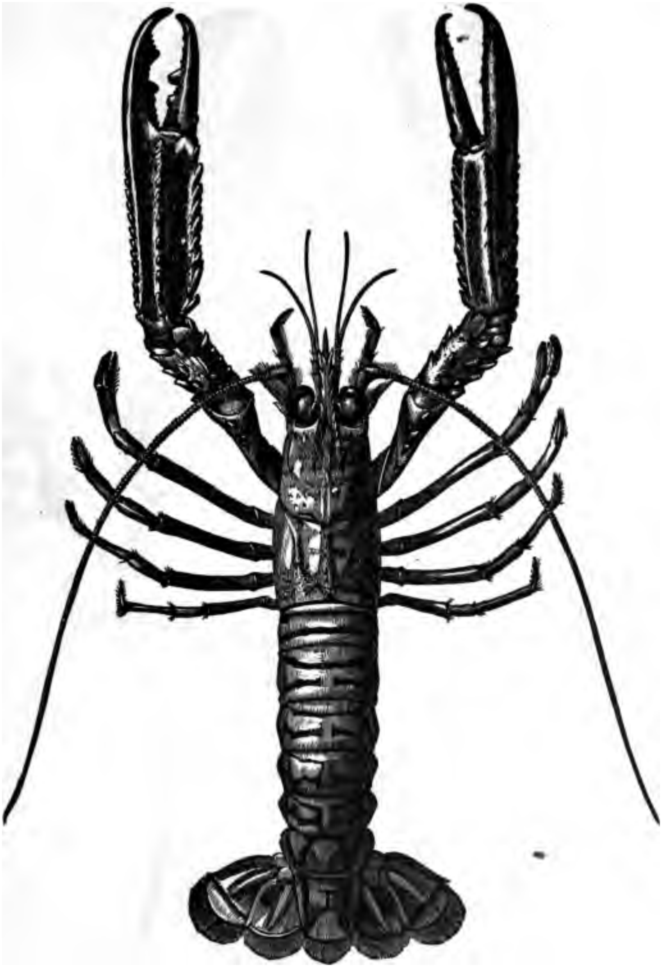


FIG. 97.—The Norway lobster (*Nephrops norvegicus*), ½ natural size. (After Huxley.)

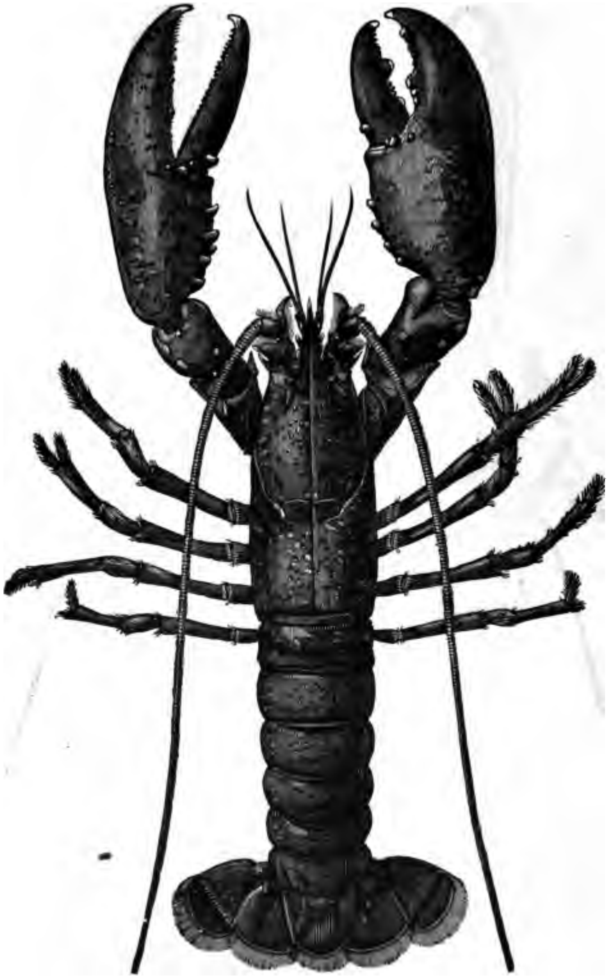


FIG. 98.—The common lobster (*Homarus vulgaris*), ½ natural size.

FIG. 99.—Marine cray-fish (*Palinurus vulgaris*), about ¼ natural size.

NOTE.—On the Florida reef nearly every coral head or branch affords protection to one or more cray-fishes, as they are there called. The animals partly undermine them, thus serving the coral by preventing the fatal inroads of sand and mud.

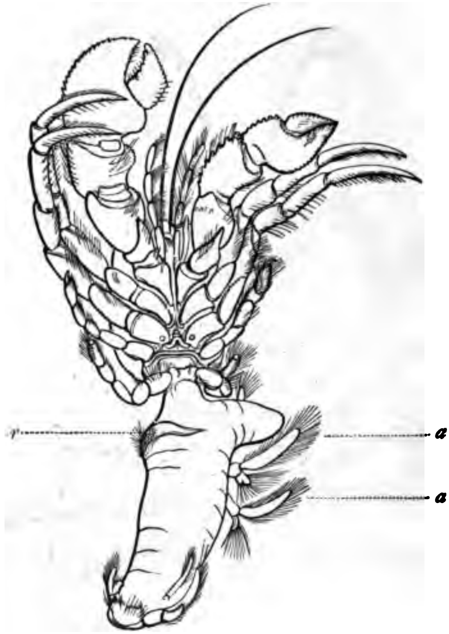


FIG. 100.—Hermit out of the shell, showing soft abdomen. *r*, hardened ridge which bears against the inner edge of the aperture of the shell; *a*, *a*, appendages to which the eggs are attached. (After Morse.)

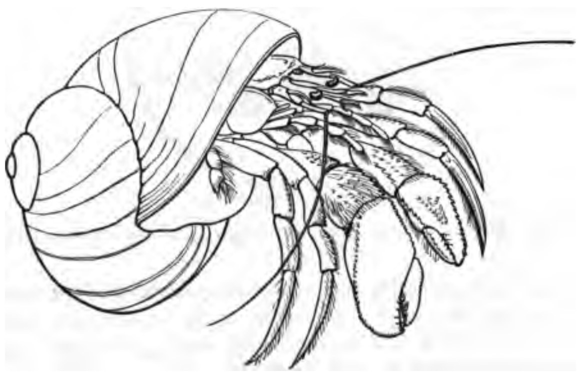


FIG. 101.—Hermit-crab in the shell of a sea-snail. (After Emerton.)

Hermit-Crabs.—In the Hermits, that are either marine or terrestrial, the abdomen is soft (Fig. 100), and to protect it they take possession of empty univalve shells (Fig. 101), or even old tobacco-pipes thrown overboard by sailors,* while others bore into wood, sand, or sponges, the

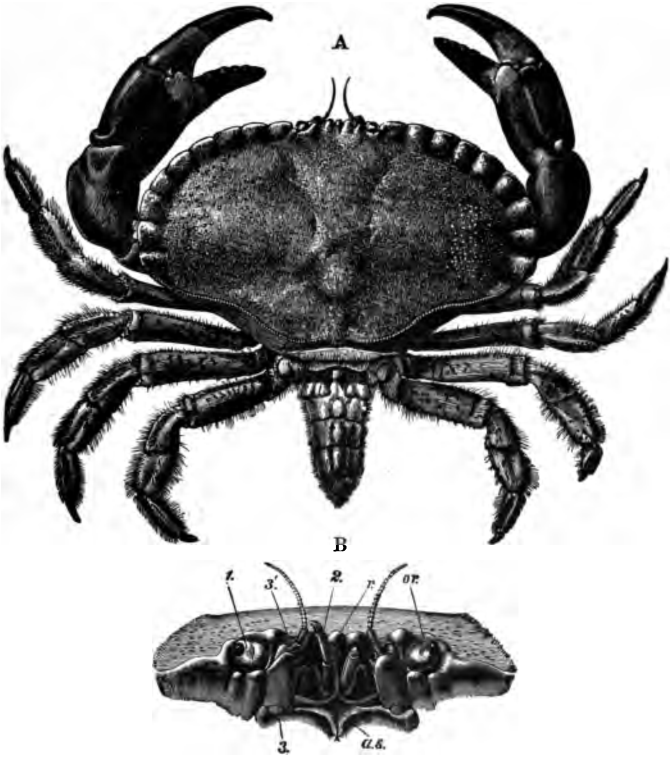


FIG. 102.—The English edible crab (*Cancer pagurus*), ½ natural size. A, dorsal view, with the abdomen extended. B, front view of "face": *as*, antennary sternum; *or*, orbit; *r*, rostrum; 1, eyestalk; 2, antennule; 3, base of antenna; 3′, free portion of antenna. (After Huxley.)

* The author kept a land hermit for several months that had taken up its quarters in an old clay pipe. It crawled up a table daily to drink from a saucer of water placed there for the purpose.

large claw closing the entrance like an operculum. The claws are often brilliantly colored blue, purple, and red.

NOTE.—On Bush Key, Tortugas group, the author has often observed land-hermits and a Gecarcinus climbing bay cedars and robbing young noddies of their food, despite their vigorous protests.

The largest ally of the Hermit is the *Birgos latro*, found in the Spice Islands and various parts of the Indian Ocean. The abdomen is protected by hard plates; consequently, they do not need a shell. They attain a length of three feet. Professor Van Beneden states that one lifted a goat from the ground by its ears. They subsist upon cocoanuts, breaking the shells by hammering them with their claws. They visit the water daily, but breathe air, the gills having all the attributes of true lungs.

Short-tailed Crabs (*Brachyura*).—The short-tailed crabs (Fig. 102) differ from the Hermits in having well-developed hind-feet, an abdomen capable of being bent under the body, and a broad and flat carapace.

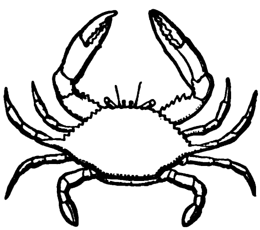


FIG. 103.—*Lupea*, short-tailed crab, with the last two claws adapted for swimming.

Marine Crabs.—The largest of these is the *Macrocheira* of Japan, that often measures twenty-two feet between the large biting claws, each of which is ten and a half feet long. The body is small, and resembles a moss-covered rock. The claws are adapted for crawling. The *Lupea* (Fig. 103) has the last two claws adapted for swimming.

NOTE.—Some of the spider-crabs of our coast purposely plant seaweed upon their backs, where it grows, affording them effectual protection. A crab deprived of this growth will recover its carapace immediately. *Cancer fulgens*, according to Sir Joseph Banks, is luminous. The most remarkable luminous crustacean, according to Nördenskiold, is the little *Metridia armata*, that exists in such quantities in the snow on the shores of the Arctic Ocean that persons and animals appear to be walking in fire, the splashes of light presenting a wonderful spectacle. The light is of a bluish-white tint, which in the spectroscope gives a one-colored Labrador-blue spectrum.

Oyster-Crabs (*Pinnotheres*).—These are the delicate forms commonly found in oysters and various bivalve shells, as well as the water-lung of Holothurians (Fig. 104). While the oyster-crabs find protection in other ani-

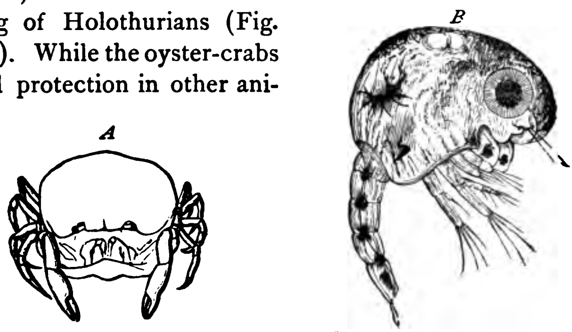


FIG. 104.—*A*, *Pinnotheres*, living in a Holothurian (*Pinnotheres holothuriæ*). *B*, the zoea stage of the young of *A*, highly magnified.

mals, and the hermits steal shells to cover themselves, a number of curious forms shown in Fig. 105 take up their position upon a branch of coral, as *Sideropora palmata*, and

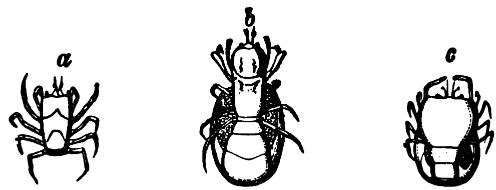


FIG. 105.—Crabs that form galls on corals. *a*, *Cryptochirus* (male); *b*, *Coralliodytes* (female); *c*, *Hapalocarcinus marsupialis* (female), that carries its young in a sac or marsupium.

finally produce a gall, or are covered by the coral and live so imprisoned, obtaining their food through a small hole or window. One of these crabs (*c*, Fig. 105) is remarkable in having a pouch in which the female carries her young; the sac is formed by a prolongation of the lateral plates of the abdomen.

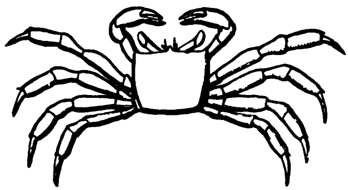


FIG. 106.—*Ocypoda*, a marine crab that lives on land.

Land-Crabs.—Land-crabs are common on all shores, many, as the *Ocypoda* (Fig. 106), living in holes, hibernating in the winter, and mimicking the sand in their absence of color. In the South the land-crabs, *Gecarcinus* (Fig. 107), that live in the bushes, are of various tints, equally protective among the leaves of the dead bay cedars and the fruit of the prickly-pear, about which they cling. They are all swift runners, and in Ceylon, a large land-crab is chased on horseback.

FIG. 107.—*Gecarcinus rusticola*, a land-crab.

NOTE.—At St. Paul's rocks Professor Moseley observed the richly colored *Grapsus*, a land and water crab, carrying off young birds; and at Ascension Island the large land-crabs even steal young rabbits from their holes and devour them.

Order VIII. **Merostomata.**—The king or horseshoe crabs (Fig. 108) attain a length of two feet, and have a wide geographical range. The last segment of the ab-

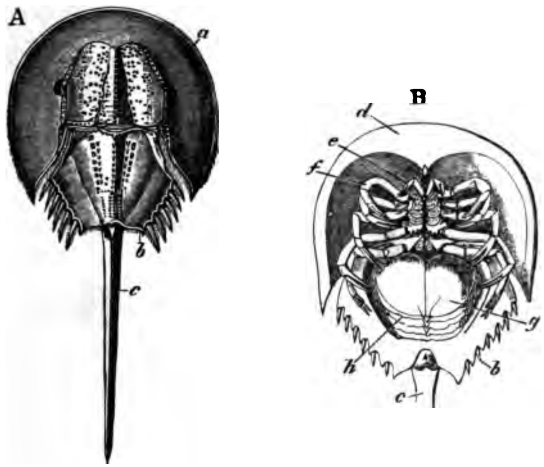


FIG. 108.—Horseshoe crab. A, *Limulus Moluccanus*, dorsal view. B, *Limulus rotundicauda*, ventral view (after Milne-Edwards): *a*, anterior; *b*, middle division of the body; *c*, telson; *d*, subfrontal area; *e*, antennules; *f*, antennæ; *g*, operculum; *h*, breathing appendages.

domen forms a long, sharp spine. The cephalo-thorax is broad, shaped like a horse's foot; the feet are arranged about the mouth. The abdomen bears six pairs of broad swimming feet, except the first having upon the under side a set of about one hundred respiratory leaves or plates. The young resemble the extinct trilobites, to which they are allied. Some of the extinct forms, as Fig. 109, attained a length of nine feet.

VALUE OF CRUSTACEANS.—They are all valuable scavengers. The crab, lobster, and shrimp fisheries give employment to thousands of persons. The cocoanut-husks that the great Birgos tears up to line its nest are used by the Malays in basket and mat making. Concretions

from the stomach of the fresh-water cray-fish are used as an antacid. The horseshoe is valued as guano.

FIG. 109.—Gigantic extinct crustacean (*Pterygotus*), nine feet long, swimming among Crinoids. (After Buckley.)

Specimens for Study.—In dissecting a crab, cray-fish, or other specimen, the carapace should be carefully removed with knife or scissors, the gills examined, the mouth-parts removed and compared with cut No. 81, and the difference between the parts noted. The claws should also be compared, and their various offices thoroughly understood. The brain, stomach, and muscles can be studied by cutting away the red membranous hypodermis. By injecting carmine into the arteries through the heart, the arterial system can be traced. The eggs, eyes, etc., can be hardened in alcohol, and cut in sections for microscopic examination. The ear and other organs should receive particular attention. The smaller crustaceans found in ponds, etc., should be examined alive under the microscope. Barnacles can be found on oyster-shells at any restaurant, and when placed in water show their cirri.

Works on Crustaceans for further reference.

"Challenger Reports"; "A Naturalist's Sojourn in Jamaica," Gosse; "Crustacea of the United States Exploring Expedition," J. D. Dana; "North American Astacidæ" (Fresh-water lobsters), H. A. Hagen, in "Memoirs of Museum of Comparative Zoology," vol. ii, No. 3, 1871; "Habits of certain Cray-fish," C. C. Abbott, "American Naturalist," vol. ix, p. 80; "Descriptions of the North American Phyllopoda," A. S. Packard, Jr.; "Report of Hayden's Survey," 1873, p. 613; "Report of Peabody Academy of Sciences," 1873; "Report of United States Commissioner of Fisheries," 1874; "Crustacea," S. J. Smith; "The Lobster and Lobster-Fishing," W. W. Wheildon, "Proceedings of American Association for the Advancement of Science," vol. xxiii, 1874; "Early Stages of the Lobster," "Popular Science Monthly," vol. iii, 1872, p. 401; "Barnacles," J. S. Kingsley, "American Naturalist," vol. xi, p. 102; "The Cray-fish," Huxley.

Class II.—INSECTS (*Insecta*).

General Characteristics.—Arthropoda, with the head, thorax, and abdomen distinct; breathing by air-tubes or tracheæ; the young passing through changes called a *metamorphosis.*

Skeleton.—The skeleton (Fig. 110) is external, and composed of a horny substance called *chitine.* As in the crustaceans, the body is made up of segments, numbering in the winged forms generally four in the head, three in the thorax, and ten or eleven in the abdomen. The mouth-parts of insects consist, as a rule, of four separate divisions; namely, the upper lip, or *labrum;* a pair of crushing or cutting jaws (*mandibles*); and a smaller pair (*maxillæ*), to which small jointed feelers called *maxillary palpi* are attached. The lower lip, or *labium,* is in reality a pair of jaws, and to it are attached another pair of jointed feelers known as *labial palpi.* Near the compound eyes rise the sense-organs, or *antennæ.* The *thorax* is separated into three segments: the first, *prothorax*, bearing the first pair of legs; the second segment, or *mesothorax*, bears the elytra or first pair of wings—in the beetles, hard, chitinous storehouse for the wings proper (here is also attached the sec-

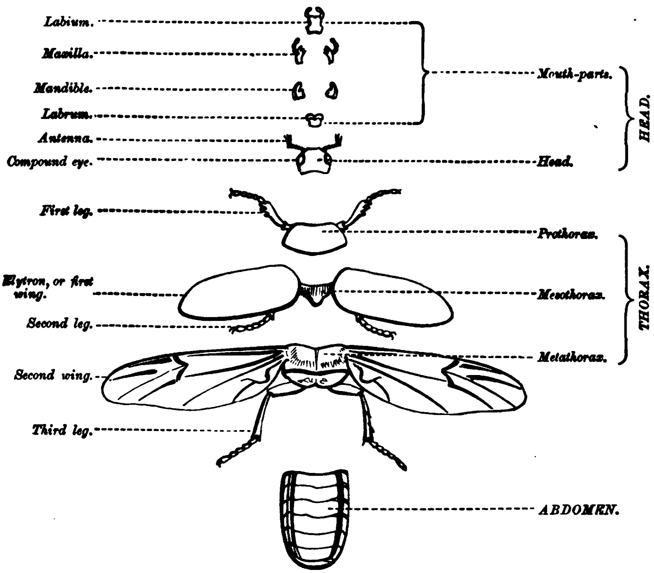


FIG. 110.—Skeleton of common beetle. (After Morse.)

ond pair of legs); the third segment, or *metathorax*, bears the third pair of legs and the second pair of wings, that are elastic membranes stretched over a framework of tubes. The abdomen bears the sting, ovipositor, or spinnerets, as the case may be. The legs are generally composed of from six to nine joints, and usually terminate in two hooks, with perhaps pads or suckers (Fig. 111).

Digestion.—The mouth-parts (Fig. 112, *a*) are modified in different insects for sucking, biting, stinging, etc. The

FIG. 111.—Foot of house-fly, showing the pads by which it clings.

food passes by the œsophagus, *b*, into a membranous stomach called the crop, *c*, and thence, in the biting in-

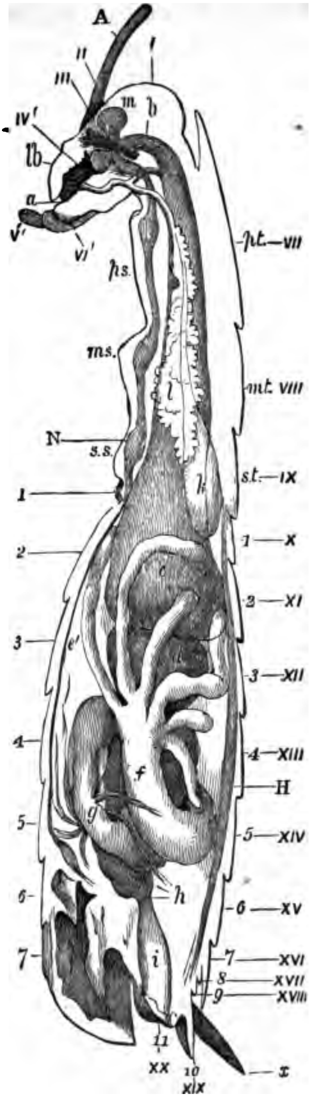


FIG. 112.—Longitudinal and vertical section of a female cockroach (*Blatta*). 1 to XX, somite of the body; 1 to 11, somite of the abdomen; *A*, antenna; *lb*, labrum; *a*, mouth; *b*, œsophagus; *c*, crop; *d*, proventriculus, or second stomach; *h*, intestine; *i*, rectum; *l*, salivary gland; *k*, salivary receptacle. By an error, the duct is made to terminate above instead of beneath the lingua. *H*, position of heart; *m*, cerebral ganglia; *N*, thoracic ganglia; *f*, chyle stomach. (After Huxley.)

FIG. 112.

sects, into a second stomach, or gizzard, *d*, that is provided with muscular walls and chitinous plates. From here it passes to the true stomach *f*, and finally to the intestine *h*.

Circulation.—The heart, *H*, is tubular in shape, extending along the back, and composed of numerous sacs, separated by valves that allow the blood to flow toward the head, where it branches out, returning through the tissues, there being no true veins or arteries.

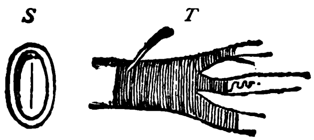


FIG. 113.—*S*, spiracle or breathing-plate, with the slit in the center which opens to take in air. *T*, part of a breathing-tube, showing the spiral thread which keeps it in its round shape.

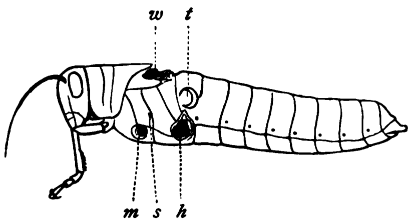


FIG. 114.—Insect showing the spiracles, or openings in the sides of the body which communicate with the air-tubes within the body: *w*, showing where the wings were attached; *h* and *m*, where hind and middle legs were attached; *s*, spiracle on thorax; *t*, tympanum. (After Morse.)

FIG. 115.—Tracheal or air-tube system of a larval dragon-fly. Tracheæ are shaded.

Respiration.—The insects all breathe by a system of air-channels or tubes, and some, as the spiders, by lungs as well. The air-tubes are called *tracheæ*, and are wound with a minute thread (Fig. 113) that seems to preserve their shape. The tracheæ connect with the exterior at various parts of the sides of the body, the openings (Fig. 114) being called *spiracles*, *stigmata*, or *breathing-holes*. The tubes extend over a greater part of the body (Fig. 115), bringing fresh air in contact with the blood in the tissues. This is even accomplished in the wings, so that they serve as lungs as well as organs of flight. Breathing seems to be accomplished by a contraction and expansion of the abdominal segments.

Nervous System.—The nervous system of insects is made up of a chain of ganglia that is connected by a double nervous cord, and occupies the ventral portion of the body. The portion above the œsophagus is called the *cerebral ganglia*. Fig. 112, *m*, shows the brain; and from here nerves pass to the various sense-organs. The ganglia below is called *thoracic* (Fig. 112, *N*), and sends nerves to the wings, legs, and other parts.

Fig. 116.—Larvæ of insects.

Development.—Most insects are produced by eggs, while some appear directly in the adult form. The changes through which the former pass are called *metamorphoses*. The butterflies, beetles, etc., pass through three changes from the egg to the perfect insect. The first stage is called the *larva*—grub, maggot, or caterpillar (Fig. 116). In this form it is worm-like, has numbers of feet, eats voraciously, changes its skin (moults) frequently, and finally in many instances spins a silken case or

Fig. 117.—Cocoons. *A*, showing inside of cocoon, containing the remains of a chrysalis-skin.

cocoon about itself (Fig. 117). The skin is now cast again, and the insect appears a short, seemingly lifeless *pupa* or chrysalis (Fig. 118), in which state it remains a greater or less time, finally shedding its skin and appearing a perfect insect or *imago*. This is known as a complete change. Others, as crickets, dragon-flies, grasshoppers (Fig. 119), pass through a partial change. Insects are found everywhere; far out at sea, as the *Halobates* (Fig. 148), in deep caves, in hot springs, and on the highest glaciers, as the glacier-flea (Fig. 133). The bees and ants live seven years, some locusts thirteen or seventeen years, while the May-flies are born and die within twenty-four hours. In all, about 19,000 species of insects are known.

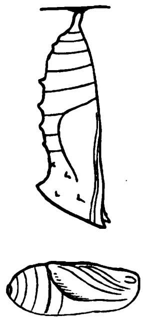


FIG. 118.—Chrysalides. (After Morse.)

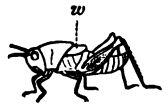


FIG. 119.—Example of incomplete change or metamorphosis. Young grasshopper: *w*, wing just appearing.

Sub-Class I.—MALACOPODA.

Peripatus (*Peripatidæ*).—The *Peripatus* is one of the simplest insects, having a long, soft, and cylindrical body, bearing from twenty-eight to sixty-six feet. Upon the head is a pair of jointed extensible antennæ; the feet are soft, and supplied with two claws. When alarmed, it instantaneously ejects a secretion that seems to crystallize in the air, forming a complete web in front. It is found in the West Indies, Panama, and Cape of Good Hope.

SUB-CLASS II.—CENTIPEDES (*Myriapoda*).

General Characteristics.—Head free; thorax and abdomen continuous; joints cylindrical, and often numbering two hundred, each bearing a pair of locomotive organs.

Order I. **Chilognatha.**—In the Millepedes (Fig. 120), the body is cylindrical, each segment bearing two pairs of

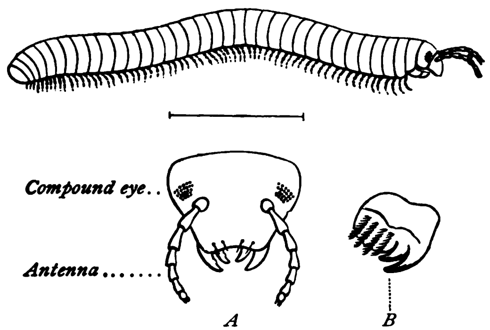


FIG. 120.—A common millepede. The line underneath the figure represents the length of the specimen from which the drawing was made. *A*, a magnified view of the head of the milleped represented above. *B*, a magnified view of the left jaw. (After Morse.)

legs. They are vegetable feeders, and harmless. The eggs are laid in the earth, and the larva at first has only three pairs of legs (Fig. 121). *Spirostrephon*, from the Mammoth Cave, is covered with hair.

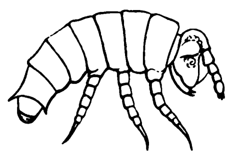


FIG. 121.—Highly magnified figure of a very young millepede, shortly after hatching from the egg.

Order II. **Pauropoda.**—The *Pauropus* has only six segments besides the head. The young have three pairs of feet.

Order III. **Chilopoda.**—The Centipedes (Fig. 122) attain a length of ten or twelve inches, and have a flattened body composed of from 30 to 200 joints or segments. In some the eyes are simple ocelli; in others they are compound. The *Scolopendra heros* is extremely poisonous, the glands being in the two large fangs (Fig. 123). *Cermatia forceps*, of the Middle and Southern States, is also said to be poisonous.

NOTE.—*Scolopendra electra* is a luminous species, and is common in England, Belgium, and France. It is 1½ inch long, and has 140 legs. According to Phipson, the luminosity, like that of some minerals, is only evident after the insect has been exposed to the sun. Another luminous species is found in Asia.

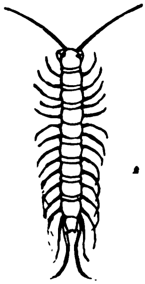


FIG. 122.—Centipede.

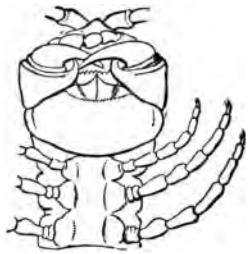


FIG. 123.—*Scolopendra Hopei.* Under surface of head, showing poison-fangs.

Sub-Class III.—SPIDERS AND SCORPIONS (*Arachnida*).

General Characteristics.—The body is in two sections, cephalo-thorax, and abdomen; four pairs of legs, simple eyes, and no antennæ.

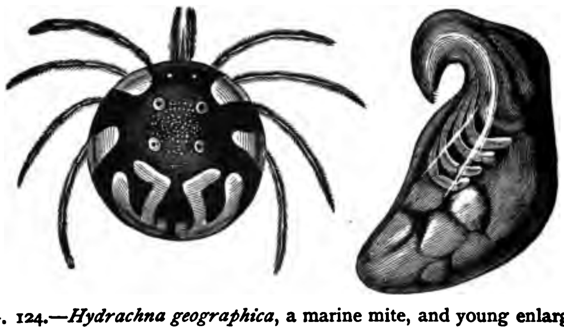


FIG. 124.—*Hydrachna geographica*, a marine mite, and young enlarged.

Order I. **Mites** (*Acarina*).—The mites are mostly parasitic, as the cattle-tick; others are the cheese and sugar mites. The body is oval, and the thorax not separated from the abdomen. Some are marine (Fig. 124). The lowest forms are parasitic in the lungs and liver of man, and in the horse and sheep.

Order II. **Scorpions** (*Pedipalpi*).—In the scorpions the body is plainly segmented and large, the tail long and slender, ending in a curved sting (Fig. 125) that contains two poison-glands. They have crab-like claws, and breathe by lungs as well as tracheæ. In Ceylon they attain a length of twelve inches, in Florida four. In striking, the tail is raised over the back and then struck down.*

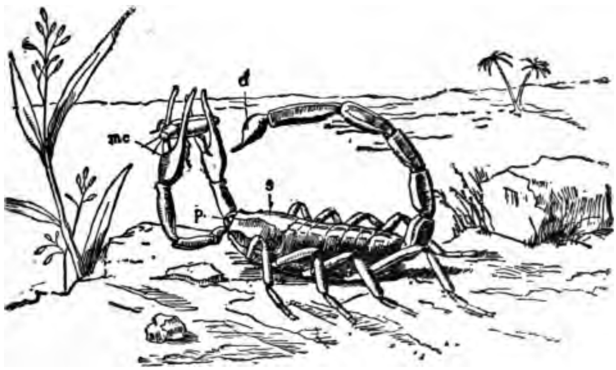


FIG. 125.—Scorpion with cricket in its claws. *s*, carapace; *m c*, mouth-claws; *p*, mouth; *d*, poison-sting.

The young are born alive, and cling to the mother. False or book scorpions (*Chelifer*) occur in books, under stones, and in the bark of trees. They have no poison-gland, and cast their skins in a delicate web, in which they

* At Loggerhead Key, the extremity of the Florida reef, it is interesting to note that the scorpions have obtained a foothold and are very common, living in board-piles, coming out at night, frequently being found and killed in the house, the effect of the sting resembling that of the wasp. The so-termed suicide of the scorpion is similar to the action of a man tearing his hair or biting his tongue in agony, and self-destruction is an accidental result.

FIG. 126.—Spinnerets of a spider. *t*, one of the tubular hairs from the spinnerets, magnified. (After Morse.)

hibernate. In the whip-scorpions the abdomen ends in a long whip or lash. The "Daddy Longlegs" belongs to this order, and, according to Phipson, some are luminous.

Order III. **Spiders** (*Araneina*). *General Characteristics.*—Insects having an unsegmented abdomen connected with the thorax by a delicate

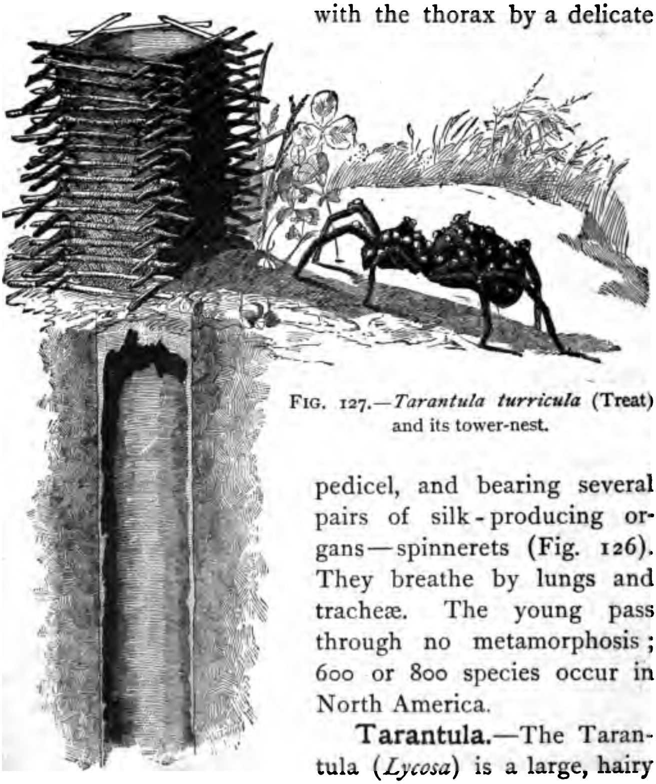


FIG. 127.—*Tarantula turricula* (Treat) and its tower-nest.

pedicel, and bearing several pairs of silk-producing organs—spinnerets (Fig. 126). They breathe by lungs and tracheæ. The young pass through no metamorphosis; 600 or 800 species occur in North America.

Tarantula.—The Tarantula (*Lycosa*) is a large, hairy spider, living under rocks and in holes in the ground, which they often excavate to a depth of nearly a foot, lining the sides with silk, and covering the opening with a scaffolding of mud and wood cemented together. The *Tarantula nidifex* erects a tower over its tube, the foundation-pieces of wood selected being generally the exact shape of the hole. These are piled one upon another precisely as the woodsman builds his log-cabin, until a regular chimney is the result. *T. turricula* (Treat) (Fig. 127) erects a somewhat similar tower; the female carries the young on her back.

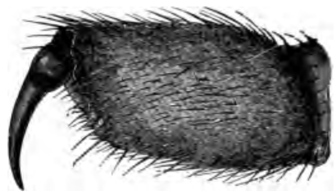


FIG. 128.—Poison-fang of a spider (*Clubiona*), highly magnified.

Crab-Spiders (*Mygale*).—These often measure six or seven inches across, including the legs. They are covered with thick, reddish hair, and possess terrible fangs (Fig. 128). They have four lung-sacs and two pairs of spinnerets. They prey upon birds (Fig. 129) and various small animals.

Mygale Henzii is common on our western plains and in Utah. Some are called trap-door spiders, from the fact that after their well-like nest is excavated they cover the entrance with a circular door that works on a perfect hinge. The dwelling is generally formed in gravelly ground, and material moved piece by piece, until finally a well is sunk perhaps a foot deep. To prevent the sides from caving in, the spider now covers them with a coating of silk, so that the interior presents a perfectly smooth surface. The door is formed of various material, all wound about with silk in a firm, flat, oval mass, the spider whirling itself about in the operation, finally producing a door attached to one side by a silken hinge that fits exactly, even keeping out water, and is so adjusted that it is

FIG. 129.—The bird-spider (*Mygale avicularia*) capturing a humming-bird.

self-closing. Upon the top, leaves or mosses are often placed, evidently to disguise the entrance.

NOTE.—Bates, the naturalist, found a tarantula eating a finch, while near at hand was another finch entangled in a dense white web that was stretched across a hole in a tree. The author once found one, the only living creature, upon a dismantled wreck floating in the Gulf Stream off the northwestern coast of Cuba. When placed in a saucer, its legs extended beyond the edges. Some of this genus are trap-door spiders.

Trap-door Spiders.—The spiders of the genus *Cteniza* and *Nemesia* are remarkable for their nest-building habits. The burrows differ greatly in different species. Generally they are cylindrical shafts sunk into the ground, lined with silk, and covered by a trap-door with a silken hinge, that fits so closely that the opening is never suspected from without. Some plant mosses, etc., upon their doors to mislead enemies, and employ many devices.

NOTE.—On the Island of Timos a *Cteniza* comes out at night, fastens the trap-door open by threads of silk, and spins a web about six inches long. In the morning it is taken down, the trap closed, and every vestige of the nocturnal net removed.

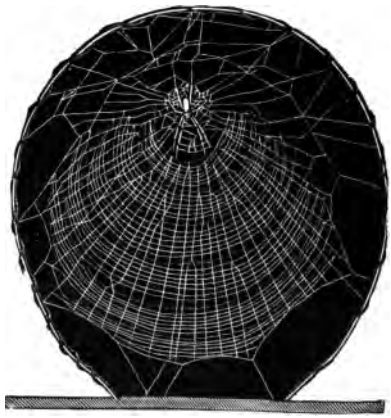


FIG. 130.—Web of *Nephila plumipes*, in a wire ring reduced, from a photograph. (After Wilder.)

The Garden Spiders construct rich geometrical webs (Fig. 130), so delicately arranged that the slightest touch is noticed by the inmate. The spinnerets (Fig. 126) are generally four or six projections pierced with numberless holes, through which a glutinous secretion is drawn that, upon exposure to the air, hardens and forms a silken thread (Fig. 131, *s*) that is seemingly inexhaustible.

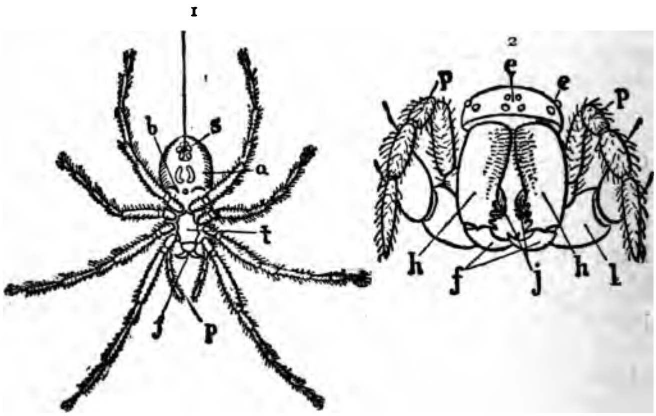


FIG. 131.—Parts of a spider. 1, Under part of a spider's body: *t*, thorax, or chest, from which the eight legs spring, and to which the head is united in one piece; *f*, fangs; *p*, palpi, or feelers, attached to the jaws; *a*, abdomen; *b*, breathing-slits; *s*, six spinnerets with thread coming from them. 2, Front of spider's head: *e*, eyes; *p*, palpi; *l*, front legs; *h*, hasp of fangs; *f*, poison-fangs; *j*, outer jaws.

NOTE.—Professor Wilder wound several miles of silk from the Southern *Nephila plumipes*, the largest spider in the United States (Fig. 130). In the Pacific islands an *Epeira* spins a web strong enough to catch birds. Professor Moseley found a finch entangled in one of their webs. Some spiders spin a web that bears them away through the air like a balloon. The *Dolomedes* builds a raft of leaves and silk, and launches it in search of food. Many mimic their surroundings, while others communicate so rapid a movement to their webs as to become invisible. The *Salticus* leaps through the air after

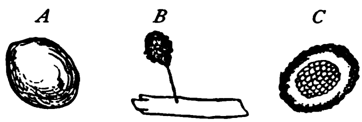
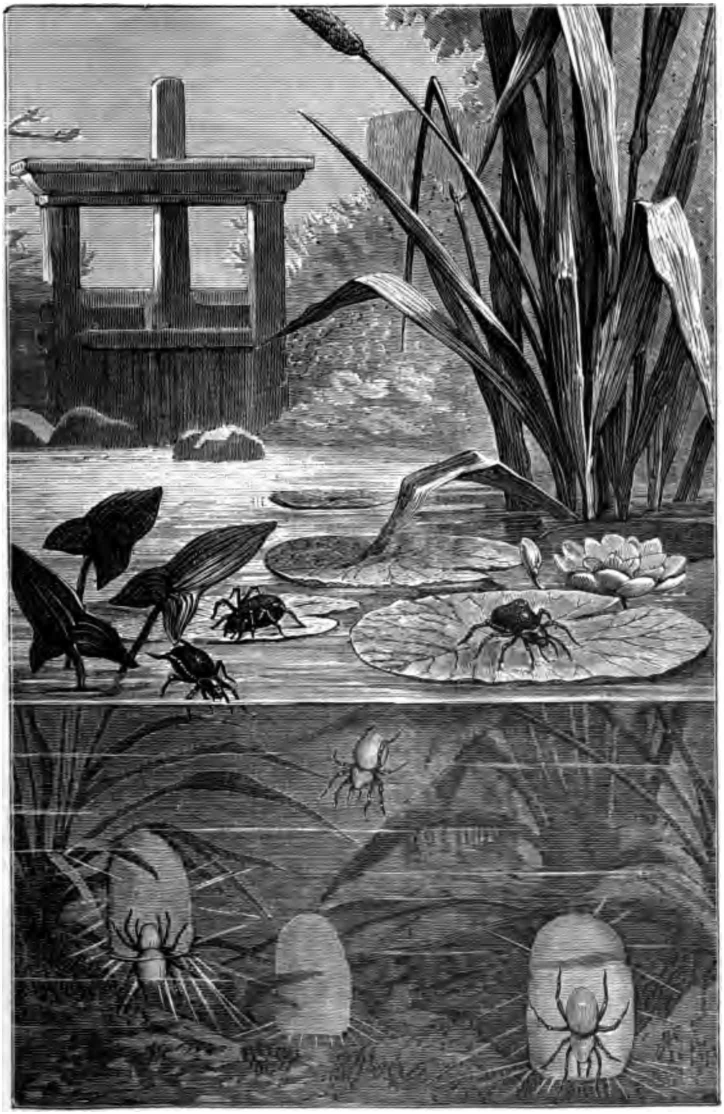


FIG. 132.—Spiders' nests of different kinds, containing eggs. *A* and *C* are common nests in sheds and barns; *B* was found under a board in the field—the part containing the eggs stands upon a stalk. (After Morse).



Aquatic spiders and their diving-bells.

PLATE VIII. PROTECTIVE RESEMBLANCES.

I

2

3

4

Insects that find protection in their resemblance in color and shape to plants: 1. Achias longivideus (male). 2. Heteronotus aronatus (*Diptera*). 3. Hyprauchenia Westwoodii. 4. Bocydium tintinnabulariferum (*Hemiplera*).

its prey; the *Argyronetra aquatica* lives in air-bubbles under water; and the *Attus volans* of Australia has flaps or wing-like extensions of the abdomen, that it elevates or depresses during leaps from plant to plant. The egg-sacs (Fig. 132, *a*) are sometimes attached to the webs, carried about by the mother, or affixed to stalks (Fig. 132, *b*), and resemble small plants.

VALUE.—Spiders are useful in destroying other noxious insects. The silk is of value to opticians as cross-lines in optical instruments, also as a mechanical styptic. The silk of certain spiders has been woven. One of the kings of France possessed a coat made of this silk. In Bermuda the silk of *Nephila* has been used as sewing-silk.

Works on Spiders for further reference.

"Structure and Habits of Spiders," J. H. Emerton; "Harvesting Ants and Trap-door Spiders," J. T. Moggridge; "The Triangle Spider," B. G. Wilder, "Popular Science Monthly," 1875; "Practical Use of Spider-Silk," B. G. Wilder, the "Galaxy," July, 1869; "Pedipalpi of North America," H. C. Wood, Jr., "Journal of Philadelphia Academy of Natural Science," vol. v; "Mites, Ticks, and other Acari," "Popular Science Monthly," vol. xiv; "Termayer's Researches on Spiders' Silk," "Proceedings of Essex Institute," vol. v; "Phalangeræ of the United States," H. C. Wood, Jr., "Proceedings of Essex Institute," vol. vi; "Harper's Monthly," vol. lx, Treat. Packard's "Guide to the Study of Insects."

Sub-Class IV.—SIX-LEGGED INSECTS (*Hexapoda*).

General Characteristics.—The Hexapods have antennæ and two pairs of jaws or maxillæ.

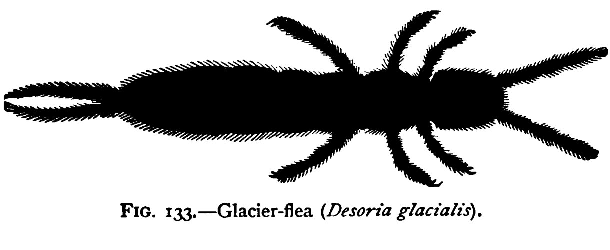


FIG. 133.—Glacier-flea (*Desoria glacialis*).

Order I. **Spring-Tails** (*Thysanura*).—The spring-tails are minute wingless forms that possess a forked spring,

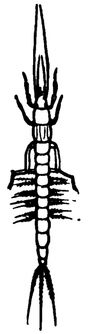


FIG. 134.— Larva of Ephemera.

held in place by a hook, that when released sends them high into the air. A single *Podura* will deposit 1,360 eggs. The glacier-flea (Fig. 133), found upon the glaciers of Europe and on snow-banks of North America and Europe, belongs to the order. Some species have bristles instead of springs, as the *Campodea*, found under stones and old wood.

Order II. **Lace-Winged Insects** (*Neuroptera*). — *General Characteristics.* — Insects having four fine net-veined wings, generally a long, slender abdomen, and mouth adapted for biting.

May-Flies (*Ephemera*).—These remarkable insects are of a greenish-brown color, with gauze-like unequal wings dotted with brown spots. The larva (Fig. 134) is about an inch long, its sides bearing several plume-like gills by which it breathes in the water.

VALUE.—In some countries they occur in such numbers that they are used as guano. The Central Africans make bread of them.

Dragon-Flies (*Libellulidæ*). — The darning-needles (Fig. 135) are adorned with lustrous metallic tints and lace-like wings. The abdomen is long and bears no sting; the eyes are compound and accompanied by three ocelli. The eggs are deposited in the water, and are hatched into flattened larvæ (Fig. 135, *a*) that lead an aquatic life for about two years. They secure their prey with a proboscis with hooks and joint that when at rest folds over the face and is called the mask, *m*. The pupa, *b*, finally creeps up the stem of a plant, bursts from its old skin, and appears a perfect insect, *c*.*

* In Lombok, Malay Archipelago, the natives catch the large species and eat them. The American species are voracious; the larvæ catch young fish, and the adult has been seen to take minnows from a pond.

Caddis-Flies (*Phryganea*).—The caddis-flies often have antennæ twice as long as the body. The eggs are

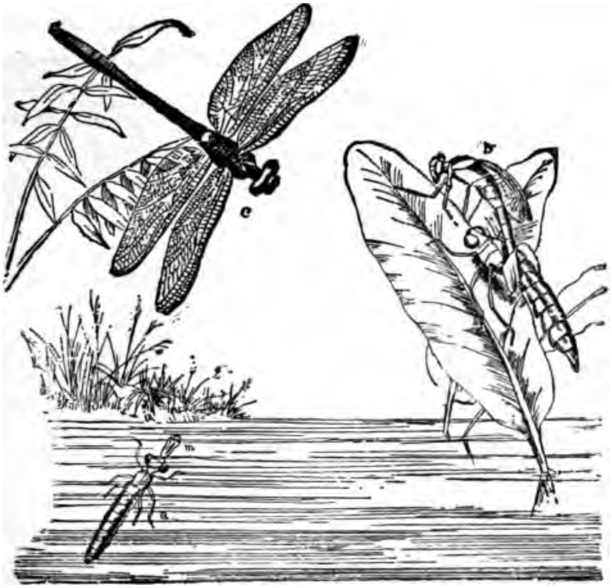


FIG. 135.—Life of the dragon-fly, about one half life-size. *a*, grub living in the water; *m*, mask or long lower lip with which it seizes its prey; *b*, dragon-fly creeping out of its last grub-skin; *c*, perfect dragon-fly on the wing.

carried about by the female, attached to her abdomen, and finally deposited upon some water-plant where they hatch, the larvæ seeking the bottom, where they build coverings (Fig. 136) of wood, stone, shell, or sand. When about to change into a pupa they close the mouth of the case, finally biting their way out, and crawling to the surface a perfect insect.

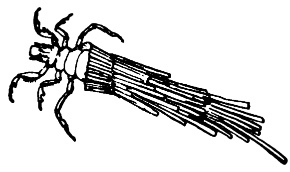


FIG. 136.—Caddis-worm, with its case, made of sticks.

Ant-Lion (*Myrmeleon*).—The ant-lion in its complete state resembles a small dragon-fly. The eggs are laid in dry, sandy places, the young larvæ when hatched excavating a pitfall by whirling their bodies about, and throwing the sand out (Fig. 137). The pit complete, the ant-lion

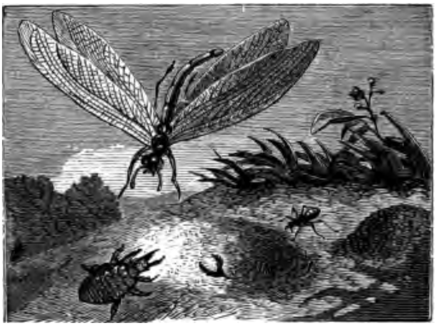


FIG. 137.—Ant-lion. Adult, and larvæ, the forceps of one showing at the bottom of the pitfall.

conceals itself at the bottom, only its forceps appearing, ready to grasp the ants that tumble in. This hunting life is led for two years, when it envelops itself in a round ball of sand and silk, and in three weeks breaks out a perfect insect.

NOTE.—The aphis-lion (*Chrysopa*) lays eggs that mimic delicate plants or fungi. They appear growing from the ground attached to stalks, and are placed near food adapted to the young.

White-Ants (*Termitidæ*).—These insects in North America are generally of four kinds: winged kings and queens, and soldiers and workers that are wingless. The workers are the smallest and youngest, and build the nest, attend the queen, young, etc. The soldiers are those that have undergone the first metamorphosis.* They have large

* Packard considers the soldiers and workers specialized forms.

heads and powerful jaws. The African termites * build immense nests (Fig. 138), and the queen is often 40,000 times larger than the workers.

VALUE.—Eaten in Central Africa, and the nests used as fuel.

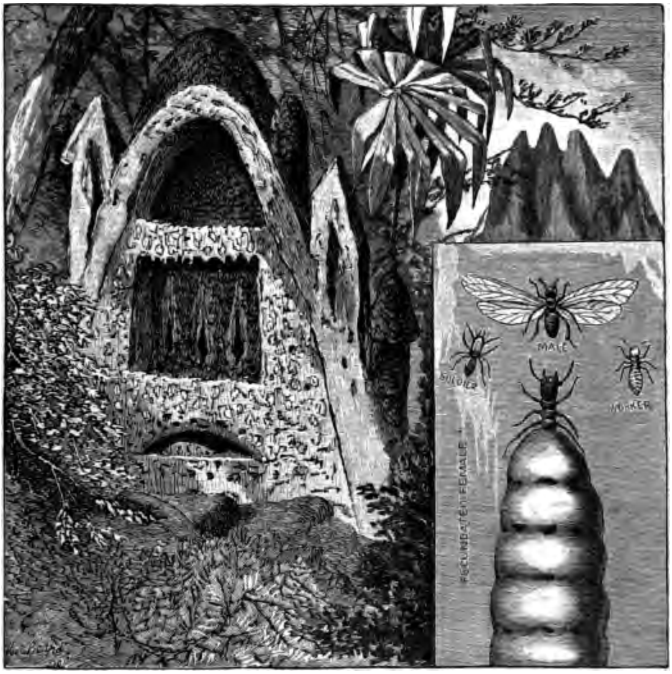


FIG. 138.—White ants, showing enormous queen, male, worker, and soldier, and section of nest, showing the queen's cell.

* Their hills have been seen twelve feet high and nearly one hundred feet in circumference. They are divided into various apartments, the semi-egg-shaped cell in the center containing the imprisoned queen who grows sometimes to a length of six inches. The workers attend the royal chamber, removing the eggs that are laid by millions, and placing them in nurseries or cemented cells made for the purpose. The workers do great damage, and in the Isle of France a new building was ruined in a few months by them. In Colombo, Ceylon, a large house fell completely in pieces, the result of their ravages.

Works on Neuroptera for further reference.

"Synopsis of described Neuroptera of North America," H. A. Hagen, "Smithsonian Miscellaneous Collections," vol. iv, No. 1, 1862; "Transformations and Anatomy of Corydalus Cornutus," Holdeman and Leidy, "Memoirs American Academy," vol. iv; "Immature State of the Odonata," L. Cabot, "Catalogue of Museum Comparative Zoology," No. 5, 1872; "Caddis-Worms and their Metamorphoses," "Popular Science Review," July, 1868.

FIG. 139.—Praying mantis.

Order III. **Straight-Winged Insects** (*Orthoptera*). —*General Characteristics.*—Insects having four straight, narrow, net-veined wings; metamorphosis complete; about 5,000 species are known.

Mantis (*Mantidæ*).—These insects (Fig. 139) have elongated bodies, with the fore-legs toothed and adapted for grasping their prey, and are remarkable for their curious postures, that, with their coloring, is protective. They are voracious, attacking their fellows and other insects. *Mantis argentina*, from South America, according to Burmeister, catches small birds. The eggs are deposited in oblong clusters on fences, assuming the general color of the surroundings.

NOTE.—From the supplicating position of the fore-legs (Fig. 139), they are called the praying mantis, and in Africa certain natives venerate them. A pink mantis in Java mimics an orchid, and captures the insects that alight on it by mistake. Another, in the Philippine Islands, resembles a dried leaf.

Walking-Sticks (*Phasmidæ*).—The walking-sticks (Fig. 140) resemble the *Mantidæ*, but the fore-legs are not adapted for grasping. They are wonderful mimics, their bodies resembling old and new twigs. One even mimics a moss-grown stick, its legs and body being covered with curious irregular growths. In the Malay Archipelago and South America they attain a length of fourteen inches.

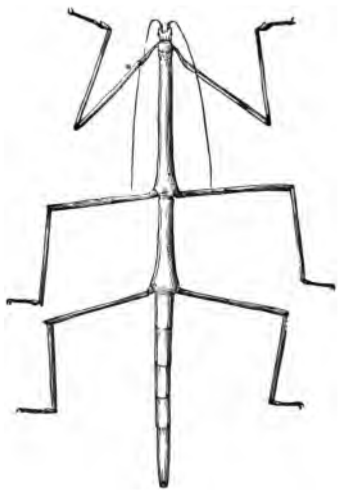


FIG. 140.—Walking-stick (*Phasma*), a wingless orthopterous insect.

Walking-Leaves (*Phyllium*).—The wing-covers, in these insects (Fig. 141), so imitate leaves that they are readily taken for them. Even the veins and midrib of the leaf are often perfect, and mold-spots of various colors are also mimicked in some, so that the insect resembles a dried leaf well decayed. The eggs might even be taken for deeply-ribbed seeds.

Grasshoppers (*Acrydii*).—The grasshoppers (Fig. 142) have a compressed body, short antennæ, and hind-legs adapted for leaping. Their noise, which is often deafening, is made by rubbing the thighs (Fig. 143) against the fore-wings. Their eggs are deposited, 50 to 100 at a time, in a cocoon-shaped mass, in the ground, though the female has no produced ovipositor. The organs of hearing are at the base of the abdomen.

FIG. 141.—*Phyllium siccifolium*, feeds on leaves, and mimics fresh leaves.

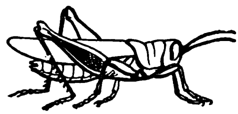


FIG. 142.—Grasshopper.

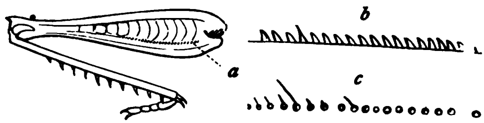


FIG. 143.—Leg of a grasshopper, magnified, showing ridge of fine teeth on the inside of the leg, marked *a*, by which the insect rasps the wing; *b*, *c*, different views of ridge of fine teeth, highly magnified.

NOTE.—Some species migrate in such vast numbers that they have been known to darken the sun. Their bodies, once washed ashore on the African coast, formed a wall fifty miles long and three or four feet in height. Jaegar passed through a swarm in Russia 400 miles long and two feet deep. They threatened a famine, and 30,000 soldiers, armed with shovels, were sent out to reduce their numbers. In 1478 30,000 persons starved to death in Russia, the result of their raids.

Locusts (*Locustariæ*).—The green locusts (Fig. 144) have large heads, long, slender antennæ and legs. The base of the anterior wing is transparent, forming a drum, with which the males utter shrill calls, the sounds in some species being different at day and night.

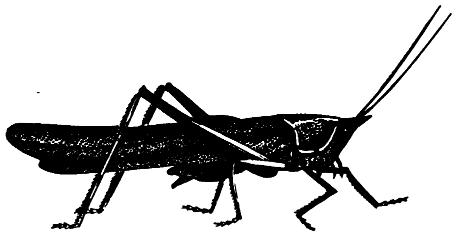


FIG. 144.—Meadow locust (*Orchelimum vulgare*).

The female has a long ovipositor for boring holes in the ground and wood for the reception of its eggs. The katydid is a familiar form, making the curious noise from which they are named by rubbing the inner surface of the hind-legs against the outer surface of the front-wings.

NOTE.—Mr. Belt observed a locust that so resembled a leaf that the ants ran over it, completely deceived.

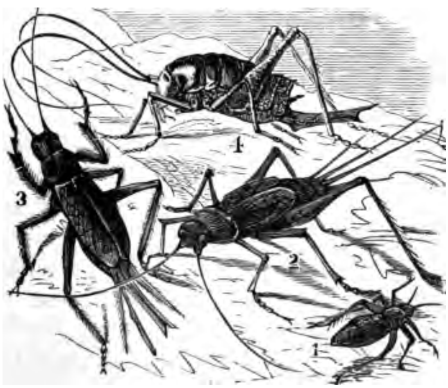


FIG. 145.—1, wingless cricket; 2 and 4, field-cricket; 3, house-cricket.

Crickets (*Gryllidæ*).—The crickets (Fig. 145) have a somewhat cylindrical body, large head, placed vertically, and long antennæ, while the ovipositor is often as long as the entire body. The shrill cry is the call of the male, made by elevating the fore-wings and rubbing them on the hinder ones. Their eggs often exceed 300 in number, and are generally placed in the ground.

NOTE.—The mole cricket shows great affection for its eggs, placing them in underground cemented cells, and moving them near the surface or deeper, according to the weather. They have obtained such a hold upon the extreme outer keys of the Florida reef that it is almost impossible to cultivate anything.

Works on Orthoptera for further reference.

"North American Orthoptera and Catalogue of New England Species," S. H. Scudder, in "Boston Journal of Natural History," vol. vii; "Songs of the Grasshoppers," S. H. Scudder, "American Naturalist," vol. iii, p. 113.

Order IV. **Half-Winged Insects** (*Hemiptera*).—*General Characteristics.*—Bugs having the mouth-parts in the form of a sucking beak; the fore-wings thickened at their base.

Bird-Lice (*Mallophaga*).—These are low forms, parasitic upon the hairs and feathers of other animals. *Nirmus* lives on birds, *Gyropus* on the porpoise, etc.

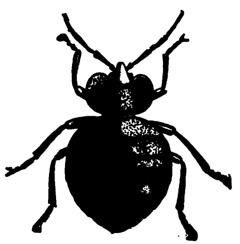


FIG. 146.—Bed-bug.

Bed-Bugs (*Membranacei*).—In this family are found the flat-bodied bed-bugs—*Cimex* (Fig. 146). The eggs are oval, the young escaping by pushing up a regular lid at one end. They infest wood-work, pigeons, swallows, bats, and various animals.

Chinch-Bugs (*Lygæidæ*).—In the common chinch-bug the female deposits about 500 eggs twice in a season. They appear upon wheat in June, and afford a good example of incomplete metamorphosis (Fig. 147).

NOTE.—In 1864 chinch-bugs caused a loss in wheat and corn of $100,000,000; and in 1850 their ravages in Illinois alone amounted to $4,000,000.

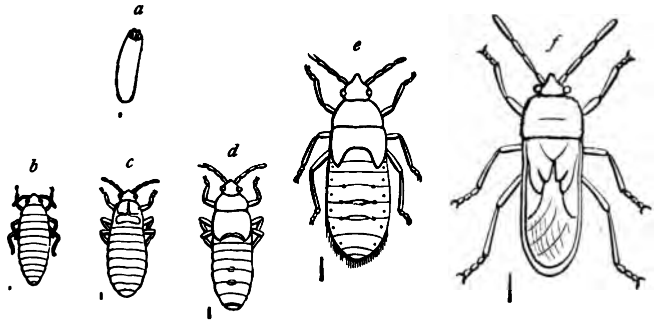


FIG. 147.—Different stages of the chinch-bug. *a*, egg; *b*, newly-hatched larva; *c*, larva after first moult; *d*, larva after second moult; *e*, pupa; *f*, perfect insect.

Water-Measure Insects (*Hydrometridæ*).—These are narrow, boat-shaped insects, having long legs with which they dart over ponds and streams. The *Halobates* (Fig. 148) is found on the ocean, hundreds of miles from land, with its eggs.

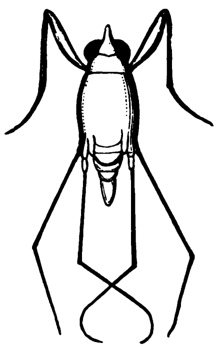


FIG. 148.—*Halobates*, an insect that goes to sea.

Water-Boatman (*Notonectidæ*).—These aquatic insects dart about upon their backs with great rapidity, using their hind-legs, that are edged with strong cilia, and blade-like, as oars. They fly, swim, and dive with equal ease. The eggs are attached to aquatic plants.

Harvest-Flies (*Cicadidæ*).—The seventeen-year Cicada (Fig. 149) is wedge-shaped, with a broad head and prominent eyes. The shrill sound is made by a drum-like organ at the base of the abdomen. The eggs, num-

FIG. 149.—Seventeen-year cicada.

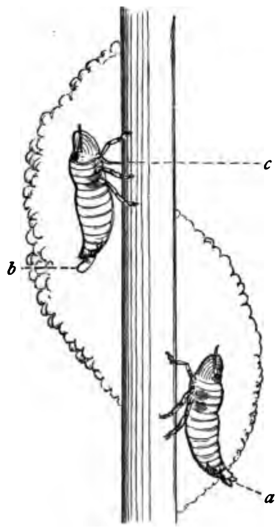


FIG. 150.—A portion of a grass-stem, with the young froth-insects (*Ptyelus*) magnified. *a*, the insect reaching out the hinder part of the body to secure a bubble of air; *b*, an insect allowing a bubble of air to escape in the fluid—the dotted line *b* indicates the bubble; *c*, the mouth-parts, like a sting, piercing the grass. (After Morse.)

bering 400 or 500, are deposited the last of May in holes in the twigs of the oak, so formed by the ovipositor that the wood covers them. They hatch in about six weeks, the larvæ burrowing in the ground and remaining nearly seventeen years, then appearing in the adult form. Allied to them are the lantern-flies (*Fulgoridæ*).*

Leaf-Hoppers (*Cercopidæ*).—The tree- or leaf-hoppers are remarkable for their strange shapes. They are small, with broad, triangular heads, and hind-legs adapted for leaping. The froth-insect

* The following authors have expressed their belief from observation and other sources in the phosphorescent properties of the *Fulgoridæ*: Madame Merian, Dr. Donovan, author of "Insects of India," Marquis Spinola, a colleague of Mr. Westmael, Lady Seymour, and Dr. Phipson.

(*Ptyelus*) is common in the grass in early summer. When hatched, the young crawl up blades of grass, puncture them with their mouths, and suck the juice, a watery fluid escaping from various pores of the insect and completely covering it. To obtain air, its tail is thrust through the fluid (Fig. 150, *a*), seizing a bubble by means of claspers, that passes along beneath the abdomen, entering the spiracles. After a time the liquid becomes filled with air, *b*, and assumes the frothy appearance familiar as frog-spittle, from which the perfect insect finally escapes.

Bark-Lice (*Coccidæ*).—The bark-lice are minute scale-like insects, the males alone having wings. The cochineal (Fig. 151) is a familiar form of the family.

VALUE.—The cochineal industry gives employment to thousands of persons. From *Coccus siensis* comes wax; 400,000 pounds have been obtained in a single year, and made into candles, etc.

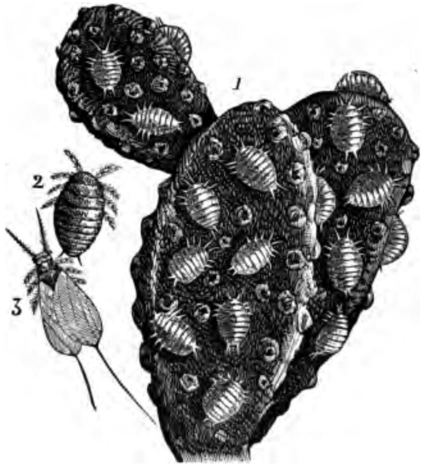


FIG. 151.—1, Cochineal insects on a branch of cactus; 2, female; 3, male.

Plant-Lice (*Aphidæ*).—These insects (Fig. 152) have flask-shaped bodies and a three-jointed beak. They multiply in a marvelous manner. Eggs are deposited by the impregnated female in the autumn that hatch in the spring, producing, as a rule, wingless forms, that in turn produce not eggs but living winged or wingless young, that in ten or eleven days produce others, and so on, so that the original female may be represented in the twelfth generation by one quintillion descendants, all born in a single summer. Upon the approach of cold weather, or from a lack of food, males and females are produced by the viviparous form, and eggs are laid that in the spring give rise to successive broods, as above.

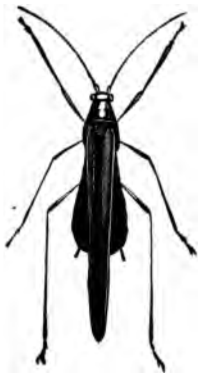


FIG. 152.—Aphis.

Order V. **Beetles** (*Coleoptera*).—*General Characteristics.*—Insects having their fore-wings thickened, forming horny sheaths, called *elytra*, or wing-covers for the hinder pair, that are principally used in flight; mouth-parts adapted for biting; metamorphosis complete.

The **Girdler** (*Oncideres*).—This beetle displays remarkable intelligence in providing for its young. The eggs are deposited in perforations in the tender brushes of hickory, and, as the young require dead wood to eat, the mother girdles the limb below the eggs with her mandibles, so that it dies by the time the larva hatches.

Spring-Beetles (*Elateridæ*).—These beetles are light-givers (Fig. 153), and when placed upon their backs have the power of springing repeatedly into the air by using a spine situated between the legs. The larvæ are known as wire-worms, and feed upon vegetable matter, sometimes remaining five years in the larval state. The yellow luminous spots are upon

FIG. 153.—A luminous beetle (*Pyrophorus noctilucus*).

each side of the thorax, and emit a vivid light visible even in broad daylight.

NOTE.—The light of the common fire-fly (*Lampyris*) gives a spectrum from which blue and violet are omitted. Jaeger, the naturalist, states that the Elaters were frequently the means of saving his life by lighting his way out of the dense forests of St. Domingo.

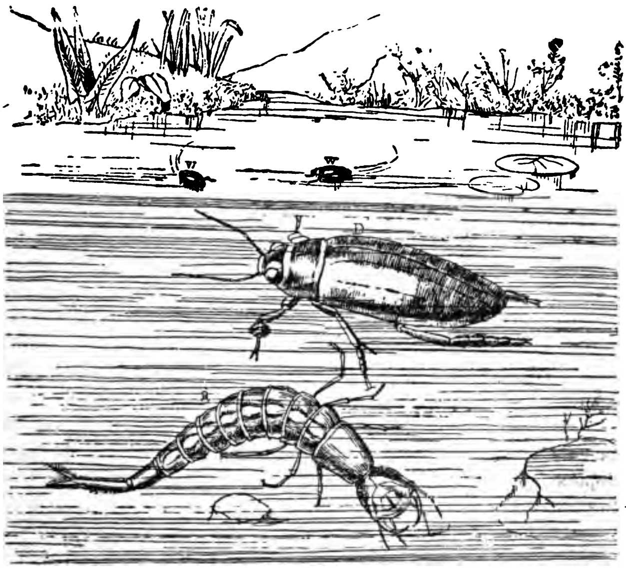


FIG. 154.—Diving-beetle (*Dytiscus marginalis*). *g*, grub, showing pincers.

Diving-Beetles (*Dytiscidæ*).—These aquatic beetles (Fig. 154) are of an oval or rounded form, with the posterior legs fringed for swimming, and feet provided with suckers (Fig. 155). The larvæ are ferocious creatures, called water-tigers (Fig. 154, *g*), having flattened heads and scissor-like jaws, with which they capture small fishes, tadpoles, and insects. The body ends in a pair of respiratory tubes, that are thrust into the air. When ready to change, the larva creeps ashore, builds a round cell, and in five days assumes the pupa state, a few weeks later appearing as a full-fledged beetle. Others of more or less interest are the long-horned beetles (*Cerambycidæ*), weevils (*Curculionidæ*), tiger-beetles (*Cicindela*), ground-beetles (*Carabus*), burying-beetles (*Silphidæ*), etc.

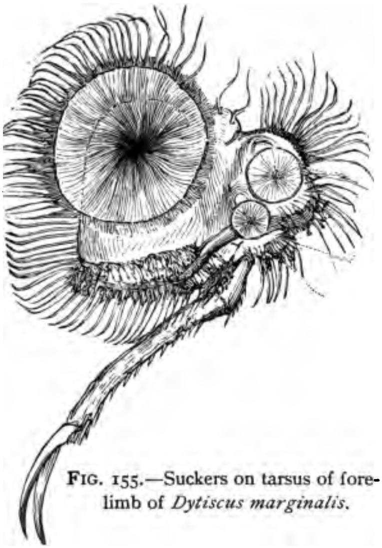


FIG. 155.—Suckers on tarsus of fore-limb of *Dytiscus marginalis*.

Works on Coleoptera for further reference.

"List of Coleoptera of North America," J. L. Le Conte, "Smithsonian Miscellaneous Collections," vol. vi, No. 3; "Larval Habits of the Blister-Beetles, and Remarks on other Species of the Family Meloidæ," C. V. Riley, "Transactions of St. Louis Academy," vol. iii, No. 4; "Colorado Potato Beetles," C. V. Riley, "Popular Science Monthly," vol. vii; "Annales des Sciences Naturelles," 1869–'70.

Order VI. **Two-Winged Insects** (*Diptera*).—*General Characteristics.*—Two-winged insects with mouths formed for sucking or lapping, composed of from two to six needle-like bristles forming a proboscis encircled in a sheath; metamorphosis complete.

FIG. 156.—Blue-bottle fly (*Musca vomitoria*), larva and pupa.

Flies (*Musca*).—The common fly hibernates in winter. The eggs are deposited in offal about stables, remaining in the pupa state

FIG. 157.—Tongue of blow-fly.

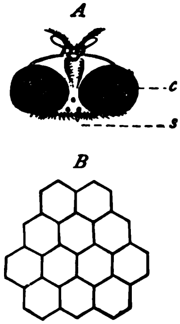


FIG. 158.—Showing compound and simple eyes of fly. *A*, head, enlarged 8 times: *c*, compound eye; *s*, simple eyes. *B*, portion of the surface of a compound eye, highly magnified.

(Fig. 156) about fourteen days. The proboscis of the fly (Fig. 157) is a fleshy, tongue-like organ bent under the head when at rest. In flying, the wings describe a figure 8 in the air, making 19,800 revolutions in a minute, or 9,400 simple oscillations. The eyes (Fig. 158) are both compound and simple. The feet (Fig. 111) have delicate pads for clinging upon smooth surfaces.

Fleas (*Pulicidæ*).—The fleas (Fig. 160) are wingless, have a compressed body, and

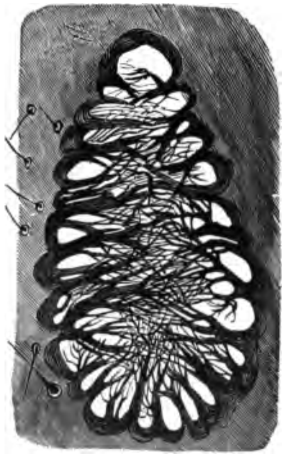


FIG. 159.—Spiracle of a fly.

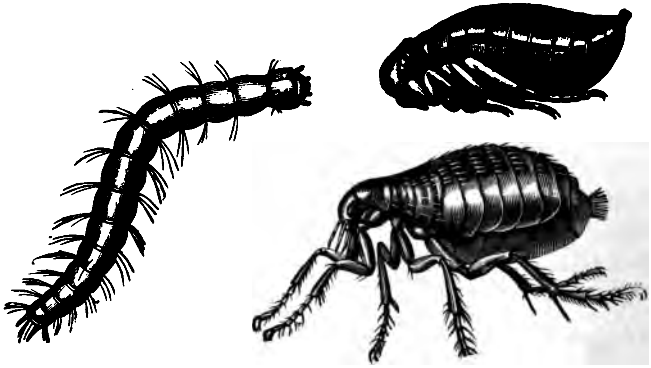


FIG. 160.—Metamorphosis of the flea (*Pulex irritans*).

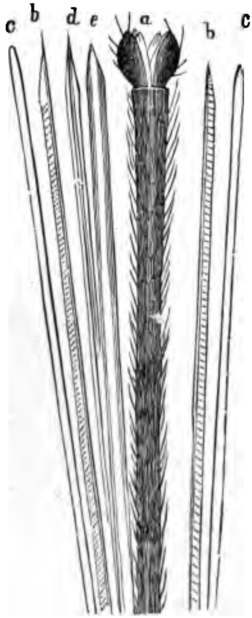


FIG. 161.—Lancets of the female gnat: *a*, labium; *b*, *b*, mandibles; *c*, *c*, maxillæ; *d*, tongue; *e*, labrum.

two simple eyes. The eggs of the cat-flea are eight or ten in number, oval, and $\frac{1}{48}$ of an inch long. The larva resembles a minute caterpillar, and has four long hairs on the side of each joint. In twelve days in summer, in which time the larvæ attain their full growth, they inclose themselves in a small silken cocoon, remaining in this condition from eleven to sixteen days, finally appearing in the pupa form.

NOTE.—If a man could jump as high in proportion as a flea, a leap over the Capitol at Washington would be an easy feat. A flea can draw one hundred times its weight, and so easily tamed are these minute creatures that a trained company of them was exhibited in New York a few years ago. Through a magnifying-glass they could be seen standing erect, drawing carriages in which were seated other fleas; others marched to and fro armed with spears and hauling cannon, while others still, as prisoners, dragged about chains and balls.

Mosquitoes (*Culicidæ*).—The gnats and mosquitoes have long and slender mouth-parts, the sucker consisting

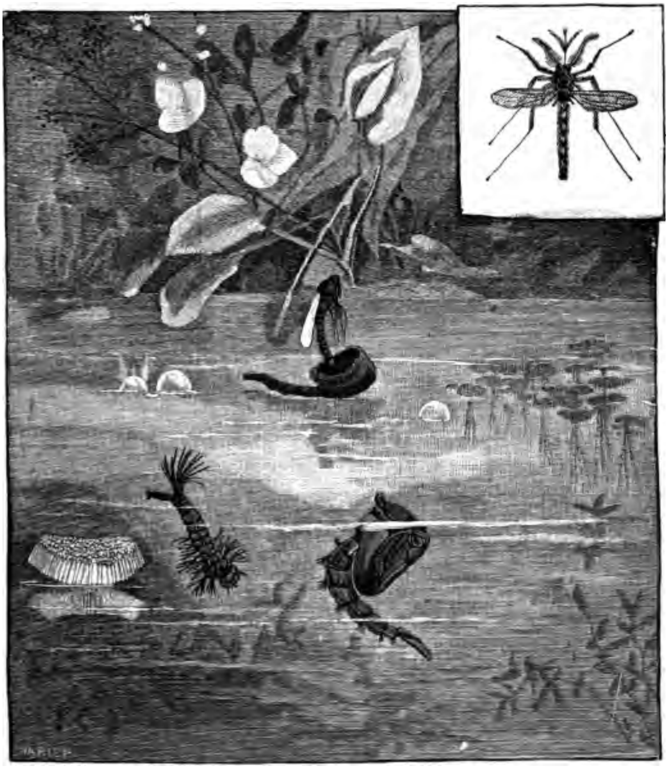


FIG. 162.—Metamorphosis of mosquito. Eggs, larva, later stage on the raft, and adult.

of six bristles (Fig. 161) folded together in a gutter-like case. Their legs are long, and body elongated and slender, antennæ fringed (Fig. 163). The eggs (Fig. 162) are deposited on the water, and the larvæ breathe by a star-shaped organ at the hinder extremity, through which air passes to the tracheæ. They finally shed their skins and appear as pupæ, in which state they breathe through two tubes in the thorax. In a few days the skin breaks between the breathing-tubes and the insect emerges, and, after floating about for a while on the old skin as a raft, it flies away a perfect insect.

FIG. 163.—Antenna of mosquito, magnified.

NOTE.—In the small town of Elizabethport, Russia, in the month of June, 1830, 30 horses, 40 foals, 70 oxen, 90 calves, 150 hogs, and 400 sheep were killed by mosquitoes alone. The females generally do the most damage.

Works on Diptera for further reference.

"Transformations of the Common House-Fly, with Notes on Allied Forms," A. S. Packard, Jr., "Proceedings of the Boston Society of Natural History," vol. xv; "Catalogue of Described Diptera of North America," R. Osten-Sacken, in "Smithsonian Miscellaneous Collections," vol. iii, No. 1, 1862; "Animal Parasites and Messmates," Van Beneden.

FIG. 164. — Head of Sphinx-moth, showing coiled tongue, and pollen-masses that have been taken from some flower, attached to the eyes.

Order VII. **Butterflies and Moths** (*Lepidoptera*).—*General Characteristics.*—Small-headed insects with four wings, which with the body are covered with scales; the tongue consisting of two tubular or hollow threads adapted for suction, and coiled when not in use; metamorphosis complete, the larvæ or caterpillars having abdominal legs.

Moths.—*General Characteristics.*—The moths are, as a rule, nocturnal or night-fliers, and are distinguished from the butterflies by their feathered antennæ (Fig. 164).

Dwarf-Moths (*Tineidæ*).—The common clothes-moth deposits its eggs in woolens, the white larvæ creating much damage in making their cocoons.

Silk-Worm Moths (*Bombycidæ*).—These large moths have heavy, thick bodies, small heads, the tongue short and almost useless. The eggs are deposited upon the mulberry (Fig. 166) and other leaves, the young worms eating for about a month, and then forming a yellow or

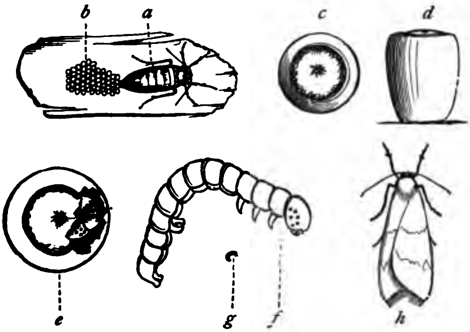


FIG. 165.—Canker-worm moth, eggs, and worms. *a*, female canker-worm moth laying her eggs, *b*; *c*, top-view, and *d*, side-view, of an egg, magnified; *e*, canker-worm eating its way out of the egg, magnified; *f*, magnified view of canker-worm; *g*, natural size of canker-worm after leaving the egg; *h*, male canker-worm moth. (After Morse.)

FIG. 167.—Swinging cocoon of a South American moth.

white cocoon. They now change to a chrysalis, and in eight or nine months escape, a perfect insect. A South American member of this family has a swinging, basket-like cocoon (Fig. 167).

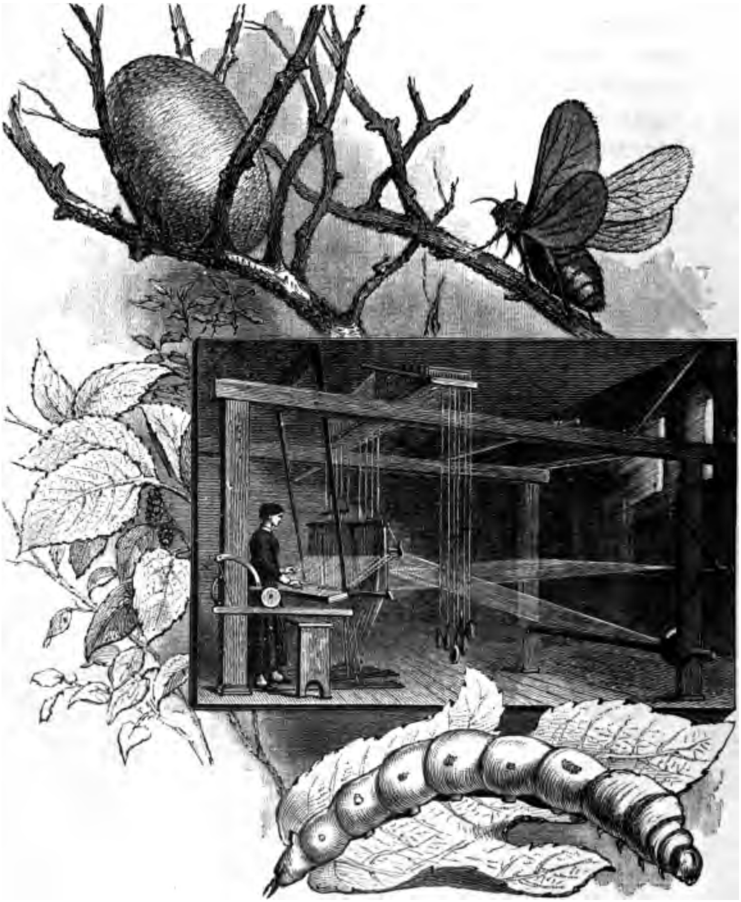


FIG. 166.—The silk-worm, moth, and cocoon, on a mulberry branch. With view of silk works, illustrating the economic value of the worm.

NOTE.—In France and Italy four days are required to form the cocoon, while in England and certain parts of India forty-six days are necessary for its completion; 360 of these cocoons weigh 1¼ pound. In the United States the *Telia polyphemus* is valued for its silk. Little windows have been cut in their cocoons and mica inserted, so that the growth of the chrysalis might be observed.

VALUE.—The silk goods produced yearly in the United States alone are valued at $27,000,000.

FIG. 168.—Death's-head moth.

Hawk-Moths (*Sphingidæ*).—The hawk-moths are large, swift-flying insects, with stout, spindle-shaped bodies, the tongue remarkable for its length. The curious death's-head moth (Fig. 168) belongs to this family.

VALUE.—The moths fertilize flowers, carrying pollen from one to another, often attached to their eyes (Fig. 164).

Butterflies (*Papilionidæ*).—*General Characteristics.*—The butterflies are day-flying *Lepidoptera*, and distinguished from the moths by their knobbed antennæ.

Vanessa.—In this genus (Fig. 169) the wings are richly marked. The larva is cylindrical, and covered with stout, long-branching spines. The *V. antiopa* is one of the commonest forms, and famous for its habits of hibernation.

FIG. 169.—Metamorphosis of the peacock butterfly (*Vanessa Io*).

Sulphur-Butterflies (*Colias*).*—In this family the wings are rounded, and form a gutter for the reception of the abdomen. They are the commonest butterflies we have.

* In some countries they flock upon certain trees, completely covering them, so that in the sun they appear to have a golden hue. Darwin met a vast cloud of them, ten miles at sea, off the Bay of San Blas, and as far as could be seen the swarm extended. Sir Emerson Tennent observed a flock in India that was several days in passing a given point at a high rate of speed. Sir Robert Schomburgh observed a cloud of another genus crossing the Essequibo River, South America, that was nine miles wide, and was nine hours in passing the stream.

Leaf-Butterflies (*Kallima*).—When on the wing the East Indian *Kallima paralekta* presents a brilliant purple color, but when it alights it seems to disappear from view,

FIG. 170.—The protective resemblance of the leaf-butterfly (*Kallima*). (After Wallace.)

so exactly resembling a leaf (Fig. 170) that persons fail to see it when within a few inches. The tail of the hind-wings is pressed against the limb, forming the stem and completing the deception.

NOTE.—A butterfly observed by Wallace in the Malay Archipelago, when pursued by birds, imitated the flight of a poisonous butterfly so effectually that the pursuers gave up the chase. *Kallima Hugeli*, of India, when not in flight, mimics dry oak-leaves, and can hardly be distinguished from a dead leaf. The Indian butterfly *Melanitis* mimics various species of fungi, utterly disappearing from sight when it alights a few feet away among the dry spikes of pine-leaves, etc.; while in the Indian *Kallima machis* no two species are alike, all resembling dead leaves, even the minute fungi growing upon them being imitated in various ways.

Works on Butterflies and Moths for further reference.

"List of Butterflies of North America," H. S. Scudder, "Buffalo Academy of Science," vol. viii; "North American Silk-Worms," L. Trouvelot, "American Naturalist," vol. i; "Silk-Worms and Silk-Culture," in "Popular Science Monthly," vol. iii; "Monograph of the Geometrid Moths of North America," A. S. Packard, Jr., "Memoir of Hayden's Survey," vol. x; "List of Noctuidæ of North America," A. R. Grote, "Bulletin of the Buffalo Academy of Natural Science," vol. ii, 1874.

Order VIII. **Membrane-Winged Insects** (*Hymenoptera*).—*General Characteristics.*—Insects having transparent wings with few veins. The mouth-parts adapted for lapping, biting, or cutting. The females of some have a sting or piercer. Metamorphosis complete.

Horn-Tails (*Uroceridæ*).—The males have a long horn on the abdomen. The saw of the female is attached to the middle of the abdomen, extending far beyond it.

FIG. 171.—Gall-fly.

Gall-Flies (*Cynipidæ*).—To these insects (Fig. 171) are due most of the excrescences called galls, found upon oaks and other plants. They have short, broad heads, the thorax oval and thick, the abdomen compressed and attached to the thorax by a short, delicate peduncle. The females puncture a leaf or branch with their ovipositors; the blades of the latter divide, and the egg is forced through this channel into the wound. An abnormal growth of wood is formed about it, from which in time the perfect insect escapes.

VALUE.—A decoction of certain galls, with sulphate of iron, forms the principal ingredient of ink.

FIG. 172.—Ichneumon-fly, showing mechanism of ovipositor.

Ichneumon-Flies (*Ichneumonidæ*).—These insects (Fig. 172) are remarkable for depositing their eggs in other insects, using for the purpose a long ovipositor that is protected by a sheath composed of four stylets. *Rhyssa persuasoria* bores into solid wood in search of its prey. The larva, a soft, footless grub, feeds upon its host, and when about to become a pupa spins a cocoon, from which it escapes in the adult form.

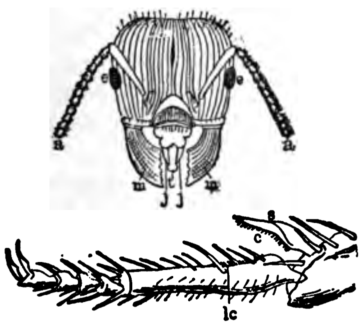


FIG. 173.—Ant's head and foot. Head: *e*, *e*, eyes; *a*, *a*, antennæ; *m*, *m*, mandibles; *j*, *j*, jaws; *t*, tongue. Foot: *s*, spur; *c*, *s*, comb of spur; *lc*, leg-comb.

Ants (*Formicariæ*).—The ants, in the opinion of Sir John Lubbock, stand next to man in point of intelligence. They erect wonderful dwellings, store up food, are agriculturists, keep and tend their cattle (*Aphidæ*), seem to possess a sign-language, go to war in organized bodies, and in many ways show remarkable intelligence. The head (Fig. 173) is generally triangular, the antennæ are slender, and the eyes of two kinds—compound and ocelli; the

FIG. 174.—Foraging ants returning with slaves and captives after a battle (magnified).

former consist of many facets differing in different species. They live in communities of often 500,000. Both males and females are winged, while a third and wingless kind are called workers. These have the care of the young, and are builders. In some ants the neuters or workers have powerful jaws and are called soldiers, defending the family. During the summer the males and females leave the nest and fly away, soon losing their wings. The females are taken by workers to form new nests and become queens. They live seven or eight years.

Foraging Ants.—In South America the *Ecitons* are greatly dreaded. They march against other ants, and carry away their larvæ (Fig. 174) and pupæ to bring them up as slaves. In the *Œcodoma* the nest is of enormous dimensions, extending one hundred feet or more beneath the ground. They cut leaves from trees to thatch their nests. The leaves are also used to encourage the growth of fungi

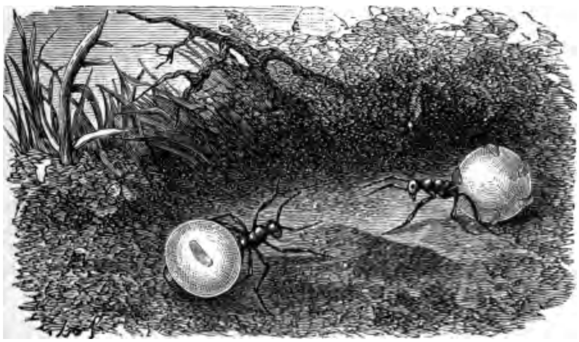


FIG. 175.—Living bottles—honey-ants expanded with honey.

upon which the young are fed. They tunnel under rivers, as the broad Paraiba of Brazil, a fact proved by forcing smoke through the tunnel.

Agricultural Ants.—The agricultural ants of Texas have regular farms on which they seem to cultivate the plant *Aristida stricta.*

Honey-Ants.—In the *Myrmecocystus melliger* of Texas, certain individuals are selected as storehouses by the rest, filled with honey (Fig. 175), and suspended in special apartments as living bottles. They are cared for and tended by the others, and made to give up their honey when it is needed.

VALUE.—The honey-ants are eaten as a delicacy in Mexico. Formic acid is obtained from the bodies of others. All are scavengers.

FIG. 176.—Mud-dauber wasp building nest.

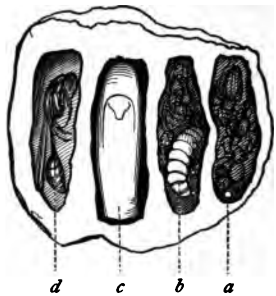


FIG. 177.—Showing a wasp's nest of four cells cut open. *a*, representing a cell with the egg at the bottom, and the remaining space filled with spiders; *b*, the larva full-grown, after having consumed all the spiders; *c*, the pupa; and *d*, the imago, or perfect mud-wasp, ready to come out.

Mud-Wasps.—These large wasps (Fig. 177, *d*) paralyze insects with their sting, storing them up in a benumbed condition in the egg-cells as food for the future young (Fig. 177). The nests are either

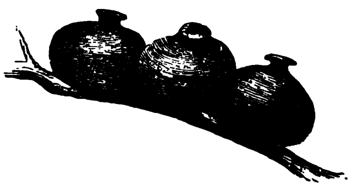


FIG. 178.—Mud-cells of a South American wasp attached to a branch.

built in the sand or gravel. Those of other species are attached to various objects (Fig. 178). The sand, wood, and paper wasps are other familiar forms.

NOTE.—The wasps live in temporary societies composed of males, females, and neuters or workers. The sting of the latter is poisonous. The males die at the approach of winter, the females hibernating. In spring their nests, composed of ground vegetable matter or sand, are formed, and the young reared. The first brood are neuters, and assist in building a nest for the others; finally, in the autumn, a third generation is produced, composed of males and females, the nest now containing perhaps one hundred cells.

Carpenter-Bees.—Among the bees, which constitute the highest forms of the *Hymenoptera*, the carpenter-bees (*Xylocopa*) are the giants. They bore tunnels in solid wood at the rate of one quarter to one half an inch a day. In the Virginia carpenter-bee the entrance is at first against, then follows the grain of the wood, the tunnel often being from one to one and a half feet in length. This is divided off into cells (Fig. 179), each provided with its pollen and egg; the partitions in the tunnel being formed of the powdered dust formed in cutting the tunnel. The larvæ feed upon the pollen.

FIG. 179.—Carpenter-bee, showing eggs, pollen-heaps, and partitions.

Honey-Bees (*Apiariæ*).—These insects (Fig. 180) are of three kinds—queens, workers, and males. They live in communities of sometimes 20,000 individuals. The cells are formed of wax secreted by the workers, and a queen is created by feeding a larva upon "royal food." The eggs are oblong white objects, the larvæ first resembling maggots. They are fed by the workers, inclosed in

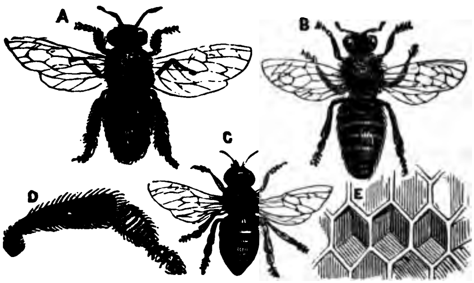


FIG. 180.—Common honey-bee. *A*, drone; *B*, queen; *C*, worker; *D*, leg of worker, showing cavity for propolis; *E*, cells for honey.

the cell, where they spin a cocoon, become pupæ, and finally appear as perfect bees. The leaf-cutters, humble (Fig. 181), and mason bees are other well-known forms.

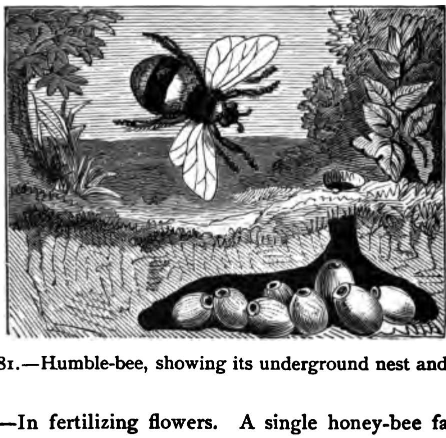


FIG. 181.—Humble-bee, showing its underground nest and eggs.

VALUE.—In fertilizing flowers. A single honey-bee farm in San Diego, California, produces 150,000 pounds of wax and honey a year, valued at $30,000.

NOTE.—In New Zealand it has been found almost impossible to cultivate red clover, from the fact that there are no humble-bees to carry the pollen It is said, however, that the flowers are changing, so that other insects can perform the work.

According to Sir John Lubbock, the language of bees is expressed by humming. "A tired bee hums on E′, and therefore vibrates its wings only 330 times in a second. A bee humming on A′ will, on the other hand, increase its vibrations to 440 per second."

Specimens for Study.—Insects, as the grasshopper, should be spread as in Fig. 182, and the wings and exterior parts studied. Fresh specimens should then be

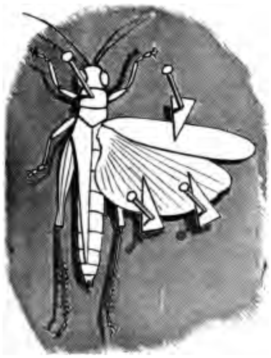


FIG. 182.—Grasshopper with the wings of one side expanded. *f*, forward-wing; *h*, hinder-wing. (After Morse.)

FIG. 183.—Insect pinned. (After Morse.)

separated, the segments, joints, mouth-parts, antennæ, etc., pasted on a card, numbered and labeled. The perfect insect should be preserved as in Fig. 183, pinned to a section of cork and glued in a covered box, a label with the name and locality accompanying it. Longitudinal sections of specimens hardened in alcohol should be made, the upper portion of the integument cut off, leaving the delicate hyperdermis. Lift this carefully and examine the heart, ganglia, etc. The various organs should be compared with Fig. 110 and drawn. In making collections, endeavor to have all the different stages, telling the entire story from the egg to the perfect insect. The eggs can be pasted on cards, and the larvæ preserved in alcohol.

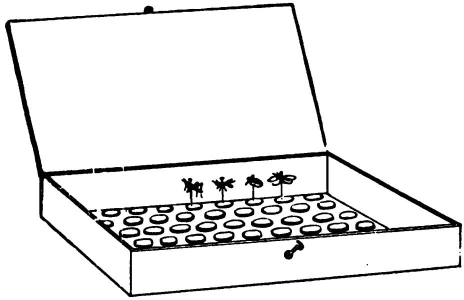


FIG. 184.—Model of box for preserving insects collected. (After Morse.)

Works on Bees for further reference.

Langstroth "On the Honey-Bee"; "Sting of the Honey-Bee," "Popular Science Monthly," vol. xiv, p. 635; "Habits of the Humble-Bees, and the Leaf-Cutting Bee," F. W. Putnam, "Proceedings of the Essex Institute," vol. iv; "Humble-Bees of New England and their Parasites," A. S. Packard, Jr., "Proceedings of the Essex Institute," vol. iv; "Ants," E. R. Leland, "Popular Science Monthly," vol. vii; Lubbock's "Ants, Bees, and Wasps"; "Agricultural Ants of Texas," H. C. McCook, "Proceedings of the Philadelphia Academy," and "Encyclopædia Americana," vol. ii.

Works on Insects in general for further reference.

Packard's "Guide to the Study of Insects"; Packard's "Half Hours with Insects"; Burmeister's "Entomology"; Lubbock's "Origin and Metamorphoses of Insects"; Harris's "Insects of Massachusetts injurious to Vegetation"; Wood's "Strange Dwellings"; Treat's "Insects injurious to Vegetation"; the works of Professor Riley; "Smithsonian Reports"; "Annual Reports of the State of Missouri"; "Introduction to Entomology," Kirby and Spence; Wood's "Natural History," and "Homes without Hands"; "Malay Archipelago," Wallace.

CHAPTER VIII.

EIGHTH BRANCH OF ANIMALS.

SEA-SQUIRTS (*Tunicata*).

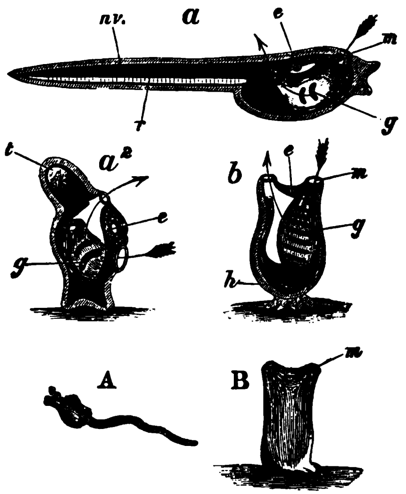


FIG. 185.—Diagram of the growth of a sea-squirt, or ascidian. A, *a*, young free-swimming stage (*Clavelina*). a^2, intermediate stage, when first settling down. B, *b*, full-grown sea-squirt. *m*, mouth; *e*, hollow brain with eye; *g*, gill-slits; *h*, heart; *r*, rod of gristle in free-swimming form; *nv*, nerve-cord in same; *t*, tail in process of absorption in intermediate form. (After Haddon.)

General Characteristics.—Though the adult ascidians possess little outward resemblance to the backboned animals, the free-swimming young (Fig. 185, *a*), that look like tadpoles, have a gristly cord, *r*, with a nerve-cord, *n v*, above it like the notochord that we shall see in the lancelet; consequently, they are believed to represent the simplest phase of backboned life. They are bag- or barrel-shaped animals, sometimes growing upon stalks;

again, swimming free, singly, in chains upon the surface, or attached to the bottom. Fig. 185, B, represents a common form of a fixed ascidian or tunicate resembling a jar or bottle with two mouths.

Covering.—In the simple ascidians (Fig. 185) the body seems inclosed in two coats, a leathery outer one called the test, composed mainly of cellulose, a substance usually found in plants, and an inner muscular one.

Internal Structure.—The sac is provided with two openings, generally surrounded by short incurved tentacles ; one is the mouth, *m*, and the other for the passage of rejected matter, the fertilized eggs, etc. The mouth is generally the upper opening, and leads into a chamber called the respiratory sac, *g*, whose walls are perforated with a network of ciliated openings. An orifice in the bottom of the sac leads to the gullet that connects with the stomach and intestine, the latter bending and finally leading to a chamber connected with the ex-current or atrial orifice. The liver is large and of a vivid green hue ; the ovaries yellow. When the tunicate is handled, water is ejected from both openings : hence the name sea-squirt.

Circulation.—The heart (Fig. 185, *h*), by the beating of which circulation is effected, is a straight, tubular, muscular organ, open at both ends. For a certain number of times in some species, the blood is thrown one way, then the action is reversed and it is propelled in the opposite direction, so flowing alternately.

Respiration.—The network that we have seen in the branchial chamber is traversed by blood-vessels that here are brought in contact with water that is wafted along by the cilia ; the blood takes up oxygen, and so is purified. As food is also brought in with the water, the sea-squirt breathes and obtains food by the same action.*

* Compare this with the account of the oyster, on page 52.

Nervous System.—In the simplest forms, the nervous system consists of a simple cord ganglion, between the two body-openings.

Development.—They multiply by eggs and by budding, the young in some cases assuming at first a free-swimming tadpole form (Fig. 185, *a*), finally becoming attached, a^2, the tail *t* absorbing, and the animal assuming the adult form B.

Pyrosoma.—The pyrosoma (Fig. 186), or fire-body, is a gigantic compound ascidian, sometimes five feet long, twelve inches across, with walls three inches thick. It is a colony of ascidians forming a cylindrical, barrel-shaped

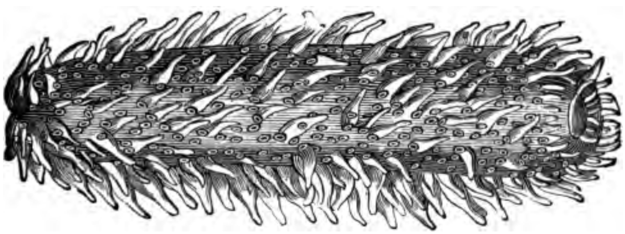


FIG. 186.—*Pyrosoma gigas*, a luminous compound ascidian.

object open at one end. Here the circulation of water aids in locomotion. The mouths, or the inhalent openings, are upon the outside of the pyrosoma, and the exhalent upon the inside. Each individual of the colony is continually engaged in drawing in water, sifting out the particles of food, and ejecting it from the interior opening, all these little currents finding their way out of the single large opening, the combined volume forcing the entire colony along.

NOTE.—The pyrosoma is one of the most wonderful animals of the sea in its illuminating properties. In the southern seas they resemble bodies heated to a white heat, illuminating the greater depths, so that the forms of sharks, porpoises, and other larger animals are seen distinctly far below; and when at the surface light up the sails, masts, and rigging of vessels, as if by magic. Bebra, the naturalist, wrote a description of one in his cabin by its own light, and read by their phosphorescence from his cabin-window. Professor Moseley wrote his name upon one with his finger as it lay upon deck; each letter seemed to ignite, increasing in brilliancy, spreading over the entire animal until it seemed at a white heat. They are found in nearly all the southern seas, and are important factors in the illumination of the submarine world.

Salpæ.—These are minute pelagic, free-swimming ascidians. There are solitary and chain *Salpæ*; the former (Fig. 187) are barrel-shaped, even the hoops being repre-

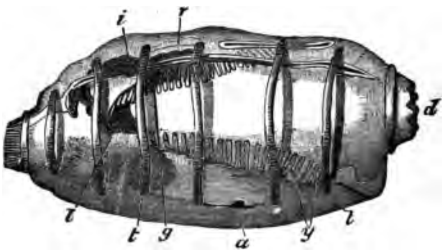


FIG. 187.—*Doliolum*, an ascidian allied to the salpa. *a*, nerve; *d*, mouth; *g*, œsophagus; *i*, stomach; *l*, intestine; *r*, heart; *t t*, muscles.

sented by circular bands or muscles. In both, the openings are at each end, and locomotion is produced by a regular contraction and expansion of the mantle. The salpa in its development affords another example of alternate generations. The solitary asexual salpa, by budding, produces a family of chained salpæ; these in turn produce, not buds, but fertilized eggs, that, after passing through several changes, assume the solitary asexual salpa form.

NOTE.—They are brilliantly luminous, the chains stretching away for great distances, resembling luminous snakes winding their way over the sea. Their light in the darkest night rivals that of the moon upon the water.

Appendiculariæ.—These (Fig. 188) are the simplest forms of the class, minute pelagic creatures with tadpole-like tails.

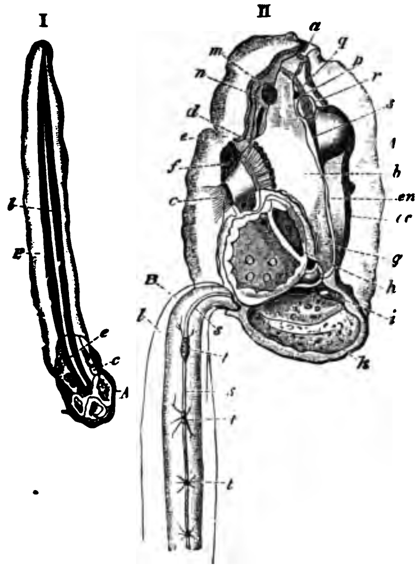


Fig. 188.—*Appendicularia flabellum.* I. The entire animal, with the "tail" in its ordinary position, or turned forward. II. Side view of the body, with the "tail" forcibly bent backward. *A*, the body; *B*, the tail; *a*, oral aperture; *b*, the pharynx; *c*, an atrial opening; *d*, the corresponding stigma, with its cilia; *f*, rectum; *g*, œsophagus; *h*, *i*, stomach; *l*, urochord; *m*, cellular patch at the side of the oral end of the body; *p*, ganglion; *q*, ciliated sac; *r*, ear; *s*, posterior nerve with its ganglia, *t*; *en*, endoderm; *ec*, ectoderm. (After Huxley.)

Works on Tunicates for further reference.

"Ascidians of the Coast of New England," A. E. Verrill, in "American Journal of Science," vol. i, 1871; "Structure and Affinities of the Sea-Squirts (Tunicata)," J. C. Galton, "Popular Science Review," July, 1868; "Invertebrata of Vineyard Sound," Verrill; "Development of Salpa," Brooks, "Bulletin of Comparative Zoölogy," Cambridge, 1876.

CHAPTER IX.

NINTH BRANCH OF ANIMALS.

BACKBONED ANIMALS (*Vertebrata*).

General Characteristics.—The Vertebrates are distinguished by the possession of a backbone, or vertebra, but the fundamental distinction between them and the preceding forms lies in the fact that the body is divided into two tubes (Fig. 189)—the upper, *C S*, containing the nervous cord, and the lower the heart, digestive organs, etc. The eyes, ears, and nostrils are two in number, and are placed in the same relative position in all. The eyes have movable lids; the mouth opens transversely; the lower jaw is on the under part of the head, and moves up and down, instead of opening sidewise, as in the insects and crustaceans. The jaws are armed with teeth. The blood, except in the lancelet, is red.

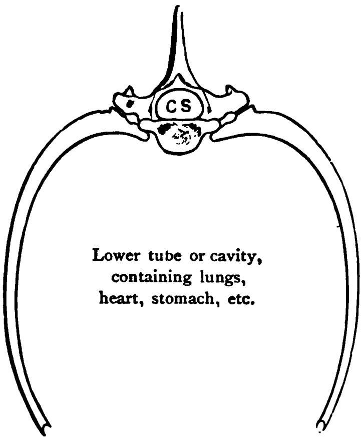


FIG. 189.—A vertebra and a pair of ribs, from a cat. *C S*, upper cavity, containing cerebro-spinal cord; and lower, containing lungs, etc.

Skeleton.—The skeleton, that in the preceding forms has been upon the outside, is now internal. In the sharks, sturgeons, etc., it is soft, and composed of cartilage, while in others it is of bone. The backbone is composed of a row of bones, called vertebræ, that extend from the head to the tail, known collectively as the vertebral column. In the upper portion of each vertebra, except those in the tail, will be found a hole or arch (Fig. 189, *C S*), through which extends a long, white cord, connected with the brain, called the cerebro-spinal cord, that is thus protected from injury. The various bones of the head, that are extensions of the backbone, form a box or covering for the brain, known as the cranium or skull. The limbs never exceed two pairs, and are fundamentally the same in all Vertebrates, merely being adapted to the habits of the animal in flying, leaping, swimming, digging, clinging, or walking. These are features that characterize all Vertebrates, except the lowest forms. The peculiarities of structure that distinguish the different divisions will be treated under the following heads, that represent the different classes of the backboned animals: 1. The lancelet; 2. The lamprey; 3. The true fishes; 4. Amphibians; 5. Reptiles; 6. Birds; and 7. Mammals.

Class I.—Leptocardii.

The Lancelet (*Amphioxus*).—This worm-like creature (Fig. 190) is the lowest animal in which we find a notochord in the adult. The body is lance-shaped, having no skeleton, brain, cranium, or paired fins; yet it has a backbone, represented by a cartilaginous string, called the notochord (Fig. 190, *r*), with a nerve-cord, *n v*, over it. The heart is long and simple, and the blood colorless. The mouth, *m*, is oval, surrounded by delicate tentacles; and the eyes are mere specks, *e*. The young pass through a metamorphosis, being at first oval, ciliated bodies; later, resembling a larval ascidian. They breathe by taking in water at the mouth, *m*, that passes through the gill-slits, *g*, oxygenating the blood, then passing out through an opening,

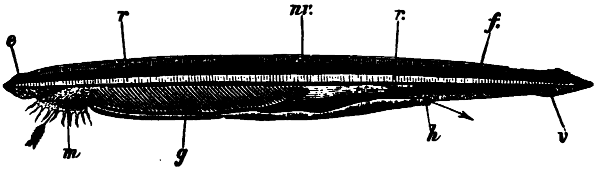


FIG. 190.—The lancelet. *m*, mouth; *e*, eye-spot; *f*, fin; *r*, rod or notochord, the first faint indication of a backbone; *n v*, nerve-cord; *g*, gills; *h*, hole out of which water passes from the gills; *v*, vent for refuse of food.

h. Compare this with the respiration of ascidians (page 146). The common lancelet lives in the sand in the shallow water of our coast, from Virginia to southern Florida.

An Australian lancelet has a high dorsal fin, and about Zamboanga one is found living in a sea-cucumber (*Scabra*).

Class II.—POUCH-GILLED VERTEBRATES (*Marsipobranchii*).

General Characteristics.—The animals of this class are worm-like in appearance. They have no jaws, the mouth being adapted for sucking. The respiratory organs (Fig. 191) are pouch-like cells or cavities, which open externally by seven small holes in the lamprey, and internally connect with the mouth and a cavity beneath the œsophagus. The nasal aperture that, in the higher Vertebrates, is paired, is here single, in the hag connecting with a sac that leads to the mouth; but in the lamprey there is no such connection.

Hag (*Myxine*).—The hag is about a foot in length. The eyes are minute and under the skin. They are generally found in deep water, where they are parasitic on various fishes. The teeth are represented by two comb-like rows on the tongue. There is also a single median or middle tooth (Fig. 191, *a*). They secrete an enormous quantity of slime, and a single hag has so filled four cubic feet of water that the mass could be lifted out with a stick, forming, according to Couch, a continuous sheet. The eggs are large, and covered with horny cases, having short filaments that wind about sea-weed.

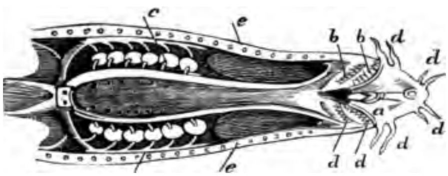


FIG. 191.—Organs of respiration in the Myxine. *a*, single hooked tooth; *b b b b*, double rows of lingual teeth; *c*, branchial cells; *d d d d*, tentacula; *e*, mucous glands.

Lamprey (*Petromyzon*).—The lamprey eel (Fig. 192) lives in both salt and fresh water, and attains a length of three feet. When young they are blind and toothless, and were long considered separate animals (*Ammocœtes*), (Fig 192). The adults have sunken eyes, and teeth on the cartilage supporting the lips. The mouth is a sucker, the tongue acting as a piston, and during the breeding-season they use it to advantage in building their nests. They follow the shad up rivers in the spring, deposit their eggs, and return to the ocean in the autumn. They are eaten in England.

NOTE.—The nests are formed of piles of rocks weighing several pounds, which are brought from up-stream by successively lifting them from the bottom, allowing the tide to carry them along. Some of the nests are three feet high and four in circumference, and in some cases the eggs are deposited in mere hollows in the sand. The young remain in their castles until able to protect themselves, and do not assume the parent form for three years. For an illustrated account of nest-building fishes see the article on the subject by the author in "Harper's Monthly," Christmas number, 1883.

FIG. 192.—Figure of a full-grown lamprey and of the young lamprey, formerly called *Ammocœtes*, showing the seven holes through which it takes in water to breathe.

Class III.—THE TRUE FISHES (*Pisces*).

General Characteristics.—Aquatic Vertebrates with a cartilaginous skeleton, as in the shark, or a bony one, as in the perch; as a rule, scaled, and breathing by means of gills; limbs represented by fins.

Skeleton.—At first glance, the skeleton of a bony fish (Fig. 193) seems to have two backbones; the lower, however, is the vertebra, that extends from the head to the tail. The upper series, *f* and *c*, are median or middle fins, supported by interspinous bones. The backbone is composed of sometimes two hundred vertebræ in bony fishes, and over three hundred and fifty in cartilaginous ones, that in the former are hollow upon each side, the inclosure so formed containing a glutinous substance. The vertebræ are all connected at their edges by ligaments, that allow more or less lateral motion. To the central or abdominal portion of the backbone the ribs are attached, their lower ends hanging free in the muscles. The head

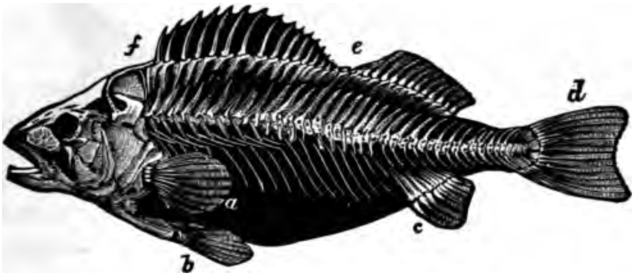


FIG. 193.—Skeleton of the perch (*Perca fluviatilis*). Shows the jointed nature of the vertebral column, and the facilities afforded for lateral motion, particularly in the tail (*d*), dorsal (*e*, *f*), ventral (*b*, *c*), and pectoral (*a*) fins, which are principally engaged in swimming.

is made up of a complicated arrangement of bones ; the jaws armed with many rows of teeth, in some cases being movable. The limbs or fins are formed of bony or cartilaginous rays ; those in pairs corresponding to the limbs of man. Thus, the pectoral fins (Fig. 193, *a*) correspond to the arms. A pectoral arch, scapula, clavicle, and coracoid bones are found, and generally the ulna, radius, and carpus. The lower portion of the fish is termed ventral, and the ventral fins (Fig. 193, *b*) that are attached to the pelvic arch represent the hind-limbs, though the bones of these limbs are not present. The single fin (Fig. 193, *e*) is a lower middle fin, that is supported by interspinous bones, that in turn are connected with the vertebra by ligaments. The tail or caudal fin (Fig. 193, *d*) is formed of a number of spreading rays, and is of two distinct types: heterocercal, in which the lobes are unequal, as in the shark (Fig. 198), and homocercal, where they are equal, as in the perch (Fig. 193).

Digestion.—The teeth that rudely prepare the food for digestion are loosely attached to the bones of the

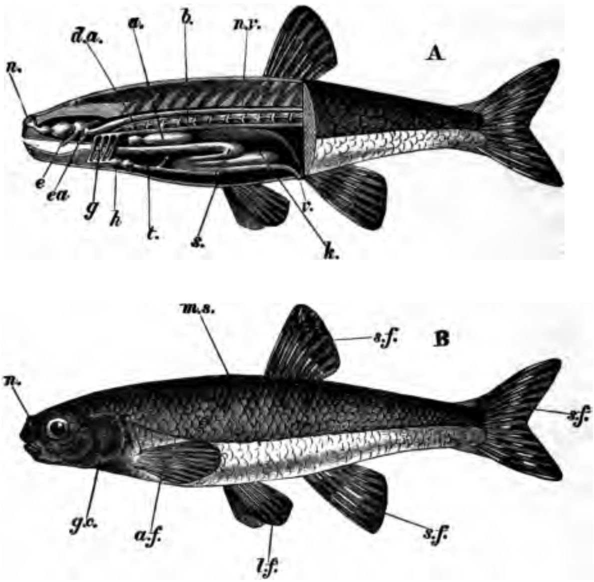


FIG. 194.—Internal structure of the minnow, ribs removed, and the living fish. A, *n*, nose-pit; *e*, eye-nerve; *e a*, ear-nerve; *g*, gills; *h*, heart; *t*, food-tube; *s*, stomach; *k*, kidney; *v*, vent; *d a*, dorsal artery; *a*, air-bladder; *b*, backbone; *n v*, nerve-cord or spinal cord. B, *n*, nose; *gc*, gill-cover; *a f*, arm-fin; *l f*, leg-fins; *s f*, single fins; *m s*, mucous scales.

mouth, and even the tongue, not being confined to the jaws alone. Food passes into the food-tube (Fig. 194, *t*), and thence into the stomach, *s*, the rejected portions being expelled at *v*. The liver is generally large. The position of the kidneys is shown in Fig. 194, *k*.

Circulation.—The heart (Fig. 194, *h*), as a rule, consists of two chambers—an auricle and ventricle. The former receives the impure blood and pumps it into the latter. From here it is sent into a chamber or arterial bulb that divides into four* pairs of branches, one leading into each gill. The blood enters the gills, is purified, then by the branchial veins passes into the dorsal artery (Fig. 194, *d a*), so finding its way slowly over the body and back to the auricle. So slowly is this circulation accomplished that the blood rarely attains a temperature above that of the surrounding water.† Hence the fishes are said to be cold-blooded.

Respiration.—Lifting up the gill-cover (Fig. 194, B, *g c*). we see the gills, A, *g*, by which the bony fishes breathe. They are blood-red, membranous leaflets, supported by cartilaginous arches separated by slits, the entire arrangement placed on each side of the head in what are called branchial chambers. Water is taken in at the mouth, passes between the arches and over the gills, supplying oxygen to the blood that has been pumped there by the heart for the purpose, passing out again under the gill-cover (Fig. 194, B, *g c*), so that there is a continuous current of water flowing in at the mouth and out at the gills. Most fishes have an air-bladder (Fig. 194, A, *a*) that contains gases, principally nitrogen, that enable them to maintain a certain specific gravity. In some fishes it has the attribute of a lung.

Nervous System, etc.—The nervous system of fishes consists of a small brain and spinal cord (Fig. 194, A, *n v*), that throws off delicate threads to the various parts, the fins, the eye, A, *e*, the ear, A, *ee*, and the nose-pit, *n*. The nasal organs, except in the lung fishes and myxinoids, do not connect with the mouth. They are represented by covered pits lined with nerves. Water laden with odors flows

* Sometimes five.

† In the active fishes (*Scombridæ*) the respiratory process is so energetic that the temperature of the blood is often higher than that of the surrounding medium.

in, and the news is telegraphed to the brain, just as the impression of an object seen is carried by the optic nerve *e*. The ears, A, *e a*, are little cavities placed on each side of the head, containing a liquid, in which float two otoliths, or ear-stones.

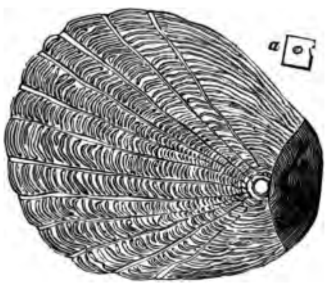


FIG. 195.—Scale of a flounder, highly magnified. *a*, natural size.

Covering.— Fishes are covered with scales (Fig. 195), that overlap each other like shingles on a roof, and grow, totally unlike those of reptiles, out of little pockets in the skin, being kept soft and slimy by a secretion under them, but principally from that which exudes from about the mucous scales (Fig. 194, B, *m s*).

Development.—Most fishes deposit eggs or roe. Some are ovoviviparous, while others, as the *Zoarces*, *Ditrema*, etc., are viviparous, or produce their young alive.

ECONOMIC VALUE.—As nearly all fishes are valuable as food, reference to their economic value has not been given in every case. The reports of the United States Fish Commission show the value of this class of vertebrates to man. Artificial fish-hatching establishments have been organized in nearly all the States. American fish-eggs are sent to Europe, and others received in return, and the arrangements for the prevention of the depletion of fisheries are becoming more complete every year.

Sub-Class I. STRAP-GILLED FISHES (*Elasmobranchii*).

General Characteristics.—In this class, we first meet Vertebrates having paired fins and a genuine lower jaw. The skeleton is made up of cartilage ; the ribs are small and often rudimentary. The skull is a simple cartilaginous box, and the jaws, and in fact all the parts, are easily bent or cut with a knife. The bones that protect the gill-openings in bony fishes are wanting, the gills being mere slits,* from five to seven pairs, with intervening straps. The lobes of the tail are generally unequal.

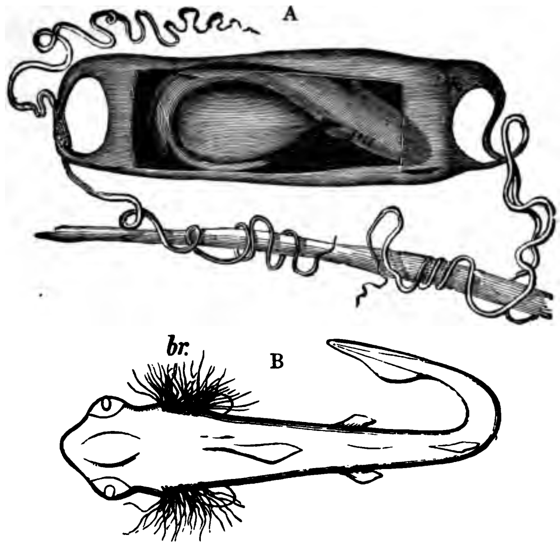


FIG. 196.—A, egg of a shark, showing the anchor filaments. B, embryo shark, showing the external gills (*br*).

Order I. **Plagiostomi. Nurse-Sharks** (*Scymnidæ*). —The nurse or sleeper is a sluggish shark found upon the eastern coast of North America, occasionally attaining a length of twenty feet. A nurse-shark of southern Florida is extremely dark in color. The latter frequent the sandy shoals in droves, and can always be seen asleep or quiet upon the bottom.

NOTE.—Dr. Bennett discovered in Australian seas a small shark (*Squalus fulgens*), probably allied to this family, that was luminous

* In embryo sharks (Fig. 196, B) the gills are external, as in the tadpole, etc.

over its entire surface except a girdle about the throat; it emitted a light of great brilliancy.

Dog-Fishes (*Spinacidæ*).—The *Squalus Americanus* is a common American variety. They have a sharp spine in front of each dorsal fin, capable of inflicting a dangerous wound. The young are born alive.

NOTE.—In August, 1883, the effect of their arrival upon the Maine coast was disastrous to many fishermen. Their vast numbers completely destroyed the fishing. They attacked oars, even biting at the sails when hanging over, and several cases are known where in former years they attacked swimmers and persons who had fallen overboard. The fishermen gave up cod- and hake-fishing, and with wire-hooked trawls captured thousands of the dog-fish, selling their livers to be made into oil, while the bodies were carted upon farms and used as guano.

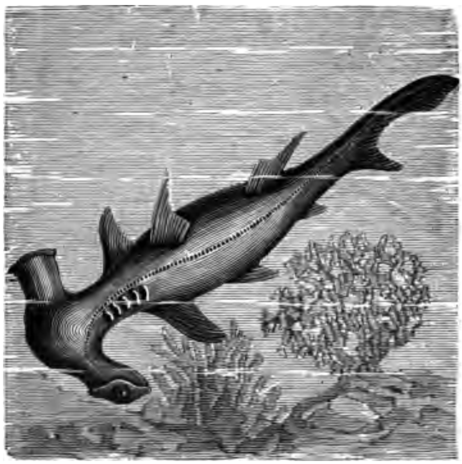


FIG. 197.—Hammer-headed shark.

Hammer-Head Shark (*Sphyrnidæ*).—The sharks of this family (Fig. 197) have the head in the shape of a hammer, the eyes being placed at the ends of the curious prolongations. They attain a length of twelve feet, and are found on both sides of the Atlantic, and from Brazil to Cape Cod. They are very ferocious. Allied is the thresher shark (Fig. 198). The tail is fully a third of the entire length, and forms a terrible weapon when swung about by the powerful fish. They attain a length of twenty feet.

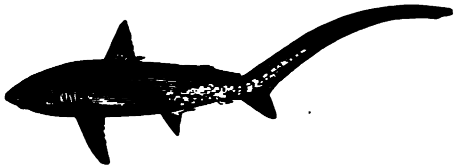


FIG. 198.—Thresher shark.

Man-Eater Shark (*Lamnidæ*).—The great *Carcharodon* has been known to attack boats. Their enormous mouths contain six or eight rows of serrated teeth. They have a wide geographical range, are mainly pelagic, living in the open sea. One species (*C. gangeticus*) lives in an inclosed lake in the Feejee Islands, breeding above the falls. It has also been found at Bagdad, three hundred and fifty miles from salt water. A shark is also found in Lake Nicaragua. The largest shark of this family ever caught was thirty-six and a half feet long, from Australian waters.

NOTE.—In repeated observations of these and allied sharks attacking objects on the surface and on the bottom, on the outer Florida reef, in no case did they turn on their backs. In attacking a cow they ran their snouts out of the water, and bit as do ordinary fishes, tearing and shaking the body like a dog. One, caught after a struggle of two hours, during which it towed the boat a long distance, contained among other curiosities the hoofs of an ox, a mass of old rope, a tin can, and other material obtained near a slaughter-house. They never attacked human beings in this locality, though bathing and swimming from key to key was often indulged in, where twelve and fourteen foot sharks were observed only a few moments before.

Basking Shark (*Cetorhinidæ*).—Bone-shark, sail-fish, and many other titles are applied to these sharks, that are the largest of all fishes. One, captured by the schooner

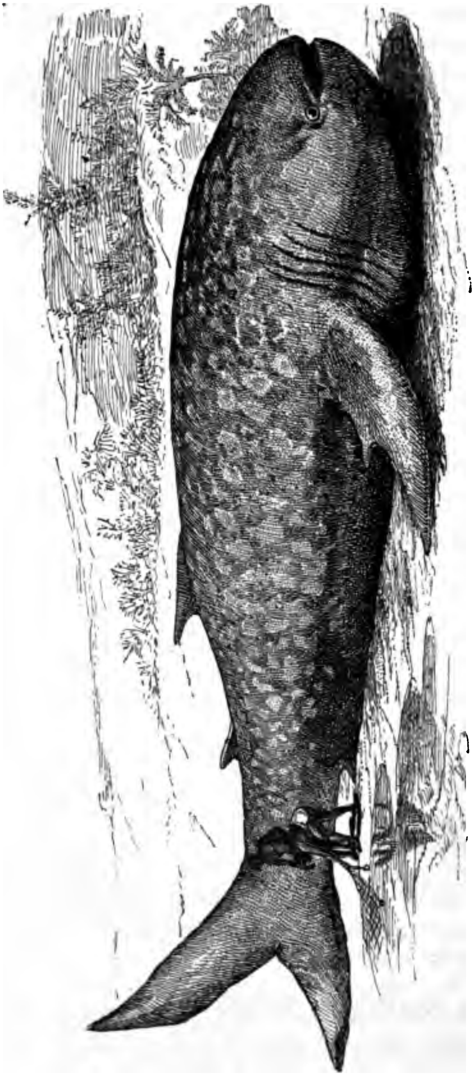


FIG. 199.—Spotted shark (*Rhinodon typicus*, Smith), showing the relative size of a specimen seventy feet in length.

Virgin, off Block Island, was about seventy feet in length. They are harmless, living upon small pelagic animals that are strained into the throat through a series of hard, elastic, whalebone-like fringes, that are arranged comb-like along the large gill-openings. The teeth are small and comparatively useless. The *Rhinodon* (Fig. 199) is a similar form of East African waters, and attains a length of sixty or seventy feet. The mouth opens on a level with the snout. When struck, they have been known to carry large boats beneath the surface.

VALUE OF SHARKS.—They are all scavengers. The skin of dog-fish and others is used as leather and shagreen. The oil of nearly all the species is valuable, and the bodies as guano. The teeth of sharks are used as weapons by the Pacific islanders. In China the shark-fin trade is an important one, they being used as food.

Saw-Fishes (*Pristidæ*).—These remarkable fishes (Fig. 200) attain a length of fifteen feet, and are common on the North American coast from Cape Cod southward.

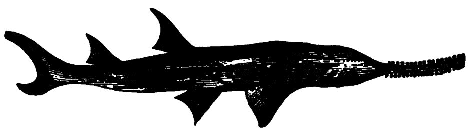


FIG. 200.—Saw-fish.

The snout is prolonged into a sword, the edges being armed with sharp, bony teeth. A species of saw-fish lives in a fresh-water lake in the Philippine Islands. The saw is used as a weapon by some tribes. They are viviparous.

Skates (*Raiaidæ*).—These fishes are all notable for the development of the side or pectoral fins that in some species appear like wings. Their teeth are grinding plates, adapted for crushing mollusks and crabs. Their eggs are deposited in a dark, rectangular, parchment-like case, having four filaments that twine about the sea-weed, preventing them from washing ashore.

Torpedoes (*Torpedinidæ*).—The fishes of this family are electricians, and are common on the New England coast. The electric apparatus (Fig. 201) is situated between the head and the bases of the pectoral fins, and is composed of numerous hexagonal membranous tubes placed side by side at right angles with the surface of the body, and so close to it that their ends are often visible above and below. The cells contain mucus, and are traversed by nerves that proceed from the eighth pair. So powerful is this battery that fishermen have been knocked over as if with an axe, the shocks also passing up the harpoon-rope, or the knife used in cutting them. Allied are sting-rays (*Trygon*), cow-nosed rays, etc. The great devil-fish (Fig. 202), that has curious prolongations or claspers at the head, attains a width of twenty-seven feet. They have been known to tow large vessels against the wind for long distances by fouling the anchor. The Japanese use the skeletons of rays in the imitation of tortoise-shell.

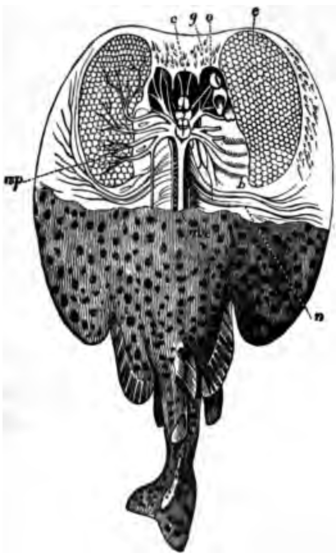


FIG. 201.—The torpedo, with its electrical apparatus displayed. *b*, branchiæ; *c*, brain; *e*, electric organ; *g*, cranium; *me*, spinal cord; *n*, nerves to the pectoral fins; *np*, nerves going to the electric organ; *o*, eye.

FIG. 202.—Devil-fish (*Cephalopterus diabolus*).

Order II. **Holocephali.**—The *Chimæra* (Fig. 203) is a northern representative of this group, while the curious *Callorhynchus* is found in Antarctic regions. The gill-openings are protected by a membranous covering, suggesting the gill-covers of bony fishes. The teeth are curiously arranged, there being four in the upper and only two

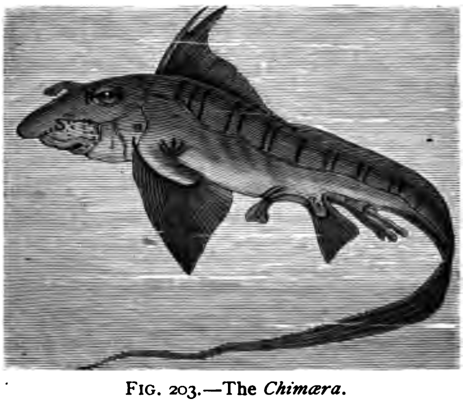


FIG. 203.—The *Chimæra*.

in the lower jaw. The air-bladder is absent. The male Chimæra has a curious, comb-like, cartilaginous appendage armed with hooklets on the top of the head, that is either erect or hidden in a hook-armed groove.

NOTE.—The eggs of the *Chimæra* are deposited in thick, leathery cases, and those of *Callorhynchus* are remarkable for their mimicry or protective resemblance, resembling the leaf of the fucus or sea-weed to which they are attached. They form a long, depressed ellipse, with a plicated and fringed margin, and, swaying in the current, their true nature would never be suspected.

Sub-Class II. BRIGHT-SCALED FISHES (*Ganoidei*).

General Characteristics.—The Ganoids have hard, glistening scales, cartilaginous or ossified skeletons, and one pair of gill-openings, protected by opercular bones.

FIG. 204.—Sharp-nosed sturgeon (*A. oxyrhynchus*).

Order I. **Chondroganoidei.** The **Sturgeons** (*Acipenseridæ*).—The sturgeons (Fig. 204) have cartilaginous skeletons, the skin being armed with bony bucklers or plates, arranged in longitudinal rows. The mouth is toothless and under the snout, and is adapted for sucking in soft food (Fig. 205). The sharp-nosed sturgeon attains a length of eight feet. It breeds, as do the entire family, in fresh water, the female depositing millions of eggs. The shovel-nosed sturgeon and the curious spoonbill (*Polyodon folium*) are found in the Mississippi. Glue, cement, court-plaster, isinglass, etc., are made from the air-bladders of sturgeons.

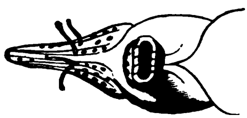


FIG. 205.—The sturgeon's head seen from below, showing the tube-like mouth and the four barbels or feelers.

NOTE.—The *Acipenser huso* attains a length of twenty-five feet. The fisheries at Ruibinsk, on the Volga, Russia, give employment, according to Duncan, to one hundred thousand persons, and the fish have been seen so packing a river three hundred and sixty feet wide and twenty-nine feet deep, that the backs of the upper ones were out of the water.

Order II. **Lung-Fishes** (*Dipnoi*).—The lung-fishes are eel-shaped, and covered with large scales. Some, as the *Lepidosiren*, have two perfect lungs, as well as gills. When left dry in pools, they form cases in the mud, which they line with a mucus, and lie dormant until the return of the water. The *Ceradotus* of Australia (Fig. 206), discov-

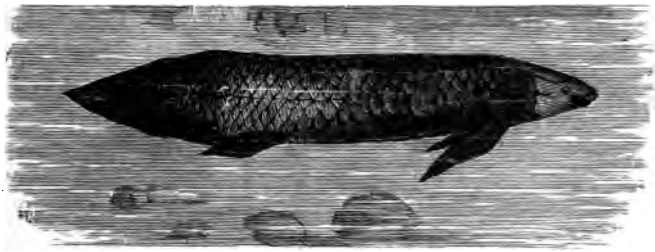


FIG. 206.—The *Ceradotus* of Queensland, Australia, an air-breathing and water-breathing mud-fish of the ancient type, with paddle-fins.

ered in 1870, attains a length of six feet. When under water the heart pumps the blood to the gills, but when they are deprived of it the gases from the air-chamber are expelled with a loud noise, and fresh air taken in, the blood being now carried the other way, or toward the chambered, lung-like air-bladder, to become freshened.

NOTE.—The *Protopterus*, a lung-fish of Africa, has plume-like fins, and is also noted for its burrowing habits, forming burrows a foot from the surface. One, sent to England in its earthen case, came to life months after, when soaked in water. Some remain in their dry nests for several seasons. Many of the family have the faculty of reproducing lost fleshy parts of their fins, etc.

Order III. **Branchioganoidei.**—This order is represented by the Polypterus of the Nile. The dorsal fin is broken up into numerous points, each being supported by

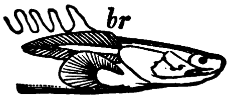


FIG. 207.—Young of the Nile *Polypterus*, showing external gills, *br*.

a ray and spine (Fig. 207). The young have external gills (Fig. 207, *br*).

Order IV. **Garpikes** (*Hyoganoidei*).—The garpikes (Fig. 208) have beak-like jaws with sharp teeth; the scales are large and resemble white enameled plates. The air-bladder is lung-like, and the fishes are often seen at the surface inhaling air. They occur in the Western and Southern rivers and Great Lakes. The eggs are hatched the last of May. The scales are used as arrow-tips by some Indians.

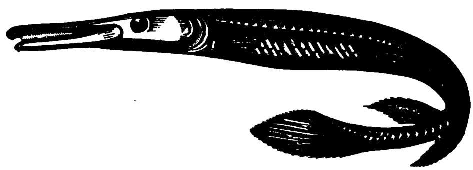


FIG. 208.—Garpike (*Lepidosteus osseus*).

Sub-Class III. BONY FISHES (*Teleostei*).

General Characteristics.—In these fishes (Figs. 193, 194) bone takes the place of cartilage. The skull is composed of many bones; the optic nerves cross each other; the gills generally number four pairs, and have several opercular or protective bones.

Eels (*Apodes*).—The eels are without ventral fins. The *Anguilla* is common in the United States, living in fresh-water streams, but depositing its eggs, often 8,000,000 to a single fish, in the ocean, the young ascending the rivers. The sexes are difficult to distinguish; the females have the highest dorsal fin, smaller eyes, and a lighter color than the males, while the snout is generally broader at the tip than in the male. The conger-eel attains a large size, and ranges from Newfoundland to the West Indies. In

Southern waters the ferocious and snake-like *Muræna* is found, attaining a length of three feet.

NOTE.—In a pond near Wells, on the Maine coast, the eels invariably go down into salt water at night, and, as the stream is narrow, the sight is remarkable, thousands filling the channel, leaving the water when alarmed and passing over the dry rocks to the ocean. The sound, a single note, frequently uttered by the eel, is, according to Abbott, more distinctly musical than those made by other fishes, and has a metallic resonance.

Order III. **Thread-jawed Fishes** (*Nematognathi*).
Cat-Fishes (*Siluridæ*).—The cat-fishes may be recognized by the curious barbels or threads that hang from their jaws. They have no scales, the skin being in some species protected by bony plates. Some are marine, but the majority live in fresh water. A blind cat-fish (*Gronias*) inhabits a subterranean stream in Pennsylvania. The *Arius*, of South America, carries its eggs in its mouth, and even the young fish. In a species of *Arius*, in Panama, the mother first carries them about in a fold of the skin, and later the male receives them in its capacious mouth. The female *Aspredo* carries its eggs about attached to dangling capsules, that cover the fins and ventral surface of the body, disappearing after the breeding season. The com-

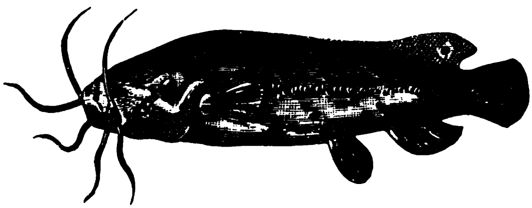


FIG. 209.—An electric cat-fish (*Malapterus electricus*).

mon cat-fish carefully guards its young, while the South American *Doras* and *Callichthys* build nests of leaves in which the young are placed. These fishes also leave ponds that dry up, and crawl overland (see frontispiece) in great numbers in search of water, during this time breathing air directly. The *Arges* are almost blind forms, living in subterranean streams. A cat-fish from the Nile, *Malapterus electricus* (Fig. 209), is electric, the cells forming a layer over the entire body except the head and fins. The South American *Lau-Lau*, is the largest of the family, and protects its young in its mouth. The *Corbetis fossilis* (Fig. 210) breathes air directly as well as taking it from the water.

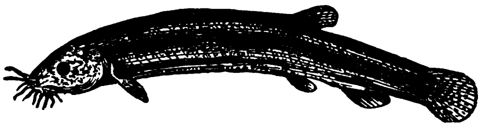


FIG. 210.—*Corbetis fossilis*. It swallows air-bubbles which pass through the intestine, where the mucous membrane takes up the oxygen for respiration.

The fourth order of fishes, *Scyphophori*, is represented by the Nile *Gymnarchus*.

Order V. **Perfect-headed Fishes** (*Teleocephali*).—*General Characteristics.*—This order embraces most of our common fishes. The skeleton is bony, and the name applies to the diversity and perfection of the bones of the head.

FIG. 211.—Electric eel (*Gymnotus electricus*).

Gymnotus.—The *Gymnotus electricus* (Fig. 211) is one of the lowest of the *Teleosts*. The batteries are four in number, and situated, in pairs, on each side of the body, occupying together nearly all the lower portion.

Carps (*Cyprinidæ*).—The carps comprise many species, and abound in nearly all streams throughout the Old World and North America. They have weak, toothless jaws. The stone-toters (*Exoglossum*) build nests by carrying stones, which they pile in heaps. The dace (Fig. 212), common minnows, and shiners, are all related.

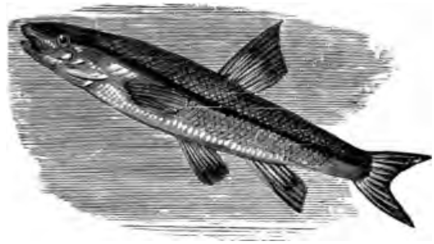


FIG. 212.—Black-nosed dace.

NOTE.—The dace (*Rhinichthys atronasus*) is one of the most interesting of the nest-building fishes. During the breeding-season males and females clear away a spot, perhaps under the water-lilies, and in the oval depression the eggs are deposited, the pair covering them with a layer of stones; then another layer of eggs is deposited, and another of stones, until a mound of eight or ten inches in height is the result, and here the young are hatched.

Blind, Cave-Fishes (*Amblyopidæ*).—These comprise three genera and four species of ghostly, sightless fishes (Fig. 213) living in the limestone caves of the Middle and

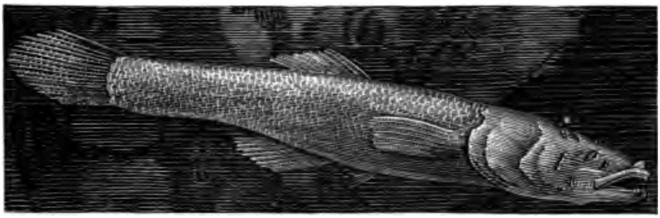


FIG. 213.—Blind-fish (*Amblyopsis*), Mammoth Cave.

Southern States. Though blind, they are supplied with sense-organs so delicate that they are enabled to capture fishes with eyes that have strayed into their domain.

Wyandotte and Mammoth Caves are noted localities for them. The *Amblyopsis* is viviparous.

Herring-Pikes (*Elopidæ*).—This family includes the tarpon (*Megalops thrissoides*) and the big-eyed herring. The former attains a length of over eight feet, and is the most beautiful of all fishes, ranging from Cape Cod to Florida. An allied form, the *Studis* or *Piraruca*, of South America, attains a length of fifteen feet, and a weight of four hundred pounds. They have skeletons of most massive build. The young, according to Schomburgh, enter the mother's mouth in time of danger. Allied are the herrings (*Clupeidæ*), shad, menhaden, and the gizzard-shad. They are nearly all important food-fishes. Menhaden oil and guano are valued. The scales of the tarpon are used in ornamental work.

Salmon (*Salmonidæ*).—Salmon are found in Europe and America, in the latter country from the polar regions to Cape Cod. They live in both fresh and salt water. In the breeding-season they ascend the rivers, leaping the falls with great skill, and at this time are often caught. The eggs are about the size of a pea, and are deposited in depressions or nests. When very young, they are banded and known as *parr* (Fig. 214). At a year old they are silvery, and previous to descending the rivers are known as *smolt*. When they return from their first visit to the sea they are called *grilse*, only after their second return being known as salmon. Allied is the common trout, that lives permanently in fresh water, breeding in the autumn and early winter.

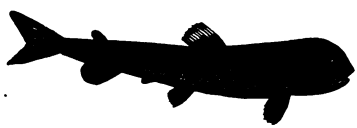


FIG. 214.—Young salmon (*parr*).

NOTE.—Salmon are found in the Yukon River, Alaska, 3,000 miles from the sea. In 1882 the Columbia River salmon-fisheries alone realized in first hands $2,782,000, giving employment to 7,000 persons.

Lamp-Fishes (*Stomiatidæ*).—In these and allied fishes the skin is naked, or the scales extremely minute, and nearly all have organs that look like pearl or glass buttons imbedded in the skin. According to Leydig, they are of three kinds: first, eye-like organs; second, pearly, glass-like organs; and, third, luminous organs. According to different authors, they are eyes, electric or light-giving organs. Gunther considers them all luminous, and that their function is to light the dark recesses of the submarine world.

In the *Stomias* the pearly spots are along the ventral surface, a veritable row of glowing lights. Allied to the *Stomias* is the lamp-fish (*Scopelus*); upon its head is a soft prominence that glows like a head-light. Willemoes-Suhm says, "One of them hung in the net like a shining star." Other phosphorescent spots are scattered along the lower surface of *Scopelus Humboldti* and *Benoitii* (Fig. 216). Another allied form is the Bombay duck or *Harpodon* (Fig. 216), that is luminous over its entire surface. The eyes of *Ipnops* are adapted for receiving and perhaps emitting phosphorescent light, and a curious phosphorescent organ is found upon the head. Several species of the genus *Echiostoma* live in Australian seas at a depth of two and a half miles. They are black, with long, fringed barbels, and below the eyes and in other places are several luminous spots. The *Bathyophis ferox* lives at a depth of nearly three miles, the greatest depth attained by any fish. It has long barbels or feelers, and rows of gleaming lights on its various parts. Allied is the *Chauliodus* (Fig. 216, 1). The tips of the fins are luminous, while a row of luminous spots extends the entire length of the body. The little fishes *Argyropelecus* (Fig. 217) and *Sternoptyx* are found in the Mediterranean. The body is extremely deep, rising suddenly and narrowing off to the tail. The luminous spots are in groups from the head to the tail. Perhaps allied to this group is a strange fish (Fig. 218) about twenty inches in length, with a pouch-like mouth and no fins, found in water over a mile deep in the Mediterranean, and also dredged off the American coast. It differs from all

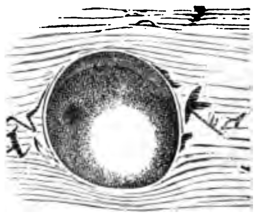


FIG. 215.—Luminous organ from side of *Scopelus* (Fig. 216, 8).

FIG. 216.—Luminous fishes of the deep sea.—1, *Chauliodus*, one foot long; 2, 9, 10, 11, *Harpodon*, or Bombay duck, six inches; 3, *Plagiodus*, six feet; 4, *Chiasmodus*, one foot, with *Scopelus* in its stomach; 6, *Beryx*, one foot and a half; 8, *Scopelus*, one foot.

other known bony fishes in having six pairs of internal branchial clefts, and consequently five pairs of gills. It has no swimming-bladder.

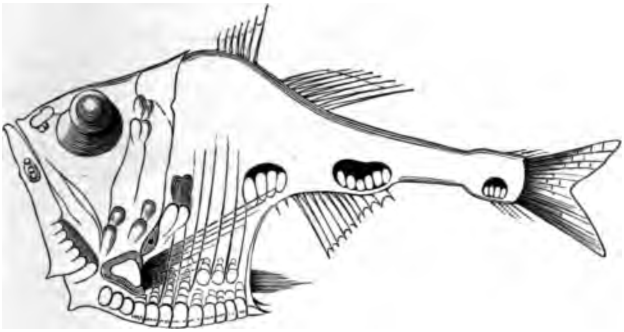


FIG. 217.—*Argyropelecus hemigymnus*, twice natural size, snowing groups of luminous organs.

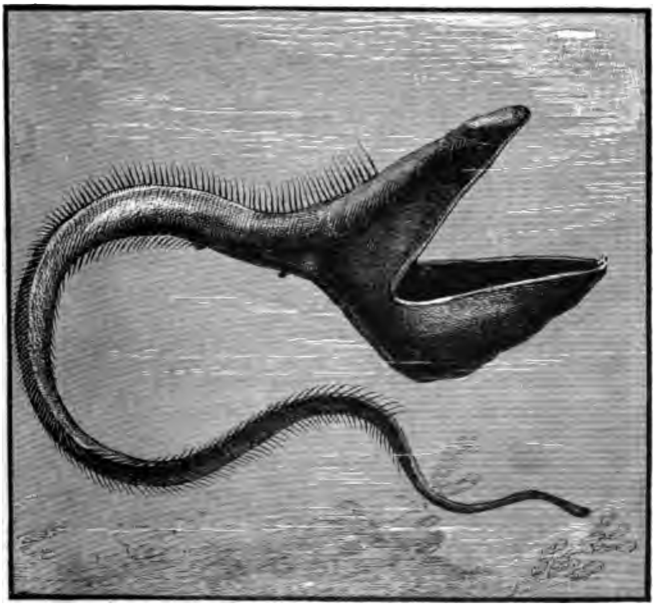


FIG. 218.—The Pelican fish (*Eurypharynx pelecanoides*).

Pikes (*Esocidæ*).—The pikes (Fig. 219) have long, depressed snouts, and with a single exception (*Esox lucius*) belong to the United States. The *Muskallonge* of the Great Lakes attains a length of four feet.

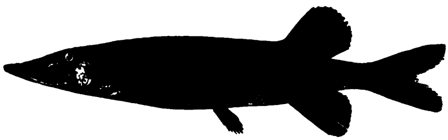


FIG. 219.—Pike (*Esox*).

NOTE.—All the family are voracious, often attacking ducks and even larger birds. They have been known to live over a hundred years. The pickerel is common in the various rivers and lakes of North America. A pike has been observed by an English naturalist to leap a foot out of water, and take a young bird from an overhanging limb.

Flying-Fishes (*Exocœtus*).—The flying-fishes range from Cape Cod to Florida, and in many seas. The pectoral fins are developed in a remarkable manner, so that they resemble wings. When the fish rises from the sea, the tail is worked vigorously, the wing-like pectorals vibrate rapidly, and once clear of the water the fish soars away, with or without the movement of the fins, either in a straight line, or curving by a motion of the tail, often clearing a distance of a quarter of a mile (Fig. 223).

Gar-Fishes (*Belonidæ*).—The gar-fishes have long, slender bodies, the jaws narrow, pointed, and armed with extremely sharp teeth. They almost invariably lie at the surface. They are green above and silvery beneath.

NOTE.—They attain a length of two feet and over. In the Pacific they are of large size, and when alarmed leap away in a series of bounds out of water, and very often, according to Moseley, occasion the death of natives wading about by accidentally striking them, the bill piercing the flesh like an arrow. The *Hemirhamphus* has only the lower jaw elongated, and is a light-bearer, having a gleaming, phosphorescent pustule at the tip of its tail.

FIG. 220.—Sticklebacks and their nest (*Gasterosteus aculeatus*).

Sticklebacks (*Gasterosteidæ*).—Sticklebacks are common in North American streams, and other species in

Europe (Fig. 220). The cheeks are mailed, and the single dorsal fin is preceded by spines, the number of which vary in different species. They live in salt or fresh water, are quite small, and noted for their care of young, and as nest-builders.

Ribbon-Fishes (*Trachypteridæ*).—In these fishes the body is long and ribbon-shaped, the dorsal fin extending nearly the entire length of the body, the caudal fins being placed obliquely.

NOTE.—They are probably the origin of many of the sea-serpent stories. According to Professor Wilson, of the University of Glasgow, Lord Norbury's smack Sovereign captured an allied form off the Scotch coast that was sixty feet in length, and from nine to ten inches in depth, the dorsal fin being six or seven inches deep.

Remora (*Echeneididæ*).—These fishes (Fig. 221), found in many seas, have upon the top of the head a flattened, oval disk, formed of pairs of transverse ridges or plates,

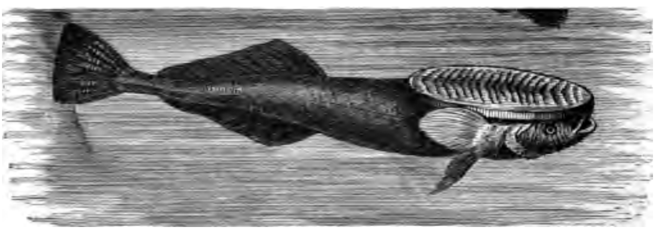


FIG. 221.—Remora, showing the sucking-disk by which it clings to sharks.

that are movable and directed obliquely backward, and form vacuum-chambers, the whole constituting a sucker, by which they attach themselves to sharks, turtles, and various large fishes.

NOTE.—In Mozambique and other countries the remora is used to capture turtles. A ring and string are attached to the tail, by which the owner holds it. and when a turtle is sighted the fish is tossed over and attaches itself to the victim, that is soon hauled on board.

Perches (*Percidæ*).—The perches are carnivorous fishes of great variety, about one fifth inhabiting the fresh-water streams of various countries, while the others are marine. *Perca fluviatilis* is a common form in the United States. They spawn during the winter, forming nests or hollows in the gravel near the shore, in which they deposit their eggs. Allied are the pond-fishes (*Eupomotis aureus*), that are often richly colored. They are famous nest-makers, both male and female aiding in clearing away the refuse of the bottom where the nest is to be made. A depression is then formed and the eggs deposited and carefully guarded. The spotted sunfish hibernates in the winter, burying itself in the mud.

Bass (*Labracidæ*).—The bass are mostly marine fishes The striped-bass attains a length of five feet, and range from Nova Scotia to Florida. The white perch, yellow pike-perch, and striped lake-bass, are allied forms. The hard-scaled bass of Californian waters attains a length of six feet and a weight of four hundred pounds. Allied are the black sea-bass, groupers, etc. The *Chromis* (Fig. 222) of Lake Tiberias, that carries its eggs and young in its mouth, belongs to this group. Nearly all are important food-fishes.

Big Drum-Fish (*Pogonius*).—The drum-fish is a large, deep fish, attaining a weight of eighty pounds, and remarkable as a sound-producer.*

* Sir John Richardson states that when aboard ship he has been kept awake by their drumming. The noises are made, according to some authorities, by beating their tails against the vessel, clapping together their pharyngeal teeth, or due to the action of the pneumatic duct and swimming-bladder. The maigre is said to produce a flute-like note, audible in twenty fathoms. Many fishes utter sounds, but perhaps the grunt (*Hæmulon*), on the outer Florida reef, is most remarkable for the variation of the sounds, that are so loud and striking as to have caused the author, on more than one occasion, to toss the fish back for its pains. The dog-fish utters a croak or bark. The gizzard-shad, hippocampus, eels, cat-fish, porcupine-fish, sunfish, carp, gurnards, etc., utter sounds, either accidental or intentional.

FIG. 222.—*Chromis* of Lake Tiberias, the male of which carries the eggs and fully-developed young in its mouth: showing the mouth forced open by the brood within, and the young swimming in.

Dolphins (*Coryphænidæ*).—The dolphins (Fig. 223) are large-headed pelagic fishes, tapering to the tail; the dorsal fin high, and extending nearly the entire length of the body.

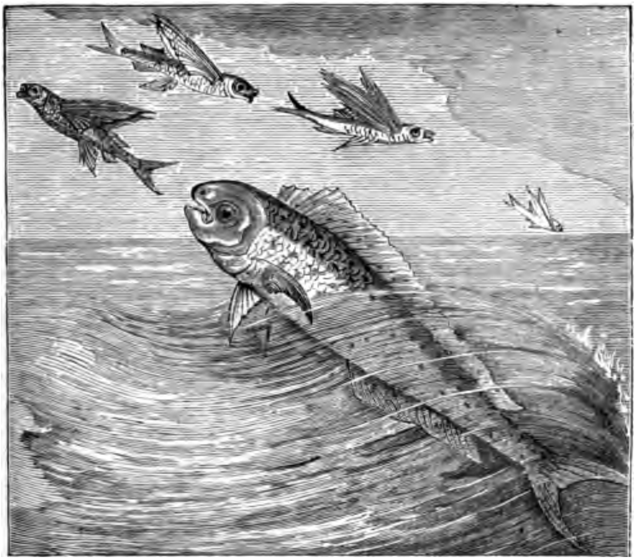


FIG. 223.—Flying-fish (*Exocœtus*) pursued by the dolphin.

NOTE.—They are justly celebrated for their wondrous colors, that defy description, especially when dying, the various changes being due to the pressure of the convulsively contracted muscles on the chromatophores or pigment-cells.

Allied to them are the pompino and pilot-fishes (*Naucrates*). The latter are little fishes that resemble the bluefish in shape, and accompany large fishes, several always being found with large sharks.

Mackerel (*Scomber*).—The mackerel is one of the most valuable of the food-fishes. They are from ten to eighteen inches in length, and richly ornamented with steel-blue and pearly tints. They run in schools, ranging

FIG. 216.—Luminous fishes of the deep sea.—1, *Chauliodus*, one foot long; 2, 9, 10, 11, *Harpodon*, or Bombay duck, six inches; 3, *Plagiodus*, six feet; 4, *Chiasmodus*, one foot, with *Scopelus* in its stomach; 6, *Beryx*, one foot and a half; 8, *Scopelus*, one foot.

other known bony fishes in having six pairs of internal branchial clefts, and consequently five pairs of gills. It has no swimming-bladder.

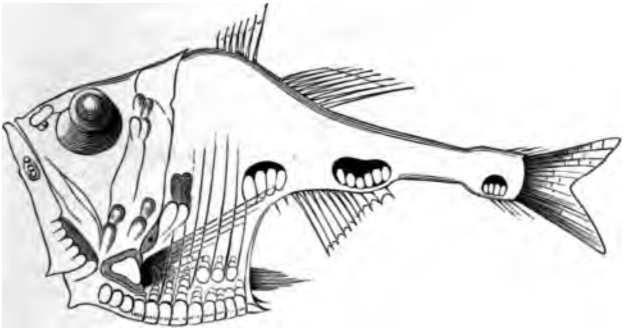


FIG. 217.—*Argyropelecus hemigymnus*, twice natural size, snowing groups of luminous organs.

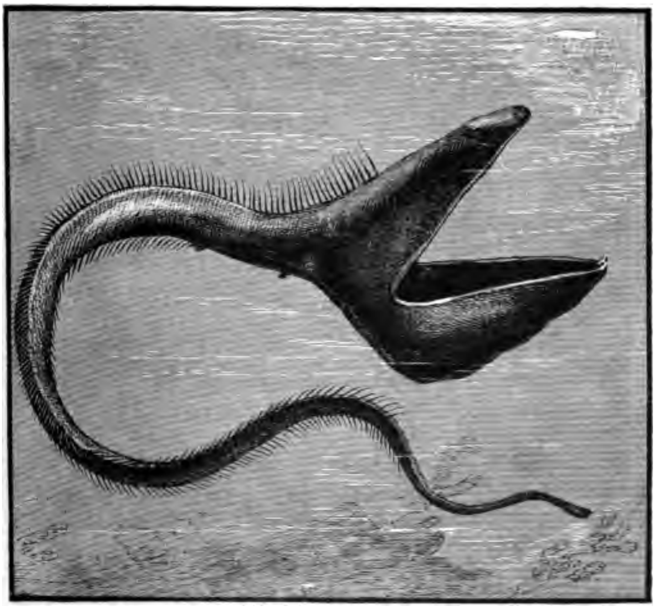


FIG. 218.—The Pelican fish (*Eurypharynx pelecanoides*).

For other accounts, and very complete history of the family, see "Report of Fish Commission," 1880.

Angel-Fishes (*Chætodontidæ*).—The *Chætodon rostratus* of Java has elongated jaws, through which, according to Cobbold and others, it can shoot drops of water at insects on overhanging bushes (Fig. 226). The archer-fish (*Toxotes*) has a prolonged under jaw, and by the same authorities is also accredited with shooting powers.

Surgeon-Fishes (*Acanthuridæ*).—The doctor-fishes are common on the Florida reef, and are at times found farther north. They are from six to eight inches long, and have at the side of the narrow, keel-like portion of the tail a lance-like blade that can be thrown out at will, and proves a dangerous weapon.*

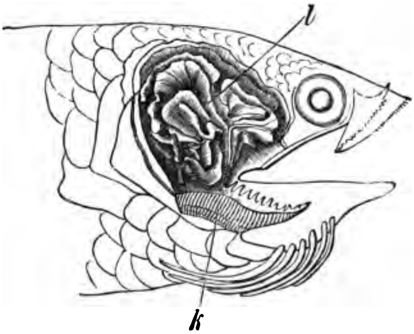


FIG. 227.—*Anabas scandens:* head, with *k*, the gill-cavity, laid open, and *l*, cavity containing the foliated labyrinthine structure.

Climbing-Fishes (*Labyrinthici*).—These fishes, mostly from the East Indies, are noted for their powers of living out of water. To this end they have accessory gill-cavities, or labyrinthine organs (Fig. 227) that contain air and not water, as often stated.

NOTE.—The *Anabas* (see frontispiece) has been known to live out of water for five or six days, and makes long trips overland when the pools dry up. In certain parts of India they have been seen leaving the water in schools and crossing the country, using their pectoral

* In specimens kept in an aquarium on the Florida reef they were found to be extremely pugnacious, striking their knives against all new-comers, lacerating and cutting them severely.

fins as feet. Daldorf, the Danish naturalist, captured an anabas climbing a palm—the *borassus*. This latter performance, however, is not a habit of the fish.

Allied to the Anabas is the *Gourami*, a valued food-fish, that, though originally from the fresh waters of Cochin-China, has been introduced into many other countries.

NOTE.—They are famous nest-builders, forming a nest out of grass (*panicum*) and mud, about six days being required to erect it. From eight hundred to one thousand eggs are then deposited, the young appearing in about two weeks, and remaining in the nest, only venturing out with the parents, who guard them with great vigilance. The *Ophiocephalus*, an allied Indian fish, also builds a nest for its young by biting off grass and weeds. It also burrows in the mud when streams dry up, but does not migrate overland.

Tautogs (*Labridæ*).—The nipper, or cunner, is the most familiar form of this family. The blackfish (Fig. 228), or tautog, is common in Long Island Sound, attaining

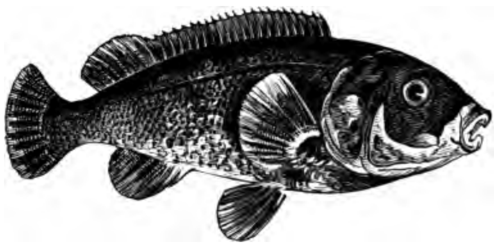


FIG. 228.—Blackfish, or tautog.

a large size. They spawn in May and June, depositing their eggs in the eel-grass and other weeds. Allied are the parrot-fishes of Florida, that have bony teeth fused into a parrot-like bill, with which they attack the branch coral.

NOTE.—The related *Acara* of South America builds a nest in the sand, in which the eggs are deposited, while some species, after the eggs are laid, take them in their mouths. This is continued from time to time, and either eggs or newly-hatched young may be found in the cavity of the gills or the space inclosed by the branchiostegal membrane. The unhatched eggs, according to Agassiz, are always found in the same position in the curious nursery—namely, in the upper part of the branchial arches, protected or held together by a special lobe or valve formed of the upper pharyngeals. Here they are held until the young are able to care for themselves.

Sculpins (*Cottidæ*).—These are marine fishes of fantastic shape, each individual often varying in color. The head and opercular bones are armed with sharp spines, and the fishes resemble the mossy rocks amid which they lie. The sea-raven, or yellow sculpin, is an allied form, attaining a length of two feet, and is remarkable for its grotesque coloring. The males of some species erect nests for their young. Allied are the sea-robins (*Triglidæ*). The flying-robin (*Dactylopterus*) has enormous pectoral fins by which it soars over the water like the flying-fish. Sailors have been knocked over by them, and they are frequently blown aboard vessels.

Gobies (*Gobiidæ*).—The gobies are small fishes, in which the thoracic ventrals are united, forming a hollow disk. They have no air-bladders, and are remarkable for their habit of leaving the water. The scaleless and black gobies and several other species are found on the western coast of North America.

NOTE.—In the *Periophthalmus* (frontispiece), common at the Feejee Islands, Ceylon, and other localities, the pectoral fins are greatly developed, the head blunt, and the eyes staring and prominent. They leave the water and hop along the shore so fast that it is difficult to catch them, resembling frogs more than fishes. They feed out of water, preferring a shell-less mollusk, the *Onchidium* (Fig. 72), and insects. The *Boleophthalmus* has similar habits. The *Blennius pholis* also leaves the water at times. The black goby is said to build a nest for its eggs.

Lump-Fish (*Cyclopteridæ*).—The lump-fishes range from the polar regions to Cape Hatteras, and are clumsy and shapeless, covered with tubercles. Their pectoral and ventral fins unite in forming a disk or sucker by which they attach themselves to rocks. The *Liparis* is an allied form in which the ventral and pectoral fins also form a sucking disk. The *Lepidogaster* has two sucking-disks.

NOTE.—According to Gunther, the male lump-fish forms a nest, the female laying 150,000 eggs, and the former guarding them with jealous care. The young follow the male, or, according to Duncan, cling to it at first by their suckers; later they are often seen at the surface of the water off shore on the New England coast.

Star-Gazers (*Uranoscopidæ*).—In these fishes the eyes are placed upon the top of the head. They are armed with spines capable of inflicting dangerous wounds. Allied are the toad-fishes (*Batrachidæ*) (Fig. 229). The female toad-fish excavates a hollow among the rocks, where the eggs are deposited, and in which the male takes its place, defending the nursery with great pugnacity. The young when hatched cling to the rocks by their yolk-bags. One of this family, from Panama, has a perfect poison-gland, the spine calling to mind the venom-fang of a snake.

FIG. 229.—Toad-fish (*Batrachus tau*).

Cod (*Gadidæ*).—The cod is one of the most valuable of all fishes. They attain a length of five feet and a weight of one hundred pounds. They have three distinct dorsal fins, and a barbel projects from the under jaw. Their range is from Cape Hatteras north on both sides of the Atlantic. In November they spawn in-shore along the New England coast; each female depositing about 9,300,000 eggs that rise to the surface and float, the young appearing twenty days later. In summer the fish seek the cold waters from ten to fifteen miles off shore. The haddock belongs to this family, and closely resembles the cod in habits and appearance. The tom-cod, ling, cusk, and pollock, are all allied forms.

NOTE.—The *Chiasmodus* (Fig. 216) is a deep-sea ally; the top of the head, the under jaws, and the fins, all gleam with vivid phosphorescence; but, more remarkable yet, their jaws work independently and alternately as in the snakes, and the stomach is capable of such distention that they can swallow fishes twice their own size.

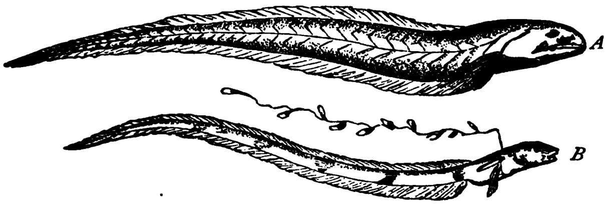


FIG. 230.—Fierasfer and young, a fish that lives in holothurians and star-fishes. *A*, adult; *B*, young.

The **Fierasfer** (Fig. 230, *A*) is a silvery, eel-like form, rarely found out of the digestive canal of holothurians (see page 39). One species inhabits a star-fish (*Culcita*). The young (Fig. 230, *B*) pass through several changes before assuming the adult form.

FIG. 231.—Young flounder (*P. Americanus*), showing different positions of the eye as it moves over. (After Agassiz.)

Flounders (*Pleuronectidæ*).—When young, the flounder is somewhat cylindrical; has an eye upon each side, and swims vertically like other fishes. Later it sinks to the bottom, lying upon its left side, the eye moving over, the successive stages of the movement being shown in Fig. 231, until both eyes are upon the right side, which is now the upper portion. The mouth is generally twisted to conform with the new position. On the lower side the pigment-cells are not developed, and the skin is white, but the upper surface is colored and susceptible to change and adaptation to the prevailing color of the bottom.

NOTE.—This protection, afforded many animals, is due to the contraction and expansion of the different colored pigment-cells that are contained principally in the cutis. They contract or expand according to the light reflected ; the impression is received by the eye and transmitted by the sympathetic nerves. A blind flounder does not adapt its color to the surroundings. By severing some of the nerves Pouchet produced, at pleasure, a fish striped on one side and spotted on the other, etc. The experiment may easily be tried by placing flounders on white, brown, and black bottoms, and changing them about ; so also with the octopus, anolis, and many others.

Order VI. **Pediculati. Walking-Fishes** (*Antennariidæ*).—These are pelagic fishes, floating about upon the surface of the sea among the vast fields of sargassum. The body is compressed, and three or four inches long ; the fins ornamented with barbels, so that they can be scarcely distinguished from the weed, which they also mimic in color. They are interesting nest-builders (Fig. 232), collecting the floating weed into balls as large as a cheese, connecting it by bands of a glutinous secretion probably taken from a special gland, as in the sticklebacks (Fig. 206). The eggs are attached on the sides and within. Allied are the anglers (*Lophiidæ*) (Fig. 233), so called from several spines on the head that have upon their ends barbels of flesh. The spines move up and down over the enormous mouth like a fishing-rod ; the waving bait attracting the smaller fishes, that often fall victims to the curious fisherman. Some of this family, discovered by the "Challenger," are bedecked on all parts with fringes that exactly mimic sea-weed. The

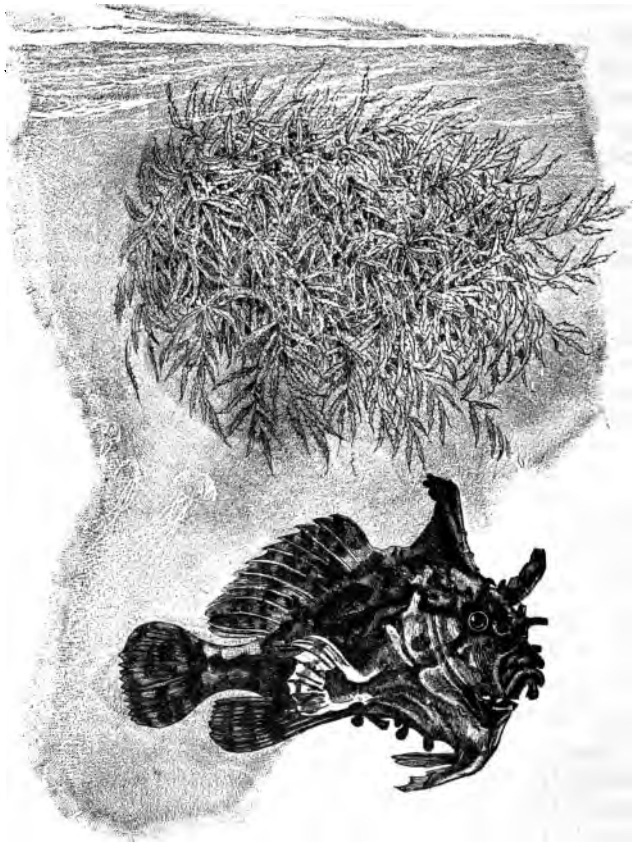


FIG. 232.—The *Antennarius marmoratus* and its floating nest, formed of gulf-weed. Fish natural size, the nest reduced.

young pass through many changes before assuming the adult form.

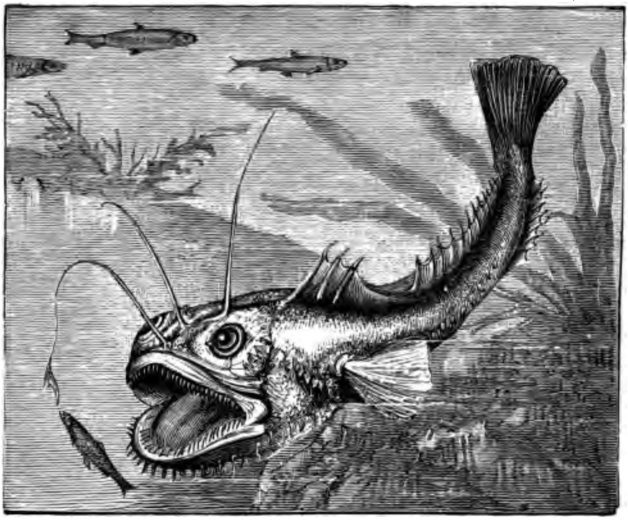


FIG. 233.—The angler (*Lophius piscatorius*).

Order VII. **Lophobranchii. Sea-Horses** (*Hippo-campidæ*).—These curious fishes have a fibro-cartilaginous skeleton. The gills take the form of tufted lobes on each side of the branchial arches. The snout and lower jaw are developed into a tube, at the end of which is the mouth. The tail is prehensile, like an opossum's, and by it they cling to plants, or swim upright by the dorsal fin alone, their movements being slow and deliberate.

NOTE.—They are wonderful mimics. The leaf-finned sea-horse, or *Phyllopteryx eques* (Fig. 234), from Australian waters, is provided with numbers of reddish streaming filaments that resemble plants, forming a perfect protection to the fish as they float about. The male sea-horse receives the eggs into a pouch on its ventral surface. When they hatch, it presses the pouch against a stone or shell, and forces them out. The pipe-fish belongs to this group, and is also a mimic of the weed. The male receive the eggs from the female and carries them in a pouch. In the genera *Nerophis* and *Protocampus* the pouch is wanting, the eggs being attached to the abdomen of the female. In the *Soleno-*

stoma, an allied form of the Indian Ocean, the *mother* carries her eggs in a pouch formed by the ventral fins, they being held in place by long filaments extending from its sides.

FIG. 234.—Sea-horse (*Phyllopteryx eques*), that is protected by its resemblance to sea-weed.

Order VIII. **Plectognathi.** *General Characteristics.* —In these fishes the scales are often modified into spines or plates. The ventral fins are generally absent.

File-Fishes (*Balistidæ*).—The file-fishes are remarkably deep and thin, and are often protected by plates or spines resembling those of the Ganoids. Allied are the trunk-fishes (Fig. 235) (*Ostracionidæ*), that are inclosed in a box or armor composed of bony plates or scales; the tail, mouth, and fins being the only parts movable.

FIG. 235.—Trunk-fish (*Ostracion Yalei*).

Porcupine-Fishes (*Tetradontidæ*).—These fishes are often covered with sharp spines, and when removed from the water they inflate themselves with air, resembling an oval, spiny balloon.* Each jaw is divided in the middle, so that they appear to have four teeth. The diodons are allied forms.

Sunfishes † (*Orthagoriscidæ*).—These are oval or oblong in shape (Fig. 236). The dorsal and anal fins are

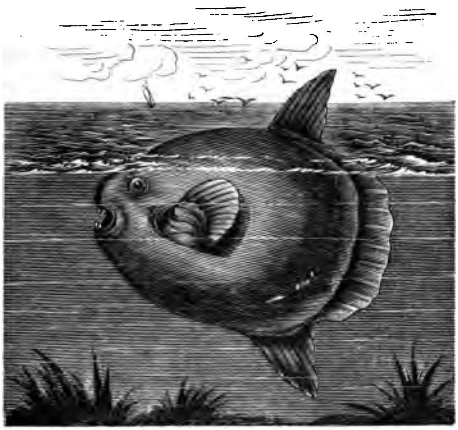


FIG. 236.—Sunfish (*Orthagoriscus mola*).

* They are often figured in this shape, but it is unnatural, and only attained when the fish is forcibly taken from the water. The *Diodon antennatus* has undivided, teeth-like mandibles, so powerful that when swallowed by a shark they have been known, according to Darwin, to eat their way out through the stomach and skin of the fish.

† They are sluggish fishes, rolling along at the surface, and are quite common on the eastern coast of the United States and in other seas. The body is covered with a thick mucus and infested by parasites, goose-barnacles even living in its mouth. Semper and Cobbold refer to its luminous qualities. They attain a height of six feet, and weigh five or six hundred pounds. The liver alone is valuable.

alike and opposite each other, the caudal fin seemingly a mere projective rim of the entire hinder part of the body. Powerful muscles lead into it, but it is probably of little use in locomotion.

Specimens for Study.—The habits and exterior parts of fishes can be studied from minnows, sunfish, sticklebacks, etc., kept in an aquarium or a glass vessel of any kind provided with aquatic plants to aërate the water. Dissections of small specimens are best made in a dish under water, when each part shown in Fig. 194 should be determined. With a delicate knife, the various organs can be exposed, as the brain, nostrils, ears, etc. In preparing a first skeleton, boil the fish, and reconstruct the skeleton as well as possible by (Fig. 193) marking all the parts and observing their relations one to another. In studying the circulation, inject into the veins some colored fluid, as vermilion. It is extremely important to make a drawing of the fish or its parts.

Works on Fishes for further reference.

"Challenger Reports"; "Game-Fishes of the United States," Killbourne text, by G. Brown Goode; "American Fauna," by J. B. Holder, M. D.; "Fishes of Massachusetts," Storer; Goode and Bean, "List of Fishes of Massachusetts Bay and Adjacent Waters," in "Bulletin of the Essex Institute," vol. ii; "Reports of the United States Commissioner of Fisheries and Various State Commissioners"; "Skates' Eggs and Young," F. W. Putnam, "American Naturalist," vol. iii, p. 617; "Gar-Pikes, Old and Young," B. G. Wilder, "Popular Science Monthly," vol. ii; "Respiration of Amia," B. G. Wilder, "Proceedings of the American Association for the Advancement of Science," 1877, also in "Popular Science Monthly"; "Blind Fishes of the Mammoth Cave," "American Naturalist," vol. vi, p. 6, and "Report of Peabody Academy of Science," 1871; "List of Fresh-Water Fishes of North America," D. S. Jordan, "Bulletin of the Buffalo Academy of Natural Science," vol. iii; "Introduction to the Study of Fishes," Gunther; "Development of Osseous Fishes," Agassiz, "Proceedings of the American Academy of Arts and Sciences," vol. xiv; and the works of Brehm, Wood, and Cassell.

Class IV.—AMPHIBIOUS VERTEBRATES. SALAMANDERS, TOADS, etc. (*Batrachia*).

General Characteristics.—The Batrachians are amphibious Vertebrates that breathe air by perfect lungs, though some adult forms have gills. They pass through a distinct metamorphosis. The higher forms have paired limbs, the toes not being clawed as in the reptiles. They are generally oviparous.

Skeleton.—In the frog the skull is closely connected with the body, and differs from that of higher Vertebrates in being partly cartilaginous (Fig. 237). The bones of the limbs, when present, resemble those of higher Vertebrates.

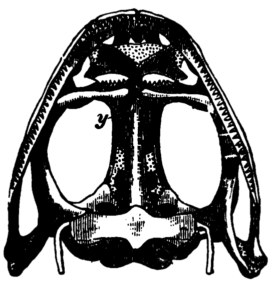


FIG. 237.—Skull of the frog (*Rana esculenta*), from below, showing teeth and the cartilaginous girdle-bone, *y*.

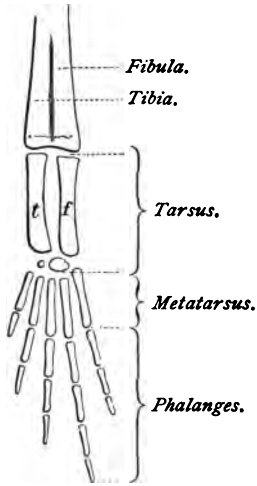


FIG. 238.—Bones of the right leg of a young toad, greatly enlarged. The femur not shown; the tibia and fibula are combined together. (After Morse.)

This is shown in Fig. 238, which should be compared with the limb of the cat.

Digestion.—The mouth is generally large, and in the frog (Fig. 237) the upper jaws are armed with delicate, saw-like teeth. Tadpoles have the jaws enveloped in horny beaks. The liver is two-lobed, and the intestine short and straight, not enlarging into a stomach proper. Frogs and toads feed upon insects as a rule.

Respiration.—At first Batrachians with few exceptions breathe by means of gills, as the fishes, the breathing-organs being external, as in the young of the curious fish *Polypterus* (Fig. 207). Frogs, toads, and newts have at first two sets of gills, an external and an internal pair. The former disappear first. As growth progresses, they lose the latter also, then breathing by perfect lungs.

Circulation.—When young and possessing the red gills, blood is pumped to them as in the fishes, the heart then possessing two chambers, an auricle and a ventricle. Later, when the lungs appear, the auricle divides and the heart becomes three-chambered ; the blood, on account of its incomplete aëration, is cold.

Development.—The Batrachians pass through a distinct metamorphosis. The eggs are generally placed in or near the water, enveloped in some cases in a jelly-like mass, the young first being water-animals, breathing by external gills (Fig. 243), finally changing to the adult form.

Order I. **Trachystomata. Sirens** (*Sirenidæ*).—The sirens are long, slender creatures, with permanent gills. They have no hind-limbs ; even the fore pair, which are either three- or four-toed, are weak and almost useless. The great siren (*S. lacertina*) attains a length of three feet, is nearly black in color, dotted with light spots, the abdomen pink or purple. It has four toes on each fore-limb, and is found in the muddy ditches and swamps of the Southern States. A small siren (*Pseudobranchus striatus*), with three toes, is found in the rice-field streams of Georgia.

Order II. **Proteida.**—The *Proteus* (Fig. 239) is a blind * Batrachian found in the subterranean caves of Adelsberg in Carniola, Austria.

FIG. 239.—*Proteus* of Carniola caverns, showing the external gills.

NOTE.—They are pure white, have bristling gills and gill-openings, and small teeth. The limbs are four in number, the fore pair having three toes and the hinder pair two. They breathe under water by the gills and above by lungs, while experiment has shown that the former can be removed without injuring them. The mud-puppy (*Necturus*) of the United States is a familiar form in the Mississippi country and upper New York. The body is broad and flat; each foot has four toes; they attain a length of two feet. They are extremely sluggish, living in muddy water. The eggs are about the size of peas.

Order III. **Tailed Amphibians** (*Urodela*).—In this order the gills are generally only present in the early stages; the body is slender and eel-like. The Congo snake (Fig. 240) has extremely delicate limbs, and inhabits the muddy waters of the Southern States. The hell-bender, or *Menotoma*, found in the Mississippi Valley, possesses permanent gills, is flat, with weak limbs and a prom-

* The eyes of the *Proteus* are destitute of a crystalline lens, although they have a retina.

inent tail. The gigantic Japanese salamander, over three feet in length, belongs to this order; they are incorrectly supposed to pass through fire without harm. The largest salamander in the United States is the *Amblystoma* (Fig. 241). The history of *Amblystoma mavortium* is extremely remarkable. The young for a long time were considered separate and distinct animals. They lived in the elevated lakes, 8,000 to 9,000 feet above the sea, from Montana to Mexico, and were well known as axolotls, having external gills and true

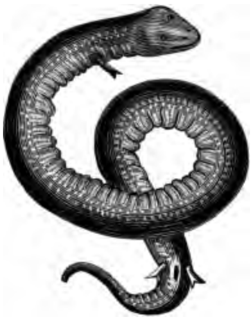


FIG. 240.—Congo snake (*Amphiuma means*).

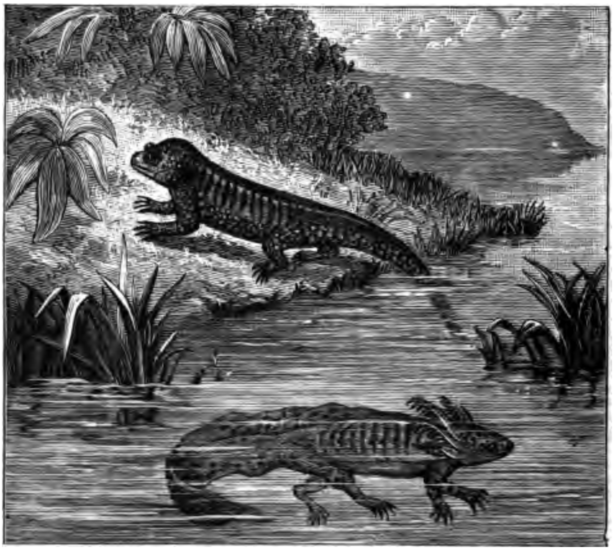


FIG. 241.—Axolotl, a creature living and breeding for generations in the water. Amblystoma coming out of the water—an axolotl which has lost its gills and breathes by lungs alone.

lungs, yet living in the water. Finally some of them were taken to Paris, where their gills shriveled, and they finally left the water, becoming true lung-breathing animals, the *Amblystoma;* so the axolotl was only the larval form, that owing to the extreme dryness of the atmosphere in Mexico never developed, but lived, multiplied, and died in the water.

NOTE.—It is now known that in the lakes of Utah and Wyoming other species attain the adult form. The eggs are deposited in masses, the young appearing in July. They reproduce lost parts, legs and tail if removed appearing a few weeks later. They are useful scavengers, and are eaten by the Mexicans. If the lungs and gills of the axolotl are removed, it still can breathe by absorption through the skin. Frogs can breathe in a similar way.

FIG. 242.—The newt (*Lissotriton punctatus*). Male and young in the water, female on the bank.

The tritons, or newts (Fig. 242), are common in various parts of the world, and are often brilliantly colored. A spotted newt in England bends up the side of a leaf, gluing it together and forming a nest for a single egg, all the others being placed with equal care. Our common triton lays its eggs singly on submerged plants ; others are connected by a thread, whether on land or in the water.

Order IV. **Blind Snakes** (*Gymnophiona*).—The animals of this order are snake-like only in external appearance and in name, having elongated cylindrical bodies destitute of legs. The skin is smooth, containing imbedded scales, and some species secrete in small pores a viscous secretion similar to that of snails. The eyes are small and beneath the skin. The *Cœcilia* of the tropics attains a length of several feet, and lives underground like the earth-worm, feeding upon insects. A Surinam species is viviparous ; the young are born in the water and have external, leaf-shaped gills, that are absorbed as they leave it.

Order V. **Tailless Amphibians** (*Anura*).—We now come to the frogs and toads, in which the body is short, thick, and tailless in the adults, with four limbs, the hinder pair adapted for leaping. The skin covers the body loosely, the muscles not adhering to it. The tongue is fastened to the front of the jaw, the tip pointing down the throat ; as a rule, the lower jaw is without teeth. The eggs (Fig. 243, *e*) are deposited in jelly-like masses in some pool ; in two weeks, more or less, the young appear, those of American toads being darker than those of frogs. They now cling to the weed by little suckers near the mouth parts, 1 ; branching tufts now appear on each side of the head—these are the gills, 2 ; the mouth soon appears, the tufted gills are absorbed, and we have the tadpole with six fish-like gill-slits. The legs are now seen, 4, first appearing as little bumps under the skin, and finally we have an animal resembling a lizard, with four legs and a long tail, 5 ; the latter is gradually absorbed, 6 ; and the toad or frog crawls upon the shore in perfect form, 7.

FIG. 243.—Metamorphosis of the frog. *e*, eggs; 1, tadpoles just out of the egg; 2, with outside gills; 3, with gills hidden, and beak-like mouth; 4, hind-legs appearing; 5, all legs grown, but fish-tail remaining; 6, putting on frog appearance, tail being absorbed; 7, young perfect frog.

Toads (*Bufonidæ*).—The toads in the adult form are terrestrial, the toes are webbed, and the skin generally covered with warty protuberances. The eggs of *Pelobates* are deposited in the water in a loop. The male of the *Alytes* of Europe winds the eggs about its body in strings, and goes into the water, remaining until the young appear. The spade-foot is noted for its sudden appearance in certain localities. It remains but a day or so in the water, where the eggs are hatched in about six days, the young leaving the water in three weeks. The toads hibernate during the winter in burrows, and often have special nests for retreat during the day.

NOTE.—The tales concerning their poisonous properties, and power of living in solid rock, are fabulous. A South American species mews like a cat, while the European fire-bellied toad utters an extraordinary moan. Toads are extremely valuable as destroyers of noxious insects, and are in turn preyed upon by snakes.

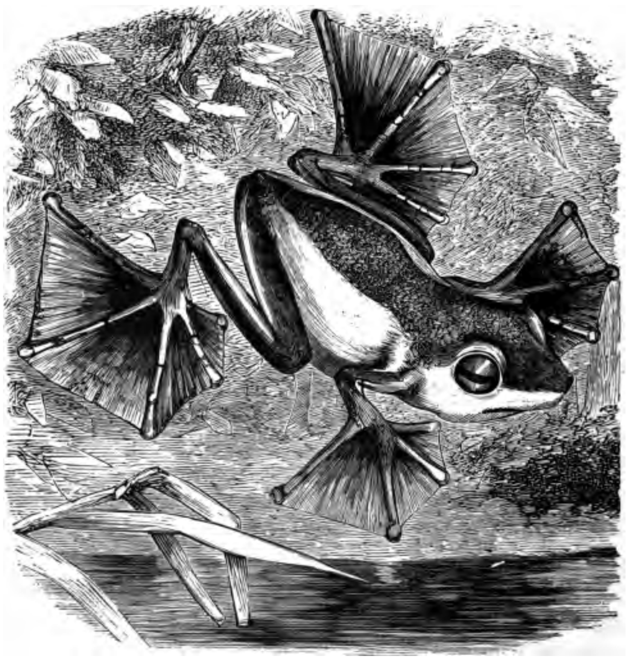


FIG. 244.—Flying tree-toad of Borneo (*Rhacophorus*).

Tree-Toads (*Hylidæ*).—The tree-toads are the most interesting of the order. They are all of small size, and have the tips of the fingers and toes provided with a disk with which they cling to trees and any surface. Their habits are very singular. In tropical Africa, a species (*Polypedates*) deposit their eggs on leaves by the side of streams into which they are washed by the rain. In the Island of Guadeloupe there are no marshes, and the young tree-toads appear directly in the adult shape : this is called a *suppressed metamorphosis*. A tree-toad in Martinique carries its young tadpoles clinging to its back, presenting a strange sight. In the Andes, a toad (*Nototrema*) has a sac on its back in which the young are carried. The most remarkable tree-toad is a flier (*Rhacophorus*, Fig. 244) from New Guinea. Its toes and fingers are completely webbed so that they form parachutes, the little creature springing from limb to limb like a flying-squirrel. They are four inches in length, the web of the hind-feet expanding four square inches. Nearly all tree-toads are green or brown in color, adapted to the leaves or limbs of trees, thus escaping their enemies. *Hyla micans* exudes a luminous secretion that may serve to frighten its enemies, while a French species exudes when attacked a strong, pungent odor.

VALUE. — The tree-toads protect the trees from noxious insects. *Hyla arborea* is used as a barometer, placed in a bottle, with a small ladder upon which they ascend in pleasant weather, remaining at the bottom if it promises to be inclement. In the Surinam toad (Fig. 245), allied to the family, the male

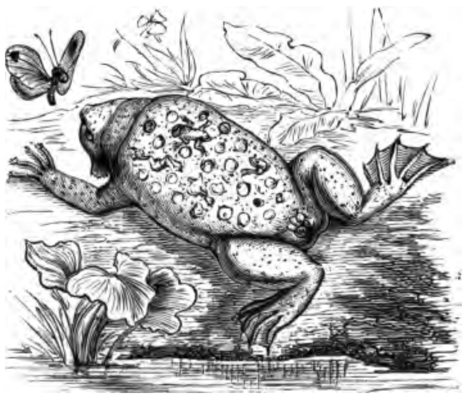


FIG. 245.—Surinam toad, showing young escaping from the cells in the mother's back.

places the eggs on the female's back, where they become imbedded, cells growing up around them, the mother lying in the mud until they appear, when a strange spectacle is seen, the young leaping from their prisons in all directions.

Frogs (*Ranidæ*).—The frogs are the highest forms of the order. The upper jaw and palate have fine, sharp teeth (Fig. 237), and the throats of the males are provided with vocal sacs. The bull, marsh, and pickerel frogs are our common species. Their eggs are laid in masses in the water in April, May, and June. They hibernate in the mud during the winter. The bull-frog has been known to attain a length of two feet, and its noise can be heard for over a mile. They mimic the color of the rushes of the river-side in which they live. Their geographical distribution is wide. One species is found living in the hot springs of Pisa where the temperature is 115° Fahr. They live upon insects, but the great Indian tiger-frog has been observed to capture sparrows. The American leopard-frog is one of the most active, leaping ten or twelve feet at a single bound. In the paradoxical frog of South America, the larva, instead of growing, decreases in size to attain the adult shape.

VALUE.—The capture of edible frogs forms a valuable industry in France.

Works on Amphibians for further reference.

"Smithsonian Reports"; Holbrook's "Herpetology of North America"; Allen's "List of Reptiles and Batrachians near Springfield, Massachusetts"; Huxley's "Vertebrates."

Class V.—TRUE REPTILES. SNAKES, LIZARDS, etc. (*Reptilia*).

General Characteristics.—The true reptiles, snakes, lizards, and turtles, are distinguished from the Amphibians by having scaled bodies, clawed limbs, and by not passing through a metamorphosis or tadpole stage, developing directly from the egg. They have many features in common with the birds, as true nostrils and a long windpipe. About three thousand living reptiles are known.

The Skeleton.—The skeleton varies much in different orders. The vertebræ in many of the snakes consist of three hundred different bones working on a ball-and-socket plan. The limbs in the various forms are adapted for walking or swimming, as the case may be.

Digestion.—With the exception of the turtles, that have a horny mandible, the reptiles all possess sharp teeth, arranged either in rows or separate cavities, that are adapted for crushing, cutting, or holding prey. The stomach of snakes is but little removed from an ordinary intestine. In the crocodiles it resembles the gizzard of birds.

Circulation.—In the crocodile the heart is four-chambered as in the birds, while in other forms there is, besides the two auricles that are always present, but one ventricle. The blood is imperfectly aërated, consequently the reptiles are cold-blooded.

Respiration.—The reptiles breathe by lungs alone; and here we first find a true nostril, as in the birds and higher forms. In the snakes the lung is single.

Development.—The reptiles are oviparous, the egg-shell generally being soft and crisp. Some are ovoviviparous, or the young are developed before the egg is laid.

Order I. **Snakes** (*Ophidia*). *General Characteristics.*—The snakes are distinguished by their long, cylindrical, footless bodies. The bones of the backbone or vertebræ join each other on a ball-and-socket plan (Fig. 246, *b*, *c*), and often number 400. The bones of the lower jaw are merely connected by ligaments, *e*, allowing great extensibility. The teeth are not set in sockets, and point backward, being only used in holding prey. The tongue is extensile, and held within a sheath. The eyes are without movable lids, hence the staring expression of all snakes. The gliding motion is effected by the successive advancing of the large ventral or lower scales. The skin is moulted once a year, the process being assisted by the growth of casting-hairs (Fig. 247) beneath the skin, that push it

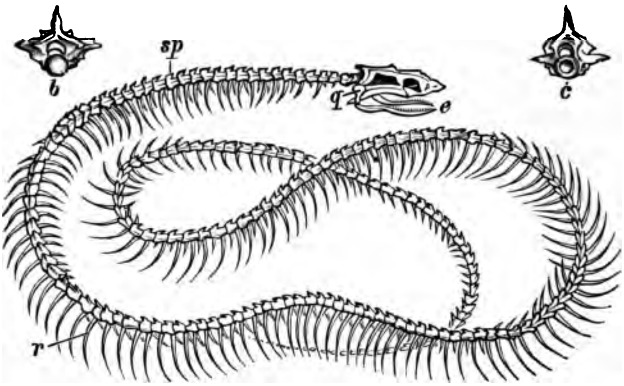


FIG. 246.—Skeleton of a snake. *sp*, spinous processes of the joints; *r*, ribs; *q*, quadrate bones, joining upper and lower jaws; *e*, front of the lower jaw, where there is an elastic band in the place of bone; *b*, ball end of joint, facing the tail; *c*, cup end of joint, facing the head.

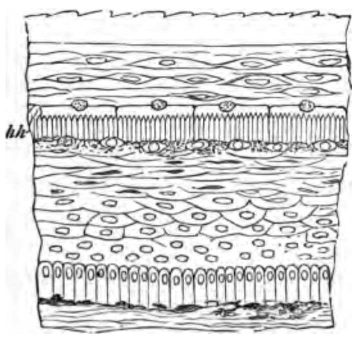


FIG. 247.—Casting process in the skin of the adder. *h h*, the casting hairs; the portion of skin above them is pushed away, and the hairs themselves form the ridges on the new skin.

upward. In the North they hibernate in winter, and in the South pass through a summer sleep. Over one thousand species are known, one hundred and thirty species being found in North America.

The Vipers (*Viperidæ*).—About twenty-two species of these snakes are known. In the puff-adder, of the Cape of Good Hope, the poison-fangs are extremely large, and the snake is much dreaded. They are confined to the Old World.

Rattlesnakes (*Crotalidæ*). — In this family are the rattlesnakes (Fig. 248), moccasins, and copperheads, forty species in all, and extremely poisonous. The upper jaws contain few teeth, but have needle-like, recurved, grooved fangs, that are raised at the slightest alarm. The poison-glands (Fig. 249) are at their base, and when the mouth closes upon an enemy the muscles that effect it press the gland, forcing the poison into the wound. They have a pit or depression between the nostrils. The true rattlesnakes rarely exceed four feet in length, and have the tail terminat-

FIG. 248.—Rattlesnake (*Crotalus*).

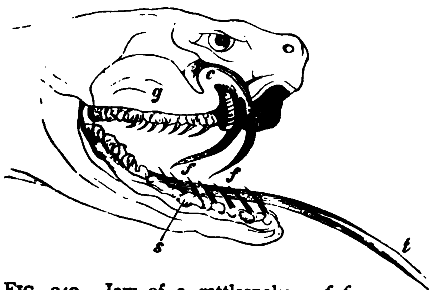


FIG. 249.—Jaw of a rattlesnake. *f f*, poison-fangs; *g*, gland secreting poison; *c*, canal leading from gland to base of fang; *t*, harmless tongue; *s*, saliva-glands.

ing in horny, button-like rattles (Fig. 248), incorrectly supposed to indicate the age of the snake. The rattle is sounded at the approach of danger. The bite of the rattlesnake is often fatal if no remedy is at hand. They hibernate in the winter, and the young have been seen passing into the mouth of the mother for protection. The fer-de-lance of the West Indies is deadly. It is dark-yellow or brown, and attains a length of six feet. It is viviparous, giving birth to fifty or sixty young.

Moccasins.—Water-moccasins are common in the Southern States, and are much dreaded. They are about two feet in length, dark brown in color, with transverse bars of black, and are extremely vindictive. The copperhead is also dreaded. Both have been observed to receive their young into their mouths, and so protect them.

VALUE.—Rattlesnake-oil is valued, and *crotalin* is obtained from the snake. Oil of the copperhead is also used in medicine. Rattlesnake leather is used in bags, cases, etc.

Sea-Snakes (*Hydrophidæ*).—These snakes, fifty species of which are known, are found in the Indian, China,

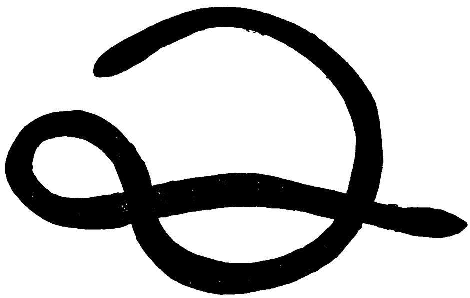


FIG. 250.—*Platurus vulcanicus*, a sea-snake living in the fresh-water lake of Taal (Luzon), and having a paddle-like tail. (After Semper.)

and Australian seas, and have been seen near Panama. They only approach the shore to breed, and, with one exception (Fig. 250), are marine. They are extremely poisonous. The tail is laterally compressed, forming a paddle, with which they swim. They attain a length of five or six feet, and are viviparous. Professor Semper found one at Mindanao on the rocks, covered by twenty young, that were all two feet long.

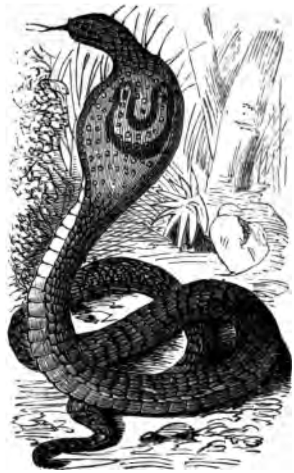


FIG. 251.—Cobra, showing the hood.

Allied are the *Elapidæ*, among the most deadly of all snakes. The fangs are erect and fixed. The *Elaps*, of Central America, is richly colored. The *Naiä haje*, of Africa, has a hood that is erected when it is excited. To the early Egyptians it was an emblem of divinity. The cobra,* or hooded snake (Fig. 251), is much feared in India. When enraged, it raises a curious hood about the head by drawing forward its anterior ribs.

NOTE.—Over 19,000 persons were killed by cobras in India in 1880, and 2,000 head of cattle. During this time, 212,776 cobras were killed by snake-killers, paid by the Government. Since 1870, 200,000 persons have been killed by these reptiles alone. According to the Emperor of Brazil, permanganate of potash is one of the most successful antidotes to the venom of snakes. Large doses of whisky or brandy, enough to intoxicate, are generally an antidote to the bite of the rattlesnake.

Pythons (*Pythonidæ*).—This family comprises the largest and most powerful of all the snakes; forty-six spe-

* Snake-charming in India is supposed by many to be a trick, but this is not so in all cases. A missionary in Burmah found that he could exert the curious influence over the cobra, and handle it without fear; he performed the same feats as the native jugglers.

cies are known, mostly inhabiting tropical regions. The Python is found in Africa and the East Indies. The rock python is a yellowish-brown color above, and inhabits the rice-fields. It attains a length of twenty-six feet, and devours large animals. The female lays about fifteen eggs, coiling about them,* her body increasing in temperature, and in this inclosure the young hatch in about fifty-six days. They frequently find their way into native houses. The natives seize them by the tail and rush off, dashing them against the trees. The boa-constrictor is a native of tropical America, and ranges from ten to forty feet

FIG. 252.—Anaconda, or water-boa.

in length. According to Wallace, Dr. Gardner measured one of the latter length that had swallowed a horse, and that they devour cattle is, he conceives, not improbable. Some of them have rudimentary hind-limbs, or spur-like hooks, that are used when the snake hangs from trees. The boas burrow in the ground. The anaconda (Fig. 252), or water-boa, is common in tropical South America, attaining a length of twenty feet, and preys upon large animals. They enter the water freely, and when hanging from the trees so resemble vines, their colors being sombre, that they are perfectly protected. Numbers of

* This habit was observed at the London Zoölogical Garden.

authentic cases are known of boas having attacked human beings.

VALUE.—The oil of the large boas is much used for various purposes; the skin is tanned, and made into boots, saddle-cloths, bags, etc.

Allied are the ground fanged snakes. The **Tree-Snakes** (*Dendrophidæ*) have long, slender bodies, adapted for movement in the trees, and in many their rich green coloring affords them complete protection. They are tropical, and often found coiled up in birds' nests. About thirty-five species are known. The whip-snakes are allied forms. **Fresh-Water Snakes** (*Homalopsidæ*).—In this family of fifty species are snakes that live more or less in fresh-water streams, and are found in all parts of the world, but especially in the East. The desert snakes are allied forms, and the curious *Dasypeltis*, that lives upon eggs, swallowing them entire.

In the *Colubridæ* represented by two hundred and seventy species, which include many of our American snakes, there are no rudimentary limbs. Both jaws are armed with teeth. The striped snakes, *Eutænia*, a common form in the Middle States, attain a length of two feet; hibernating in holes or burrows during the winter, appearing in great numbers in early spring. They prey upon toads, frogs, and other small animals. The garter-snake is viviparous, and often protects its young by receiving them into its mouth. They are extremely prolific, bearing at times seventy-eight young. The viviparous spotted spreading adder is even more remarkable in this respect, producing eighty-seven young at times. The hog-nosed snakes of North America have a short, thick body, with a large head. The black-snakes are a lustrous, metallic black, and attain a length of five feet. They are harmless, preying upon animals either in the trees or on the ground. The crack-whip snakes are incorrectly supposed by some to seize their tails in their mouths and roll along.

Order II. **Lizards** (*Lacertilia*). *General Characteristics.*—The lizards (Fig. 253) are scaly reptiles with cy-

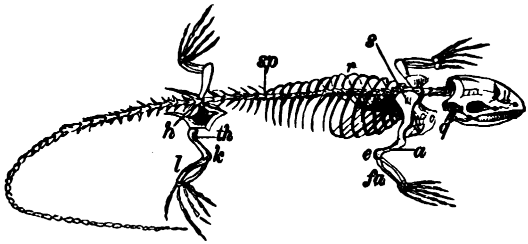


FIG. 253.—Skeleton of a lizard. *sp*, spinous processes, which in the tortoise are flattened into plates; *r*, ribs; *s*, shoulder-bone; *a*, upper arm; *e*, elbow; *fa*, forearm; *h*, hip-bone; *th*, thigh-bone; *k*, knee; *l*, bones of the leg; *q*, quadrate bone between upper and lower jaw.

lindrical bodies, long, slender tails, and have usually two pairs of feet. The jaws are not extensible, as in the snakes, and are armed with sharp, conical teeth. The tongue is free, long, and sometimes forked. All lizards are oviparous. Their eggs are deposited either in the ground or in hollow trees. About seventeen hundred living species are known; eighty-two species are found in North America, north of Mexico.

Chameleons (*Chamæleonidæ*).—These strange lizards (Fig. 254) are found in Africa and Asia, thirty species being known. The body is compressed, the skin rough, the tail round and prehensile; the tongue is cylindrical, and ca-

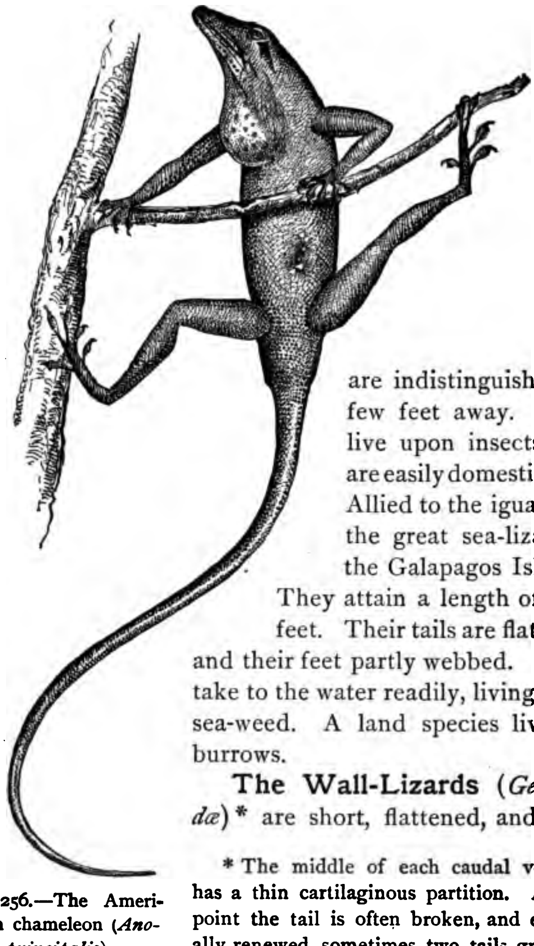
FIG. 254.—The chameleon, showing tongue.

pable of projecting five or six inches, and covered with a sticky secretion for the capture of insects. The eyes are large, with a circular eyelid, and are independent of each other. Their five toes are arranged in two opposite groups of pincers. Their movements are slow and deliberate, and their power of adapting their color to that of their surroundings is remarkable. The eggs are round, white, and deposited in the ground. In the **Flying-Lizards** (*Agamidæ*) of the East Indies (Fig. 255) the tail is long and snake-like, while between the limbs extends a membrane supported by the much-prolonged fifth or sixth hind-ribs. The female deposits three or four eggs at a time. The frilled lizard of Queensland has hind-legs adapted for leaping. The *Moloch horridus* of Australia is a sluggish form, completely covered with large and small spine-bearing tubercles. The **Iguana*** is found in the tropical portions of North and South America. It attains a length of five feet, and is extremely powerful, inflicting terrible blows with its tail. They live among the trees, subsisting upon the fruit, and are sought after as an article of food. The Anolis (Fig. 256) of the Southern States belongs to this family, and is noted for its changes of color. The horned lizard (Fig. 257) of Mexico and the Western States is covered with spines,

FIG. 255.—Red-throated flying dragon (*Draco*), showing membrane supported by ribs.

* John G. Bell, the naturalist and companion of Audubon in many of his expeditions, saw an iguana rush across the surface of a river in Central America, keeping *upon* the surface by the lightning-like rapidity of its movements. A very few minutes sufficed to cross,

and the head ornamented with spikes. They run with great rapidity, and so resemble the dry ground that they



are indistinguishable a few feet away. They live upon insects, and are easily domesticated. Allied to the iguanas is the great sea-lizard of the Galapagos Islands. They attain a length of four feet. Their tails are flattened and their feet partly webbed. They take to the water readily, living upon sea-weed. A land species lives in burrows.

The Wall-Lizards (*Geckottidæ*)* are short, flattened, and slow

FIG. 256.—The American chameleon (*Anolis principalis*).

* The middle of each caudal vertebra has a thin cartilaginous partition. At this point the tail is often broken, and eventually renewed, sometimes two tails growing. According to Gunther, they are enabled to throw off their tails spontaneously when pursued, the wriggling offcast attracting the attention of the pursuer, while the gecko escapes. They

of motion (Fig. 258). The toes are provided with clinging ridges of bristles, by which they walk upon the walls in search of insects, though in the forest species this arrangement is sometimes absent. The jaws have small teeth, and the tongue is not extensible.

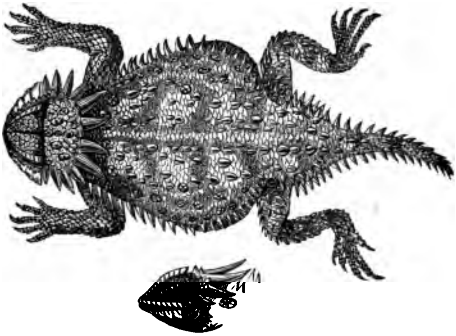


FIG. 257.—Horned lizard (*Phrynosoma cornutum*). Dorsal view and side view of head.

FIG. 258.—Gecko.

The Scinks (*Scinkidæ*) are spindle-shaped (Fig. 259) and covered with smooth scales. The five-lined and red-headed scinks are common in the Southern States. The **Glass Snakes** (*Chalcidæ*) have no feet, the body being serpent-like (Fig. 260). The glass snake

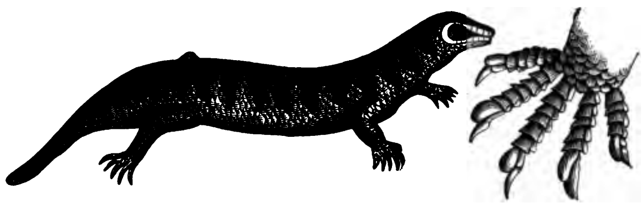


FIG. 259.—Scink (*Scincus officinalis*), showing structure of the feet.

have also been seen devouring their own cast-off skin and wriggling tail. The geckos of the East Indies utter a shrill cry. The leaf-tailed gecko is one of the most curious. One species is said to be luminous. They are all insect-eaters. Two hundred species are known.

of the Southern and Western States attains a length of three feet, and is so fragile that the slightest blow severs it in sections. The upper surface is yellowish green spotted with black.

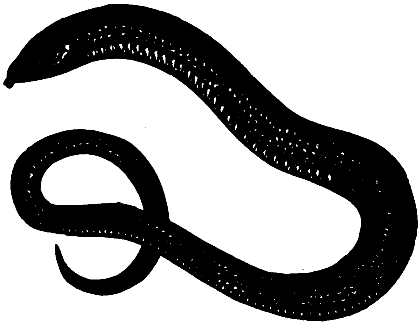


FIG. 260.—Glass snake (*Ophisaurus ventralis*).

Heloderma (*Helodermidæ*).—The "Gila monster," or *Heloderma* (Fig. 261), is the largest lizard of North America, attaining a length of three feet, and enjoying the distinction of being the only poisonous member of the order. In appearance they are repulsive, being covered with scales, the whole resembling a flinty, faceted armor. The general color is black, marked with yellowish-orange or white interspaces. The tail is cylindrical and clumsy. Their movements are slow and uncertain, resembling those of a young alligator. The teeth are fissured, and at the bases of the grooves are the ducts from which the poisonous saliva passes into the wound.* After biting, the heloderma appears sluggish,

* According to Mitchell and Reichert, the physiological action of the poison is quite different from that of snake-poison. The latter kills by paralyzing the respiratory center, while the poison of the heloderma paralyzes the heart. When injected subcutaneously it causes no local injury, the effect being to arrest the motion of the heart, which slowly becomes contracted, and the spinal cord paralyzed. It is not necessarily fatal to human beings, though an American scientist, after being bitten, was barely able to call assistance. In experiments tried by Sir John Lubbock, a live frog when bitten died almost immediately in convulsions. A Guinea-pig, bitten in the hind-leg, died in three minutes, and young rats succumbed even more quickly. The specimen kept in the New York Zoölogical Garden thrived upon hard-boiled eggs.

like many of the poisonous snakes. They occur in Mexico, Arizona, and Lower California. Allied are the water-

FIG. 261.—Heloderma, a poisonous lizard.

lizards (*Varanidæ*), the huge monitors, seven feet in length, the gigantic lace-lizard, and others.

The Double-Walkers (*Amphisbænidæ*) (Fig. 262) are found in tropical America, often in the nests of ants. They move in either direction with equal ease. Thirteen species are known in Asia, Africa, and South America.

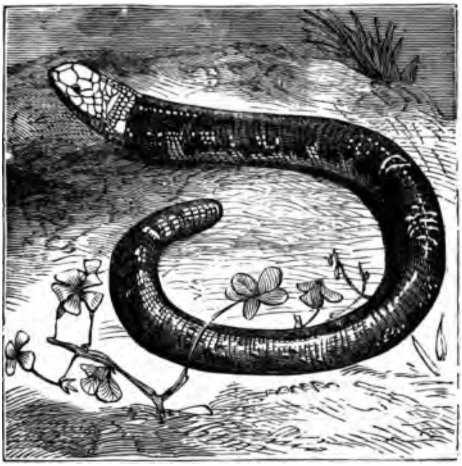


FIG. 262.—*Amphisbæna fuliginosa.*

Order III. **Turtles** (*Chelonia*). *General Characteristics*).—The turtles (Fig. 263) are distinguished by the shell or box-like covering that envelops them. The upper part forms the carapace, *r*, the lower the plastron, *pl*, the two constituting a covering into which the head, tail, and limbs can be more or less withdrawn. The generally arched carapace is formed by the greatly expanding ribs, these and the vertebræ being fixed and immovable. The plastron is generally considered a greatly expanded sternum.* The outer surface of the shell is made up of scales or plates, or a leathery substance, as in the case of the soft-shell tortoise. The jaws are toothless, being armed with a horny beak, as in the birds. The eyes have three lids;

* Some naturalists consider it a dermic growth.

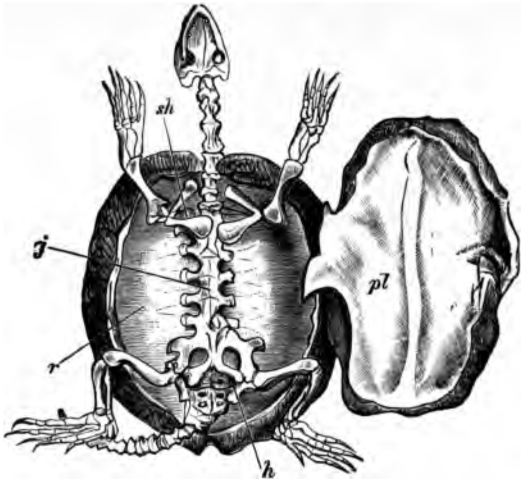


FIG. 263.—Skeleton of the tortoise, from below. *j*, joints of the backbone grown together; *r*, ribs formed into a solid cover; *sh*, shoulder-bones; *h*, hip-bones covered by carapace, which has grown over them; *pl*, plastron, or under cover.

the limbs are adapted to aquatic or terrestrial life, as the case may be. About forty species are known in North America, north of Mexico.

Marine Turtles (*Cheloniidæ*).—This family has a wide distribution in warm and tropical seas; five species are known. The leather turtle, or *Sphargis* (Fig. 264), is the rarest and largest known. The shell is a thick, leathery skin, composed of six longitudinal plates, forming raised ridges.

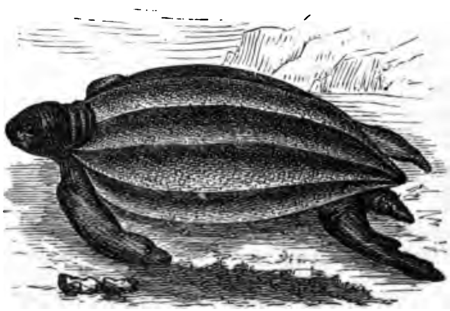


FIG. 264.—Leather turtle (*Sphargis*).

The eye-openings are placed vertically. They attain a length of eight feet, and a weight of twelve hundred pounds.* The loggerhead † is nearly as large. Its shell is made up of scales. They breed upon Loggerhead Key, Florida, and other localities, burying their eggs in the sand, leaving the sun to hatch them. The digging and covering is done by the hind-flippers. The green turtle (Fig. 265) is somewhat similar, though more delicate, the head and flippers smaller. They feed upon algæ, particularly *Zostera marina.* The hawkbill ‡ (Fig. 266) is distinguished

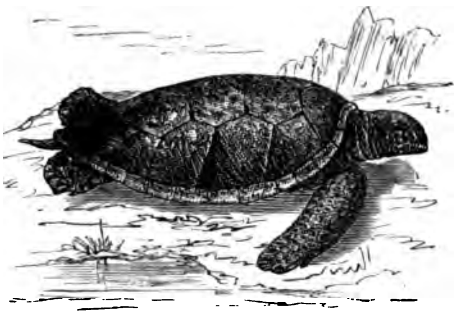


FIG. 265.—Green turtle.

* The gigantic extinct *Protostega gigas* was allied to the *Sphargis.* It measured seventeen feet between the fore-arms or flippers, and was remarkable for the rudimentary character of the bones in the adult.

† The loggerhead is extremely powerful, and I have found it difficult to turn one with the help of two men. By seizing them by the shell just over the head I have been carried a long distance in the water at a rapid rate. The steeds thus experimented upon were kept in an inclosure half a mile long and eight feet deep, and when asleep on the bottom could generally be caught by diving. Owing to their sluggish natures they often fall a prey to sharks to the extent of their flippers. I have caught them in the Gulf Stream with these organs entirely bitten off.

‡ Though the hawkbill is a vegetable feeder as a rule, they sometimes attack the *Physalia* (Fig. 19). One, two feet long, was found by the author floating on the surface, insensible, its head covered by the blue tentacles. By scraping them off with a knife the turtle recovered, and was kept as a pet for a long time.

by its more elegant shape, hooked bill, and large scales, having, like all the others, long, fin-like flippers.

VALUE.—The scales of the hawkbill are greatly valued in commerce. Oil from the green turtle's eggs is used in dressing leather, and in the manufacture of soap. The eggs are not the luxuries generally supposed, and are best when immature, and dried in the sun.

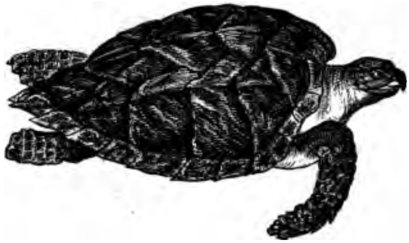


FIG. 266.—Hawkbill turtle.

In the soft-shelled turtles (*Trionychidæ*) the body is flat and circular, the shell being supple, like rubber or leather. They are carnivorous, and one species is common in the St. John's and other rivers of Florida and the Southern States. The American species are generally one foot in length, but East Indian specimens have been caught weighing two hundred and forty pounds. Allied are the snapping-turtles (*Chelydidæ*), forty-four species of which are known. The shell is elevated in front and low behind; the head large, and jaws strongly hooked, the neck long and snake-like. They attain a length of five feet, and are the most ferocious of their kind. The three American species range from Florida to Canada. The eggs are spherical, and deposited in the ground.

The land turtles (*Testudinidæ*) have high, arched shells, a broad sternum, and elevate the body in walking, instead of dragging it along. One hundred and twenty-six species are known. The terrapin, painted, spotted, and box turtles are familiar American forms. The latter are remarkable in that the plastron is composed of two parts, movable upon a single axis, so that the soft parts of the animal can be completely boxed in. They are found in dry woods, and attain a great age.

NOTE.—The most remarkable land tortoise is the *Testudo nigra*, or elephant turtle, of the Galapagos Islands. They attain a length of six feet, and eight men can barely lift the largest. They feed upon the cactus, and their paths from the springs can be seen all over the islands. Though large and clumsy, they can travel eight miles in three days. The eggs are spherical, and larger than a hen's egg. They are either buried in the sand or dropped among the rocks. During the breeding-season the male utters a hoarse roar or bellow. They are valued for their flesh and oil. The *Colossochelys* is an extinct land tortoise of the Tertiary period, found in India. They were twenty feet in length, the shell being twelve feet long and six feet high, and would serve as a covering for six or seven men.

Order IV (*Rhynchocephalia*).—This order is represented by a single animal—the *Sphenodon punctatus*, or *Hatteria*, of New Zealand. Its general appearance is like the iguana, having a similar row of dorsal spines. It attains a length of three feet, and forms a burrow, lining it with grass, that is also occupied by three species of birds—petrels, etc. The lizard occupies one side of the nest and the birds the other. It is nocturnal in its habits, and lives to some extent upon the food the birds bring in to their young.

Order V. **Crocodiles** (*Crocodilia*). *General Characteristics.*—The crocodiles and alligators form the highest order of existing reptiles. The brain and heart closely resemble those of the birds. Their skin is covered with bony plates, and the teeth are lodged in separate sockets; the nostrils can be closed, and the feet are partly webbed. They lay twenty or thirty eggs, that are buried in the sand and hatched by the sun.

Alligators (*Alligatoridæ*).—The alligators,* of which ten species are known, are distinguished by having both

* Their nests are sometimes in the sand or in mounds of decayed vegetation. In the colder months they hibernate in the mud. In Nicaragua they have been known to seize human beings, pigs, and even horses, often drifting down upon their prey, their bodies resembling submerged logs. Their voice is a loud bellow like that of a bull.

large front teeth as well as the canines fit into pits in the upper jaw. They are common in the Southern United States and tropical America, attaining a length of eighteen feet.

VALUE.—Skin as leather, oil, and musk.

Crocodiles (*Crocodilidæ*).—These reptiles are found in the rivers and marshes of nearly all tropical countries. The lower canine teeth fit into notches in the upper jaw, instead of pits. The muzzle is sharp and narrow. The hind-legs have a fringe of compressed scales behind, and the toes are webbed nearly to the tip. Twelve species are known. A crocodile (*Crocodilus acutus*) (Fig. 267) is,

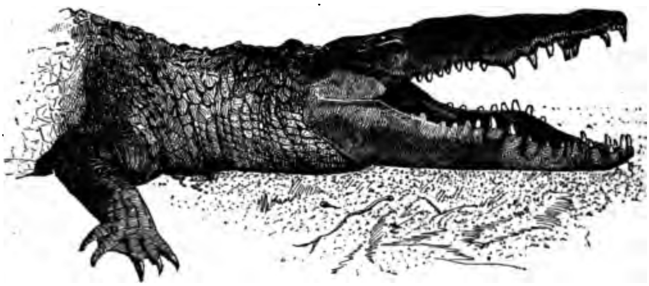


FIG. 267.—Head of Florida crocodile (*Crocodilus acutus*), from life.

though not generally known, quite common in the vicinity of Biscayne Bay, Florida, and differs much from the alligator in appearance and habits, living in salt marshes as well as fresh, and being more or less marine.*

* The crocodile shown in Fig. 267 was fourteen and a half feet in length, and was shot after being followed three successive winters. The specimen is now in the Museum of Natural History, Central Park. When shot and speared it towed the boat for some distance, and made a desperate resistance, finally diving into a hole in the bottom. Its tail protruding, a rope was fastened to it, and tied to a bent tree, and the following morning the monster was found swinging partly in the air,

In the breeding-season the female utters a bark like a dog. The eggs, somewhat resembling those of a goose, are deposited among leaves in heaps, and when hatched the young are led away by the mother and fed upon masticated food. The India crocodiles in the dry season hibernate in the mud, which hardens about them. A tent pitched unwittingly over such a case was once overthrown by the awakening hibernator. Allied are the long-nosed crocodiles (*Gavialidæ*), three species of which are known, inhabiting the Ganges and rivers of Borneo and North Africa. They attain a length of thirty feet.

VALUE.—The teeth, flesh, hide, and oil, are all valued.

Specimens for Study.—In the spring months the eggs of frogs and toads can be found in pools, and should be placed in an aquarium or some vessel, and the changes watched from day to day. In this way the history of the animal can be followed from the egg to the adult, and the habits, etc., observed. Eggs hardened in alcohol can be cut into sections and examined. The simple skeleton of the frog or toad affords an excellent object for study, and should be prepared, the bones labeled and compared with those of allied and higher forms, and the points of difference noted. Collections of the fauna of a neighborhood or country are always valuable, and should comprise the eggs, tadpoles in all stages up to the adult, preserved in alcohol, and marked with locality, name, sex, etc. A book of reference should also be kept, in which notes, observations, and sketches should be entered.

and dispatched. A smaller specimen, that was taken into the boat and supposed to be dead, suddenly recovered, upsetting it, and throwing the occupants into the water. The animals are extremely wily, and capture birds by jerking them under water by the legs; and, to show their marine habits, specimens have been seen on the reef four miles from land.

Works on Reptiles for further reference.

"Smithsonian Reports"; "Tropical Nature," Wallace; "List of Reptiles and Batrachians near Springfield, Massachusetts," Allen; Holbrook's "Herpetology of North America"; Agassiz, "Embryology of Turtles," in "Contributions to Natural History of the United States"; "Check List of North American Reptiles and Batrachians," E. D. Cope; "Serpents," "Popular Science Monthly," vol. iv.

Class VI.—Birds (*Aves*).

General Characteristics.—From the reptiles we pass to the birds, that may be characterized as warm-blooded feathered Vertebrates, having the fore-limbs adapted for flight, the jaws inclosed in horny beaks, and the bones hollow.

Skeleton.—In examining the skeleton of a bird (Fig. 268), we first notice its extreme lightness. This is due to the fact that many of the bones that are filled with marrow in other animals are in the birds hollow air-chambers. The skull-bones in the adult bird form a single piece, and except in certain extinct forms (Fig. 274) the jaws are toothless and inclosed in horny cases called beaks. The lower jaw is not joined directly to the skull as in man, but to a quadrate bone (Fig. 268, *q*), as in the reptiles and batrachians. The neck, consisting of from nine to twenty-four vertebræ, is extremely long and flexible, so that the bird can trim its feathers on any part of the body; a knot can almost be tied in the neck of the flamingo. The (dorsal) vertebræ, from six to ten in number, are firmly joined (anchylosed) in the flying birds; but in the non-fliers, as the emu and ostrich, they are movable one upon another. The vertebræ between the dorsal and those constituting the tail (caudal) are joined, forming a single bone called the *sacrum*, which, joined with the innominate bones, forms the pelvic arch to which is attached the first bone of the leg or thigh (Fig. 268, *th*). To the thigh or femur is attached the tibia, to which a small fibula is joined. The position of the knee is seen at *k*; then follows the foot, *f*, or tarso-metatarsus, that in wading birds is very long, and in powerful fliers, as the man-of-war hawk (Fig. 283), very short. The heel, *h*, is far from the ground, and to the foot-bone are attached the two, four, or five toes, as the

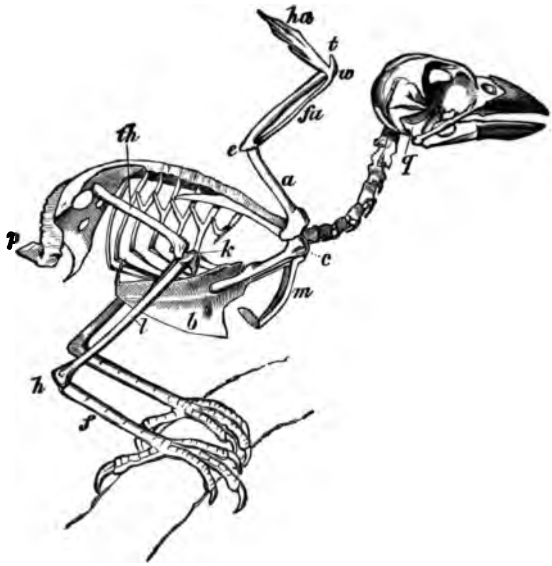


FIG. 268.—Skeleton of a sparrow. *q*, quadrate bone, peculiar to reptiles and birds and some *amphibia*; *b*, breast-bone; *m*, merry-thought or collar-bone; *c*, coracoid bone, over which the tendon works to pull up the wing; *p*, plowshare-bone, on which the tail grows. Wing-bones: *a*, upper arm; *e*, elbow; *fa*, fore-arm; *w*, wrist; *t*, thumb; *ha*, hand. Leg-bones: *th*, thigh-bone; *k*, knee; *l*, lower part of leg; *h*, heel; *f*, foot.

case may be, that are armed with scratching or clinging claws that extend in different directions. Generally there are three before and one behind, as in Fig. 268; others have two before and two behind, or, as in the swifts, all four extend to the front. To prevent birds from falling while asleep on a perch, there is a wonderful arrangement of the muscles, a number extending down the leg from the pelvis to the outside of the knee, then winding around and blending with the principal muscles of the toes. When the bird settles in roosting, the leg is bent upon the thigh, the weight of the bird acting as a lever that tautens the muscles and draws the toes and claws tightly about the limb or roost; thus the bird can sleep while standing upon one leg without fear of falling, being held fast by the weight of its body. The tail or caudal vertebræ are movable to some extent and end in the plowshare-bone, *p*, that supports the large quill-feathers of the tail. On the under portion of the skeleton we note the sternum, *b*, or breast-bone, to which the wing-moving muscles are attached. In the flying birds, as Fig. 268, it is keeled and has a sharp edge, thus offering a greater surface of attachment, but in birds like the ostrich the keel is absent. Above the sternum are the ribs, that vary in number from seven to eleven pairs. In front of the sternum the clavicles join and form a V-shaped bone called the lucky or collar bone (Fig. 268, *m*). The coracoid bone over which the tendon works to pull up the wing, is seen at *c*, and this and the scapula and clavicle constitute the "pectoral arch" to which the humerus, *a*, or first bone of the wing, is attached. The position of the elbow is seen at *e*; then follows the fore-arm (ulna and radius), *f a*. The position of the wrist is shown at *w*; then follow the carpal and metacarpal bones, which are joined at the extremities. At the upper end of the metacarpal bones there is a rudimentary thumb (Fig. 268, *t*). It has a single joint and supports what is called the false wing. The end of the wing (Fig. 268, *ha*) corresponds to the hand, and three rudimentary fingers are generally observed, that correspond to the first and third fingers of the human hand. The fingers only in rare cases are clawed, and the arm, that in other animals is used for digging, clinging, or crawling, is now only used to propel the bird through the air or water as the case may be.

Digestion.—As the birds have no teeth, they either swallow their food entire or tear it with the bill or claws. The digestive organs are shown in Fig. 269, 1. The food passes down the gullet and lodges in the crop, *c*, that is easily felt in chickens that have gorged themselves with corn. From here it passes to the true stomach just below, and is brought in contact with a secretion called gastric juice. From here it passes to the gizzard, *g*, that to all intents and purposes is an internal set of teeth or grinders, being a muscular sac with a hard, horny lining in which the grain or other food is completely ground to a pulp. To assist in this operation chickens and other grain-eating birds swallow gravel and pebbles. In the flesh-eaters, as the eagles, the coat of the gizzard is not so thick. The experiment has been tried of feeding gulls on grain,* and it was found that the gizzard assumed the appearance and functions of that of true grain-eaters. When the food is thoroughly ground, that which is not absorbed as fuel for the system enters the small intestine and is finally rejected.

Circulation.—In the birds we meet for the first time a warm-blooded animal, the mean temperature of the blood, which is red, being 110° or 112°. This is due to the fact that the birds are extremely active, and that the blood is not only aërated in the lungs, but in the air-sacs of the various parts of the body. Again, the feathers are poor conductors of heat, and tend to keep up the body temperature. The heart is now four-chambered, composed of two auricles and two ventricles. In circulating, the venous blood enters the right auricle, flowing from here to the right ventricle, from which it passes through the pulmonic artery to the lungs. Here it changes into arterial blood, passes to the left auricle, then to the left ventricle,

* A gull, *Larus*, at the Shetland Islands, lives on grain in the summer and fish in the winter, a habit that must cause a yearly physical change.

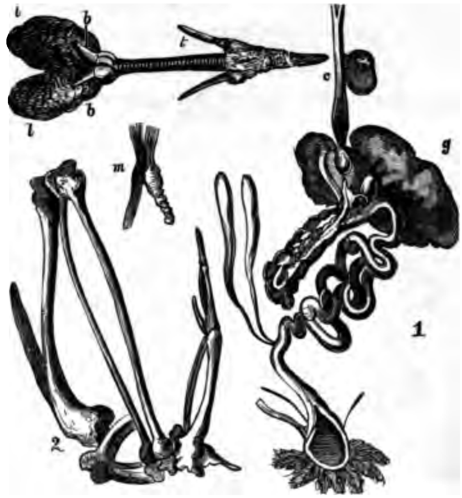


FIG. 269.—Parts of a bird. 1, digestive apparatus; *c*, crop; *g*, gizzard; *t*, trachea; *b*, *b*, bronchial tubes; *l*, *l*, lungs; 2, bones of the wings.

that sends it through the great aorta into numerous branches that lead all over the body.

Respiration.—The breathing organs are shown in Fig. 269, *l*, *l*. The lungs, *l*, *l*, are two in number, spongy in consistency, and are attached to the walls of the cavity in which they are placed. The large air-passages of the lungs end in air-sacs, that in turn connect with the cavities of the bones, so that air taken in passes down the trachea, *t*, enters the lungs, *l*, *l*, aërating the blood there, also passing into the air-sacs and penetrating the hollow bones in every part of the body; thus the bird can alter its specific gravity at will. The air-sacs are nine in number; two are placed in the abdomen, four in the thorax, and three near the wish-bone.

FIG. 270.—1, Brain of a bird; 2, eye, showing nictitating membrane.

Nervous System.—The brain (Fig. 270, 1) is larger than in the reptiles, and has no convolutions.

Covering.—The birds differ from all other animals in being covered with feathers (Fig. 271), that are modified scales or hairs, developed, like them, in sacs in the skin. They afford protection to the bird, determine its contour or shape, and are the means of enabling it to soar in the air, the long pinions being arranged to offer the greatest

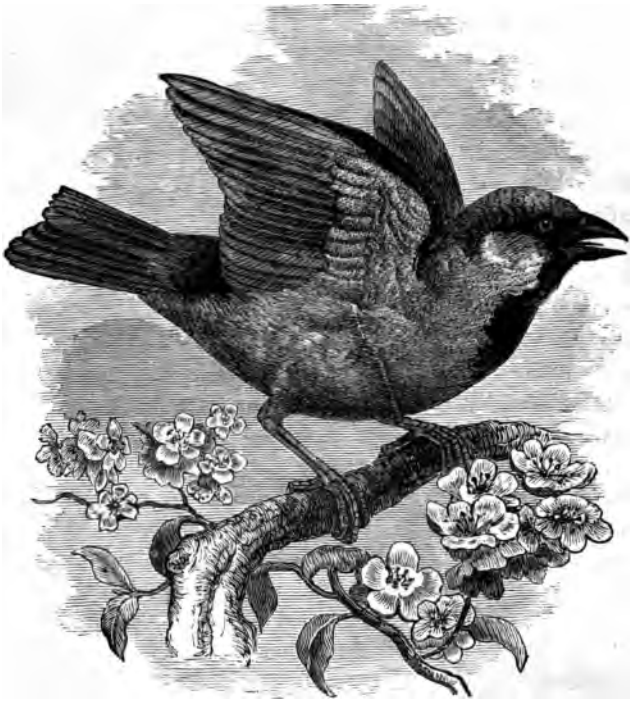
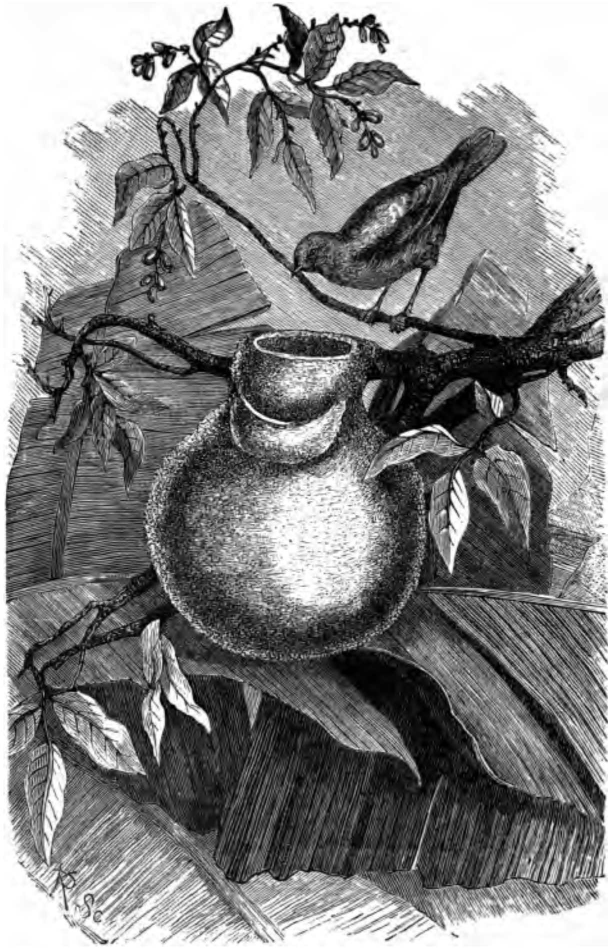


FIG. 271.—Sparrow, showing the skeleton (Fig. 268) clothed in flesh, and the graceful outline produced by the coat of feathers.

resistance. Taking a goose-feather (Fig. 272) as an example, we find that it is composed of several parts. The hollow, horny quill, 1, rests in a sac; this leads to the shaft, 2, which is horny, grooved, and filled with a substance resembling wood-pith. From the sides of the shaft spring the barbs, 3, that are so delicate that it would nat-

A COMPARISON OF FEET. PLATE IX.

1. Claw of hawk (grasping).
2. Claw of domestic fowl (scratching).
3. Claw of parrot (clinging).
4. Foot of a duck (adapted for swimming).



Nest of the Cape titmouse.

urally be assumed that under the vigorous beating of the wing they would form little, if any, resistance. There is, however, a special arrangement, shown in Fig. 273, by which each barb is locked with its fellow by little secondary branches called barbules, that are generally serrated and provided with hooks, and in this way a strong surface is presented to the wind. Plumes, as those of the ostrich, are feathers without barbules. Down is feathers in which the barbs are extremely soft and free. The feathers shed water by being oiled with a secretion the birds take from an oil-gland near the tail. After the reproductive season, birds generally moult or shed their feathers. Some birds, as the ptarmigan, do this two or three times a year.

Fig. 272.—Parts of a feather. 1, quill; 2, shaft; 3, 3, vane or barbs; 4, accessory plume.

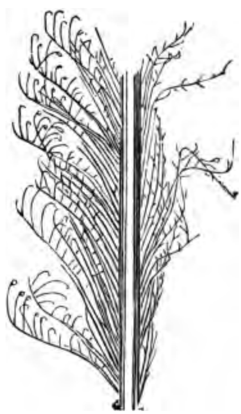


Fig. 273.—Barb from a goose-quill, showing the hooklets highly magnified.

Senses.—The eyes of some birds are remarkably piercing, and their vision extremely acute. All possess a third eyelid or nictitating membrane (Fig. 270, 2) that covers and protects the ball of the eye, so that eagles can gaze directly at the sun without blinking. The eyes of these birds and their allies are also provided with a ring of hard plates that forms an apparatus by which the bird can adjust its sight to objects near at hand or at a distance. The penguin, that passes so much of its time under water, has a similar arrangement by which it is enabled to see equally well in either element. There is, as a rule, no external ear. The nostrils are slits situated in the upper portion of the mandibles, and are protected with bristles or scales. The songs of birds constitute their language, this being particularly evident in the common fowl. The sounds made when a hawk approaches, when an egg has been laid, when calling their young, and the "song" on warm days when in search of food, are all different expressions of totally different emotions. The songs of birds have been set to music by Mr. X. Clarke (see "American Naturalist," vol. xiii, page 12).

Development.—All birds are oviparous. The eggs are either hatched by the male or female, or both, or by the sun (gulls), or artificial heat (brush-turkey). The young are generally provided with a calcareous knob upon their soft bill, as in some reptiles, with which they break the egg and escape. Some are at first helpless, and have to be fed, while others run (chickens) or fly (maleo) immediately upon their escape. About seven hundred species of birds are found in North America north of Mexico, and in all about eight thousand distinct species are known throughout the world, of which the following are some of the most typical and interesting examples:

Sub-Class I.—Lizard-tailed Birds (*Saururæ*).

The first and lowest forms of birds were extremely reptilian in their characteristics. The *Archæopterix* is a remarkable fossil form found in the Jurassic slates at Sohenhofen, Germany. It attained the size of a crow; the beaks were armed with conical teeth; the tail was formed by a long extension of the vertebræ, the feathers growing out upon the sides, and the wings were bird-like. They are all extinct.

Sub-Class II.—Toothed Birds (*Odontornithes*).

These strange fossil birds were discovered in the cretaceous beds of this country by Professor Marsh. Their reptilian and fish-like characteristics are seen in the vertebræ, which are biconcave. The jaws, long and slender, were armed with teeth (Fig. 274) placed in sockets as are those of the crocodile. Some were fliers and others had rudimentary wings. The *Hesperornis* was a large aquatic bird about six feet in height. Its jaws were supplied with teeth set in grooves, the wings were useless and rudimentary, while the feet were like those

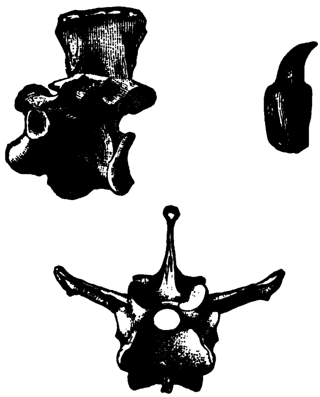


Fig. 274.—Bird with teeth, showing jaw with teeth, the sockets, a tooth enlarged, and section of the backbone. (After Marsh.)

of modern divers, so that the bird has been termed a carnivorous, swimming ostrich. They are all extinct.

Sub-Class III.—Flat-breasted Birds (*Ratitæ*).

General Characteristics.—Birds with rudimentary, useless wings; the sternum, or breast-bone, not keeled; legs powerful, and adapted for running.

The **Apterix** (*Apterygidæ*), or "kiwi-kiwi" (Fig. 275), is confined to New Zealand. It attains a height of two

Fig. 275.—The Apteryx, a nocturnal ground-bird.

feet, is tailless, and the wings are rudimentary. The bill is long, the nostrils placed at its tip. The feathers are brown and hair-like. It is nocturnal; the nest or burrow is generally placed in the ground at the root of a tree;

a single egg being deposited, that equals one fourth the weight of the bird. The feet are powerful and adapted for scratching.* A remarkable extinct form of this class is the gigantic moa, of New Zealand (Fig. 276), that lived during the time of the Maoris. The largest (*Dinornis giganteus*) attained a height of nearly ten feet. The limbs and bones were larger than those of an ox. The *Æpyornis*, an extinct bird of Madagascar, was an allied form, and supposed by many to be the roc of the Arabian tales. Remains of its eggs show one to have been equal to one hundred and fifty hen's eggs.

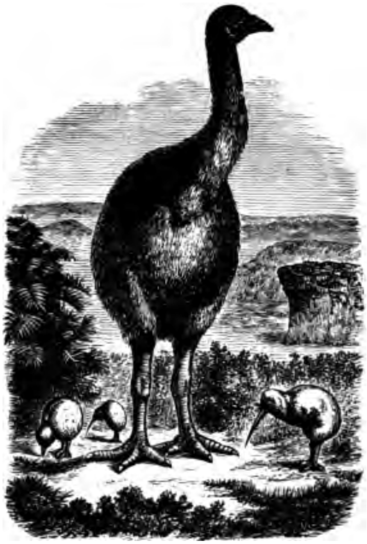


FIG. 276.—Wingless birds of New Zealand. The giant moa (*Palapteryx*) and the tiny apteryx. The moa is no longer to be found alive.

Ostrich (*Struthionidæ*).—This family is represented in South America by the **Rhea** (*Rhea Americana*). It is about three and a half feet in height, and differs from the ostrich in the possession of three toes. The head and neck are covered with downy gray feathers, those of the tail being absent. They live in flocks on the pampas. The male excavates the nest, and afterward sits upon the eggs, and, according to some authorities, collects them when they are left scattered about

* It is a curious fact that when sleeping these birds endeavor to put the head under the wing, though the latter is entirely useless as such a protection.

by the hen. During this time they are extremely fierce. They readily take to the water and swim well. The young differ in color from the parents.

The **Emeu** (*Dromaius Novæ Hollandiæ*) is an allied form from Australia, its feathers resembling a mat of long black hair. The wings are rudimentary, the nostrils are not far from the tip of the upper mandible, and the three toes are of equal length. They attain a height of seven feet. As with the rhea, the male attends to the eggs. The young at first have a protective marking of black stripes upon a white ground.

The **Cassowary** (*Casuarius galeatus*), found in the Island of Ceram and in the Indian Archipelago, also has three toes, but of unequal length, and attains a height of five feet or more. The body is covered with long, black, hair-like feathers, the wings being represented by five stiff, cylindrical shafts, that are often used as a defense. The nostrils are placed near the middle of the upper mandible, and the head is ornamented by a large, horny helmet. The eggs are protected by their grayish-green color.

The **Ostrich** (*Struthio camelus*) * is the largest living bird, attaining a height of eight feet. It is found in the deserts of Africa and Arabia. The legs are extremely

* The general color is black and gray, the tail and wing feathers being of great size and beauty. The nest is a mere hollow in the sand, in which the eggs, about thirty, are laid, each one equaling about two dozen hen's eggs, and weighing about three pounds each; in the day-time being kept warm by the sun, and at night covered by the male. The eggs upon the outer row are often eaten by the old and young birds. Their speed is greater than that of the fleetest horse. In running, the wings are spread out (Fig. 277), and perhaps used as sails. Their legs are also their protection in close quarters. Edward Verreaux, the French naturalist, saw a native instantly killed by a kick from one. Their food consists of herbage of all kinds, while stones and various strange articles are swallowed to aid digestion.

powerful, and provided with only two toes, the inner one being twice as long as the outer.

VALUE.—The oil, skin (leather), and feathers are all used. Ostriches are now farmed in this country for their feathers.

FIG. 277.—Ostrich (*Struthio camelus*) running at full speed.

Sub-Class IV.—KEEL-BREASTED BIRDS (*Carinatæ*).

General Characteristics.—All the rest of the birds are included in this class. They are distinguished by a keeled sternum or breastbone, the fore-limbs in the higher forms being developed as organs of flight.

Order I. **Penguins** (*Sphenisci*).—The *Penguins* (Fig. 278) are confined to the Antarctic region, and are remarkably fish-like in their habits. The wings are small, and covered with scale-like feathers, and are used, as well as their webbed feet, as paddles. The king-penguin (*Aptenodytes longirostris*) is one of the largest, attaining a height of three and a half feet, colored dark above, the breast white, a black patch in front being surrounded by two narrow bands of bright orange-yellow. They congregate in bands, and from a distance appear like soldiers marching upon the sands. On Marion and other islands they breed in vast numbers, living in well-organized communities.*

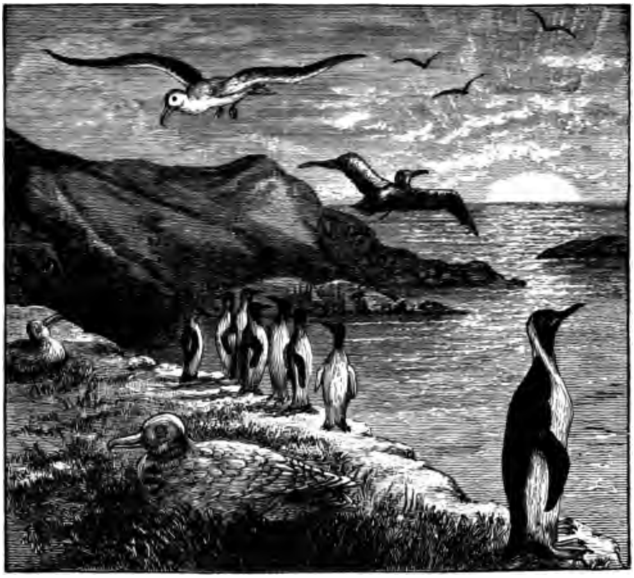


FIG. 278.—Albatrosses and penguins.

* The cities or rookeries of the king-penguin are extremely interesting. They are generally upon flat ground, and divided by mound-like ridges into two irregular portions. In the larger stand the old birds, their beaks pointing upward, not outward, as generally figured in books. The smaller area is the nursery, and in it, crowded together, are the young, and breeding pairs, that are exceedingly ferocious, fiercely attacking young intruding males, and sometimes killing them. The young are curious-looking creatures, covered partly with down and feathers, giving them a grotesque appearance. The breeders carry the single egg about with them in a pouch between the legs for seven

They deposit one egg, that, instead of being placed upon the rocks, is held in a pouch until hatched. During this time they hop along, the feet being close together to hold the egg in; at other times, when not holding the egg, they walk like other birds. Allied is the jackass-penguin (*Spheniscus Magellanicus*) of the Cape of Good Hope and Falkland Islands. The former makes nests for its eggs in the rocks, of stones and shells of *balanus* that are washed ashore.

The rock-hopper penguin * (*Eudyptes saltator*) is found in vast rookeries at Inaccessible Island. From the sides of the head projects backward, like a quill-pen, a tuft of sulphur-yellow plumes. In the water the wings are used as fins. The nests are shallow depressions, containing two greenish-white eggs, that are incubated by both male and female.

VALUE.—Oil, and the skin as fur. At Heard Island the skins are used as fuel in the winter.

Order II. **Pygopodes**. *General Characteristics.*—The birds of this order are aquatic, some with rudimentary wings, that are used almost as fins, and covered with scale-

weeks, when the young appear, and during this time are probably fed by the males. The egg is greenish-white and pointed at the end.

* The rookeries of the rock-hoppers at Inaccessible Island are of vast extent, covering one quarter of the island, and giving shelter to perhaps five hundred thousand birds, and formed in the vast fields of tussock-grass, that is worn out into streets, alleys, and lanes, from three to five feet in width. Along these streets the nests of the penguins are placed; and so fierce are they, and so vast their numbers, that a passage through the bird-city is attended by the greatest danger. From the sea to the rookery a roadway has been worn smooth by the feet of the birds, and up this highway they are seen passing in companies and bands. In the water, their motions are similar to those of a porpoise, leaping from it in a like manner. They are remarkable for their migrations. They leave Inaccessible Island April 15th; the males return the last of July, the females August 12th. Where they go is not known, and, as there are no landmarks, their return is a wonderful example of instinct, and only comparable to that of the seals,

like feathers. The bill is flattened and knife-like, the feet webbed, and placed so far back that upon shore the birds stand erect. The bones of this and the preceding order are solid.

Auk (*Alcidæ*).—The great auk* (*Alca impennis*) (Fig. 279) is remarkable as having become extinct since 1870, and hardly seventy perfect specimens are known in the world. Its length was about three feet, that of the wings four inches. The bill was powerful, wings small, the back black and breast white. They laid a single egg, about as large as that of a swan, spotted with small, irregular blotches. The little auk (*Simorhynchus pusillus*), common in the Arctic regions, is the smallest species known, being only seven inches in length. They lay on the ice or rocks a small, bluish-white egg. Their cry is *Rott-tet-tet-tet-tet*, continually repeated. They are found in large numbers in northern Norway. The *Guillemots* (*Uria*) (Fig. 280, 5), six species of which are known in the Arctic waters, have long, straight, pointed, conical bills. The general color is dirty black. They breed in vast quantities on inaccessible cliffs, always facing the sea. A single egg is laid, and, according to Sir John Richardson,

FIG. 279.—Great auk, a bird that has become extinct within fourteen years.

* Three hundred years ago they were caught by the boat-load by the early fishermen, and now the preserved specimens are so rare that $650 was paid for one in the Museum of Natural History, New York. It formerly ranged the coast of Maine, where its bones are now sometimes found in the shell-heaps,

the mother of the British guillemot takes the young on its back and carries it to sea on the first voyage. Under water the wings are used as in flying. Allied are the *Puffins* (*Fratercula*) (Fig. 280, 4), that have short, deep,

FIG. 280.—A group of sea-birds. 1, cormorant; 2, black-winged tern; 3, gulls; 4, puffins; 5, guillemots.

wedge-shaped bills. The common puffin, or sea-parrot (*F. Arctica*), is common on the North Atlantic coast, attaining a length of thirteen and a half inches. Their nests are tunnels in the ground, at the extremity of which the single egg is placed. The nest is often occupied by a family of rabbits.

VALUE.—Auk and puffin leather, oil, and fur.

Loons (*Colymbidæ*).—The great northern diver or loon (*C. torquatus*) is a familiar example, ranging throughout the whole of North America. They dive with great skill, and swim under water a quarter of a mile, faster than a man can row; are good fliers, but move slowly on land.

The **Grebes** (*Podicipitidæ*) are abundant in northern America, and common in many countries; they are distinguished by the structure of their feet; the membrane, instead of uniting the toes, being cleft nearly to the base of the latter, forming membranous margins (Fig. 281). The bill is long and slender. The crested grebe (*P. cristatus*) attains the length of about twenty-four inches, and extent of wings thirty-four. The head is ornamented with a large double crest of brown feathers. They frequent the fresh-water lakes and streams, and are powerful swimmers, often remaining under water with the tip of the bill exposed when pursued. The nest is formed of rushes in the water, and often floats about. The eggs number from two to seven, and the young follow the mother as soon as hatched, often taking refuge upon her back.

FIG. 281.—Foot of grebe (*Podiceps*), showing swimming membrane on each toe.

NOTE.—The nest of the Castanean grebe (*P. cornutus*), according to Fouray, is a perfect raft, and is paddled about by the mother.

The eared, horned, Western, and red-necked grebes are American species.

VALUE.—Skin as fur, muffs, etc.

Order III. **Longipennes** (*Long-winged*). *General Characteristics.*—This order includes the birds with extremely long, slender, and pointed wings, generally aquatic but not submarine swimmers. They have wondrous powers of flight, and long, slender, and compressed bills; the anterior toes webbed.

The **Petrels** (*Procellariidæ*) are aquatic swimming birds rarely approaching the shore, except to breed. The bill is complicated, seemingly composed of several parts, the nostrils opening from distinct tubes. The stormy petrel,* or Mother Carey's chicken (*P. pelagica*), is a typical form.

The **Giant Petrel** (*Ossifraga gigantea*), of the Southern Ocean, is the largest. They and their large allies prey upon young gulls. Among the Antarctic ice is found the snow-white petrel (*Pagodroma nivea*).

NOTE.—About Kerguelen's Land the petrels invariably burrow in the ground, those of the genus *Oestrelata* forming burrows six inches in diameter, ending in a round chamber in which is placed the nest. The solitary petrel forms a burrow ten feet long. The diving petrels (*Pelecanoides*) also burrow and are wonderful divers, unlike others of the tribe.

The **Prions** are small, gray, petrel-like birds, with boat-shaped bills, that honey-comb the ground at Kerguelen's Land with their nests.

The **Shear-Waters** (*Puffinus*) somewhat resemble the petrels. The wandering shear-water is common on the Atlantic coast, and attains the length of twenty inches, the wing fourteen inches. The Antarctic species burrow, the peat-beds at Tristan da Cunha being entirely honeycombed by them. The European species breed on the rocks and in rabbit-burrows. The largest member of the family is the albatross (Fig. 278), common in the

* Petrels when placed upon the deck of a vessel have great difficulty in rising.

Southern Ocean. They are powerful fliers, rarely approaching the shore except to breed. The wings spread often twelve or fifteen feet; the bill is extremely powerful, curved, and acute; the nostrils form two tubes at the base of the upper mandible.

The **Wandering Albatross** (*Diomedea exulans*). The male is snow-white, except the tail, which is dark; the females are sprinkled with gray, and the young are dark gray. At Marion Island they breed in great numbers, seeming to lose the power of flight during the breeding-season. The nest is made up of tufts of grass and moss, forming a mound one foot and a half in diameter at the top. The one egg is about five inches long, with red specks at the large end, and does not rest in the nest, but is held in a pouch in the skin.

The **Mollymauk** (*D. culminata*) is about the size of a goose. The nest is a cylindrical pile of grass and clay, about fourteen inches in diameter and twelve in height, hollow on top, the edges overhanging so that they form good seats when deserted. The single egg is also held in a pouch. These pillar-like nests are also found in the streets of the penguin cities, the ground beneath them in turn being burrowed by the holes of prions and puffins At Tristan da Cunha, the albatross-nests are found in a dead crater 8,000 feet above the sea. Their food is generally fish.

VALUE.—The feathers are used for various purposes, the bones of the great albatross as pipe-stems, the skin of the feet as purses and pouches. The oil of the petrel is used for illumination in the Azores. Guano is obtained from their resorts.

The **Gulls** (*Stercorariidæ*) are found in northern and southern seas. The general color is various shades of white and black; the bill is shorter than the head, compressed, the nostrils not forming tubes but slits; the feet webbed, and adapted for swimming. They are large and buoyant and do not dive, though many plunge completely under water after their prey (Fig. 280, 3). The common tern (Fig. 280, 2) (*Sterna hirundo*) is found in Europe and North America. The bill is long, slender, and pointed, the tail long and forked. The nest is a mere depression in the sand, three spotted eggs being laid in each. During the day the sun warms them, the mother performing her office only at night. The roseate tern is a familiar form.

The **Noddy Terns** (*Anous stolidus*) have a wide geographical range. They are mild and beautiful creatures. At Tortugas they erect rude nests composed of twigs of bay-cedar dropped together upon the bushes, upon the top of which is laid the single, nearly white egg. At St. Paul's Rocks the noddies build a fanciful nest of sea-weed, cemented together and attached to the rock, a lace-like fringe hanging down all around. Upon this platform or bracket the single egg is placed.

The **Laughing Gull** (*Larus atricilla*) * is found upon the tropical and temperate coasts of North America.

The **Arctic Tern** (*Sterna macrura*) is the only successful enemy of the skua, pursuing it with extreme ferocity. Its eggs are deposited among the stones and mimic the lichen-covered pebbles, this protective mimicry being carried out in the downy young.

The most powerful of the gull family is the skua (*Stercorarius*). It has a wide geographical range, the various species being found in the Arctic and Antarctic regions of various countries.

The **Parasitic Jager**, of the Arctic region of Europe and North America, follows terns and gulls, forcing them to disgorge their prey.

The **Antarctic Skua** (*S. Antarcticus*) has all the qual-

* At Tortugas they follow the brown pelican, systematically robbing it. When the latter tosses a fish preparatory to swallowing it, the laughing gull with its victorious " Ha-ha ! " alights on its back, leans forward and snatches the morsel and flies away, generally to be robbed in turn by the man-of-war bird (Fig. 283).

ities of the eagle, being a bird of prey. The beak is sharp and curved, the claws at the tip of the webbed toes are sharp and talon-like. They prey upon the prions and other birds, dragging them from their holes, or hunting them after the fashion of the hawk. In general color they are brown. They are so ferocious as to even attack man.* In the penguin-streets of Tristan da Cunha the nests of skuas are seen on mounds, surrounded by well-picked skeletons of prions. The eggs are large and two in number. The northern skua (*Lestris parasitica*) is equally predatory, attacking other birds, sucking the eggs of the eider and other ducks often to such an extent that they can not fly away. It breeds on the unsheltered rocks, forming no nest, the eggs, two in number, being perfectly protected by their resemblance to the ground. If, however, an enemy approaches, the skuas shuffle off as if wounded, and thus avert the danger.

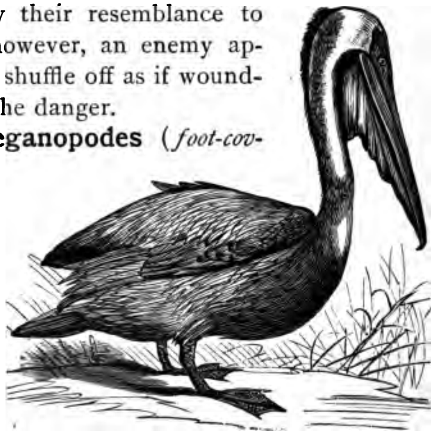


FIG. 282.—Brown pelican (*Pelecanus fuscus*).

Order IV. **Steganopodes** (*foot-covered*). *General Characteristics.*—The birds of this order are aquatic and characterized by short, partly-hidden, completely webbed feet, and an unfeathered pouch beneath the bill capable in some of extraordinary expansion. The tropic birds, gannets, darters, and cormorants, are representatives.

* Professor Moseley states that at Kerguelen's Land and other localities they had to beat them off with clubs, and that when a duck was shot the skuas would often pounce upon it, so that two shots were required to obtain a single bird.

The **Pelicans** (*Pelecanidæ*), of which two species are known in the United States, are distinguished by their long beaks hooked at the end, and enormous pouch depending from the lower mandible. The brown pelican (*Pelecanus fuscus*) (Fig. 282) is common in the South.

VALUE.—The oil of various gulls is used by the Esquimaux as lamp-oil. The breast-feathers of gulls are valuable in trade and used as "roll-plumes."

The **White Pelican** (*P. trachyrhynchus*) ranges from northern Florida northward, and formerly bred about the Great Salt Lake. They never dive for fish, but swim along, plunging their heads into the water, relying upon their quickness. They shed their crest in a manner somewhat similar to the casting of a deer's horns.

FIG. 283.—Frigate-bird (*Tachypetes aquila*).

VALUE.—The brown pelican is eaten at St. Thomas, and the leather of the pouch and fur is utilized.

The **Frigate-Birds** (*Tachypetidæ*), or man-of-war hawks (Fig. 283), are confined to the warmer regions. The membrane beneath the throat is a bright vermilion. The bill is long, sharp, and hooked at the end, the wings long and extremely powerful,* the tail forked. On Ascension

* At Tortugas, Fla., it was the custom of a number of these birds to station themselves over the lighthouse about two thousand yards up, during the prevalence of the heaviest gales, and through the glass they seemed to rest on the wind, the wings being merely outstretched, and no movement being noticed except an occasional pitching down,

Island they form nests in the guano-beds, and at Fernando do Norhona the nests are built on the edge of high precipices and contain a single egg. The *T. minor*, at Raine

FIG. 284.—Red-headed pochard (*Fuligula*), showing position in alighting.

Island, northeast Australia, builds as a nest a platform of twigs about eight inches in diameter, raised in the bushes. The American species has a strong, musky odor. They follow gulls on the Florida reef, forcing them to disgorge fish. Their oil is sometimes used in medicine.

FIG. 285.—Swan swimming, showing the web expanded and closed.

Order V. **Ducks and Geese** (*Lamellirostres*). **Ducks** (*Anatidæ*).—About fifty-nine species of ducks (Fig. 284) are known in North America. They are swimming birds, and have a wide geographical range, all

then up. They faced the wind, which tended to blow them up and away, but by pitching down slightly they seemed to ride on the gale—like a kite—gravity acting as the string. They would retain this position for hours, and it was never attempted except when the wind was blowing a gale.

the toes except the hind one being connected by a web (Fig. 285). They are distinguished by the bill, which is broad and flattened, covered with a tender, sensitive covering. The edges of both mandibles are furnished with a series of fine, tooth-like plates that interlock and form a strainer; the upper mandible ends in a rounded nail.

The hooded merganser, eider-duck (*Somateria mollis sima*), and the Labrador duck (*Camptolæmus*), are representatives; the latter is remarkable as having become extinct within a few years. It ranged as far south as New Jersey. The wood-ducks (*Aix sponsa*) are found all over the United States, and winter in the South. The nest is occasionally placed in hollow trees, in which case they bring the young down in their beaks.

The Kerguelen's Land teal (*Q. Eatoni*) * is peculiar to that country and the Crozet Islands.

The Canada goose (*Branta Canadensis*) is the common wild goose of North America. They attain a length of about three feet, and migrate south in the winter, flying in long lines or triangles, generally led by a drake. They nest in timber along streams. The brant, snow, ross, and black geese are allied forms.

The swans are characterized by long, snake-like necks that add to the grace and beauty of their appearance. The trachea or windpipe is consequently extremely long, especially in the trumpeter, in which it enters a cavity in the breast-bone, makes a turn, forming a large coil, finally leading to the lungs.

The whistling swan (*Cygnus Americanus*) ranges over North America.

* In Three Isle Harbor, Kerguelen's Land, Professor Moseley approached a flock of these birds to shoot them; having never seen man before, they ran at him in lines, seven in a row, each led by a drake, and gathered about him like farm-yard fowl, gazing with apparent astonishment. When the nests were approached, they fluttered away, as if injured, a trick common in many of our birds.

FIG. 286.—Black swan of Australia.

The black swan (*C. atratus*) (Fig. 286) of Australia is a beautiful bird. They breed in the lake in Central Park, New York, the time of incubation being about six weeks. When the female leaves the nest, the male always takes her place.

VALUE.—The flesh, quills, and feathe.s, and as game.

FIG. 287.—The flamingo, a wading bird.

The **Flamingo** (*Phænicopteridæ*) (Fig. 287) is common in the warmer portions of America, also southern Europe. At the Bahamas the nests are of marl, columnar, from one to four feet high, partly in the water. The birds set with legs doubled under them, not hanging down.

Order VI. **Wading Birds** (*Grallatores*). *General Characteristics.*—The birds of this order are characterized

FIG. 288.—A group of wading birds. 1, stilt; 2, avocet; 3, peewit; 4, dunlins; 5, curlew sandpiper; 6, sanderling; 7, oyster-catcher; 8, curlew; 9, turnstone.

by long legs and neck, bill generally long, body compressed, the wings short and rounded. The rails are runners, and the cranes essentially wading birds and slow fliers.

The **Cranes** (*Gruidæ*) are large birds, the head sometimes devoid of feathers, the legs long, the toes not webbed, the hinder one being highly elevated.

The sand-hill crane (*Grus Canadensis*) is a common American form. They attain a length of four feet, and their nests are built on open plains in the West, often six thousand feet above the sea. Many winter in Cuba. The whooping crane (*G. Americana*) attains a length of four and a half feet, and is found in the interior from the Gulf of Mexico to Minnesota. The demoiselle crane (*Balearica*) is a beautiful species from southern Europe and Africa. The head bears a curious, straw-colored brush. . The South American trumpeter (*Cariama*) is an interesting form found on the elevated plateaus. Allied are the crying birds (*Aramidæ*), rails, gallinules, coots, etc.

The *Gallinula gigantea* in 1694 lived in the Mascarene Islands, but is now extinct. It was a rail six feet in height. Another allied form was the *Notornis*, supposed to be extinct, and known up to 1850 only by its fossil bones; a specimen was discovered alive in New Zealand in 1860. It is now probably extinct.

VALUE.—All are valued as game, and the rich feathers of the gallinules for various ornamental purposes.

Avocets (*Recurvirostridæ*) (Fig. 288, 2) are distinguished by their long legs and bills, the latter turning upward. The American avocet (*R. Americana*) ranges the entire area of North America. Their general length is eighteen inches, the wings eight inches. The head and neck are colored a reddish brown, the wing-coverts and back black, the lower portion white. The nest is formed of dry grasses and weeds in the high grass near the water, and generally contains four eggs.

Phalaropes (*Phalaropodidæ*) have toes with narrow lobes or expansions as we have seen in the grebes and coots, enabling them to swim and walk over the sea-weed far out to sea. Only three species are known, and all found in America.

In the **Snipes** (*Scolopacidæ*) the bill is elongated and soft-skinned. The sexes are generally alike. The America woodcock (*Philohela minor*) is found in eastern United

States, and other species in Europe, Asia, and Africa. They go south in October, return in March, and lay in April. The nest is on the ground and formed of leaves. The eggs, generally four, are light reddish-yellow in color, with red and brown protective markings. The mother-

FIG. 289.—Ruff (*Machetes pugnax*).

birds are noted for their care of the young, and have been seen taking one between their legs and flying off at the approach of danger. The American or Wilson's snipe (*Gallinago Wilsoni*) is a typical form inhabiting the entire continent. It attains a length of eleven inches. The bill is long and straight. Their flight is erratic. The nests are in the grass and formed of leaves. The eggs, usually four, simulate the color of the surroundings in their greenish-white, gray, and brown tints. They affect lameness and broken wings to attract attention from the nest. Allied are the spoon-billed sand-piper, sanderling (Fig. 288, 6), godwit, curlew sand-piper (Fig. 288, 5), and the ruff (Fig. 289), the plovers, turn-stones (Fig. 288, 9), oyster-catchers (Fig. 288, 7), and the curious sheath-bill

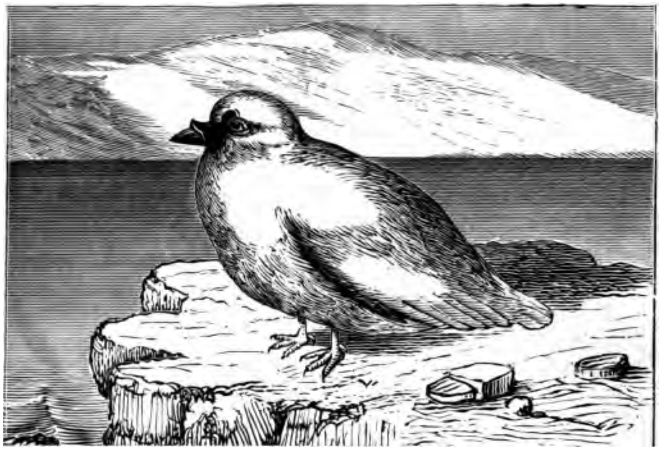


FIG. 290.—The sheath-bill (*Chiornis minor*) of Kerguelen Island.

(*Chiornis*) (Fig. 290) of Kerguelen Island. They are confined to a few localities in the Antarctic regions, and are so tame that they follow visitors about like chickens, and are readily taken by hand. They are closely allied to the oyster-catchers (*Hæmatopodidæ*).

The **Spoonbills** (*Plataleidæ*) have the bills compressed and enlarged at the tip. The roseate spoonbill (*Ajaja rosea*) is common in the Southern States, attaining a length of thirty inches, the wing about fifteen, and the bill seven and a half. The general color is a pale rose-red.

A white species is found in Europe and Asia. They nest in communities in trees, depositing from two to four thick-shelled, whitish eggs with reddish-gray and yellow spots. The ibis is an allied form.

The **Storks** (*Ciconiidæ*) have long, slender legs, the bill extremely stout and thick. The South American jabiru (*Mycteria Americana*) is the only representative in America. The Australian jabiru is one of the handsomest of the family, and has a wide range in that country. The white stork (*Ciconia alba*) (Fig. 291) is a common European form, with strong, conical, pointed bill. In the winter they migrate southward. They frequent marshes.

FIG. 291.—The white stork.

Allied is the pouched stork or adjutant of India (Fig. 292), that has a curious skinny pouch hanging under the throat. They attain a height of five feet. A tame one has been known to swallow a whole boiled fowl, and to snap up a live cat. Allied to this group is the remarkable whale-headed stork (*Balæniceps rex*), in which the beak resembles a wooden shoe. They frequent the banks of the White Nile. The nest is a simple hole in the ground. The marabou stork, from which the feathers of that name come, is the most valuable of the family.

FIG. 292.—The adjutant-bird, showing the foot resting from heel to toe upon the ground.

Herons (*Ardeidæ*).—The great blue heron (*Ardea herodias*) is a familiar example in the Eastern States, ranging as far south as Guatemala, Central America. They

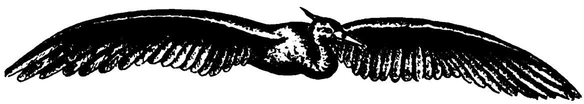


FIG. 293.—European heron (*Ardea cinerea*) in full flight—a slow flier.

attain a length of four feet, and are slow fliers (Fig. 293). The general color is grayish-blue, with black and white markings. In the breeding-season the back of the head bears a crest. They breed in Carolina near the sea and in New Jersey in the cedar-swamps, returning to the same locality for successive years. They feed upon fish and various small water-animals. The Florida great white and green herons are all familiar American forms. The cattle-heron (*Bubulcus ibis*), of Africa, follows herds of elephants and buffaloes for the purpose of obtaining the insects that infest them. The American bittern (*Botaurus minor*) is found in all parts of temperate North America and as far south as Guatemala. They are nocturnal, feeding at night, and utter a strange, booming call or note. They are known to nest at Hudson's Bay in June, the nests being formed in swamps, and containing four green eggs.

VALUE.—Feathers, and as game.

The **Bustards** (*Otididæ*) of the Old World form, to some extent, a connecting link between the wading and scratching birds.

Order VII. **Scratching Birds** (*Gallinæ*). *General Characteristics.* — These land-birds are poor fliers, have short, stout bills, powerful feet for scratching, and the hind-toe generally elevated. The domestic fowl is a typical form.

FIG. 294.—Red-legged partridge (*Perdix rubra*) in full flight—a rapid flier.

The **Partridges** (*Perdicidæ*) (Fig. 294) are small birds of compact form, with short beak, the nostrils protected by a scale. They have a world-wide distribution. The Bob White (*Ortyx Virginiana*) is a familiar form, about nine and a half inches in length, the general color chestnut-red, barred and streaked with lighter tints below, the head richly marked with black and white streaks. In the female the white markings of the head are brownish-yellow. They nest in the grass, laying from ten to fifteen white eggs. To divert attention from the young, the mother has been known to throw herself at the feet of a sportsman and pretend to be dying, suddenly recovering when the young had escaped. In Pennsylvania they are known as partridges, and in New York as quails.

The plumed partridge (*Oreortyx pictus*) and the California quail (*Lophortyx*) are other forms.

VALUE.—As game. The Chinese quail (*Coturnix*) is only four inches in length, and is kept in cages for its fighting propensities, and formerly for the singular purpose of warming the hands of its owner in winter.

Grouse (*Tetraonidæ*).—About fifteen species are known. The prairie-hen (*Cupidonia cupido*) is a familiar example. Its length is about seventeen inches. From the sides of the neck extends a tuft of pointed feathers, beneath which is a bare spot capable of inflation, and intensely red. They range from the prairies southward to Louisiana. In early spring they congregate, and are extremely pugnacious, fighting for their mates, and uttering curious booming sounds that can be heard a mile. The nest is formed, between April and May, of leaves of grass, and concealed in the grass. The eggs, eight to twelve in number, are light-colored, and are hatched in about nineteen days. The mother shows great intelligence in trying to allure invaders from the nest. In most parts of the Scandinavian Peninsula is found the noblest ally of this family—the capercali (*Tetrao urogallus*). The black cock (*Lyrurus tetrix*) of Europe is an equally rich form.

The white ptarmigan (*Lagopus albus*) somewhat resembles the grouse ; the feet and toes, however, are covered with feathers. The general hue is a cinnamon-brown, variegated with darker tints. The plumage changes with the seasons, and in winter is a dazzling white, the claws being shed also. They live in communities, and during the breeding-season unite in large flocks. The nests, of grass, earth, and feathers, are concealed with great skill, and contain from twelve to sixteen yellowish or reddish-brown, spotted eggs.

VALUE.—As game.

The **Wild Turkey** (*Meleagris gallopavo*) of the United States is an allied form, four feet in length, the general coloring a glossy, coppery black. The neck is unfeathered, the breast of the male bearing a tuft of long bristles. There are only two species, and from the Mexican variety is descended the common turkey. They are strictly American birds. The **Pheasants** (*Phasianidæ*) form a large and beautiful group of birds confined to the Old World. The peacock (*Pavo cristatus*), that was first introduced into Europe by Alexander the Great, is a familiar type. The Argus pheasant (*Argusianus giganteus*), from Sumatra, is one of the most remarkable. The Chinese golden pheasant (*Phasianus pictus*) is a resplendent species.

VALUE.—Peacock oil, fat, and feathers, are all valuable articles of trade. Pheasants as game, and their feathers in decoration.

The **Domestic Fowl** (*Gallinæ*) came originally from the jungle-fowl of India. Allied are the Guinea-fowl.

Mound-Builders (*Megapodidæ*).—This strange group of Old World birds are allies of the preceding family, and are confined to Australia and India. The wattled talegallus (*Talegallus Lathami*) * in general appearance resem-

* In early spring the bird throws together a heap of decayed leaves, etc., amounting often to two or three cart-loads, arranged in a

bles our common turkey, though smaller, being only two and a half feet long. It is found in New South Wales, and is remarkable for its method of hatching its eggs.

The ocellated leipoa (*Leipoa ocellata*) of western Australia forms a mound of fine iron-stone gravel, mixed with vegetable matter, forty-five feet in circumference and nearly five feet high, the heat developed in the interior being

FIG. 295.—Brush-turkeys and their egg-mounds.

pyramidal form four feet in height, the leaves being grasped in the claws and hurled backward, as shown in Fig. 295. The mass soon ferments, producing heat, and in it the white eggs are buried, fifteen inches deep, in a circle, the large end upward, and from nine to twelve inches apart, an opening being left in the center to govern the temperature of the mound, the birds also exposing the eggs on warm days. The young are hatched in thirty days, remaining in the mound twelve hours after being hatched. On the second night they return to the mound, and are partly covered by the male, the next day being able to fly and remain with the parents.

about 89°. The light-brown eggs are placed in a circle, the pointed ends downward, separated by about three inches of earth, and about them are often seen the galleries of the white ants, that form the first food for the young. The young, when hatched, scratch out alone, and are perfectly featherless. The mother, however, takes care of the brood after they come out.

The megapodius (*Megapodius tumulus*), of Australia, is about the size of a pheasant, of a reddish-brown color, and a wily mimic when alarmed, alighting on a limb and crouching close, extending its neck so as easily to be mistaken for a dead branch. The mounds are generally near the water, and sometimes measure a hundred and fifty feet in circumference and fifteen or twenty feet in height; in this case, probably, the work of generations. The white eggs are extremely large, and over three inches long, and are placed in the top of the mound at intervals near the sides, at a depth of six feet, the larger end being upward. The young, as soon as hatched, are able to care for themselves, though they undoubtedly follow the mother.

The breeding habits of the **Maleo** (*Megacephalon maleo*),* of the Island of Celebes, are still more remarkable, and exactly like those of the turtle. They resemble the Guinea fowl, but have a hard, round excrescence on the head.

Allied are the **Curassows,** the strange hoasin, in which the keel of the breast-bone is cut away in front.

* In August and September they go to the shore, and male and female excavate a hole in the volcanic sand four feet deep, just above high-water mark. A single pale brick-red egg is deposited and lightly covered; ten or twelve days later the female returns, and so on until six or eight have been laid, and several hens that have come ten or fifteen miles for the same purpose may lay in the same hole. The young birds are hatched by heat in the sand, and break the shell and struggle up through the ground like turtles, where they are enabled to immediately take wing—a wonderful and necessary provision —as they never see the parents, and are at once thrown upon their own resources.

Order VIII. **Pigeons** (*Columbæ*). *General Characteristics.*—The pigeons (Fig. 296) and doves are characterized by heavy bodies and short legs. The bill is short, straight, and compressed, the nostrils protected by a fleshy scale. They live in communities, and are, strictly speaking, ground-birds. The rock dove is the progenitor of the common stock. The ground dove (*Chamæpelia passerina*) ranges the United States from Washington to the South

FIG. 296.—Wood-pigeon on her rude nest.

Atlantic and Gulf coasts. They attain a length of six and a half inches. The general color is a grayish olive with a bluish gloss, the bill black with a yellow tip, and the iris of the eye orange-red. They congregate in flocks of four or five, and nest in low bushes. The Carolina and scaly doves are other American forms.

The passenger pigeon * (*Ectopistes migratorius*) is a

* These migrations are, as we shall see in the lemings, squirrels, rats, etc., not confined to any special time, but are made to obtain a new food-supply. Wilson estimated that a flock contained 2,000,000,000,000 birds, and consumed per day 17,427,000 bushels of corn.

typical form, found east of the central plains of North America. They migrate in communities of millions, covering every limb and branch of forests twenty or thirty miles in extent, breaking down great trees and limbs, rising in the air like clouds, darkening the sun, and creating a sound with their wings like the roaring of a hurricane, or of distant thunder; and so rapid is their flight that they attain a speed of more than a mile a minute. The nests are of twigs rudely placed together, often one hundred in a single tree, in which two eggs are laid, producing generally a male and female. They are fed with a milky fluid from the stomach of the parents.

Of all the pigeons of the Old World, the crowned pigeon (*Goura victoræ*) of New Guinea and the toothed pigeon (*Didunculus strigirostris*), of the Navigator Islands, are most remarkable.

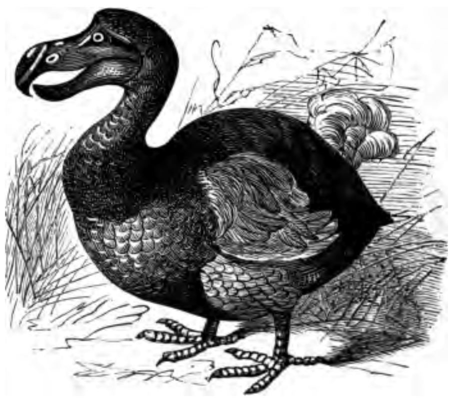


FIG. 297.—Dodo, an extinct giant pigeon.

The famous dodo (*Didus ineptus*) (Fig. 297) lived upon the Island of Mauritius in 1598, but so complete is its extinction by man that it is now only known by a few pictures, bones, feathers, and other parts, in a few museums. It was a pigeon-like bird as large as a swan, with an enormous hooked bill and rudimentary feathers.

The solitaire (*D. solitarius*) and Nazarene (*D. nazarenus*) are other allies that have disappeared within comparatively a few years.

VALUE.—As game. Pigeon-oil is used by Indians, and the birds do a great work in dispersing seeds. After the Dutch Government at the Moluccas destroyed all the nutmeg-trees on all the islands except Great Banda, they were obliged to send a yearly commission to destroy those that grew from nutmeg-seeds transported there in the crops of the fruit-pigeons (*Carpophaga concinna*). Coffee-seeds and many others are in this way carried from place to place.

NOTE.—The Feejee pigeons (*Chrysœna*) have remarkable feathers upon the breast and neck. The barbs are devoid of barbules, having instead small swellings arranged along at intervals, giving the plumage a remarkably loose appearance.

Order IX. **Birds of Prey** (*Raptores*). *General Characteristics.*—The birds of this order correspond in their habits to the carnivorous mammals. They prey upon animals dead or alive, and for the purpose have hooked bills, and powerful claws.

In the **Vultures** (*Cathartidæ*), the head and part of the neck is bare, and the wings powerful. The California condor (*Pseudogryphus Californianus*) rivals the great condor of the Andes in size, and four of them have been seen to drag a young grizzly bear several hundred feet. Their total length is about fifty inches, and the spread of wings nine feet. They soar high and sight their food, which consists of dead animals, from great distances. The nest,

FIG. 298.—Turkey buzzard.

rudely constructed of sticks, is placed upon rocks and other eminences.

NOTE.—The author once made the acquaintance of a caged condor that soon learned to recognize him, stretching out its head to be scratched like a dog, delicately nibbling at his fingers, and showing every evidence of good-fellowship. Its dignified movements are in strange contrast to those of the shuffling, ungainly eagles.

FIG. 299.—Condor.

The turkey buzzard (Fig. 298) (*Cathartes aura*), the condor (Fig. 299) of the Andes, and the king-vulture of Mexico and South America, are other familiar forms.

Of the Old World vultures the Lammergyer (*Gypaëtus barbatus*) is the largest.

In Africa is found the long-legged secretary vulture (*G. serpentarius*).

VALUE.—They are scavengers, and the quills are used in trade.

FIG. 300.—Eagle, nest, and young.

The **Falcons** (*Falconidæ*) have strongly-hooked beaks and claws, and are adapted for securing living prey. The bald eagle (*Haliaëtus leucocephalus*) is a typical form, ranging throughout temperate North America, and attains a length of three feet and stretch of wing of seven feet. The general color is brown, the neck, head, and tail white after the third year. They are arrant cowards, driven about by the small king-bird, and stealing the hard-earned plunder of the osprey. The nest is generally in a tall tree, composed of sticks, sods, etc., and added to year by year, often assuming great proportions.

In South America the harpy eagle (*Thrasætus harpyia*) is most formidable and preys upon the sloth, while the sea, golden* (Fig. 300), imperial and African screaming eagles are other typical forms.

The hawks are much smaller than the eagles, and, including the latter, fifty-three species are known in North America. The sharp-shinned hawk (*Accipiter fuscus*) is common all over North America. The female, contrary to the rule among birds, is larger than the male.

The swallow-tailed kite (*Elanoides forficatus*) † is peculiarly an American bird. In their habits and flight they resemble the swallows, and also feed upon insects, wasps, and grasshoppers, and have been seen darting about in a swarm of bees, catching them in their claws and eating them. The prairie falcon, sparrow hawk, osprey, goshawks, harriers, etc., are other familiar forms.

* These birds are extremely powerful, and have been known to carry off large animals and children, and in one instance a golden eagle attacked a pig and was carrying it off when the owner rushed out. The eagle then dropped the pig, and attacked the man with such fury that only the timely assistance of several villagers saved his life.

† Prof. Moseley saw a kite of another genus (*Milvus*) at Cape Verd Islands that had the habits of a gull and flew about the ship, picking up with its feet bits of garbage, eating also on the wing. One of the birds was seized by a shark while it was fishing, and after a short struggle drawn under water.

NOTE.—Over nine species of hawks and falcons were formerly used in hunting; as early as 400 B. C. this sport was indulged in, and in the reign of Edward III to kill a falcon was punished with death. In 1290 Kublai Khan in Central Asia had no less than ten thousand falcons. The khan rode upon an elephant, and his army of ten thousand formed a great circle to catch the birds. The eight hundred falcons of the King of Persia in the seventeenth century were trained to hunt wild boars, asses, antelopes, and foxes, and to blind them. The sport is carried on to this day near Abasheher, Persia. The Bedouins of the Sahara capture large numbers to sell.

VALUE.—Hawk and eagle quills are valued in trade.

The **Owls** (*Strigidæ*) have large heads, the eyes directed forward, the plumage soft, rendering the flight noiseless, ear-tufts in some conspicuous, claws long and sharp. They have a world-wide range, and are generally nocturnal. About forty American species are known.

The great horned owl (*Bubo Virginianus*) (Fig. 301), and the screech owls, are common American forms.

The snowy owl (*Nyctea nivea*) is found in the northern portion of both continents, and is generally pure white, more or less barred with dark tints. It winters in New England and as far north as Spitzbergen, living in the ptarmigan fells, preying upon these birds and capturing them easily. From its remarkable resemblance to them, the ptarmigans often mistake it for one of their kind. They see readily in the day-time, and in northern Asia follow the lemmings and other small animals.

The burrowing owl* (*Spheotyto cunicularia, var. hypogæa*) is peculiar to America. They live in the burrows of the prairie-dogs, often in company with rattlesnakes.

Order X. **Parrots** (*Psittaci*). *General Characteristics.*—The birds of this order are characterized by heavy,

* In South America the burrowing owl (*Athene*) lives in the burrow of the *Lagostomus*, the *Agouti* also making use of the den. That it is laziness on the part of the owl is shown by the fact that if the *Lagostomus* is not in its neighborhood, it digs its own burrow.

FIG. 301.—A group of night-birds—owls.

stout, often enormous bills, the base, as in the hawks, covered by a soft skin. The tongue is short and fleshy, and the beak of the upper jaw is articulated to the skull so that it is free to an unusual extent. They are, as a rule, poor fliers, and are remarkable for their gorgeous plumage and their power of imitating the sounds of other animals.

FIG. 302.—Carolina parrot.

The Carolina parroquet (*Conurus Carolinensis*) (Fig. 302), and perhaps two others, that have been shot in Texas, are the only representatives in the United States. The former is about thirteen inches in length, the general color green, neck and head yellow, the face red, bill white, wings blue and yellow. They fly in flocks, feeding upon nuts and seeds, and show the greatest affection for their mates or wounded companions. They are undoubtedly doomed to extinction. Allied are the cockatoos, lories, etc.

FIG. 303.—A carnivorous parrot (*Nestor mirabilis*).

NOTE.—One of the most remarkable parrots is the kea (*Nestor mirabilis*) of New Zealand (Fig. 303). The general colors are brown and gray, the under portions red. The upper mandible is extremely long and sickle-shaped. Since the introduction of sheep into that country, these birds have developed a taste for them, and in consequence are in a fair way of being exterminated. This habit was first noticed in 1868, and the wound was always on the back in front of the hips. In one station on the Matataapu, nineteen out of a flock of twenty rams were killed by these parrots in a month. In another flock of three hundred and ten young, two hundred and five were killed in five months. Men are now employed to kill them.

VALUE.—Parrot feathers are used in trade, and the nestor is eaten.

Order XI. **Woodpeckers,** etc. (*Picariæ*).

The **Yellow-billed Cuckoo** (*Coccyzus Americanus*) is found throughout the whole extent of North America, from Canada to Florida, and from the Atlantic to the Pacific. They are twelve inches in length. They pair in May, the rude nest* of twigs being often placed in an apple-tree. The eggs, generally three or four, are of a greenish blue. The female often feigns lameness in order to divert attention from the nest.

The **Ani,** or tick-eater (*Crotophaga ani*), of Florida, and south to Brazil, is an allied form, and remarkable for its thin, arched, sharply-curved bill. They may with many others be termed guardian birds, as they are often seen clinging to the ears, tail, horns, and hair of cattle, carefully catching ticks and other parasites.

The **Trogons** (*Trogonidæ*) are found in North and South America, India, and Africa. The Mexican trogon

* The Old World cuckoos are remarkable for their habit of slyly depositing their eggs in the nests of other birds, thus shirking the work of incubation. In Australia they are often placed in a nest hardly large enough for one, and the knowledge of this seems to be instinctive in the young, for as soon as hatched it tumbles out the young and eggs that really belong there by pushing under them, and thus receives all the food-supply. The English, nearly all the Australian, and the Indian black cuckoos have this habit, the latter placing their eggs in the nests of crows. An allied bird of Africa, the honey-guide, preys upon the nests of honey-bees, and is protected by a remarkable covering of skin and feathers, the former so thick that a pin can hardly be thrust through it.

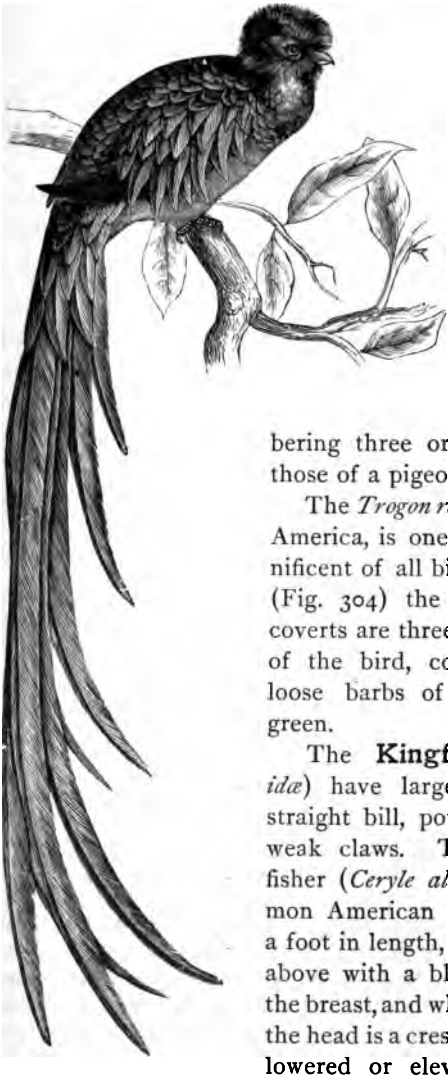


FIG. 304.—Trogon.

(*Trogon Mexicanus*) is the only species found in North America. They have broad, serrated mandibles, are richly colored, green and carmine. The nest is generally placed in a hollow tree, the eggs numbering three or four, resembling those of a pigeon.

The *Trogon resplendens*, of South America, is one of the most magnificent of all birds. In the male (Fig. 304) the two middle tail-coverts are three times the length of the bird, composed of long, loose barbs of a rich metallic green.

The **Kingfishers** (*Alcedinidæ*) have large heads, a long, straight bill, powerful wings, and weak claws. The belted kingfisher (*Ceryle alcyon*) is the common American form, a little over a foot in length, colored ashy blue above with a bluish band across the breast, and white below. Upon the head is a crest capable of being lowered or elevated. They are found in the borders of streams and lakes, dashing into the water for their prey, returning to devour it upon some branch, and uttering a harsh cry. The nest is a tunnel often six feet long, formed by the male and female in a cliff or bank adjoining the water. The eggs, generally six, are pure white.

The Australian and Indian kingfishers are remarkable for their beauty of coloring. The Australian laughing jackass is one of the largest, and noted for its demoniac laughter. The racket-tailed kingfisher, of the Malay Archipelago (Fig. 305), is one of the most beautiful of the group.

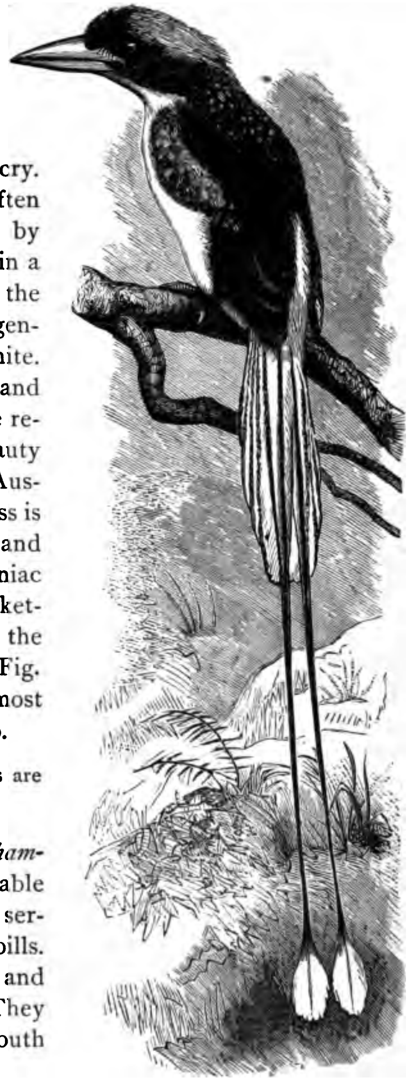


FIG. 305.—Racket-tailed kingfisher.

VALUE.—The feathers are used in trade.

The **Toucans** (*Rhamphastidæ*) are remarkable for their enormous, serrated, highly colored bills. The tongue is long and fringed with barbs. They are confined to South America.

The red-billed toucan

(*R. erythrorhynchus*) (Fig. 306) is one of the most beautiful species. They are fruit-feeders, but occasionally capture insects and small animals. The eggs are laid in hollow trees.

FIG. 306.—Yellow toucan, showing enormous serrated bill.

The **Hornbills** (*Bucerotidæ*) are even more remarkable than the preceding for the size of their bill, that in some seems almost a deformity; but, unwieldy as it appears, it is filled with air-cavities, and light in the extreme (Fig. 307). They are confined to Africa and the Eastern islands.

The great two-horned hornbill * of India attains a length of four feet, the beak ten inches, and has a second deck or ridge, thus appearing double.

FIG. 307.—Section of skull of hornbill (*Buceros*), showing air-cavities.

The **Woodpeckers** (*Picidæ*) have straight bills, adapted for hammering on wood to ob-

* Their nest-building is most remarkable and applies equally to African species. A hollow tree is selected, in which the female takes her place and forms a nest of feathers, the cavity being immediately walled up with mud by the male, leaving only a small orifice for her bill. The plaster soon hardens and she is a prisoner, fed by the male through the hole until the eggs are laid, hatched, and the young fully fledged. The young are perfectly naked at birth (Fig. 308).

tain the insects that are the objects of search. The tongue is long, flattened, and barbed, and by a peculiar muscular arrangement can be forced out with great velocity.

FIG. 308.—Hornbill and young, cemented in their nest by the male, who feeds them through a hole left for the purpose.

The ivory-billed woodpecker (*Campephilus principalis*) is a typical American form, confined to the Southern States

It is a large bird, twenty-one inches long, the general color black with white markings, the crest bright scarlet in the male. They cling upon trees, and bore and hammer out the grubs and insects there concealed, and are so powerful that in a few hours they have been known to tear off thirty feet of bark. The nest is pecked out of the trunk of a live tree, generally beneath a branch, first directly in and then downward for two or three feet, and here the six or eight white eggs are deposited. Their cries are exceedingly human, and like those of a hurt child.

NOTE.—The California woodpecker (*Melanerpes formicivorus*) is remarkable for its habit of storing up acorns for winter food by boring a hole in a tree and driving in the acorn so tightly that no other animal can get it out. So frequent are these in some trees that they appear as if studded with nails. At Mount Pizarro, where such storehouses are found, the nearest oak-trees are in the Cordilleras, thirty miles distant; thus each acorn required a flight of sixty miles besides the labor of boring the hole.

FIG. 309.—Night hawk, feeding on the wing.

The generic name of the **Night Hawks** (*Caprimulgidæ*) refers to a curious superstition that the birds milk goats and cows. They are generally nocturnal, have short, triangular bills, enormous mouths (Fig. 309) for the capture of insects, and soft plumage, that explains their noiseless, quiet flight.

The whip-poor-will (*Caprimulgus vociferus*) is a familiar form. The general color is grayish, much variegated, the ends of the outer tail-feathers white. In all the family the color is protective, their crouching positions lending still further security. They are solitary birds, only coming out at night, or late in the afternoon, then capturing insect-food upon the wing, the lonesome cry—*whip-poor-will*—being heard up to midnight. No nest is made, the eggs having a protective coloring of greenish white, speckled and blotched with bluish gray and light brown, and placed in the grass or fallen leaves.

NOTE.—According to Audubon, some take the egg in the capacious mouth and flutter away. This has been doubted, but the careful observer, Dr. Brehm, has seen the male and female night-jar each take an egg in its mouth and fly away. Both parents assist in incubation. The family is exceedingly large, and found in many countries. The lyre-tailed night-jar, of Africa, is one of the most beautiful forms.

VALUE.—The oil of steatornis is used for illuminating purposes in South America. The feathers of some are used.

The **Swifts** (*Cypselidæ*) * should not be confused with the swallow, which they much resemble. The wings are long, thin, and pointed, the feet weak, and the salivary glands, used in nest-building, highly developed.

The chimney swift † (*Chætura pelasgica*) is a typical example. The general color is a sooty brown, the throat lighter, the length five and a half inches. They are com-

* To this family belongs the famous edible-nest swift (*Collocalia nidifica*) of India and adjacent countries. The nests are confined to certain localities, and generally placed in dangerous positions. The nest is a thin, gummy shelf or basket formed entirely of saliva. The bird hovers about the wall, presses its tongue to it, attaching a single thread of gluten, that coagulates on contact with the air. By repeating this for weeks the solid nest is finally formed, at first pure and clear, but becoming later discolored by the birds. Many persons lose their lives in collecting them, having to be lowered over precipices by rattan ropes.

A Guatemalan swift forms a tube out of the down of plants, three or four feet in length, on the under side of a precipitous rock. The entrance is below, and the eggs laid on a shelf. A Brazilian species fastens a similar tube to a tree-limb and covers the outside with feathers

† Commonly called chimney swallow.

mon in the United States, and seem to seek the company of human beings. The nest is formed of twigs glued with saliva to the chimney, forming a bracket and hardening to the consistency of stone. They drink, bathe, and eat on the wing, after the fashion of the humming-birds.

VALUE.—The nests of the edible species are valued at fifteen or twenty dollars per pound in China.

The **Humming-Birds** (*Trochilidæ*) are confined exclusively to America, and generally the tropical regions, several species being found as far west as Juan Fernandez, and a few species in North America. The bill is generally long, straight or curved, the tongue capable of great protrusion, wings long and powerful, and claws minute and sharp. They are the smallest and most brilliantly colored of all birds. Our best-known form is the ruby-throat * (*Trochilus colubris*), which attains a length of three and a quarter inches.

Order XII. **Perching Birds** (*Passeres*). *General Characteristics.*—The birds of this large order have the feet adapted for grasping, one toe extending backward. The bill is sharp, horny, and generally conical. They comprise the singers, and many are wonderfully musical, the notes corresponding to our vocal expressions.†

* They nest in Massachusetts about the 8th of June. The nests, as are those of almost the entire family, are adapted to the general surroundings in color, and so protected. They are often attached to an apple-tree, made up of matted layers of flying seed-wings, and lined with the down of the mullein. The outside is covered with bits of lichen, glued on, so that the nest resembles a part of the limb.

† It has been shown that young singing birds, as a rule, learn (as do children) the language or note of the parent that brings them up. The prolonged and convulsive laughter of man is equally as ridiculous, when seriously considered, as the chattering of a monkey, or the so-called laughter of some birds. It is merely a relief from mental strain. (For experiments with young song-birds brought up by other parents, see "Philosophical Transactions," vol. lxiii, by Hon. Daines Barring-

The **Flycatchers** (*Tyrannidæ*) are a large family of strictly American, insectivorous birds, with broad, triangular, abruptly-hooked bills, and small feet adapted for perching and grasping. Their notes are simple. The king-bird (*Tyrannus Carolinensis*) may be selected out of a multitude of forms as a typical species. Their general color is a blackish ash, the tail black with white tip, the breast and lower portions white. They attain a length of nearly nine inches, and prey upon insects, securing them upon the wing. The nest is placed in a tree, and formed of artificial objects, as tow, strings, wool, and lined with fibers of wood, horse-hair, etc. The eggs, six in number, are reddish white, marked with brown streaks. The male, during the breeding-season, and at all times, is extremely bold. It feeds its mate, and attacks crows, eagles, and hawks with the greatest fury, ultimately driving them from the vicinity. They migrate south earlier than other birds.

The lyre-bird (*Menura superba*), of New South Wales, is an ally of the flycatchers, and a giant among them. The male has a lyre-shaped development of the tail-feathers nearly two feet in length, composed of sixteen feathers. The female is a small, unattractive bird. The nest is composed of moss, twigs, and grasses, and covered by a dome-shaped roof. The two eggs are white, speckled with red.

The **Larks** (*Alaudidæ*) are chiefly Old World birds, four species only being found in America. The bill is short, the nostrils concealed by the feathers, the hind claw long and straight, the singing apparatus well developed, and all are remarkable singers.

The skylark (*Alauda arvensis*) is an immigrant to this country, and common in Europe and Asia. While singing it rises in the air with seeming bounds till far out of sight, uttering a rich, melodious carol. The nest is formed in

ton. For songs of birds set to music, see "American Naturalist," vol. xiii, p. 21.)

May, and built by male and female upon the ground, generally in communities, being a simple hollow in the stubble, lined with horse-hair and grass.

VALUE.—Game, and as insect-eaters.

The **Crows** (*Corvidæ*) are birds of large size, and possess powerful bills; the voice is harsh and unmusical. The blue jay (*Cyanocitta cristata*) is the best known of the jays, and is widely distributed over America. The nest is placed in trees, formed of twigs lined with grass and delicate fibers, and contains four or five olive-brown, dark-spotted eggs. They are migratory in the Northern States.

NOTE.—The Canada jay (*P. Canadensis*) is a guardian bird that alights on the moose, hanging from its horns and fur in eager search for parasites, an act of friendship the moose does not object to. Other species in Europe perform the same office for the reindeer.

The common crow (*Corvus frugivorus*) is a familiar form, with a purplish-violet plumage, attaining a length of twenty inches. They are remarkably intelligent, and form vast rookeries, starting off each day and flying for miles, returning at night. They build in trees, the nest being composed of twigs and roots, and about two feet across. The eggs, from three to six, are laid in April, and are bluish green with olive-green or dark streaks. The male feeds his mate during the period of incubation, seeds or animal diet being equally to their taste. They have been seen to drop clams from a height to break their shells, and the rocks about Ocean Point, Maine, are covered with Echini (Fig. 35) killed in the same way.

The raven is remarkable for its vocal powers, equaling the parrot. The jackdaw, rook, and black-headed crow are other interesting allies.

The **Birds of Paradise** (*Paradiseæ*) are allies of the crows, and confined to New Guinea and the adjacent country. In their elaboration of plumage they are the most remarkable of all birds. One of the most superb forms is the ruby bird of paradise (*Paradisea rubra*) that is found on the Island of Waigiou. They fly in flocks, uttering a hoarse and harsh Whack-whack-whack! that can be heard for a long distance. They breed in May in the North.

Other remarkable forms are the resplendent epimachus, the rifle-bird, and the king bird of paradise (Fig. 310), their gorgeous colorings defying adequate description.

The **Plantain-Eaters** (*Musophagidæ*)* are peculiar to the African continent. They are about the size of the raven, and are exclusively fruit-eaters. The eggs are white, and deposited in hollow trees.

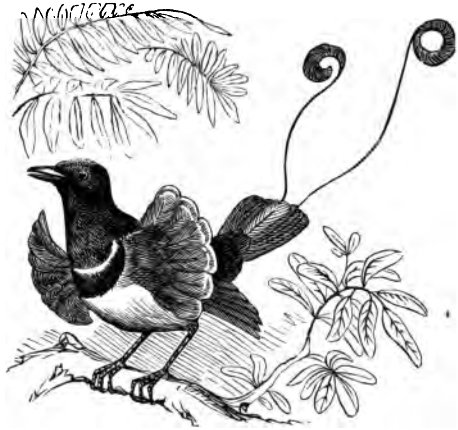


FIG. 310.—King bird of paradise.

The **Mouse-Birds** (*Colidæ*) † are so singular that they deserve particular mention. They are found exclusively in Africa, and are allies of the preceding. They resemble

* M. Jules Verreaux is authority for the statement that the coloring-matter of the red feathers of one of this family (*Turacus albocristatus*) is soluble in water. Their red feathers may be washed white twice in the same day, the color invariably returning when dry.

† The wiriwa (*Colius Senegalensis*) is invariably found upon the thickly-vined trees, darting in and out of the holes like a mouse. They have been seen to roost in a most curious manner like bats, clinging or hanging by their feet head downward, or in groups, clinging to each other in clumps upon the branches ; the first bird grasping the branch with one claw, supporting a second bird by entwining one of its legs with its own, this bird in a like manner supporting a third, and so on until they form a chain of living bird-links. They are fruit-eaters. The nest is conical and placed in trees, and contains six or seven eggs.

swallows, with high crests, and have tails longer than the body. The general color is a mouse-gray, the back-feathers being so fine as to resemble hair. The striking characteristic of the bird is the foot, that is bright red, and exceedingly powerful. All four toes point forward, and those at the exterior can be turned either way.

Starlings (*Sturnidæ*).—The only member of this family found in America is the European starling (*Sturnus vulgaris*), that is an occasional visitor in Greenland.

Oxpeckers (*Buphaginæ*).—These African birds (Fig. 311) are allied to the starlings, and have strong, hooked

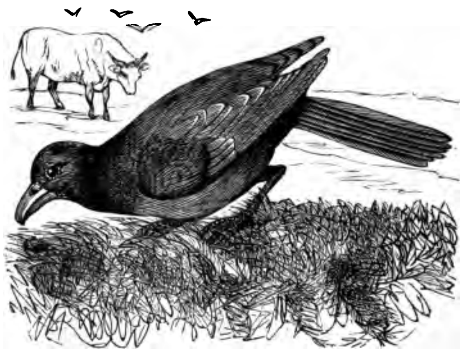


FIG. 311.—Oxpecker (*Buphaga Africana*).

claws, and a generally brownish-gray color. They come under the head of what we have termed guardian birds, following camels, cattle, elephants, and rhinoceroses, clinging to their ears, limbs, and fur, running over them like woodpeckers over a tree, and often warning them unintentionally of danger by rising with loud cries.

The **Orioles** (*Icteridæ*) have generally melodious voices and rich, lustrous plumage.

The crow blackbirds (*Quiscalus purpureus*) are familiar members of the family, arriving in New England in April. They are social birds, moving about in vast flocks. The nest is generally built in a high tree, and resembles that of the robin. Some, however, develop a curious friendship for the fish hawk, and form their nests in among the interstices of its large abode, living there in the greatest harmony.

The Baltimore oriole (*Icterus galbula*) is a familiar form throughout North America. The length is about seven and three quarter inches. They have singularly melodious voices, and are remarkable for their architectural abilities.

FIG. 312.—Bobolink, or reed-bird.

The nest is the combined work of male and female, and is hammock-shaped, swung from the branches, and made of threads of flax, silk-weed or cloth, horse-hair, and other material, the leaves of the trees forming a canopy over all.

The eggs, from four to six, are pale green, with dark spots or streaks. The young are fully fledged in three weeks.

Allied is the bobolink (*Dolichonyx oryzivorus*) (Fig. 312), or reed-bird of the Southern States, so famous for its rich notes.

Allied to this family are the several Australian bower-birds, remarkable for erecting play-houses (Fig. 313) distinct from the nest.

FIG. 313.—Bower-bird, showing the bower and the ornaments collected.

NOTE.—In the satin bower-bird the bower or play-house is the work of the male or males, and formed on the ground. The sides are made of twigs and small branches, planted by the birds in the ground, joined at the top and forming a tunnel, on the floor of which is placed bird *bric-à-brac*—highly-colored shells, pebbles, white bones, parrot-feathers, and glittering objects of all kinds. Here the male and female dance about, changing the ornaments, and showing their delight in various ways. It is, in fact, a bird ball-room. The nest is generally placed in the near vicinity.

The **Gardener-Bird** * (*Amblyornis inornata*) is about the size of the robin, of a rufous-brown hue, and is only found on the Island of Papua.

* Instead of a bower, it erects a complete cabin (Fig. 314), and plants a garden about it. A small tree is selected, and one foot and a half from the ground a cone of moss is fastened to form a support for the roof, the latter being built of slender branches of an orchid selected for its vitality, the twigs resting against the moss, the other ends entering the ground one foot and a half from the center-post, and arranged about until a perfect roof is the result, an opening on one side being left as a door, as shown in Fig. 314. The roof is thatched and interwoven with other pieces until weather-tight, the orchids continuing their growth and forming a perfect roof. About the entrance or

FIG. 314.—The gardener-bird; its house, garden, flowers, etc.

The **Finches** (*Fringillidæ*) have the bill shorter and more robust than in the preceding family, the corners of the mouth drawn down. They have a wide range in every country except Australia.

The cardinal grosbeak (*Cardinalis Virginianus*) is one of our familiar birds. The general color is red, ashy on the back, the chin and forehead black, the crest conspicuous, and the beak a bright red. Their notes are extremely melodious, especially in the breeding-season. The nests are placed in trees, and contain from four to six grayish-white eggs, with olive-brown markings.

door rich green mosses are planted and kept clean, and upon this miniature meadow bright flowers and insects are scattered, which are taken away and replenished as soon as they fade. In this curious habitation the birds meet in social and æsthetic enjoyment, the nest being entirely different and distinct.

NOTE.—The English sparrow (Fig. 271), an importation, is a grain-eater when grown, but as it breeds six and even seven times a year, and the young are invariably fed upon insects, it is of value. Public opinion is against the pugnacious immigrant, but some naturalists who have made the subject a special study think that the bird is a benefit to the country on the above grounds. In the Central Park Zoölogical Garden they have taken possession of the rafters of the eagle-house, while year after year a pair rear their young on the back of the iron eagle over the door of the Arsenal. (See "Report of American Ornithological Union," 1884.)

The **Tanagers** (*Tanagridæ*) include three hundred or more species, confined to the warmer portions of America. Their colors are brilliant, legs short, claws long, the bill conical, and sometimes serrated or notched.

The scarlet tanager (*Pyranga rubra*) is a familiar form in the New England States. The general color of the male is scarlet, the wings and tail black. Their note is *Chip-churr*, repeated at short intervals, and at other times exactly like that of a robin. They are more or less ventriloquists—a protective provision—their note sounding far away when the bird is near at hand. The nests are rudely made, the eggs marked with purple spots.

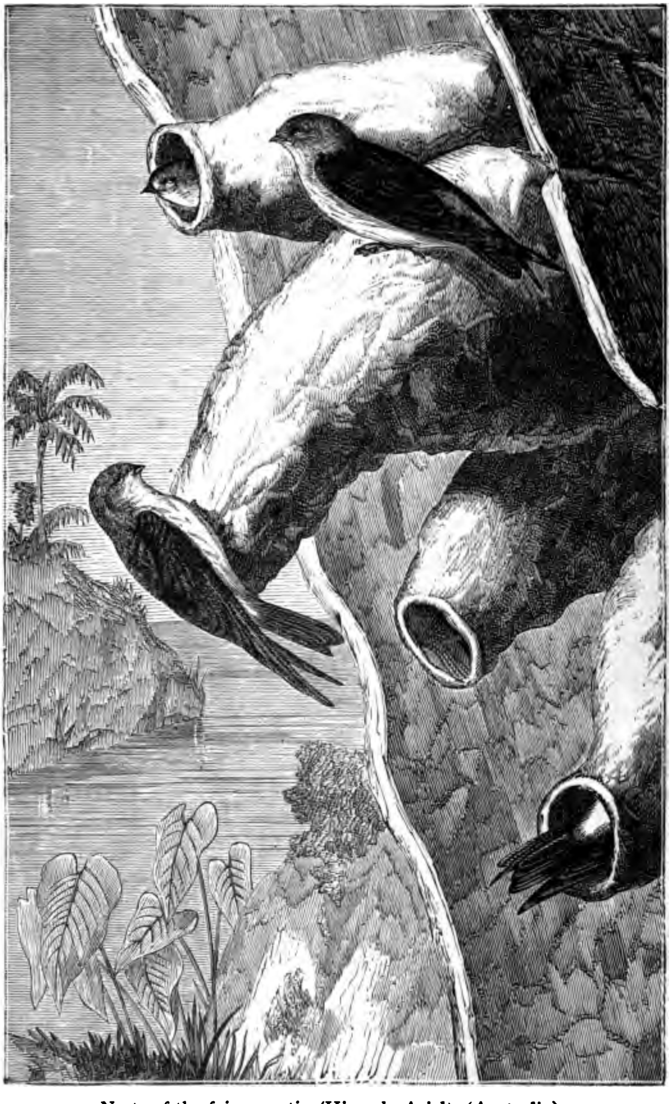
The **Swallows** (*Hirundinidæ*) have a world-wide distribution. The bill is broad, short, and triangular, the gape wide, adapted for capturing insects on the wing, the wings long and pointed, tail forked, and feet extremely weak.

The bank swallows (Fig. 315) are remarkable for their digging powers, excavating holes in the face of banks, and there forming the nest. The tunnels are often six feet deep.

The barn swallow forms its nest of mud, brought in its mouth and plastered against the wall, often assuming the shape of that of some of the weavers. An entire nest is frequently built in three days.

The **Chatterers** (*Ampelidæ*) have a short, broad, depressed bill, opening to the eyes, the mandibles notched with a tooth behind the notch, the head generally crested.

Nests of the parti-colored wren.



Nests of the fairy martin (Hirundo Ariel), (Australia).

FIG. 315.—Bank swallow, showing cave-nest and young.

The cedar-bird (*Ampelis cedrorum*) is abundant in eastern United States. The nest is made in low trees or bushes, and from three to four purplish-white and black spotted eggs are laid.

Allied to this family is the cock of the rock* (*Rupicola*)

* They are remarkable for their "entertainments," or courtships. Twenty or more of these birds have been seen standing in a circle, some seated upon rocks, while in the center a solitary male hopped

of South America (Fig. 316). It is about twelve inches long, red or yellowish in color, with a prominent crest. The female and young are brown.

FIG. 316.—Cock of the rock.

The umbrella-bird (*Cephalopterus ornatus*) (Fig. 317) resembles a crow, having, however, a curious umbrella-like crest that completely covers the head.

Among the remarkable allies of the family are the African **Weaver-Birds**, distinguished for the intelligence displayed in their nest-building.

NOTE.—The social weaver-birds breed in regular cities, a joint nest being formed generally in the aloe-tree. A thatched roof of grass is erected, the entrances beneath leading into a corridor or street, from both sides of which branch the nests, thus secure from snakes, and containing three or four bluish-white eggs, with small brown spots at the largest end. Year after year the nest is added to, often fairly breaking down the tree.

Another peculiar allied South American form is the bell-bird.

and leaped about, going through strange antics, spreading its wings and waving its tail until exhausted, then walking around as if to receive applause, retiring to give place to another, who went through similar antics, followed by all the rest in turn. They nest in the trees. Their skin is in great demand. One of the state mantles of the Emperor of Brazil was made of them.

The **Shrikes** (*Lanidæ*) have hawk-like bills, abruptly hooked, the upper mandible toothed, and both notched. They have a world-wide distribution.

The great northern shrikes, or butcher-birds (*Lanius borealis*), are about nine inches in length. They prey upon insects, mice, and other birds, and are called butchers

FIG. 317.—Umbrella-bird.

from the fact that their surplus game, birds, etc., are impaled,* while yet living, on thorns, briers, or bushes. They are great mimics, and extremely adept at learning notes. The nest is placed in trees, the greenish-gray, brown-spotted eggs being from four to seven in number.

In the wagtails (*Motacillidæ*) the bill is shorter than the head, slender, straight, and notched at the tips. The feet are strong, and adapted for walking. They are mostly confined to the Eastern Hemisphere ; the name refers to the habit of moving the tail up and down.

* A tame butcher-bird has been known to impale animals given it on a sharp stick supplied for the purpose.

The titlark (*Anthus Ludovicianus*) (Fig. 318) is a familiar American form. The nest is formed in the grass. Allied is the tailor-bird, that, with its bill as a needle and grass for thread, sews leaves together to form its nest (Fig. 319).

The wrens (*Troglodytidæ*) are chiefly denizens of tropical America, though a number of species are

FIG. 318.—American titlark.

familiar visitors about Northern homes. The common house wren (*Troglodytes ædon*) is about five inches long, and of a brown hue. The nest is generally found near the habitation of man, in holes or crevices, in which five or six pale reddish eggs are laid.

FIG. 319.—Nest of the tailor-bird of India or China.

Allied are the nuthatches, European hanging tit (Fig. 320), stone-chat, bluebird, and others.

The water-ousel (*Cinclidæ*) is essentially aquatic in its habits, not only wading in the water, but flying into and under it, using its wings as fins to reach the bottom and obtain food. It is common about brooks. The nest is placed near a cascade, and is a great globe of living moss ever kept green from the spray of the falls. The entrance is a doorway formed in the moss, leading to the interior, which is lined with soft grasses, and contains four or five pure white eggs.

FIG. 320.—Bird architecture: Hanging tit and nest.

The large family of thrushes (*Turdidæ*) is represented by the robin, mocking-bird, cat-bird, and others. The wood thrush is the highest of the class of birds. The pervading color is cinnamon-brown, grading into olive on the rump, the breast blocked or marked with distinct spots. They attain a length of eight inches, and are noted for their glorious powers of song, resembling the tinkling of a bell or the soft notes of a flute. The nest is found in low hollows, and contains four or five blue eggs.

Specimens for Study.—For purposes of study, the skeleton of a common fowl or other bird offers good material. The flesh can be boiled away, and the bones arranged as in Fig. 268; the limbs and skull should be compared with the corresponding parts of reptiles and mammals, and the difference noted. If the skeleton is to be mounted, the bird should be skinned and macerated. The tools necessary for work are a hook for suspending large specimens, forceps, scissors, scalpels, and a syringe for injecting the veins, etc. The student should be able to skin a bird, but mounting can only be learned by practice. Several works are published on the subject, as Maynard's "Taxidermy."

To skin a bird, first measure its girth over the wings. Make an incision low on the breast; skin carefully around the wings, cutting the bone at the elbow (Fig. 268 *e*), and the legs at the knee-joint, pushing the skin with the handle of the knife in preference to cutting. Care should be taken with the neck, and, if the head is not too large, turn the skin over it to the bills. Scrape away all the flesh, being careful at the eyes and ears. Sever the neck close to the skull, take out the brain, and powder thoroughly all the parts—beak, wings, legs, and tail—with powdered arsenic. Fill up the body in all parts with cotton and sew up the incision. The feathers may be cleaned by boiling in warm water. Oil-stains can be removed with a solution of soda or potash, and colored feathers are cleansed by using equal parts of warm water and ox-gall. Finally, inclose the skin in a paper band the size of your measurement, number and enter it in a blank book with the common and scientific name, sex, locality, measurements, and all the facts concerning its habits that you can. In collecting eggs, divide fairly with the birds, and if possible do not take the nest until the brood is reared. Eggs can be blown by making a single hole in the shell with a tooth-drill or some such instrument, and with a glass tube or straw the contents can be blown out. If the young bird has formed and can not be removed, break the shell and use it as an alcoholic specimen.

Works on birds for further reference.

"Key to Birds of North America," Elliott Coues; "Birds of North America," S. F. Baird, Brewer, and Ridgway; Huxley's "Manual of Vertebrates"; Owen's "Anatomy of Vertebrates"; Audubon's "Birds of North America"; "Animal Locomotion," Pettigrew; "Elements

of Embryology," Foster and Balfour; "Comparative Embryology," F. M. Balfour; Yarrill's "British Birds"; Samuels's "Birds of New England," etc. "The Auk" is the official publication (Cambridge) of the American Ornithologists' Union. Other magazines are "Nature," "Science," "American Naturalist," "Popular Science Monthly," etc. Good popular works are those of Brehm, Cassell, and Wood.

NOTE.—*The Migration of Birds.*—The majority of the birds that breed in the northern and middle sections of the United States migrate to the South at the approach of cold weather, and return in the spring, thus making two long journeys every year. These flights are made by night and day, and small birds have been seen at night through a telescope at an estimated height of three miles. The great valleys, river-courses, and coast lines are generally followed, but numbers of our birds stop at Bermuda, showing that they either venture to sea, or are blown out. Flocks of birds alight at Tortugas, Florida, during the prevalence of northers, that must have flown across the Gulf of Mexico. Many of the European birds spend the winter in Africa, while those in the United States go as far south as Central America, the West Indies, and even South America. During these flights they often congregate at certain spots in vast numbers; thus, on the Island of Heligoland, that lies in one of these paths, hundreds of different species are often seen resting, or at night whirling about the light-house, dashing against the glass, so that their dead bodies are found piled in heaps in the morning.

The primary cause of migration is probably lack of food as cold weather comes on, while many other reasons are given. Tropical birds that breed at home do not migrate, and many of our birds, as the crow, English sparrow, and others, remain with us the entire season. Many of the birds of the Rocky Mountain country have a limited migration, and some of the smallest birds make the longest journeys. Thus, the warblers (*Dendroeca*) and others, that breed as far north as Hudson Bay, winter in Mexico. As a rule, birds return to their summer homes with great regularity, many varying season after season only a few hours.

For further information on this subject see report of the American Ornithologists' Union; "Distribution and Migration of North American Birds," Baird; the works of Wallace, Von Middeldorff, Hodgson, Giebel, Palmén, and Parker, and Newton's article on birds in "Encyclopædia Britannica," ninth edition. vol. iii.

Class VII.—MAMMALIA (*Milk-givers*).

General Characteristics.—We now come to the highest and most perfect animal forms. They are covered with hair instead of scales. The young are born alive,* and nourished by a fluid called milk, secreted in the mammary glands. About twenty-one hundred species of living mammals are known, three hundred and ten inhabiting North America.

Skeleton.—The skeleton, that in the majority of birds is extremely light, is in the mammals solid, and the limb-cavities filled with marrow. Taking the cat (Fig. 321) as an example, we first note the cranium, *cra*, or skull, that is united to the backbone or vertebral column by two occipital condyles. The lower jaw is composed of two pieces, and is joined directly to the skull, and not to the quadrate bone, as we have seen in the birds and reptiles. The backbone is divided into five divisions: First, the cervical or neck region, where the vertebræ generally number seven. In the cat they are small, in the whale they are pressed together, while in the long-necked giraffe each bone is lengthened out. Second, the dorsal or back region, the vertebræ of which generally number from ten to fifteen; they support the

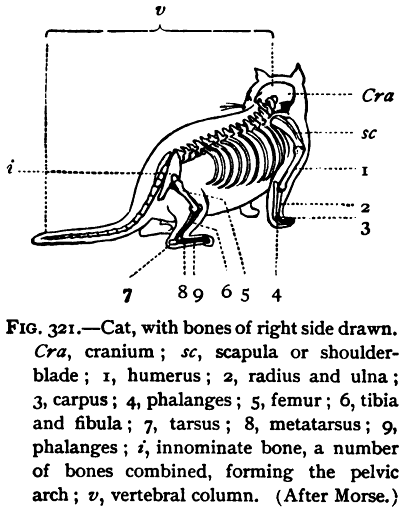
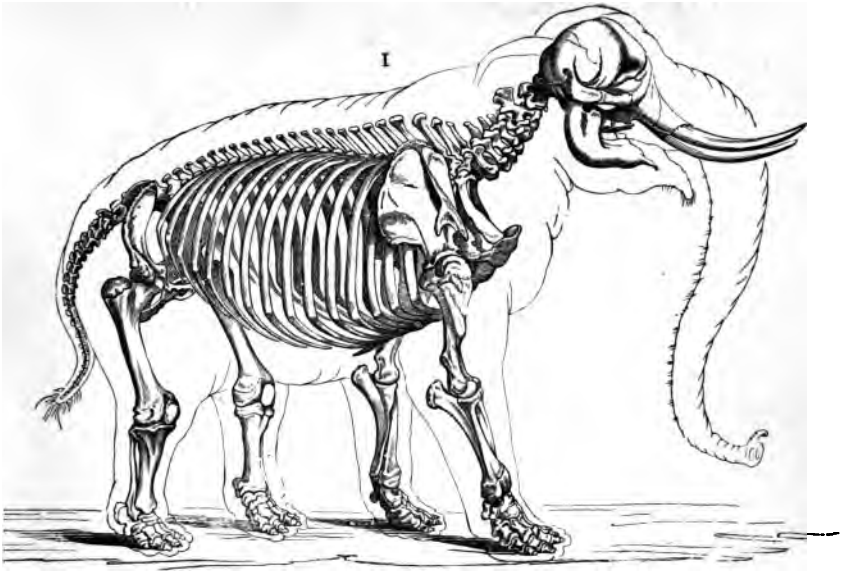
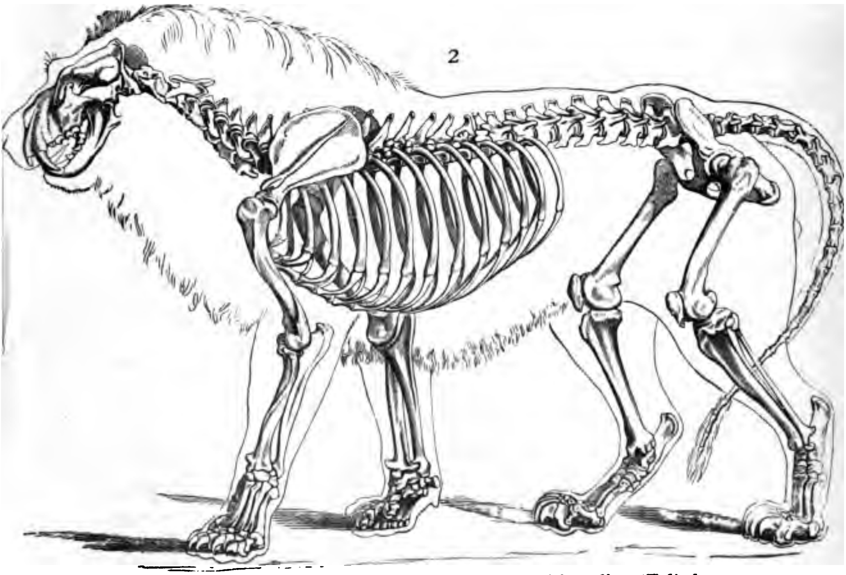


FIG. 321.—Cat, with bones of right side drawn. *Cra*, cranium; *sc*, scapula or shoulder-blade; 1, humerus; 2, radius and ulna; 3, carpus; 4, phalanges; 5, femur; 6, tibia and fibula; 7, tarsus; 8, metatarsus; 9, phalanges; *i*, innominate bone, a number of bones combined, forming the pelvic arch; *v*, vertebral column. (After Morse.)

* See note on page 297.

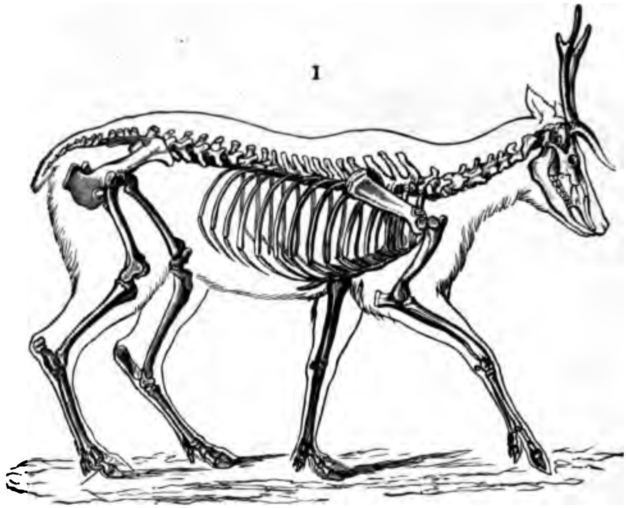
SKELETONS OF MAMMALS. PLATE XIII.

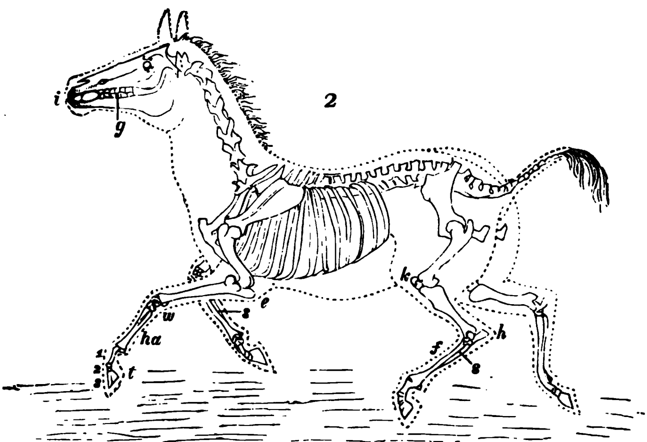




1. African elephant (Loxodon Africanus). 2. African lion (Felis leo).

PLATE XIV. SKELETONS OF MAMMALS.





1. Skeleton of a deer. 2. Skeleton of a wild ass: *i*, incisor-teeth; *g*, grinding-teeth, with the gap between the two sets as in all large grass-feeders; *k*, knee; *h*, heel; *f*, foot; *t*, middle toe of three joints carrying the hoof; *s*, splint, or remains of one of the two lost toes; *e*, elbow; *w*, wrist; *ha*, hand-bone; 1, 2, 3, joints of the middle toe.

ribs, that in turn inclose and protect the chest. Third, the lumbar or loin vertebræ, numbering from four to seven. Fourth, the sacral bones, that are anchylosed and form the sacrum; these generally number from one to nine. Fifth, the caudal or tail vertebræ, that are more movable one upon another than the others, and number from four to forty-six. The tail is a very useful member. In some of the monkeys it serves as a fifth hand; in the dog it is used to express emotion, and in the horse, ant-eater, and many animals, as a protection from insects.

Limbs.—The mammals generally have four limbs, and from this are termed quadrupeds, though in the whale the hinder pair are not present, or are rudimentary. In Fig. 321 we see the fore-limb joined to the body by the shoulder-blade or scapula, *sc*, and the clavicle or collar-bone. The first bone of this leg is the humerus, 1; then follow two bones joined together, the radius and ulna, 2, followed in turn by the carpus, 3, or wrist-bone, the metacarpals, that form the upper portion of the hand, and the phalanges, 4, or finger and toe bones. The hind-limbs in their parts resemble the fore ones, and are connected to the body by a number of bones that are joined together and known as the innominate bone, *i*, and constitute the pelvic arch. The upper bone of the leg is the femur or thigh, 5; then follow the leg-bones, similar to the ulna and radius, but called the tibia and fibula, 6; then the tarsus or ankle-bones, 7, the metatarsus or bones of the foot, 8, and the bones of the toes or phalanges, 9. There are generally five toes, but there are many exceptions, as the horse that walks on the toe-nail of its single toe, the ox on two toes, etc. The limbs are adapted to the habits of the animal. The sloths have long claws for clinging, and the moles powerful digging-claws. In the whales and seals they are paddles.

Digestion.—The jaws of all mammals, except the whale-bone whales and a few others, are provided with teeth set in separate sockets. The first set, or milk teeth, are finally discarded and a permanent set attained, generally of four distinct kinds, adapted for various purposes: incisors, canines, premolars, and molars. With these, which differ much in different animals, the food is ground up or torn, and rudely prepared, mixed with saliva and swallowed, passing down the œsophagus into the stomach. Here it is mixed with a secretion known as gastric juice, and converted into chyme, finally passing into the smaller intestine, where it is brought in contact with various secretions, as bile, pancreatic juice, etc., and is known as chyle, then passing to the blood-vessels through the lacteal tubes; thus a part of everything eaten is so much fuel for the system. From the small intestine follows a larger one through which all rejected matter passes.

Circulation.—The heart of mammals is four-chambered, comprising two auricles and two ventricles. The blood is hot, red, and contains two kinds of corpuscles, red and colorless. The latter have a nucleus, are spherical, and exhibit movements similar to those of the *Amœbæ* (Fig. 2). The red corpuscles are the most abundant, and are nearly circular. The impure blood from the body pours into the right auricle, from where it passes to the right ventricle, and thence to the lungs. Here it is changed into arterial blood by the oxygen of the air and passes back to the left auricle, then to the left ventricle, and finally is driven through the great aorta and sent flowing through innumerable branches all over the body.

Respiration.—The mammals breathe by lungs, two elastic, spongy bodies permeated with air-cells, each inclosed in a membranous sac called the *pleura*. They hang free in the cavity of the thorax. Air is taken in at the mouth and nostrils, and passes down the windpipe into the branches or bronchi, that do not connect with air-sacs in the body as in the birds. In this way the oxygen is brought in contact with the blood and aërates it.

Nervous System.—The brain of mammals is larger than that of any of the preceding or lower forms, and extending from it is the long, protected cerebro-spinal cord with its innumerable nerve-branches. All the impulses of animals arise in the brain, that seems to send messages along the nerves to the limbs and various organs, and in this way action is produced. That the nerves are the mediums of communication can be shown by severing them, the part so disconnected becoming powerless.

Organs of Sight, Hearing, etc.—The mammals all possess eyes, though in the mole they are almost useless. With the exception of some seals, the whales, and a few others, they have external ears.

Development.—Except the Monotremes, all mammals are viviparous, and differ from all preceding forms in nourishing their young with the secretion called milk. In some *Carnivora* the young are at first blind and helpless; in others, as the herbivorous animals, the young immediately follow the parent. The young of marsupials are extremely minute and helpless when born.

General Divisions. — The mammals are divided into three sub-classes: 1. *Ornithodelphia*, represented by the Monotremes; 2. *Didelphia*, or the pouched animals; 3. *Monodelphia*, or the placental mammals.

Sub-Class I.—ORNITHODELPHIA.

Order I. The **Monotremes** (*Monotremata*). *General Characteristics.*—Egg-laying mammals. Ornithorhynchus of the Australian region, and Echidna of Australia and New Guinea, with flattened or narrow, horny, bird-like bills. The eggs are laid at an age equal to a thirty-hour-old chick, and are inclosed in a strong, flexible, white shell. They measure three fourths of an inch in the long axis, and half an inch in the short. One species of Ornithorhynchus is known, while two distinct forms of the ant-eater (Echidna and Acanthoglossus) have been discovered.

Spiny Ant-eaters (*Echidnidæ*).—These animals (Fig. 322, *A*) are covered with spines like the hedgehog; the bill is long, horny, and toothless, resembling that of a bird. The tongue is long, like that of the ant-eater, and the palate armed with rows of sharp, tooth-like spines. Their claws are powerful and adapted for digging into the ant-hills where their food is obtained. They produce a single egg at a birth, that is carried in a ventral pouch.

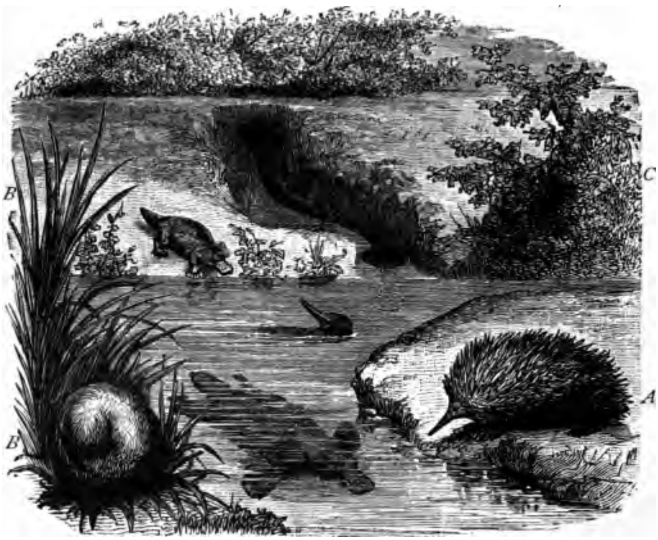
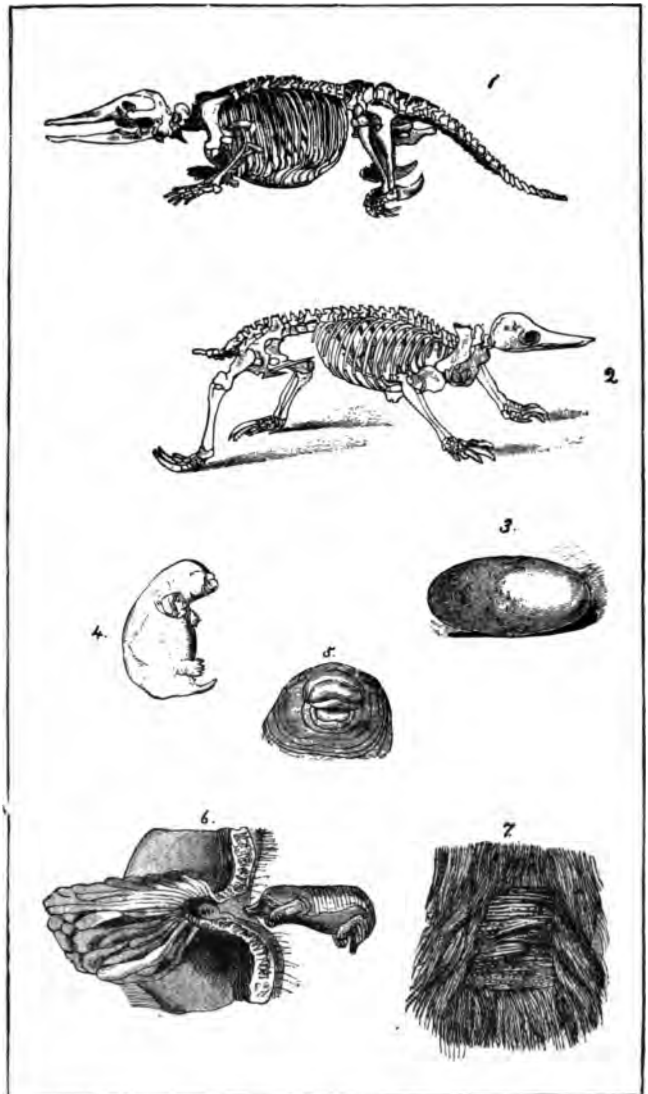


FIG. 322.—Group of egg-laying mammals. *A*, Echidna; *B*, Ornithorhynchus swimming and rolled up; *C*, nest of duck-bill in section.

Duck-bill (*Ornithorhynchidæ*).—The water mole (Fig. 322, *B*), as it is sometimes called, has a broad, duck-like, horny bill (Fig. 323, *A*), containing eight broad, flat, horny teeth. They have no external ear. The body is covered with short, brown hair with an under-pelt; the fore-feet are webbed (Fig. 323, *C*) beyond the claws, the hinder only to their base, the males possessing a bird-like spur



Egg-laying Mammals: 1. Skeleton of Ornithorhynchus anatinus. 2. Skeleton of Echidna hystrix. 3. Egg of Ornithorhynchus, showing the shape, after St. Hilaire. 4. Young Ornithorhynchus. 5. Head of young Ornithorhynchus. 6. Mammary gland, pouch, and young of Echidna hystrix. 7. Apertures of mammary gland of Ornithorhynchus anatinus.

PLATE XVI. MONOTREMES.

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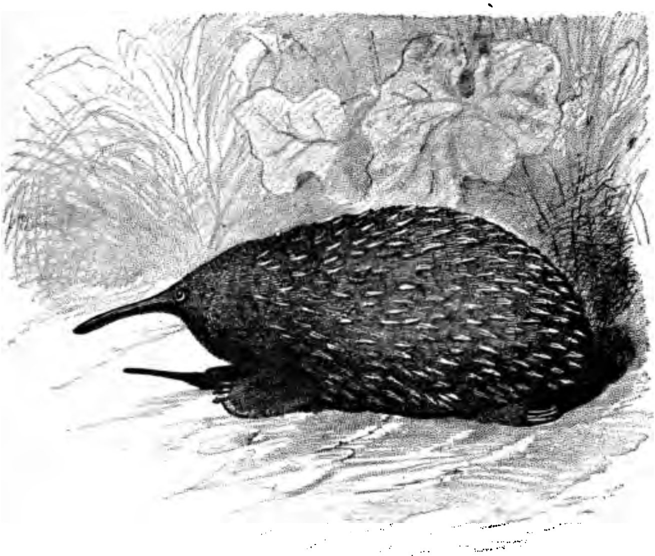

Egg-laying Mammals: 1. Acanthoglossus bruijnii; mountains of New *Guinea.* *Length* of adult, about 12 inches. 2. Ornithorhynchus anati-*nus; Australia.* Length of adult, 18 inches.

(Fig. 323, *B*). They live upon worms and vegetable matter. Their nests are long burrows in the banks of streams,

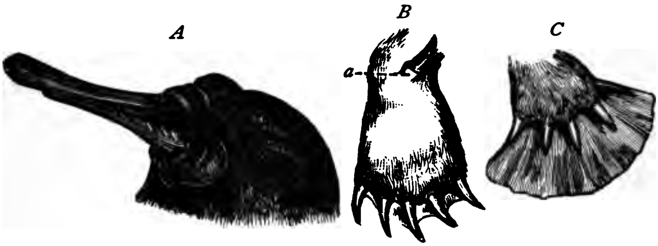

FIG. 323.—*A*, head of Ornithorhynchus, showing serrated bill; *B*, hind-foot with spur, *a*, found on the males only; *C*, webbed fore-foot.

having an opening under water. At the farther end, twenty or thirty feet from the water, leaves and grass are placed, two eggs at a birth deposited, and the young reared

Sub-Class II.—DIDELPHIA.

Order I. **Pouched Animals** (*Marsupialia*). *General Characteristics.*—In these animals the young are born in an immature state, in the great kangaroo being not over an inch in length, and immediately placed in a pouch or marsupium, where they remain attached to the teats at the bottom of the pouch, the milk being forced down the throat by the muscular action of the mother. The young are prevented from suffocating by a peculiar modification of the breathing-organs. The pouch is supported by two long, slender bones projecting forward from and attached to the front of the pelvis.

FIG. 324.—Opossum at birth.

Opossum (*Didelphidæ*).—In this family is the common opossum (Fig. 331), the only marsupial of the United States. It is about twenty inches in length, with a long, prehensile tail. The hair is white, tipped with brown. They live in the trees, eating fruit, eggs, and even small animals. When attacked, they feign death, thus often escaping. The young (Fig. 324) are placed in the pouch when extremely small, and nourished as other marsupials, and when older are frequently seen clinging to the mother, their tails curled about hers. The Yapock is a water-opossum from South America. The feet are webbed; the tail is prehensile and scaly. They feed partly upon aquatic animals.

VALUE.—In the United States about two hundred and fifty thousand skins are used yearly. The hair is used in felting, hats, etc.

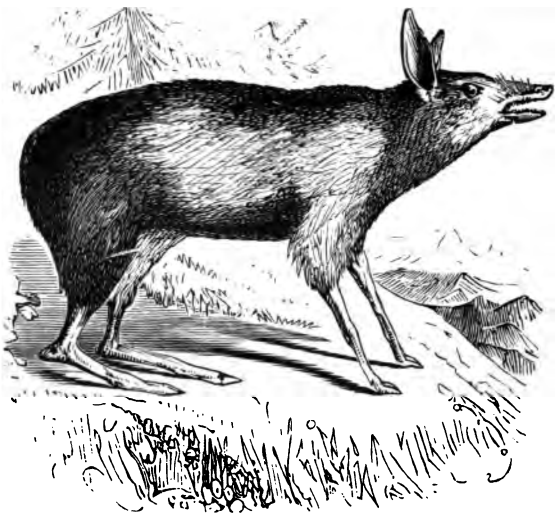

FIG. 325.—Chæropus.

Native Cats (*Dasyuridæ*).—These are carnivorous and insectivorous marsupials, ranging in size from a rat to a wolf. The Tasmanian wolf (Fig. 328) is the largest form. The marsupial bones are cartilaginous; the pouch absent or rudimentary; the tail is long, powerful, and not prehensile. The thumbs of the hind-feet are either wanting or rudimentary; the back is strongly marked with parallel bars of black. They are nocturnal in their habits, and confined to Australia and Tasmania. The Tasmanian devil (Fig. 328) has similar habits.

The **Bandicoots** (*Peramelidæ*).—The bandicoots of Australia and Van Diemen's Land are small, insectivorous marsupials, somewhat resembling kangaroos. The *Chæropus* is a remarkable little creature, resembling a pygmy deer (Fig. 325). All the toes but the fore ones are extremely minute, and it is the only animal that walks upon two toes of each foot. It burrows. Allied to these forms is the *Myrmecobius*, a beautiful animal with a long, bushy tail and no pouch, the immature young clinging to the teats, protected only by hair. It preys upon ants, and only one species is known.

Kangaroos (*Macropodidæ*).—The kangaroos are remarkable for the development of the hind-limbs, by which they take enormous leaps of twenty-five feet or more. When resting, the hind-legs (Fig. 326) and tail form a

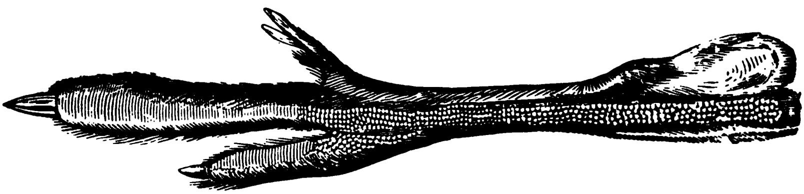

FIG. 326.—A hind-foot of kangaroo.

tripod. The tail is not used in leaping, as is generally supposed. The fore-legs are short. They attain a height of six feet, and are extremely fleet and powerful. The young are carried in the pouch, and often feed on grass from it as the mother moves along (Fig. 327), presenting a curious appearance. In the tree-kangaroo the limbs are nearly of the same length; the claws are long and powerful, to assist in climbing. In strange contrast to the great kangaroo is the *Pandemeleon wallaby*, twenty inches in length. The hare kangaroo is a powerful leaper. Mr. Gould records one as leaping over his head when chased by dogs. Fossil kangaroos are found in Australian cave-deposits. The *Diprotodon* was a kangaroo as large as an elephant.

VALUE.—Kangaroo fur and leather are somewhat used.

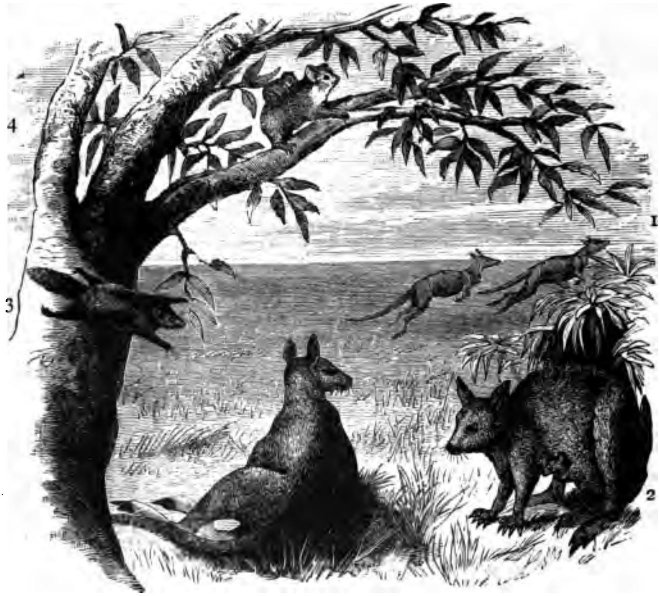

FIG. 327.—Australian marsupials. Kangaroos: 1, leaping; 2, showing young in the pouch; 3, flying phalanger; 4, koala or native bear, with a young one on its back.

Wombats (*Phascolomyidæ*). — The animals of this family are confined to Australia. They are tailless, about the size of the badger, with flat heads, and short legs, adapted for digging. They feed upon vegetation, and burrow in the ground (Fig. 328). An extinct wombat as large as a tapir has been found in Australia. The wombats are valued as food. Allied are the phalangers, the koala that carries its young on its back (Fig. 327), and many others.

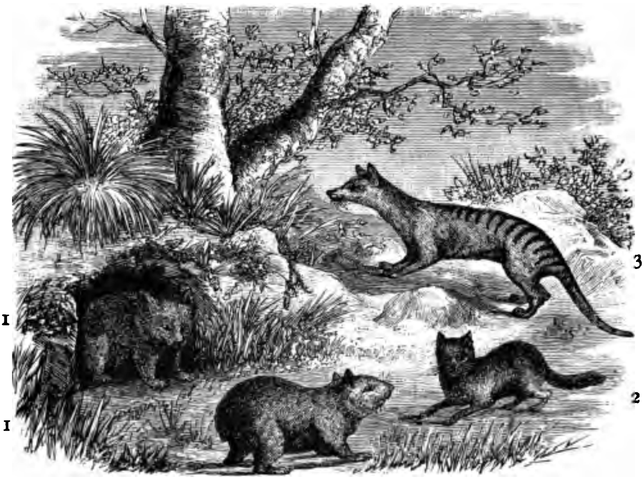

FIG. 328.—Tasmanian marsupials. 1, wombats; 2, Tasmanian devil; 3, Tasmanian wolf.

Sub-Class III.—MONODELPHIA (*Placental Mammals*).

General Characteristics.—In this sub-class are included all the rest of the mammals. They are called placental because the young, which are larger when born than the preceding forms, and generally perfect, are nourished up to the time of birth by a vascular membrane, penetrated by veins and arteries, known as the placenta.

Order I. **Edentata** (*toothless*). *General Characteristics.*—The animals of this family have no incisor teeth, some being entirely toothless. In some, scales take the place of hair.

Sloths (*Bradypodidæ*). — The sloths are confined to South America, east of the Andes. Their bodies are covered with long gray and black hair, that, in its resemblance to moss and the bark of trees, affords them protection. The three-toed sloth is called *Ai*, from the plaintive sound it utters. Their limbs are long and slender, the hinder pair the shortest, and armed with powerful claws, by which they cling to limbs, passing their entire time in hanging positions (Fig. 331), being helpless on the ground. The two-toed sloth is similar in general appearance. The *Megatherium*, a gigantic extinct sloth, was eighteen feet long and eight feet high. The *Megalonyx* was as large as a

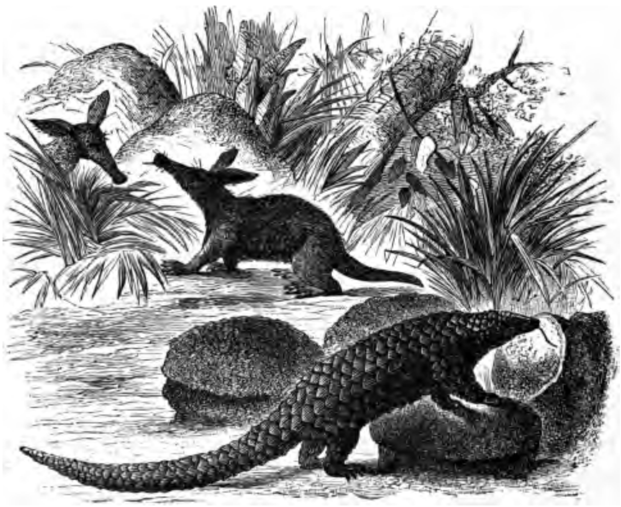

FIG. 329.—African imperfect-toothed animals. Aard-vark or Cape ant-eater in the background, and scaly manis or pangolin in the foreground.

rhinoceros—huge creatures, that pulled down large trees with their powerful limbs and claws. Sloths are eaten to some extent.

Ant-Eaters (*Myrmecophagidæ*). — These remarkable animals (Fig. 331) are found in South America. The muzzle is extremely long, the mouth toothless, the tongue of great length and used to gather up ants, the capture being helped by a viscid saliva that covers it. The body is covered with thick, coarse hairs, that are so developed upon the tail that it completely covers the body, affording protection to the young that cling to the mother's back, the family resembling a bush of dried herbage. The claws are extremely powerful, and used in tearing open the nests of ants, and persons have been killed by them. The little ant-eaters have two toes, a prehensile tail, and live in trees, finding protection in the resemblance to the bark and moss. Allied to these is the *aard-vark*, or South African ant-eater (Fig. 329), that has long ears, a pig-like snout, and burrows in the ground, coming out at night to prey upon ants.

Armadillos (*Dasypodidæ*).—These are the most wonderful of all mammals, being covered with horny plates or scales. The armor is arranged in different regions: one shield covers the head, another the shoulders, and another the rump, while between the two latter are several bands allowing free movement. The tail is protected by rings, and the legs by horny tubercles. The muzzle is pointed, as in the *aard-vark*, the ears are long, and claws powerful, adapted for digging (Fig. 331). The giant armadillo attains a length of four feet. In the *Chlamydophorus* the back only is protected by an armor made up of square, cubical plates, connected by a leathery development. The fore-claws are very powerful. A fossil armadillo, found near the La Plata, was as large as a

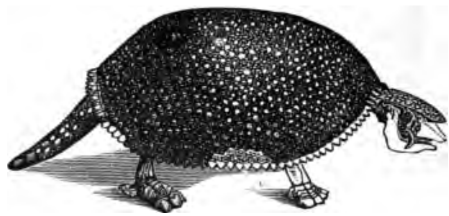

FIG. 330.—Glyptodon, a gigantic extinct armadillo.

rhinoceros. The *Glyptodon* (Fig. 330) had a solid armor and was eight feet long.

VALUE.—The native Botocudos use the armor of the tail as a trumpet, and the flesh is eaten.

FIG. 331.—1, opossum. Imperfect-toothed animals: 2, sloth; 3, ant-bear; 4, armadillo.

Pangolins (*Manidæ*).—These (Fig. 329) are the only Edentates found out of America, living in Africa and Asia. They are covered with scales arranged like tiles. The tail is extremely long, the claws powerful and long, so that they walk upon the sides of their feet. When molested they roll up into balls like the armadillo.

Order II. **Sea-Cows** (*Sirenia*). *General Characteristics.*—The sea-cows are amphibious, milk-giving animals, somewhat resembling the fishes in form. The teeth are well developed, the molars having flattened or ridged crowns, adapted for grinding food. The nostrils are upon the upper part of the snout; the fore-limbs are fin-like, and they have five fingers; the hind-limbs are absent, their place seemingly taken by a horizontal, whale-like tail.

Manatee (*Manatidæ*).—The Florida manatee (Fig. 332), that is now extremely rare, ranges from the Amazon

FIG. 332.—The manatee, or sea-cow, grazing.

to southern Florida, and attains a length of nine feet. The tail is horizontal, and semi-oval in shape. Another species is found in Africa. They occasionally come upon the shore. The young, in nursing, are sometimes supported by the flippers of the mother.

NOTE.—Steller's manatee (*Rhytina Stelleri*) was an Arctic form of gigantic proportions, attaining a length of thirty-five feet, and a weight of nearly four tons. The skin was leathery, the fore-limbs without fingers, but overgrown with coarse hairs; the tail resembled that of the whale. They had no teeth, but two horny masticating plates, one in the gum and the other in the lower jaw. Herds of these animals were discovered by Steller at Behring Island in 1741, and twenty-eight years later they were extinct, having been destroyed by man. (For a list of animals that have become extinct within a few hundred years, see article by the author in "Lippincott's Magazine," June, 1883.)

The dugong is peculiar to the countries adjacent to the Indian Ocean. The tail is shaped like that of the whale; the fore-limbs are short; the muzzle protected by numerous stiff bristles. They attain a length of twenty-five feet,

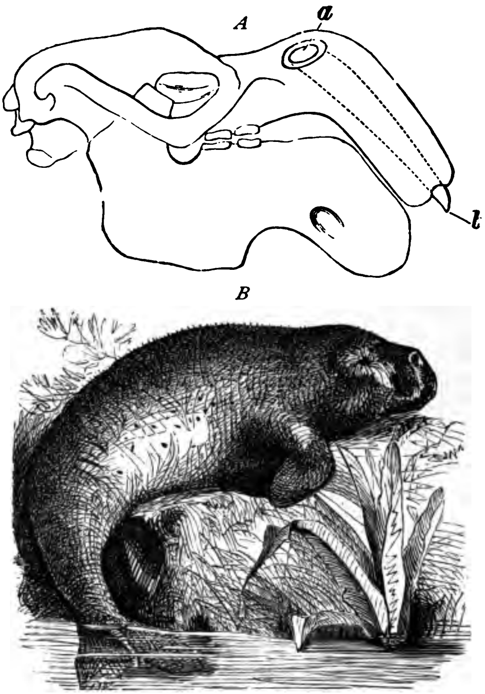

FIG. 333.—*A*, skull of female dugong; the colossal tusks in the upper jaw never pierce the thick, fleshy lip, although they continue to grow with the jaw. *a*, the root of the tusk; *b*, the point. *B*, adult dugong, showing whale-like tail.

and congregate in herds near the mouths of rivers, browsing upon the aquatic vegetation. The tusks of the female are completely incased in the upper jaw (Fig. 333).

VALUE.—Hide, oil, and bones.

Order III. **Whales** (*Cetacea*). *General Characteristics.*—We now come to the largest living animals, milk-givers, that live entirely in the water, and are in form fish-like. The fore-limbs are paddles, having bones similar to those of the arm and hand of man ; the hind-limbs absent or rudimentary, the caudal extremity being provided with a *horizontal*, fish-like tail that is the principal locomotive organ. They are often confused with fishes, but are viviparous, suckling their young (Fig. 334), giving rich, creamy

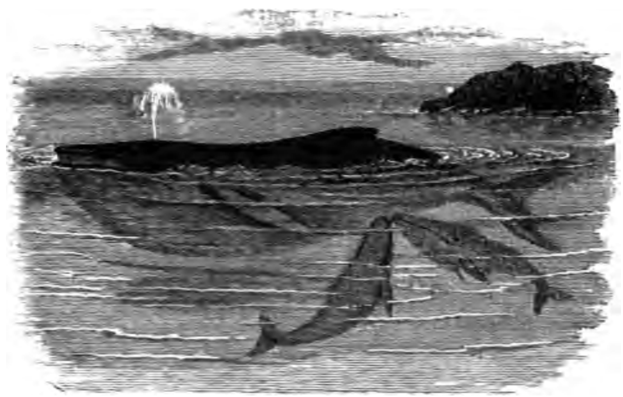

FIG. 334.—The humpback-whale suckling her young. (After Scammon.)

milk. They breathe air by means of lungs, having a provision that enables them to remain under water for over an hour without breathing. This consists of a large number of reserve blood-vessels that line the interior of the chest and spaces between the ribs, only a portion of this blood passing into circulation from time to time. The nostrils are upon the top of the head, and form blow-holes through which vapor, *not water*,* is forced. The jaws of

* This error is found in many works, but the whale no more spouts water through its nostrils than can a human being. The so-called spouting is vapor, the moisture of the breath and mucus from the nostrils.

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whales are either armed with conical teeth or plates of fibrous matter called whalebone. The amount of blood in the whale is enormous; the aorta or great artery from the heart being alone one foot across, and probably at every pulsation of the great heart ten or fifteen gallons of blood are thrown out. The cetaceans range in size from

FIG. 335.—White whale (*Beluga catodon*), a cetacean that has been carried alive from America to England by steamer, covered with sea-weed and dashed frequently with water.

the porpoise, three to five feet long, to the rorqual, one hundred and three feet in length.

Toothed Whales (*Delphinoidea*).—This group includes the dolphins, porpoises, white whales, etc. The common dolphin has long, extended jaws armed with from forty to forty-seven conical teeth, and a prominent dorsal ridge or fin. The porpoises,* the *orca*,† or killer, the blackfish, or round-headed grampus, the white whale, *Beluga* (Fig. 335), sperm-whale, and narwhal are allies.

* A friend of the author, in attempting to capture a herd of porpoises, drove them into a creek, and the capture was about to commence, when the porpoises rushed toward the boats, several leaping completely over them, and thus reaching the sea.

† The orca also preys upon the young of the walrus. In the stomach of one have been found the remains of thirteen porpoises and fourteen seals.

Whalebone-whales (*Balænoidea*).—In the embryo whales of this group minute teeth are present. They are absorbed before birth, and after it their place is taken by baleen, or plates of whalebone, that grow out and hang down upon each side in from three to four hundred plates, like saws on a rack, often attaining a length of ten feet, weighing in all one ton (Fig. 336). The outer edges are smooth, the inner frayed into numerous bristles, that form a rude strainer. Ordinarily, the lips of the lower jaw cover them, but, when feeding, the enormous lips flatten out, presenting the appearance of a scoop with whalebone sides. Into

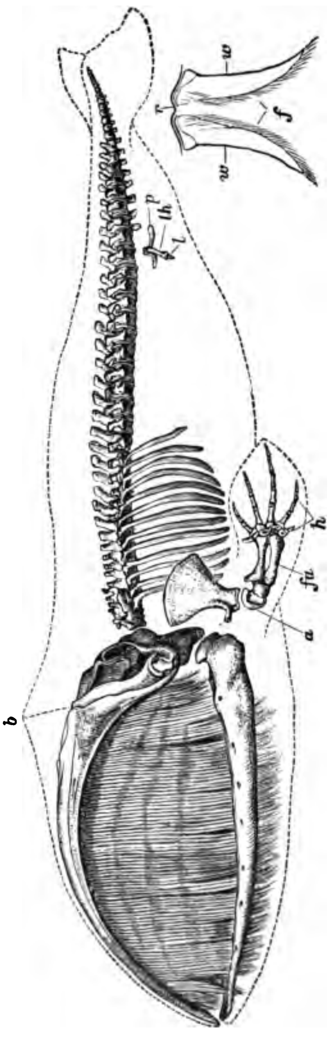


FIG. 336.—Skeleton of a whalebone-whale, and section of the mouth, with whalebone: *b*, blow-hole; *a*, upper arm; *fa*, fore-arm; *h*, hand; *p*, *th*, *l*, small remains of pelvis or hip-bone, thigh, and leg; *r*, roof of the palate; *w*, *w*, plates of whalebone; *f*, whalebone-fringe.

this trap myriads of jelly-fishes are swept, becoming entangled in the strainer; when a mouthful is obtained, the sides of the lips are raised, the tongue presses the water out through the strainer, the jellies passing down the extremely small throat that is adapted for only this kind of food.

The Greenland whale (*Balæna mysticætus*), *Balæna cisarctica*, and *australis* are familiar forms.

VALUE.—A single whale, captured by a New London vessel in 1884, realized for whalebone, $12,230; oil, $3,490; total, $15,720. Spermaceti, ivory, and ambergris, are other productions.

Order IV. **Insect-eating Mammals** (*Insectivora*). *General Characteristics.*—The animals of this order prey upon insects almost entirely. The teeth are well developed, the molars being prism-shaped, with acute *cusps* or points (Fig. 337). The feet are provided with claws, often enormously developed.

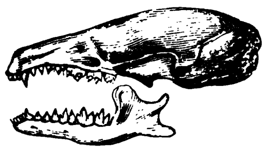


FIG. 337.—Skull of an insect-eating mammal, showing the numerous pointed teeth.

Shrews (*Soricidæ*).—In appearance the shrews (Fig. 339) resemble the rats. They have a wide distribution, but are not found in Australia or South America. The broad-nosed shrew (*Sorex*) is a common American form. The nose is long, canine teeth absent, the ears large, tail conspicuous and scantily supplied with hair. This shrew is one of the smallest quadrupeds on the continent, weighing only forty-seven grains. They secrete a protective odor, contained in two glands at the base of the tail. They burrow in the ground, and are mainly nocturnal in their habits. **Moles** (*Talpidæ*).—The moles are confined to the temperate regions of the northern hemisphere. In America, the star-nosed mole (*Condylura*) (Fig. 338) ranges from the Atlantic to the Pacific. Its length is about four inches to the tail, which is of nearly the same length. The nose terminates in numerous star-like fringes, that aid it in obtaining food. They are found near streams and moist spots. The common mole (*Scalops aquaticus*, Linn.) (Fig. 339) leaves its traces in upturned ridges in every field of the Eastern States. They attain a length of five inches. The fore-feet are greatly developed for digging; their eyes are comparatively useless, being extremely small,* giving rise to the impression that they are eyeless. Their nests are underground, and their principal food earthworms.

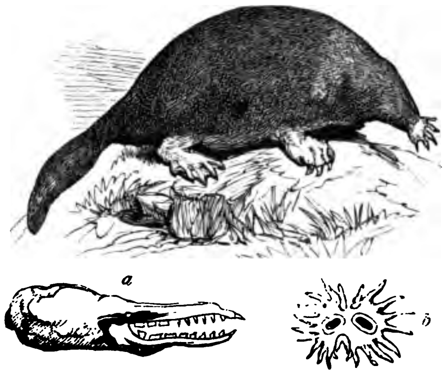


FIG. 338.—Star-nosed mole (*Condylura cristata*): *a*, jaws; *b*, end of nose.

Allied are the Solenodon of Hayti and the Tanrec of Madagascar.

VALUE.—Fur, and as insect-destroyers. A single mole is estimated to eat 20,000 insects in a year. One has been known to devour 432 maggots and 250 grubs in four days; another ate 872 maggots and 540 grubs in twelve days. In another instance two moles in nine days devoured 341 grubs, 193 earth-worms, 25 caterpillars, and a mouse, its bones and skin.

* The eyes are deeply imbedded, but are perfect, the lens consisting of a very small number of minute and little altered embryonic cells. The retina is more simple than generally seen in other vertebrates. In the embryo mole both eyes are connected with the brain by optic nerves, but in adults the optic nerve has degenerated, sometimes one and again both, so that, though the image may be possibly formed in the eye, it is with difficulty communicated to the brain.

Hedgehog (*Erinaceidæ*).*—We now come to the true hedgehogs (Fig. 339), that are not found in the western hemisphere, and are characterized by a thick

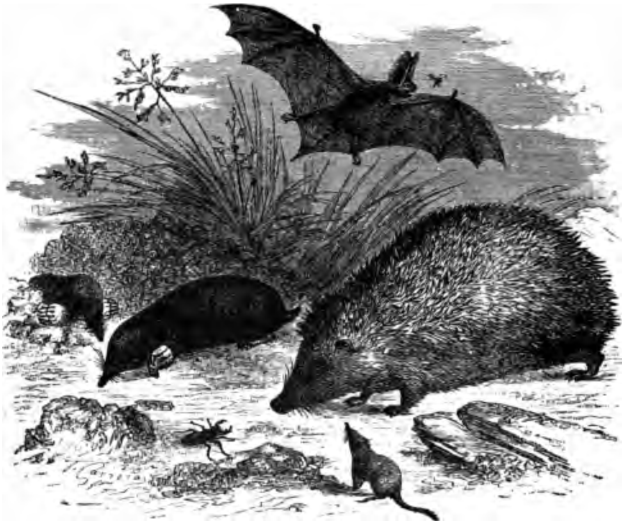


FIG. 339.—A group of insect-eaters: 1, common shrew; 2, hedgehog; 3, mole; 4, bat.

growth of sharp, spinous bristles upon the back, that, when the animal rolls itself into a ball, form a perfect protection.

VALUE.—Skin and spines.

* The nest is generally underground, and carefully made, and here the adults, as a rule, pass the cold months in a state of hibernation—a sleep so deep that no outward sign of breathing can be detected. In Dr. Hall's experiments with a hibernating animal suddenly decapitated, the heart continued to beat for a long time, as if possessed with an independent life. In another, where the brain and entire spinal cord were removed, the heart continued to beat for two hours, as if nothing had happened, and twelve hours after would contract when touched.

Flying Colugo (*Galeopithecidæ*).—The animals of this family, found in Molucca, Sumatra, Borneo, and the Philippine Islands, are the highest forms of the *Insectivora*, and are provided with a membrane similar to that of the flying squirrel, except that it also connects the tail (Fig. 340)

FIG. 340.—A group of flying mammals: 1, taguan, or flying squirrel, a rodent; 2, colugo, an insectivorous animal.

and the hind-legs, forming a complete parachute. When climbing, the membrane is folded closely, but as they spring into the air with limbs out it spreads out, supporting them in leaps of three or four hundred feet. In this way they pass from tree to tree, carrying their young.

Order V. **Bats** (*Chiroptera—Wing-handed*). *General Characteristics.*—From the Colugo we pass to the bats (Figs. 339 and 341), which are characterized by a remarkable modification of the fore-limbs for purposes of flight. The fingers of the fore-arm are greatly elongated, and support a thin, leathery membrane, that commences at the side of the neck and extends to the hind-legs, partly or wholly encompassing the tail, and is used with all the freedom of a bird's wing. The sternum is slightly keeled, as in the birds, and the teeth resemble in general those of the *Insectivora*. They are nocturnal, and hang by their hind-legs or arms in resting. The thumb is free, and forms a hook for holding and walking; the first finger is also generally provided with a claw, and in moving on the ground the bat uses its thumb, while its other fingers point backward. Some species have peculiar disk-like clinging organs (Fig. 342). The eyes are extremely minute, especially in the long-eared bats, yet, even when deprived of these organs, they show marvelous skill in avoiding obstructions.

FIG. 341.—Skeleton of a bat (lettered to compare with bird's skeleton, p. 226). *fa*, fore-arm; *w*, wrist; *t*, thumb; *ha*, hand; *h*, heel; *f*, foot.

FIG. 342.—Suctorial disk on the thumb of *Thyroptera tricolor*.

NOTE.—At the approach of cold weather the bats are deprived of food, and, being unable to migrate as the birds, retire to caves and secluded spots and sleep away the cold months in a state of hibernation. So perfect is this sleep, that the animals have been placed in illuminating gas without perceptible effect; and in other experiments the air about them, upon being analyzed, did not show evidences of having been breathed. They and other hibernators are supposed during this period to obtain nourishment by absorbing the fat that has accumulated on the under side of the neck, in the so-called hibernation-glands.

Order VI. **Gnawing Animals** (*Rodentia*). *General Characteristics.*—The animals of this order have no canine teeth, but in each jaw are two powerful, chisel-like incisors (Fig. 343), that are renewed as fast as they wear away. The molar teeth are flat, and seldom exceed four in each jaw. The lower jaw is so articulated with the skull that the motion is forward and back instead of horizontal. The limbs are adapted for walking, climbing, flying, or burrowing.

FIG. 343.—Skull of a gnawing animal (*Rodent*), showing the large chisel-teeth in front, and the gap between these and the hind teeth.

Hares and Rabbits (*Leporidæ*).—The hares (Fig. 344) and rabbits have a wide geographical range, and are distinguished by long ears, the presence of small teeth behind each of the incisors, powerfully developed hind-legs, and short, bushy tails. The fore-feet are five-toed, the hinder ones having four. Many have the feet lined with hair beneath. The white hare (*Lepus Americanus*) and gray rabbit are well-known species. The former ranges from Virginia to Labrador. The water-rabbit of

FIG. 344.—European hare (*Lepus timidus*).

the Mississippi region takes to the water when pursued, and swims and dives equally well. The jackass-rabbit (*L. callotis*) is remarkable for its long ears, while in the Alpine hare of the Rocky Mountains they are extremely short. Hares generally nest on the surface, while rabbits burrow.

VALUE.—Five million rabbit-skins are used annually in the fur-trade, and four and a half million hare-skins.

NOTE.—The domestic varieties of rabbits have all sprung from the English variety. They live in bands, burrow, and are so prolific that it has been estimated that, under the most favorable circumstances, the progeny of a single pair in four years would amount to a million ! *

Allied are the Cavies (*Caviidæ*), found in South America and the adjoining islands, seemingly taking the place of hares, the Agoutis, Guinea-pigs, the Capybara, the largest rodent, and the Paca, that forms burrows in the ground. **Porcupines** (*Hystricidæ*).—These rodents (Fig. 345) have the body and tail covered with stiff, rigid, barbed quills, from three to twelve inches in length. The molar teeth are sixteen in number, and the tongue is rough and armed with horny scales. They inhabit the temperate regions of the eastern and western hemispheres, living in burrows, and in the winter passing through a partial hibernation. The white-haired or Canada porcupine is nearly three feet long, including the tail. The spines are white, with darkened tips, the long hairs growing among them being similarly colored, and the fur a dark brown. They live upon bark and twigs, and also upon corn and various grains. The yellow-haired porcupine is much larger. The crested porcupine of Europe and Asia has spines a foot long; those upon the tail being hollow, open, and attached by slender pedicles. When not in use the spines lie flat, but are raised suddenly with a loud, crackling

* Rabbits have increased so in certain parts of Australia that a famine is threatened. One colony has lost two thousand sheep from starvation, the rabbits having eaten up the grass.

noise. The accounts of their spines being thrown are fabulous.* The Brazilian porcupine climbs trees and clings to them by its prehensile tail. The young, generally two, are produced in the latter part of spring.

VALUE.—Quills are used in commerce, as pen-holders, etc.

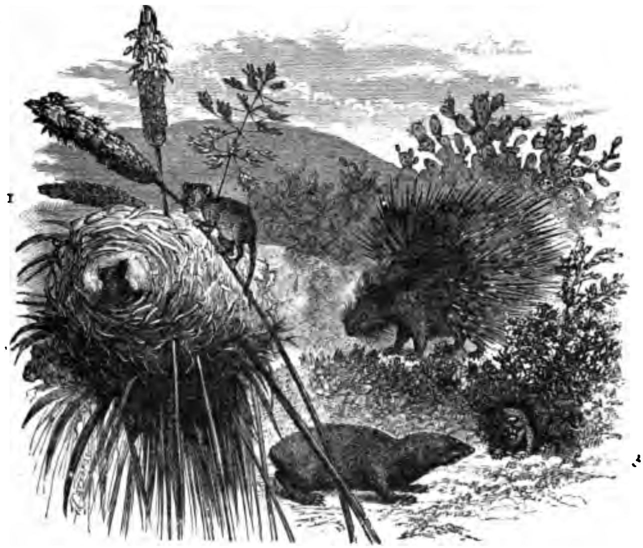


FIG. 345.—A group of rodents: 1, harvest-mouse; 2, porcupine; 3, mole-rat.

Allied are the Chinchillas (*Chinchillidæ*), that live upon the Andes of Chili and Peru, at an elevation of twelve thousand feet. Their fur is exceedingly valuable.

NOTE.—The allied Viscachas inhabit the lofty plateaus of the Andes, sixteen thousand feet above the sea. They burrow, and have a remarkable habit of collecting about their holes every curious object, so

* In experiments witnessed by the author, a rabbit was pierced by quills so quickly that it was easy to see how the illusion of their being thrown first originated. The blows were struck entirely by the tail, and so rapidly that the eye at first could not follow the movement.

that quantities of material are found there. A watch lost by a traveler was afterward found in front of a hole.

Squirrels (*Sciuridæ*). — The squirrels have a wide geographical range. They have powerful, compressed incisor teeth, prominent ears, the snout and upper lip divided, and long tails with hairs generally arranged along the sides. The gray and black squirrels attain a length of two feet, including the tail. They vary much in color, from black to all shades of gray. The gray squirrels make wonderful migrations, passing over the country in vast num-

FIG. 346.—American chipmunk.

bers, swimming streams, and divesting the land as they pass. The tufted-eared squirrel, of the San Francisco Hills, is one of the finest American species. The striped squirrels (chipmunks) (Fig. 346) have enormous cheek-pouches, used in carrying food to their nests. The flying squirrels (Fig. 340) have a fur-covered membrane, extending from the sides and connecting the fore and hind limbs, which enables them to leap great distances, the membrane acting as a parachute, held out by the limbs, and bony, boom-like appendages attached to them.

The marmots are represented in this country by the prairie-dog (Fig. 347). They inhabit the plains of the West. The fur is reddish brown, and lighter beneath. They live in burrows in communities, and utter a sharp chirp resembling a bark. The burrowing-owls and rattlesnakes live with them, the latter probably preying upon the young of both.

FIG. 347.—Prairie-dog, and the owl and snake that live in its burrow.

The woodchuck is common in North America, attaining a large size. Their fur is a grizzly color.

VALUE.—Six million squirrel-skins are used yearly by the trade. The hairs of the tail are made into delicate paint-brushes.

Beavers (*Castoridæ*).—The beavers are represented in America by one species. They are characterized by a broad, flattened, scaled tail, that is used as a scull in locomotion. They have five toes upon each foot, those upon the hinder ones being webbed. They are aquatic in their habits, living upon the bark of trees and other vegetation, or meat, when domesticated. They are famed for their industry and intelligence in the construction of their homes.* The young, from two to eight, are produced in

* The beavers show great intelligence in making their habitations. As it is necessary that the house should be under water, a small stream

FIG. 348.—The beaver (*Castor fiber*), a gnawing water-animal, showing its dam and method of felling trees.

is selected and dammed. Large trees, eighteen inches in diameter, are gnawed down (Fig. 348) and placed in position, and, if distant from the stream, a canal is built, often five hundred feet long, by which logs and food are floated to their homes. The logs are arranged against the current, curving up-stream, the interstices being filled with mud and other material. In working, the small matter is carried in the fore-paws, the webbed hinder ones and the tail being the organs of locomotion, and the latter perhaps used in moving logs and stones. The dam completed, the house is built under water, while burrows are made in the neighboring banks to be used as a last resort. The houses the month of May, attaining their growth in eighteen months, and living for nearly twenty years. They were formerly common in the New England States, where the remains of their dams can still be seen ; they are gradually becoming extinct. Allied to the beaver is the curious Sewellel (*Haplodon rufus*) of the mountains of Oregon and Washington Territory. It is nocturnal, burrows in the ground, and is about the size of a muskrat.

VALUE.—Twenty thousand beavers are taken yearly in Asia, and two hundred thousand in America. The incisors are used by the Indians as chisels, knives, and ornaments. Beaver-leather is used, and castoreum in the manufacture of perfumery.

FIG. 349.—The *Myopotamus coypu*, a valuable fur-bearing animal, at home in either salt or fresh water in South America.

Rats (*Muridæ*).—In this family are the rats, mice, and their allies that are very generally distributed over

are made of mud, and two-storied, the upper being out of water, in which the families live, while below are stored the provisions for the winter. The doors or openings connect with the water. The dams and home are repaired year after year, wood for the purpose being collected in the autumn, and when frozen the work is extremely solid.

the globe. The upper lips are divided, the snout acute, and the ears generally naked. The Bandicoot rat is the largest, attaining in India a length of fourteen inches. The Norway rat attains a length of eight or ten inches, and is of a rusty brown color. They are very intelligent and prolific. They came originally from Central Asia, appearing first in Russia in 1737, crossing in vessels to America in 1775. This is the ordinary wharf rat. The black rat emigrated to this country in 1544. The musk-rat is an aquatic form, with a flattened tail and webbed hind-feet, that forms huts of grass and roots under water, and tunnels in the bank. The coypu (Fig. 349), of the Chonos archipelago, is an allied form, also common in the streams

FIG. 350.—The lemming (*Myodes lemmus*).

of South America. The house mouse is an importation from Europe and Asia. The European harvest mice (Fig. 345) are noted as nest-builders, forming them by weaving spears of grass about stalks of grain. The American field mouse (*Arvicola*) nests under ground in spring, on the surface in midsummer, and on the surface beneath the snow in winter. It does not hibernate. The lemmings

(*Myodes*) of northern Europe (Fig. 350), famous for their migrations,* are allied forms.

The *Lophiomys Imhausi* belongs to this family, and is one of the most remarkable examples of defensive mimicry in the animal kingdom. They inhabit the fissures of the rocks in Nubia and Arabia. Allied are the pouched rats, hamsters, and the jerboas, or jumping-mice, etc.

VALUE.—Three million American muskrat-skins are used as furs annually; also used as felting, and the musk in perfumery. The skins of common rats are used as thumbs for kid gloves.

Order VII. **Hoofed Animals** (*Ungulata*). *General Characteristics.*—The animals of this comprehensive order are the most useful to man, as the camel, horse, pig, etc. Some appear to walk upon their toes, which are incased in horny hoofs, as the horse, while others are provided with blunt, broad nails.

Hyrax (*Hyracoidea*).—These curious animals (Fig. 351) somewhat resemble the rabbit, and have feet that recall the rhinoceros. They have long, curved incisors, and feet provided with pads; the toes being incased in hoofs, four in front and three behind. They are confined to Africa and adjacent countries, and conceal themselves in holes and crevices, living in communities. When feeding, one acts as a sentinel, giving a shrill, prolonged cry as a warning. The Syrian Hyrax is supposed to be the *shop-*

* These migrations are caused by a naturally restless instinct and often by a lack of food. The lemmings on the lower plateau move first, and the numbers are gradually swelled, being added to by births on the march. They swim rivers, and in coming to the sea are lost in it, thinking it a river. In the Brazilian province of Paraná a rat-plague, that devastates the country, occurs about every thirty years, and is simultaneous with the dying out of the *taquara* or bamboo, upon the seeds of which the rats feed. In Ceylon the dying down of *Strobilanthes* every seven years causes a similar plague, and in Chili the rat-swarms are coincident with the destruction of a species of bamboo (*colligue*) every fifteen or twenty years.

han of the Bible, and, as Solomon has said, they are "feeble folk," although they have "their dwelling in the rock."

VALUE.—The *Hyraceum* in the manufacture of perfumery.

FIG. 351.—*Hyrax Capensis.*

Elephants (*Proboscidea*).—The elephants are distinguished by their large size, often weighing three tons, and the presence of a trunk or proboscis (Fig. 352), that is a prolongation of the nose and upper lip six or eight feet in length, made up of forty thousand or more muscles, so arranged as to give the greatest diversity of motion. The extremity bears the two openings of the nostrils, and is produced on its upper surfaces into a finger-like process endowed with an exquisite sense of touch. The upper incisor teeth are greatly developed into tusks, that

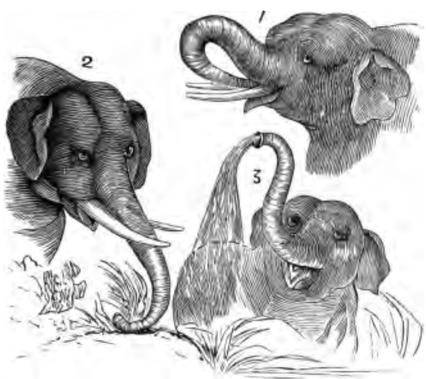


FIG. 352.—Various uses of the trunk of the elephant: 1, drinking; 2, pulling grass; 3, washing.

attain a length sometimes of nine feet, a girth of twenty-two inches, and a weight of two hundred pounds each, with which they can toss a tiger thirty feet or more. There are no incisors in the lower jaw; the canines are absent, and the molars are large, ridged transversely, and filled with cement or *crusta petrosa*. The head is extremely massive, but not indicative of the size of the brain, the upper portion containing numbers of air-cells. The limbs are powerful and five-toed, the feet resting on broad pads. The Asiatic species has small ears and an oblong head,

FIG. 353.—Asiatic elephant, showing how used by man.

while in the African the ears are immense, the head round, and the forehead convex. They roam in herds. The young in the Indian species weigh about two hundred and thirteen pounds at birth, and are thirty-four and a half inches in height. Individuals have been known to live one hundred and thirty years.

The mastodon and mammoth are extinct elephants of this country, Europe, and Asia. The latter was hairy, and had tusks fifteen feet long. Several specimens have been found in the ice in Siberia, and, though untold ages old, were perfectly preserved. They were contemporaneous with early man. An extinct pygmy Maltese elephant was only three feet high. So-called white elephants are merely albinos, and never pure white.

VALUE.—In 1880 nearly seven hundred tons of elephant-ivory was imported into Great Britain alone, and to supply the yearly demand one hundred thousand elephants are destroyed. They are also used as beasts of burden and laborers (Fig. 353).

Uneven-toed Ungulates (*Perissodactyla*). **Tapir** (*Tapiridæ*).—The animals of this family are distinguished by their short, fleshy, proboscis-like nose (Fig. 354). They have four toes on each front foot, and three on each hind one. The skin is dark and nearly hairless, the neck bearing a fleshy crest. The South American tapir has a wide range, and in the Andes is found twelve thousand feet above the sea. Their habits are partly aquatic and nocturnal. The Malay tapir is black, with the exception of a prominent white spot upon the rump. The young are spotted and striped in a beautiful manner.

Rhinoceros (*Rhinocerontidæ*).—The animals of this family rank next to the elephant in point of size, and are peculiar to Africa, India, and adjacent islands. They are extremely bulky, with bodies covered with a naked, armor-like skin deposited in folds. They have incisors in both jaws; upon the muzzle grow one or two horns two or three feet long, composed of agglutinated, hair-like fibers, having no connection with the bone, and in some species being movable.

The Indian rhinoceros (*R. Indicus*) is one of the most powerful, being nearly ten feet long, and attaining a weight of three tons. They have a single horn, sometimes three feet long, that forms a formidable weapon. The Sumatran species has two horns.

FIG. 354.—Head of swimming tapir, showing proboscis-like nose.

NOTE.—Remains of extinct rhinoceroses are found in England, France, and Germany, that were contemporary with early man. In 1771 a complete hairy rhinoceros melted out of the ice in the river Wilni, Siberia, where it had been thousands of years. The horn was four feet long.

VALUE.—Horns, hide, etc.

Horse (*Equidæ*).—This family comprises the horse, ass, zebra, and quagga, animals that have a single perfect toe upon each foot. There are two undeveloped splints, however, under the skin, that tell an interesting story in the ancestry of the family.* The domestic horse (*E. caballus*) came originally from the Old World, and is not found now in the wild state except where it has been released by man, as the mustang of South America and the muzir of Tartary.

Ponies are dwarf horses, produced in cool countries, as Shetland. The wild ass (*E. onager*) ranges in herds from the Indies to Mesopotamia. They are distinguished by long ears, the tail ending in a tuft. The hinny and mule are hybrids of the ass (*E. asinus*) and a horse. Four species of zebra are known in Asia and Africa. They are striped transversely with dark and white bands. The voice of the quagga of Africa resembles the bark of a dog. The onagga of Africa is smaller than the ass. They are dark bay with black stripes, the tail and legs being white. The peculiar marking is protective.

VALUE.—Horses, mules, asses, etc., are the most valuable of domestic animals; almost every part of the animal is valued in trade.

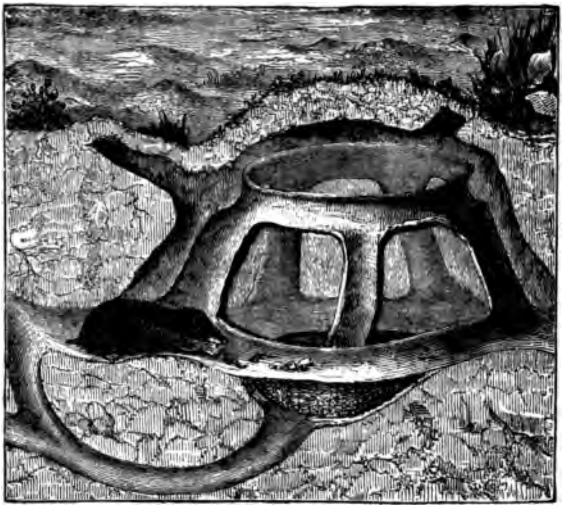
* Professors Marsh and Huxley, especially the former, have made interesting discoveries concerning the fossil horse, and its ancestry is more complete than that of any other animal. The remains are found in the Tertiary beds of North America. The earliest horse was the eohippus (Eocene time), as large as a fox. The following is the genealogy of the horse:

Period.	In America.	Front Toes.	Hind Toes.	No. of Teeth.	In Europe.
7. Recent and Upper Pliocene	— / Equus	$\frac{1}{2 \text{ splints}}$	$\frac{1}{2 \text{ splints}}$	40	Equus. / Equus.
6. Upper Pliocene	Pliohippus	$\frac{1}{2 \text{ splints}}$	$\frac{1}{2 \text{ splints}}$	42	—
5. Lower Pliocene	Protohippus	$\frac{1 \text{ large}}{2 \text{ small}}$	$\frac{1 \text{ large}}{2 \text{ small}}$	44	Hipparion.
4. Upper Miocene	Miohippus	3	3	44	Anchitherium.
3. Lower Miocene	Mesohippus	$\frac{3}{1 \text{ splint}}$	3	44	—
2. Upper Eocene	Orohippus	4	3	44	—
1. Lower Eocene	Eohippus	$\frac{4}{1 \text{ splint}}$	3	44	—

Nest of the harvest-mouse (Micromys minutus).

Plate XVIII. NOCTURNAL MAMMALS.

1



2

1. Fortress of the mole. 2. Hippopotamus and young.

Even-toed Ungulates (*Artiodactyla*). **Hippopotamus** (*Hippopotamidæ*), two species.—These huge creatures inhabit many of the great rivers of Africa. The body is extremely large, the legs short, the feet having four toes, each one being hoofed. The head is large, and the gape enormous. The teeth are of large size, and often number forty, and are used in cutting the bark from trees, which forms a prominent feature of their food. They are nocturnal animals, and are aquatic in their habits. They formerly lived as far north as England.

VALUE.—Hide, and ivory from the teeth.

Swine (*Suidæ*).—The swine are characterized by four toes upon each foot, the anterior digits being furnished with strong hoofs. The head is pointed, the snout blunt, terminating in an organ adapted for rooting, the ears large, and the skin covered with bristles. The common hog is a descendant of the wild boar, an inhabitant of the forests of Europe and Asia. The latter is extremely fierce. The masked boar of southeastern Africa, the *Babiroussa*, an inhabitant of the islands of the Indian Archipelago (Fig. 355), and the wart-hog, are allies. The peccaries (*Dicotyles*) are American representatives of the family, inhabiting Mexico and South America.

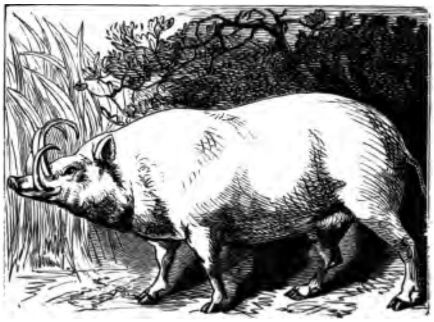


FIG. 355.—Babiroussa.

VALUE.—Flesh, hide, hair, hoofs, etc.

Deer (*Cervidæ*).—These and the following hoofed animals are generally called ruminants, from the fact that the food or cud is chewed twice before it is finally digested.* The molar teeth have two double, crescent-shaped folds, and, in biting, the incisors of the lower jaw are pressed

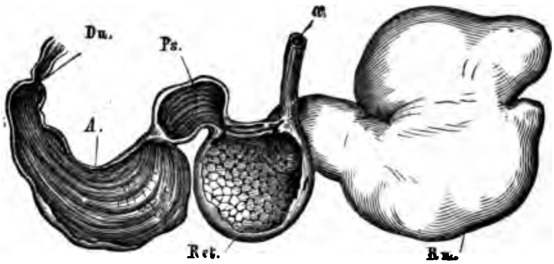


FIG. 356.—Stomach of a ruminant (sheep): *œ*, œsophagus; *Ru*, paunch; *ret*, honey-comb; *Ps*, manyplies; *a*, true digestive stomach or rennet; *du*, beginning of intestine.

against the opposite and toothless gum of the upper. The stomach (Fig. 356), with few exceptions, is divided into four compartments: 1. The paunch, *ru*; 2. The honey-

* The grass, partly chewed and mixed with saliva, is swallowed, and passes into the œsophagus; the latter is continued into a tube with a long slit on its under side, whose lips fit closely, and are water-tight. The tube thus formed leads naturally to the third stomach, and here we see a wonderful provision. The coarse food as it is swallowed at first, from its size presses open the slit, and drops into stomach No. 1, or paunch, where it is mixed with water. From here it goes into stomach No. 2, or the honeycomb, where the polygonal spaces may serve to fashion it into pellets or cuds. Now, by a simultaneous contraction of the diaphragm and abdominal muscles, a cud is forced against the cardiac aperture of the stomach into the œsophagus, and so into the mouth, where it is chewed by the molar teeth, and again swallowed at last ready for digestion. As it passes down for the second time, we would perhaps expect it to press open the slit and drop into the first stomach again; the second chewing, however, has reduced it to a pulp, so that it is now not large enough, and it passes along the tube *over* the slit and into the third stomach or manyplies, where it is strained; then passing into the true stomach, where it is mixed with the gastric juice and absorbed.

comb, *ret* (so called from the presence of polygonal spaces) ; 3. The manyplies, *ps* ; and, lastly, the stomach or rennet, *a*.

The deer are characterized by solid, branching antlers or horns that are cast yearly.* They generally have sacks beneath the eye, that can be opened or shut at will, containing a waxy secretion, having a pungent odor, and are called "tear-pits." The females, with the exception of the reindeer, are hornless. The Virginia deer (*Cariacus Virginianus*) is a typical American species, and one of the most beautiful of the family. They attain a weight of two hundred and fifty pounds, and vary in color with the seasons ; being a light brown in summer and a reddish gray in winter, the under part of the throat and tail being a white at all times. The *Wapiti* (Fig. 357) is one of the noblest American deer, and is closely allied to the English red deer or stag. They attain a length of nearly eight feet, and a height of five feet at the shoulders. The horns or antlers are shapely, with twelve points or more, and are six to seven feet long, weighing at times nearly eighty pounds. The tips or branches increase with years, and forty-five have been seen on the antlers of an English stag. In the summer the wapiti are reddish brown, and in the winter gray. They range the northern country east of the Missouri. The caribou is allied to the European reindeer ; two species range our Northern for-

* Toward the end of spring there is an increased flow of blood to the head, the blood-vessels being temporarily enlarged. Budding horns now appear ; they are highly sensitive and delicate, covered with a downy skin, called and resembling velvet, and permeated with blood-vessels. They grow with marvelous rapidity, the antlers of a full-grown stag being completely formed in ten weeks. When full growth has been attained, a burr or ring forms at the base of each, that presses and cuts off the blood-vessels ; the velvet then shrivels and peels off, assisted by rubbing, the marks of the blood-vessels being now seen as grooves. In the Indian deer, and perhaps some other tropical species, the casting does not occur annually.

ests. The antlers are thick and stubby, and vary greatly in individuals.

FIG. 357.—Wapiti (*Cervus Canadensis*).

The reindeer of Arctic Europe are about four feet long and three high, and the females also have horns. In the summer their fur is brown and in winter lighter—a protective measure.

The moose (*Alce Americanus*) (Fig. 358) is the largest of the family, having immense broad antlers, that alone weigh nearly eighty pounds, and resemble in shape the pine-branches of the northern forests. Their muzzle is broad and long, the legs long, the shoulders and neck covered by a thick growth of coarse hair. Their color is a grayish brown. They are extremely fleet, and step so high in running that they pass over a five-foot wall or fence without effort. They range from northern Maine to the Arctic regions. In the winter the herds of moose often form yards in the snow, trampling it down for several miles,

FIG. 358.—Moose (*Alce Americanus*).

banding together for protection against the wolves, to whom they often fall victims in the soft, deep snow. The great extinct Irish elk was an allied form, and their remains are now frequently found in the Irish bogs. Their horns often measured twelve feet from tip to tip, and were so broad that three or four men could rest on them. They were ten feet high, including the horns. The axis deer is an Indian species, and is spotted with white, similar to the fallow deer. In Java is found the Muntjac (*Cervus vaginalis*) ; its horns are on bony pedestals, and the male is remarkable for its long, protruding canine teeth in the upper jaw. The musk-deer of Asia has similar teeth.

VALUE.—Fur, hides, horns, teeth, hoofs, sinews, musk, etc.

Hollow-Horned Ruminants (*Bovidæ*). *General Characteristics.*—This large family includes the buffaloes, oxen, sheep, goats, and antelopes, distinguished from the deer by the peculiar structure of the horns, that are hollow, and, as a rule, not shed. Two processes of the fore-

FIG. 359. — Rocky Mountain sheep (*Capra montana*).

head (frontal) bone of the skull form the cores that are covered by the horns, that are special developments of the outer skin or epidermis.

Goats and Sheep.—In the Rocky Mountain sheep, or big-horn (Fig. 359), the horns are extremely powerful. In the female, the horns are straight, and similar to those of a goat. Their height at the shoulder is about three feet, and their weight three hundred and fifty pounds. They are now confined to the country west of the Missouri, and are fast becoming extinct.

About forty varieties of the domestic sheep are known. Its origin is obscure, but it is possibly a descendant of an Asiatic sheep (*Ovis argali*). The Barbary sheep, or *Mouflon*, has soft hair of a reddish tinge. From it and the Siberian *Argali* spring the merino sheep of the East; their tails attain a weight of one hundred pounds, and have to be sup-

FIG. 360.—Musk-sheep (*Ovibos moschatus*).

ported on racks harnessed to the animal. The musk-sheep (*Ovibos*) (Fig. 360), or ox, as it is incorrectly called, is confined to the Arctic region of North America. It is a comparatively small animal, about the size of a cow, but its long, brownish-black hair gives it a much larger appearance. The horns are broad at the base, and bent down upon the cheek, turning up again. They secrete a strong musk, the flesh even being impregnated with the odor.

FIG. 361.—Chamois and ibex.

They assemble in herds, and are becoming exceedingly rare. At the end of the glacial period an allied form roamed the Middle States. The Angora goat, Cashmere goat, and ibex (*Capra ibex*) (Fig. 361), are allies.

VALUE.—Sheep's wool. One hundred thousand Persian lamb-skins are used annually by the trade ; six hundred thousand Astrakhan, and two million European. From the goats come mohairs, cashmeres, etc. Fifteen million pounds of Angora wool alone is used annually in the trade. The horns, hides, and hoofs are all valued.

Antelopes.—The antelopes are remarkable for their speed and elegant forms. The goat-antelopes are represented in America by the mountain goat (*Aploceros mon-*

tanus). Its horns are jet black, slender, and slightly curved, resembling those of the Alpine chamois (Fig. 361). Its hair is long and white (Fig. 362).

Fig. 362.—Rocky Mountain goat (*Aploceros montanus*).

The prong-horn is a characteristic American antelope, and remarkably fleet. They are larger than the domestic sheep, and covered with coarse, brush-like hair, that is yellowish brown above, the under portion and a square patch on the rump being pure white, while the horns, hoofs, and parts of the nose are black. The horns bend slightly, and midway to the tip is a small prong, from which they take their name. The horns, though hollow, and having a persistent core, as in the ox, are shed in the autumn.

Among the gazelles, the Siberian antelope, or *Saiga Tartarica*, is the most striking. The muzzle is bent downward, and the horns beautifully shaped. They are found in Poland and Russia, and are the most northern of the family.

Allied are the chamois of Europe (Fig. 361), the gnu, the pygmy antelope, oryx, eland of Africa, etc.

Oxen (*Bovinæ*).—The domestic oxen do not present a genuine species, but represent many races that have descended from several extinct species. They are characterized by horns curving outward and downward, short tails, and broad hoofs. The American bison (*Bison Americanus*), or buffalo, formerly ranged from Virginia and Lake

FIG. 363—Skeleton of a cow (*Bos*).

Champlain to Florida, but are now confined to the far West, and fast becoming extinct. They are of large size, the head powerful and carried low. The forehead is

24

broad, the horns small, tapering, and set far apart. Between the shoulders is a prominent hump which, with the neck, head, and chest, is covered by long, shaggy hair, the remainder of the fur being short and brownish in color. They herd in vast numbers. Allied to them are the European bison, or *auroch*,* the Cape buffalo (*B. caffer*) of South Africa, the Indian buffalo (*B. bubalus*), the yak, or grunting ox—a native of Thibet—and the zebu of India.

VALUE.—Every part of these animals has its value.

Giraffes (*Camelopardalidæ*). — The giraffe is represented by a single species inhabiting the plains of Central Africa. Its neck is of remarkable length, so that its head is often eighteen feet from the ground ; the number of vertebræ, however, is seven, as in other mammals, each bone being lengthened out. The back slopes rapidly to the tail, giving the impression that the fore-legs are the longest, but they are of equal length. They have no horns, but two long, solid appendages, attached partly to the frontal and partly to the parietal bones ; these are covered by the skin, and terminate in a tuft of bristles. In front of them is a prominence caused by a thickening of the bone that has been incorrectly described as a third horn. The tongue is nearly seventeen inches long, and in its use is not incomparable to the trunk of the elephant.

VALUE.—Skins, and the bones are made into buttons.

Camel (*Camelidæ*).—The camels have two incisor teeth in the upper jaw, and six incisors below, canine teeth in each jaw, and from eighteen to twenty molars. They

* The extinct *Bos primigenius* lived in Germany and England during the time of Cæsar, and is the *urus* of the Nibelungen song. They are the ancestors of the half-wild cattle in English parks, and the Holstein and Friesland breed. The European bison has only been saved from extinction by the Emperors of Russia, who have preserved eight hundred in the forests of Bialowicza, Lithuania, and have prevented the desrruction of those running wild in the Caucasus.

have either one or two humps upon the back, composed of fatty matter; in the paunch are several cells (Fig. 364, *a*)

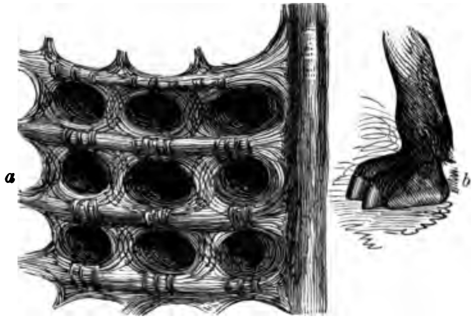


FIG. 364.—*a*, Water-cells in the paunch of the camel; *b*, foot, showing the pad.

that contain a supply of water to last them in the dry country in which they live. Their feet (Fig. 364, *b*) are equally adapted to the dry sand, the two toes uniting nearly to

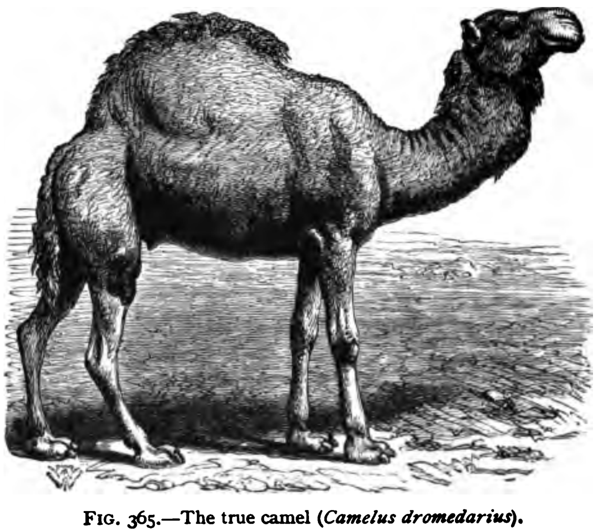


FIG. 365.—The true camel (*Camelus dromedarius*).

the point, forming a callous, elastic cushion. The dromedary, or single-humped camel* (Fig. 365), is found in Arabia, Syria, Persia, and Africa, and is remarkable for its speed, carrying a rider nearly one hundred miles a day. In the caravan they carry a load weighing from six hundred to one thousand pounds. The young are about three feet high when born, and do not attain their full growth for seventeen years. Their average age is fifty years. The Bactrian camel, or two-humped variety, is eight feet high between the humps, and about ten feet long. It came originally from Central Asia. Allied are the llama of Peru and Chili, the guanaco, and the alpaca.

VALUE.—Hide and hair, and as beasts of burden. In the Falkland Islands, guanaco-bones are used as fire-wood.

Order VIII. **Flesh-eating Mammals** (*Carnivora*).

General Characteristics. — This order includes the cats, bears, seals, etc.—animals that feed mainly upon flesh—to obtain which they have sharp claws (Fig. 373), fangs, and cutting teeth (Fig. 375). The head is generally massive and powerful, each jaw containing six incisors, behind which is placed a long, stout canine. The number of molar teeth varies with the species, and they have trenchant edges for cutting.

Sub-order I. **Pinnipedia. Seals**† (*Phocidæ*).—The common seal (*Callocephalus vitulinus*) has no external ears; the arms and legs are short, the latter being large and fan-shaped; the inner and outer toes are large and long, the three middle ones shorter; the palms and soles are hairy, and the claws distinct and sharp. They are extremely intelligent, and susceptible of domestication. The

* These animals have been introduced into the deserts of Nevada, and are rapidly increasing in numbers.

† Members of this family have been seen in the Caspian Sea, in Lake Baikal, and lately the harbor seal has been observed in Lake Champlain, and other streams in central New York. The common seal has been caught in Chesapeake Bay.

general color is a dark, slaty gray, and their maximum length about five feet. The young, generally two at a birth, are white or a light yellow, a provision that renders them inconspicuous on the ice.

FIG. 366.—Harp seal.

The harp seal (*Pagophilus*) (Fig. 366), the ringed seal, the hooded seal (*Cystophora*) of Greenland and northern

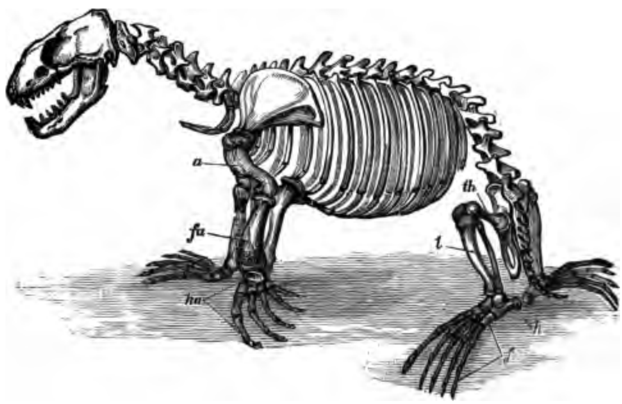


FIG. 367.—Skeleton of a sea-lion, showing how the whole foot rests on the ground, as in the bear family: *th*, thigh; *l*, leg; *h*, heel; *f*, foot; *a*, upper arm; *fa*, fore-arm; *ha*, hand.

Europe, and the sea-elephant (*Morunga*), of Antarctic waters, are others of the family. Then follows the walrus (*Trichechidæ*) (Fig. 368).

Eared Seals (*Otariidæ*).—The sea-lion (*Otaria*) (Fig. 367) is a familiar example. The sea-bear (*Callorhinus*), common in Behring Strait and Kamchatka, is one of the famous fur-seals of commerce.

VALUE.—Hides, ivory, viscera, etc. One million Atlantic hair-seals are killed annually, and two hundred thousand Pacific fur-seals, and many more from the South Atlantic.

Sub-order II. **The True Carnivora** (*Fissipedia*).—The **Raccoons** (*Procyonidæ*) are bear-like animals with sharp, pointed muzzles, ranging from Canada to Paraguay. The common raccoon (*Procyon*) is found throughout the United States. They are nocturnal, vegetable or flesh-eating animals, about a foot long, exclusive of the tail, which is nearly ten inches in length. Their color is a rusty gray with many black-tipped hairs, the tail barred with five black rings. They bear from five to six young in May, the nest generally being in a hollow tree. The black-footed, crab-eating, and Californian raccoons are different species, similar in their habits. The coatimundi (*Nasua*) is found from Mexico to Paraguay. The kinkajou and *Bassaris* are allies.

VALUE.—Five hundred thousand coon-skins are annually used as fur.

Bears (*Ursidæ*).—This family has a wide geographical range, being represented in all countries except Australia. The white or polar bear (Fig. 368) (*Ursus maritimus*) is found in the Arctic regions. The body is large, and covered with white hair, the tail rudimentary, the foot enormous, measuring one sixth of the length of the entire body, and armed with powerful claws. They are particularly distinguished from other bears by having the soles of the feet covered with close-set hairs—a provision that prevents their slipping on the ice, while their white fur renders them invisible at any great distance.

FIG. 368.—Polar bear and walrus, showing how the bear walks with the heel flat on the ground, and the walrus also.

NOTE.—Many animals that can not migrate and are deprived of food by cold weather are enabled to enter into a state of torpor called winter sleep or hibernation, and thus bridge over the foodless season. In the extreme south certain animals during the dry period enter into a summer sleep called estivation. In complete hibernation all the functions of life are almost at a stand still; the respiration is reduced and irritability of muscular fibre increased. Hibernation is favored by cold but not produced directly by it, and the hibernator is not insensible to extremes. In entering the sleep the temperature of the body sinks to nearly that of the surrounding atmosphere. If, now, the cold is intense, they are awakened and then are frozen. According to Semper, the zizel, or *Spermophilus*, attains the lowest temperature in this condition of any known animal, namely, 2° (centigrade), the exact temperature of the outside air in one experiment, so that the animal may be said to have become cold-blooded. The normal temperature of the zizel is 32° (centigrade). As the cause of the sleep is not directly the result of cold, neither is the awakening caused by a rise in temperature. In experiments with the same-mentioned animal it awoke without any change in the outside temperature, being two hours and forty-five minutes in awakening. In the first hour and forty-five minutes the body temperature rose 6.6° (centigrade), and in the following fifty minutes 17°. It was accompanied by no vigorous movements or quicker respiration. During hibernation animals can be placed under water without ill effect, though it would be fatal in a few moments if awake. According to Kirby, joint author of "Introduction to Entomology," an authentic case is recorded of an instance of human hibernation in India. The man was buried alive in the presence of Sir Claude Wade, the grave guarded and watched for several months, and the hibernator finally taken out, gradually awakening.

The black bear (*Ursus Americanus*) is quite common in northern New York. They attain a weight of four hundred and fifty pounds and a length of eight feet, and are of a dark-brown or black color. In extreme weather the females prepare a den, and as a rule pass into a state of hibernation, during which the intestines are clogged with vegetable substance, generally taken from the pine. In January or February, generally every third year, the young (three or four) are born, remaining under the mother's protection for five or six months. They prey upon sheep, calves, etc., and also eat berries, honey, ants, etc. The grizzly bear (*Ursus ferox*) of the western slopes of the Rocky Mountains, the Syrian bear of Mount Lebanon, the Malayan bear, and the sloth or honey bear (*Melursus*) of India, are others of the family.

VALUE.—Oil, fat, skin, teeth, hair, and viscera.

Badgers, Otters, etc. (*Mustelidæ*).—The true badgers (*Taxidea*) are found in central and western North and South America, and are thick-set animals about two feet long, not including the tail, which attains a length of six inches. The skunk (*Mephitis*), twelve different species, ranges from Canada to the Straits of Magellan. The common skunk is almost entirely nocturnal, feeding upon mice, insects, and various kinds of food. They hibernate in midwinter.

Otters.—The otter (*Lutra*) (Fig. 371) has representatives in nearly every part of the globe. The North American species is generally found upon the banks of streams, in which its burrow or nest is built. The sea-otter (*Enhydra*) (Fig. 369) is twice as large as the above, attaining a

FIG. 369.—Sea-otter (*Enhydra marina*), showing the front paws and the hind webbed feet.

weight of eighty pounds, and is found on the Pacific coast of America and Asia. Its habits are almost identical with those of the seal. In warm weather they proceed up the rivers, returning to the sea in winter, passing nearly their entire time in the water, eating and even rearing and nursing their young in the kelp-beds. The front feet are short with small claws, the hind ones being perfect swimming-flippers with long toes and stout claws. Their teeth are rounded and adapted for crushing crustaceans, mollusks, or fish.* Their fur is an extremely rich brown.

* The sea-otters are remarkable for their playfulness. When approached, they place one paw over the eyes, as if shielding them from

NOTE.—The adaptation of the limbs in the sea-otter is extremely interesting and worthy of special attention, and an advantageous study would be a comparison of the limbs (Fig. 370) of different animals.

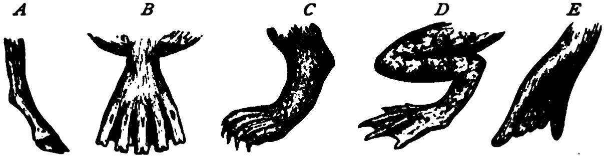


FIG. 370.—Feet of various animals compared. *A*, deer; *B*, ornithorhynchus; *C*, otter; *D*, frog; *E*, seal.

The common mink of this country (Fig. 371) attains a length of seventeen inches to the tail, which is eight inches longer. The body-color is a dark chestnut-brown, the tail black, and tip of the chin white. The marten or American sable (*Mustela*) ranges from northern New York northward, and is much valued. It attains the same length as the common mink, the tail being about two inches longer. Its color is a rich, glistening, golden red, clouded with black; the legs and tail are dark, a light patch appearing upon the throat; the feet are thickly furred. They burrow, and nest in old trees, and bring out a litter of from two to seven young in April. The fisher, or pekan, weasels, etc., are allies. The most ferocious of the group is the glutton, or wolverine (*Gulo*). It is confined to the cold regions of Europe, Asia, and North America, coming as far south as the Great Lakes. In the latter country it attains a length of three feet and a half to the tail, which is about one foot in length and extremely

the sun, then scratch themselves on the limbs, twisting about in various ways, and when just out of the water they are so absorbed in their toilet that they can frequently be taken. The males and females show the greatest devotion, kissing and patting each other like human beings. The mother's antics with the young are equally amusing; she tosses it in the air, fondles it in her arms, catches it with her fore-feet like a ball, and swims about with it clasped to her breast. The Chinese train the sea-otter to fish, and many are used for the purpose.

bushy. The paws are large and heavy, the soles densely haired, and furnished with six small, naked pads. They feed upon small animals, and the young, generally from two to four, appear in May. They are to some extent arboreal in their habits. The grison (*Galictis*) of northern and central South America is a fierce member of the group.

VALUE.—Fur and hide of all are valuable.

FIG. 371.—A group of valuable fur-bearers. 1, Arctic fox; 2, silver fox; 3, sable; 4, otter; 5, mink; 6, ermine.

Dog (*Canidæ*).—This family comprises the dogs, wolves, and foxes, and has a wide geographical range. Nearly all possess the mechanism for retraction of the claws, but the action is not sufficient to protect them from wear; thus they are modified for purposes of digging. The American red fox (*Vulpes*) has a slender, pointed muzzle, and is of a reddish-yellow hue. It preys upon domestic fowls and small game of all kinds. The young are reared in burrows in the ground. The Arctic fox (Fig. 371) is white in the winter and brown in summer. They live in burrows in communities of twenty or thirty.* The holes are connected underground and generally found stored with sea-birds. The prairie, swift, gray, coast, silver, and cross foxes are familiar American members of the family. The wolf (Fig. 372) (*Canis*) somewhat resembles the fox, but is larger and much more powerful. The coyote, or prairie-wolf, is a typical American species. They attain a length of thirty-eight inches to the base of the tail, which is fifteen inches longer. They live more or less in communities, and the young, often ten, are reared in burrows, appearing in April. The gray, black, dusky, red, and Mexican wolves are other species. The Asiatic wolves are noted for their ferocity. The jackal is a wolf-like creature of Asia and Africa. The dog (*Canis familiaris*) is probably a descendant of the wolf.

VALUE.—Skin, hide, oil, bones, teeth, and for domestic use.

FIG. 372.—The wolf (*Canis lupus*), showing the dog-like form.

* These animals formerly existed in incredible numbers on Behring Island, and were so tame that they overran the camps, carrying off hats, mittens, and clothing, nosing the sleepers in the night, and having actually to be driven away with clubs.

Civets (*Viverridæ*).—This large family has no representatives in America—the civets, genets, and ichneumons being characteristic of Africa and the Oriental region. Allied are the hyenas (*Hyænidæ*), found in India and Asia Minor and Africa.

Cat (*Felidæ*).—The cats, of all the *Carnivora*, are the most beautiful and active. Their bodies are shapely, many presenting a noble appearance, the type of grace and power. The head is short and broad, the feet armed with powerful, retractile, sheathed claws (Fig. 373), five on the

FIG. 373.—Claws of the cat or tiger: *A*, claw held back by the strong ligament *l*; *B*, claw pulled forward by the tendon *t* being drawn back, so that *l* is stretched out.

fore-feet and four behind, the soles hairy, and provided with soft, elastic pads that aid in their stealthy approach upon prey. The tongue is provided with a rasping surface, composed of sharp recurved prickles; the limbs are powerful and adapted for prodigious leaps, for which nearly all the family are noted. The hunting leopard (*Felis jubata*), of southern India and Africa, is an interesting form, and a rapid runner, being employed in hunting by the natives. The claws are retractile,* but in their action more like those of the dog.

The lynxes (*Lynx*), of which four species are known in North America, are characterized by thick-set bodies, the tail short and truncated, and ears ornamented with tips. The American wild cat attains a length of about twenty-eight and three quarter inches, the tail seven inches,

* Claws are retractile when they are held back naturally by the muscles, and thus prevented from wearing away, only being extended when wanted to secure prey or assist in climbing.

height at shoulder fifteen and a half inches. The fur is soft and thick, the color upon the sides a light red, overcast with grizzly gray ; below they are white and spotted, the inner surface of the ear and the tip of the tail black. They are powerful animals, and prey upon small game of various kinds. They nest in hollow trees and logs.

The Canada lynxes (Fig. 374) are the largest, attaining a length of three and a half feet. They are extremely powerful, attacking large animals, sheep, etc. ; are good swimmers, and easily recognized by their gallop. They produce their young, generally two, in dens or hollow trees. The red cat and Texas wild cat are other species.

FIG. 374.—Canada lynx (*Lynx Canadensis*).

The domestic cat (*Felis*) has been domesticated for over a thousand years, and was probably first used in Egypt. The yaguarundi ranges from southern Texas to central South America. The tail is nearly as long as the body, the prevailing color a grayish brown. The ocelot and tiger-cats range from Texas southward.

The puma or panther is the largest and most powerful true North American cat, equaling in size a large hound, weighing one hundred and seventy-five pounds, and common throughout the less frequented parts of the country. They are extremely powerful, leaping forty or fifty feet or more from an elevation, and taking to trees and climbing generally only when pressed. They prey upon various animals, and have been known, though rarely, to attack man. In southern Florida they swim from key to key with perfect ease. The general color of the puma in best condition is a rich mouse-gray with light beneath. The jaguar is the American tiger, and differs from the puma in being essentially arboreal. It ranges from Texas to southern South America, and is the largest and handsomest cat in the Western Continent, attaining a total length of over five feet, and is so powerful that it has been known to kill a mustang, swim with it across a river, dragging it into the bush beyond. The general color is brownish yellow above, white beneath, with numerous darker spots. The sides of the body are marked with a series of irregular figures. They are accredited with wonderful powers by Humboldt and other writers, in opening turtles and catching fish with their powerful claws. The leopard is perhaps the most beautifully marked of the family, and ranges the jungles of Asia, Africa, and the Indian Archipelago. The skin is richly marked with oval spots. The black leopard * is singularly treacherous and utterly untamable. The tiger † of India (Fig. 375), next to the lion, is the most powerful of the cat tribe, majestic in appearance, the type of agility, cunning, and ferocity. They are as large as the lion, with a longer body and rounder head. The color of the fur is a rich fawn above, striped and barred irregularly with black, the under portion being

* Albinos are found among all animals, a condition generally the result of a lack of pigment. Its absence in the eye produces the so-called "pink" eyes. Albinism, then, is not properly a disease, and in no wise affects physical or mental vigor. The black leopard is a subject of melanism, owing to an over-supply of coloring-matter in the cells.

† The marks of the tiger, leopard, ocelot, and the color of the puma, are all protective, and when crouching upon a limb or on the ground help tc render them inconspicuous.

pure white. They are extremely ferocious, attacking the largest animals. In 1881 eight hundred and eighty-nine persons were killed by them alone in southern India, while the leopards killed two hundred and thirty-nine. Wallace records that, in one of the localities he was in (Singapore), the tigers, on an average, killed one native a day throughout the year. The young, generally two at a birth, are

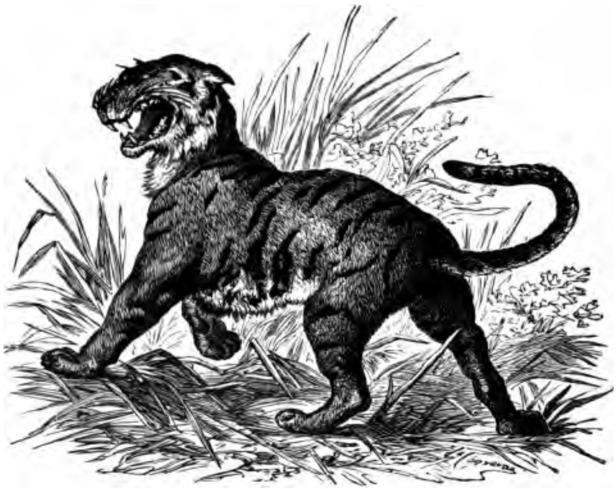


FIG. 375.—The tiger, showing slim body, muscular thighs, strong front-legs and paws, and short face with large teeth, all with sharp edges, especially one (the *carnassial*) near the back in both jaws.

carried about in the mouth, after the manner of the domestic cat. The ounce is an allied cat. The lion (*Felis leo*) is the royal member of the cat family, and justly so from its magnificent bearing. It is found in Africa and Asia, the two probably being merely varieties. The African lion is much more dreaded and displays greater cunning than its ally. The largest of these attain a length of nine feet, exclusive of the tail. The neck of the male is protected by a thick mane, giving them a ferocious appearance. The general color of the hide is tawny; the feet and paws are immense, the animal being adapted for leaping and overpowering the largest game. The females are somewhat smaller than the males, and have no manes. About twenty extinct species of this family have been found, resembling lions, tigers, etc. The remains of a ferocious tiger (*Machærodus*) have been discovered in England and other countries. It lived contemporaneously with man, and had serrated teeth, and fangs eight inches long, more like sabers than teeth.

VALUE.—Five hundred lion-skins are used annually by the trade; one hundred thousand wild-cat, and over one million skins of the common cat are made into cheap furs.

Order IX. **Primates.** *General Characteristics.*—We now come to the last and highest order of mammals, represented by the lemurs, monkeys, and man. In the higher forms of apes and monkeys a vast improvement or advance is noticed. The body is now carried more erect, claws are replaced by finger-nails, the fingers are long and more perfectly adapted to a greater number of uses than in the preceding forms, and the great toe of the hind-feet is much enlarged and opposable to the others; the legs are exserted quite free from the trunk, the brain is large, the ears rounded, having a distinct lobe; the body is hairy, the tail long or short, and the face in many extremely human in its detail. The primates are divided into two sub-orders: 1. *Prosimiæ*, comprising the lemurs; and 2. *Anthropoidea*, including all the rest that are divided provisionally into five divisions or families as follows: 1. The marmosets (*Hapalidæ*). 2. The American monkeys, having three true molar teeth on each side of each jaw (*Cebidæ*). 3. The Old World monkeys, except the man-like apes (*Cercopithecidæ*). 4. The man-like apes (*Simiidæ*); and, 5. Man (*Hominidæ*).

Sub-order I. **Prosimiæ. Lemurs** (*Lemuroidea*).— The lemurs are the lowest of the primates, a group of beautiful animals ranging in size from a cat to a good-sized monkey (Fig. 376). The entire body is covered with hair, and even the face in some. The head is small and fox-like, the skull small, narrow in front, and flattened; the ears are conspicuous and often tufted. They are gregarious, and diurnal in their habits, rarely leaving the tree-tops, among which they leap with the greatest agility. They are found in Madagascar, southern and eastern Asia and Africa. Fossil remains of lemurs have been found in North America.

FIG. 376.—1, the aye-aye; 2, lemur in the forests of Madagascar.

Aye-aye (*Chiromyidæ*). — These interesting animals (Fig. 376) are found in Madagascar, and are remarkable for their enormous compressed, curved, incisor teeth, that have persistent pulps and enamel in front only, as we have seen in the rodents. The toes have claws, except the great ones, which have a flat nail; the digits are remarkably long and slender, especially the middle and third of the fore-arms. They are about the size of a cat. The general color is dark brown, the long, loose, outer fur having a woolly under-coat. They feed upon the succulent juices of sugar-cane, also insects and grubs obtained from trees with their powerful teeth. They are truly nocturnal. Their nests are formed of balls of leaves lodged in the forks of large trees.

Lemur (*Lemuridæ*).—The ring-tailed lemur (*Lemur catta*) is one of the most striking of the family, and is of a beautiful gray color, its tail marked with alternate rings of black and white, the face and inner surface of the ears white, and the top of the head dark. It is the only ground member of the family, living among the rocks and bushes, walking on all-fours. The upper canine teeth are extremely large, the lower canine extending out horizontally from the jaw. The young, generally two, are at first nearly naked, and are carried about in the arms of the mother, later clinging to her long hair. They utter loud cries, and feed upon eggs, young birds, insects, fruits, buds, or flowers (Fig. 376). The *Propithecus* is a common form in Madagascar; the Indris is the largest of the group. Allied is the lori (Fig. 377).

FIG. 377.—Loris, showing (1) skull and (2) opposable thumb.

Sub-order II. **Man-shaped Animals** (*Anthropoidea*).

Marmosets (*Hapalidæ*).—The marmosets are confined exclusively to South America, and are rarely larger than large squirrels. They have long, non-prehensile tails, and walk upon all-fours, the feet and hands being similar, and the digits armed, with the exception of the great toes, with nail-like claws. As the thumbs are not opposable, they can not grasp with the facility of other monkeys.

FIG. 378.—A woolly monkey and young (*Lagothryx Humboldtii*), showing grasping tail.

Weepers (*Cebidæ*).—In this large family we first meet the true monkeys, the family embracing all the South American forms. They are distinguished by the possession of more molar teeth than those that follow, having in all thirty-six teeth, while the rest have only thirty-two. Many also possess a long, prehensile tail of so much use in clinging that it serves the purpose of a fifth hand (Fig. 378). The red-faced spider-monkey (*Ateles*) is one of the most remarkable for the attenuation of its form. The tail is extremely long and bare upon its under surface, and with it they swing from limb to limb with the greatest ease. In walking upright, the arms are often held high in air, and the long tail curled over the head. The horned monkeys (*Cebus*), the bearded saki (*Pithecia*), and the howling monkeys (*Mycetes*), are familiar forms. The voice of the latter is so powerful that it can be heard a mile, the hyoid apparatus and windpipe (larynx) being wonderfully modified into a sound-producer, the body of the former assuming the functions of a large bony drum or air-sac connecting with the larynx. In the male these curious vocal organs are one third larger than in the female. Following are the *Cercopithecidæ*, a group of monkeys peculiar to the Old World. The face of the dog-faced apes is produced into a dog-like snout, more or less blunt or truncated; the eyes are small, deeply set, and placed close together. The wanderoo (*Macacus*), the Gibraltar monkey (*Macacus inuus*), the mandrill and chacma, and the babboon (*Cynocephalus*), are familiar forms. Allied are the **Sleepers** (*Semnopithecidæ*), of Africa and Asia.

Apes (*Simiidæ*).—The animals of this family in their physical development show a near approach to the human type. Their position is nearly erect, the tail absent, and the arms are much longer than the legs. The gibbons (Fig. 379) (*Hylobates*) attain a length of three feet. In the siamang, when standing erect, the fingers drag upon the ground, the limbs being used to swing them through the trees; the thumbs and great toes only have nails. In color they are black, the hair being long, coarse, and glossy. They live in troops in the forests of Java, Borneo, etc., and are generally led by a chief, who gives warning at the approach of danger. The females show great solicitude for their young, and when in danger give vent to loud cries that, in this genus, are augmented by a large sac in the throat that communicates with the larynx, which when

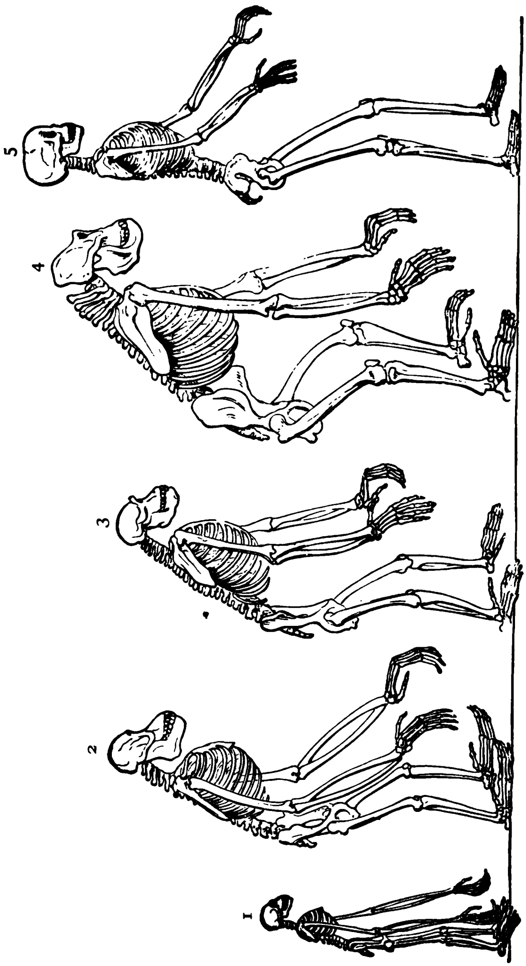


FIG. 379.—Comparison of skeletons of primates: 1, gibbon; 2, orang; 3, chimpanzee; 4, gorilla; 5, man. (After Huxley.)

filled with air is distended like a huge goitre in the neck. The *Hylobates agilis* is remarkable for its leaps, clearing spaces of forty or fifty feet, and, according to Darwin, they are the most musical mammals next to man, "singing a complete and correct octave of musical notes." The orang-outang (*Simia*) (Fig. 379) is found in the islands of Borneo and Sumatra. They attain a length of a little over four feet, and a weight of one hundred and fifty pounds. The number of ribs is the same as in man, and there is some resemblance in the form of the brain, yet the capacity of the brain of the orang is only twenty-five cubic inches, while in man it is from seventy-five to ninety-two cubic inches. The arms are extremely long, the knuckles touching the ground in walking. The face is bare, the skin shiny black, and under the throat hangs in loose, flabby folds. The body is covered with reddish hair, twelve or fourteen inches long. In the male *Simia Wurmbii* the face is widened to an extraordinary extent by a hard, gristly expansion of the cheeks, measuring across the face thirteen inches. The female is smaller, the hair a lighter brown. They are entirely arboreal, living always in the tree-tops, never jumping, but swinging their heavy bodies five or six feet at a time by collecting the branches. When at rest or wounded, they break off branches and twigs and form platforms or nests in the tree-tops. Their favorite food is the fruit of the durian-tree. The voice is loud and resonant, and can be heard for a long distance.

The chimpanzee (*Mimetes*) (Fig. 379) is found upon the west coast of Africa, from the Gambia to the Benguela, and inland to 28° east longitude. They attain a height of nearly five feet, can stand or walk erect, but prefer to bend forward upon the knuckles (Fig. 380). The face is black and exceedingly human in its outline; they approach man, however, most closely in the character of the skull, their dentition, and the proportionate size of the arms; the brain capacity, however, is only twenty-six cubic inches. The canine teeth are powerful, though their food is entirely vegetable. They are arboreal, living in the trees, and forming nests of branches in the crotches near the ground. They are very intelligent, easily domesticated, and often brought to this country and Europe.

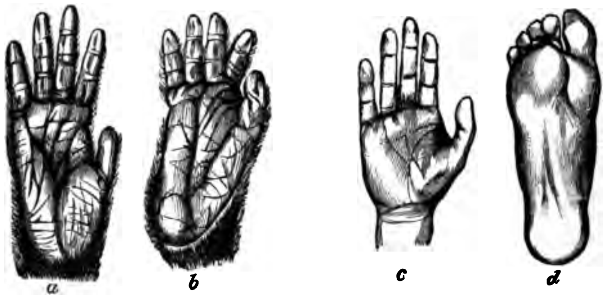


FIG. 380.—*a*, hand, *b*, foot of chimpanzee. (After Vogt.) *c*, hand, *d*, foot of man.

The gorilla (*Troglodytes*) (Fig. 379) is the largest and most powerful of the order, though perhaps ranking with the chimpanzee as regards its position in the scale of life. They are also found in western Africa, and have a less extended range, being found only between the rivers Cameroons and Congo, in the mountains of Guinea. Their habits are similar to those of the chimpanzee, though living in small communities, generally led by a single male. They erect uncovered platforms in the trees upon which to rest, deserting them during the day, and forming others at night. They attain a height of five feet six inches, and a weight of two hundred pounds. The color of the fur is a blackish dun, turning gray with age. The skin is black, the ridges of the forehead (Fig. 381) prominent, the nose flat, lips and chin protruding, and the expression of the face demoniacal. The limbs are enormously powerful, and the first joints of all the fingers and three of the toes are connected by a strong web. While the chimpanzee resembles man in the characteristics given, the gorilla is more human in the proportions of the leg to the body and of the foot to the hand, in the size of the heel, curvature of the spine, the form of the pelvis, and the capacity of the brain, which is from twenty-nine to thirty-five cubic inches.

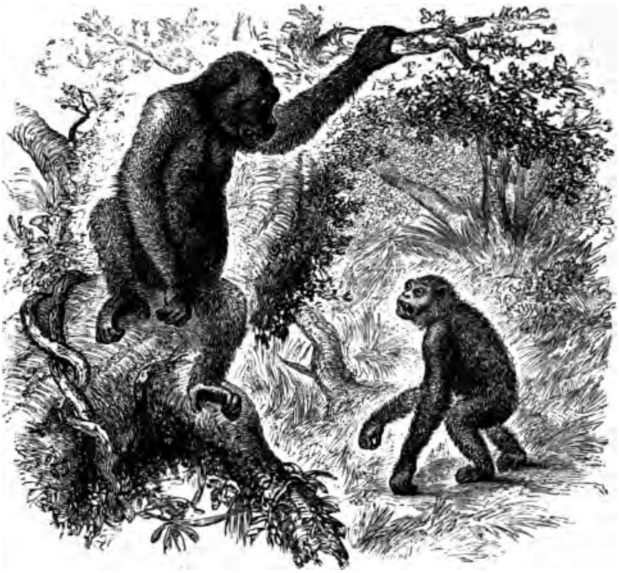


FIG. 381.—The gorilla (*Troglodytes gorilla*).

Fossil monkeys have been found in the Selwalik hills of India, in France, Greece, Italy, Germany, and North and South America, none dating earlier than the Miocene time of geology.

VALUE.—Skins, concretions, and as domestic animals.

Works on Mammals for further reference.

"Manual of Vertebrates," Huxley; "Anatomy of Vertebrates," Owen; "Marine Mammalia," Captain C. M. Scammon; "Osteology of Mammalia," Flower; "Antelopes and Deer of North America," J. D. Caton; "North American Beaver," Morgan; "Fur-bearing Animals of North America," Elliott Coues; "Standard Natural History,"

edited by Elliott Coues, M. D.; "Mammals of the Adirondacks," C. Hart Merriam, M. D.; "A Naturalist's Rambles about Home," Dr. C. C. Abbott.

Man (*Hominidæ*). *General Characteristics.*—Man (*Homo sapiens*) stands as the exponent of the highest perfection of animal life, unique and distinct from all preceding forms as regards his mental organization. In structure (Fig. 379) he differs but little from other primates. The general physical differences are his erect position, the span of the arms equaling the height. The forehead or cranial box in man overhangs the orbits; in the gorilla (Fig. 381) the forehead is hollowed out. The brain in man is more than twice the size of that of the gorilla, its capacity being from seventy-five to ninety-two cubic inches, while in the latter it is only thirty-five cubic inches. The brain of the former shows a greater number of convolutions; and, finally, man alone possesses a perfect vocal communication, known as language.

The present human population of the globe is 1,433,887,500. Man represents but a single genus and species. The different races are divided in accordance with certain external peculiarities; thus, according to Huxley, two primary divisions are noticed: 1. The races with crisp or woolly hair, *Ulotrichi*, represented by the African negro (Fig. 382, 1, 2, 3), the Bushmen of ultra-Saharal Africa, the Negritos of the Malay Peninsula and Archipelago, and those of the Papuan Islands. They are characterized by yellow, brown, or black skins; the lower part of the face protrudes, the waist is broader than in the white race, and the fore-arm, hand, foot, and leg are sometimes longer in proportion than Europeans. This is also true of the Australians. The legs are a little less than half the height, and the thigh-bone is flattened from side to side as in the gorilla. The heel of the negro, contrary to general opinion, is not longer in proportion to the foot than in white races, the projections seen being

FIG. 382.—Comparison of different races: 1, negro, West Africa; 2, Barolong, South Africa; 3, Hottentot; 4, Gilyak, Northern Asia; 5, Japanese; 6, Colorado Indian, North America; 7, European.

fleshy, and an expansion of soft parts due to not wearing shoes.

2. Those with smooth hair, *Leiotrichi*, are divided into four groups upon a similar plan: 1. The Australoid group, comprising the low Bushmen, in which the height averages four feet seven inches, and the legs less than half the height of the body. The hair, eyes, and skin are dark, the hair wavy. The skull is long, and the brow-ridges extremely prominent. The inhabitants of the Deccan belong here, and from them have sprung, in the estimation of Professor Huxley, the ancient Egyptians. The habits of the Bushmen are more like those of the lower primates than men. 2. The Mongoloid group. Herein are included the Chinese and Japanese (Fig. 382, 5), Mongols, people of Thibet, the Polynesians, Micronesians, and the American tribes (Fig. 382, 6). The Patagonians are the tallest people known, averaging six feet, the women five feet ten inches, while the Esquimaux and the Bushmen are the smallest, averaging four feet seven inches. Three hundred and ninety-one years ago nearly the entire continent of America was peopled with powerful native Indian tribes, that have been gradually driven to the West, 944 individuals only being found now in the New England States, 303,217 * in the United States, and 103,969 in the British possessions, 407,217 in all, in North America, speaking about four hundred and thirty distinct languages. Their ultimate extinction or loss of individuality is merely a matter of time. Among the typical tribes the Pueblos of the Southwest, the Thlinkeets † of the Northwest, the Utes, or Colorado Indians (Fig. 383), are prominent. All of this group have straight hair. The North American Indians have a reddish skin, the Chinese yellow, while the Polynesians are dark brown.

* Report of 1880.

† In early days the process of flattening the head was common throughout North and South America.

3. The *Xanthochroic* group (Fig. 382, 7), comprising the Slavonians, Germans, Norwegians, Swedes, Anglo-Americans, English, French, Italians, etc. These are the most intelligent and advanced, and form the great and powerful nations of the earth.

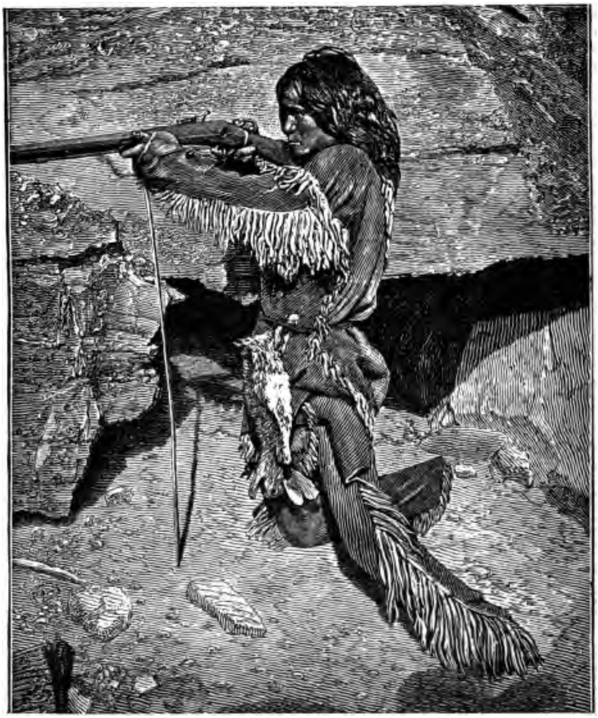


FIG. 383.—Colorado Indian.

4. The *Melanochroi*, or dark whites, including those with dark hair and eyes, and generally long skulls ; such are the Iberians, and the dark-complexioned though white people of western Asia, Persia, etc. Besides these differences, that form the characteristics of races, there are oth-

ers. Thus, the form of the skull differs greatly, even among individuals. The Australians and Africans are *prognathous*, or forward-jawed, while the Europeans are *orthognathous*, or upright-jawed. When the skull is high and narrow, they are said to be *dolichocephalic*, or "long-headed." Others are termed *brachycephalic*, or "short-headed," while a medium is called *mesocephalic*, or middle headed.

Early Man.—Man was contemporaneous with the cave-bear, the mammoth, and other huge animals that lived during the Post-tertiary period. Fossil remains and implements have been found in Quaternary deposits. The oldest remains found in America, on the authority of Professor Whitney, is a human cranium taken from a shaft one hundred and fifty feet deep in Calaveras County, California. It was imbedded in the gold-drift, and covered with five successive overflows of lava. Another fragment of a human skull was found imbedded one hundred and eighty feet below Table Mountain, associated with bones of the mastodon. According to Professor Whitney, these finds date to the Pliocene time of geology, a time prior to the volcanic eruptions that spread their lava over a large portion of the State.

Specimens for Study.—The suggestions for the preparation of skeletons, on page 291, may be applied to mammals also.

Works on Man for further reference.

"Hand-Book of Human and Comparative Histology," S. Stricker; "Human Physiology," J. C. Dalton; "Elementary Lessons in Physiology," Huxley; "Natural History of Man," Von J. F. Blumenbach; Lyell's "Antiquity of Man"; F. Cushing, "My Adventures in Zuñi," in the "Century," February, 1883; "The Human Body," Martin; "Anthropology," Tylor; "The Essentials of Anatomy, Physiology, and Hygiene," R. S. Tracy.

QUESTIONS.

BRANCH I.—1. What is a cell? 2. Mention some differences between animals and plants. 3. What are the characteristics of the simplest animals? 4. Describe a moner; its method of eating. 5. What is a nucleus? 6. Define a contracting vesicle. 7. Define an amœba. 8. Describe a shelled amœba. 9. What is a radiolarian? 10. What great work do these forms accomplish? 11. Define a gregarine. 12. In what are they remarkable? 13. Define the infusorians. 14. How do they differ from the preceding forms? 15. What is a cilium? 16. Define a monad. 17. What is a compound monad? 18. How does the acineta differ from the monad? 19. What are the characteristics of the suctorians? 20. Describe the bell animalcules. 21. What is meant by budding?

BRANCH II.—1. Describe the structure of a sponge. 2. What are spicules? 3. How does a sponge eat? 4. Describe the different uses of the large and small pores. 5. Explain the development of the sponge. 6. Define a lime-sponge. 7. Give examples of other kinds. 8. How do they benefit man?

BRANCH III.—1. What are the general characteristics of cœlenterates? 2. Define a hydra; show the use of its arms. 3. What is a lasso-cell? 4. Describe a lime-secreting hydroid. 5. What is meant by alternate generations? 6. Give an example. 7. How do the discophores differ from hydroid medusæ? 8. Where are the eyes in a jelly-fish? 9. Describe the development of an aurelia. 10. Explain the use of the water vascular system. 11. Describe the physalia. 12. How does it secure prey? 13. Define a sea-anemone. 14. What is a septa? 15. Describe the development of sea-anemones. 16. How do corals differ from anemones? 17. About how fast does coral grow? 18. Are corals found out of the tropics? Give example. 19. What is a coral reef, and how formed? 20. What is an atoll? 21. Of what value is coral to man? Anemones? 22. What is a gorgonia? 23. Describe a sea-fan. 24. What are the general characteristics of the comb-bearers?

BRANCH IV.—1. What are the general characteristics of echinoderms? 2. What is a pedicellaria? How used? 3. Describe the water vascular system, and its use. 4. What is a crinoid? 4. Define an echinus. 6. How does it differ from star-fishes? 7. What is a madreporic plate? 8. Define a holothurian. 9. How do they breathe? 10. What is the position of the madreporic plate? 11. Describe the development of holothurians.

BRANCH V.—1. What are the general characteristics of worms? 2. Describe a planarian worm. 3. Give its life-history from the egg to adult. 4. What fable is there associated with the Gorgius aquaticus? 5. Define a rotifer. 6. Why are they termed wheeled? 7. What are the polyzoans? 8 In what do they differ from other worms? 9. Define a brachiopod. 10. Give examples. 11. Describe a leech. 12. What peculiarity is there about their teeth? 13. Describe the eggs and habits of young. 14. Describe an earth-worm. 15. How does it crawl, eat, dig, etc.? 16. For what are they valued by man? 17. Describe a marine worm. 18. What do you conceive to be the use of the luminous property in worms? 19. Give examples of luminous forms.

BRANCH VI.—1. What are the general characteristics of mollusks? 2. Describe the parts of a clam-shell. 3. Describe the internal organs. 4. How does the oyster breathe? 5. Describe the nervous system. 6. Where are the eyes, and ears? 7. How is the foot of clams used? 8. How does the pecten move? 9. What are the habits of the pholas? 10. Define a univalve. 11. Mention a surface shell. 12. What is an operculum? 13. Define the heteropoda. 14. Define an air-breathing gasteropod. 15. Describe the land-slugs. 16. What peculiar secretion have they? 17. Describe the eyes of the onchidium. 18. What are the highest forms of mollusks? 19. Describe the nautilus. 20. Can it leave its shell? 21. Has it an ink-bag? 22. What peculiarity is there about its eye? 23. Describe a squid. 24. How does it differ from the preceding forms? 25. How is the siphon used? The ink? 26. How is the body supported? 27. Describe the octopus. 28. How does the argonaut differ from the nautilus? What fable is there about them? 29. Where and how are the eggs placed?

BRANCH VII.—1. Define the arthropoda. 2. What are the distinctive characteristics of crustaceans? 3. Describe the skeleton of the cray-fish. 4. How does it breathe? 5. How is molting accomplished? 6. Describe the metamorphosis of a crab; mention an exception. 7. How are the eggs carried? 8. Describe the growth of a barnacle. 9. What are cirri? 10. Mention some peculiarity about the brine-shrimp. 11. What crustaceans secrete a bivalve shell? 12. Define the decapods. 13. How do the hermits differ from preceding forms?

14. Describe the oyster, land, and king crabs. 15. What are the general characteristics of insects? 16. Describe the skeleton; of what is it composed? 17. Describe the internal organs. 18. How do insects breathe? 19. Describe the metamorphosis of an insect. 20. Give an example of an incomplete metamorphosis. 21. How does the peripatus defend itself? 22. Define the myriapoda; where are the poison-glands? 23. Describe the scorpions. Spiders. 24. How is the silk produced? 25. Define the hexapoda, and give examples. 26. Define the orthoptera. 27. Define the hemiptera, and give examples. 28. Describe the metamorphosis of the froth insect. 29. Mention some insects that are particularly valuable to man. 30. Define the coleoptera. 31. How does the diving-beetle cling? 32. Define the diptera. 33. Describe the metamorphosis of a fly. 34. What are the characteristics of the butterflies? 35. How do they differ from moths? 36. Define the hymenoptera. 37. How would you preserve an insect for study?

BRANCH VIII.—1. What are the general characteristics of ascidians? 2. How do they breathe, eat, move? 3. Give example of compound ascidian. 4. Describe the salpa and appendicularia. 5. How are they allied to vertebrates?

BRANCH IX.—1. Define a vertebrate? 2. Define the fishes. 3. Describe the parts of the skeleton. 4. How do the fins compare with the limbs of other forms? 5. Why are fishes cold-blooded? 6. What is the use of the air-bladder? 7. Describe the manner of breathing. 8. Describe the internal organs. 9. Do fishes ever leave the water? Give examples. 10. What is meant by interspinous bones? 11. What is meant by a cartilaginous fish? a bony one? 12. What is meant by a pouched-gilled fish? 13. Describe the manner of breathing in the lung-fishes. 14. In the amphibious fishes.

BATRACHIANS.—1. Define the class batrachia? Give examples. 2. How does the skeleton differ from that of other vertebrates? 3. How do they breathe? 4 Describe the circulation. 5. Describe the development. 6. What peculiarity is there about the axolotl? 7. How does a siren differ from a frog?

REPTILES.—1. What are the general characteristics of true reptiles? 2. In what do they resemble the birds? 3. How do they differ from the batrachians? 4. Is the blood cold? 5. Describe the manner of development. 6. Describe the moulting process of snakes. 7. Describe the color-changes of reptiles. 8. How do the teeth of crocodiles and snakes differ? 9. Are crocodiles found in this country? Where? and what are their habits?

BIRDS.—1. Define the birds. 2. How do they differ from the reptiles? 3. What modification of the limbs is observed? 4. Describe the head.

wings, legs. 5. How do they roost when asleep? 6. How does the circulation differ from that of reptiles? 7. Why are they warm-blooded? 8. How do they breathe? 9. How are birds covered? 10. Describe a feather. 11. Describe the development of birds. 12. What are the peculiarities of lizard-tailed birds? 13. Describe the toothed birds. 14. What is meant by flat-breasted birds? Give an example. 15. Define a keel-breasted bird, and give examples.

MAMMALS.—1. What is meant by a mammal? 2. How is it distinguished from the birds? reptiles? 3. Describe the skull. 4. What is the use of the backbone? the ribs? tail? 5. Describe the limbs and their uses. 6. Describe the digestive process. 7. How does it differ from that of birds? 8. Describe the circulation of blood. 9. Is there anything about the blood-corpuscles that reminds you of the amœba? 10. Describe the process of breathing. 11. How does it differ from that of birds? of reptiles, fishes, insects? 12. What are the uses of the nervous system? Designate them. 13. Define the development of a mammal. 14. What are the great groups of mammals? 15. Define the monotremes. 16. In what do they resemble the reptiles? 17. How does their development differ from that of other mammals? 18. What are the general characteristics of marsupials? 19. What is a placental mammal? 20. Define the sirenians. 21. What are the general characteristics of whales? 22. Do they spout water? 23. How is whalebone used? 24. Define the insectivora. 25. How do their teeth differ from those of other forms? 26. Define the bats. 27. How do they pass the winter? 28. How is the wing-membrane supported? 29. What organs for clinging besides claws have some bats? 30. Define a rodent. Give examples. 31. Does the porcupine throw its quills? 32. Define the ungulata. 33. Describe the hyrax. 34. What are the characteristics of elephants? 35. Describe the tapirs, rhinoceroses, horses. 36. How do the hippopotamus, peccary, etc., differ from them? 37. Define a ruminant. 38. Describe the process of digestion. 39. How are the horns of deer reproduced? 40. Is there an exception to their casting? 41. What deer has long canine teeth? 42. How do the bovidæ differ from the deer family? Give examples. 43. Define the carnivora. 44. How do bears often pass the winter? 45. How do the seals differ from other carnivora? 46. Define the primates. 47. How may the monkeys be grouped? 48. What are the characteristics of the higher apes? 49. Into what general groups is the human race divided? Give examples.

GLOSSARY.

Abdomen. (Lat. *abdo*, I conceal.) In mammals, that portion of the body-cavity which is separated from the thorax or chest by the diaphragm. In insects the third or last portion.

Acalephæ. (Gr. ἀκαλήφη, a nettle.) Jelly-fishes or sea-nettles.

Acanthocephala. (ἄκανθα, a thorn; κεφαλή, head.) Parasitic worms

Acarina. (Gr. ἄκαρι, a mite.) An order of Arachnida.

Actinozoa. (Gr. ἀκτίς, a ray; ζῶον, animal.) A class of Cœlenterata.

Acephalous. (Gr. ἀ, without; κεφαλή, the head.) Destitute of a distinct head.

Adductor. Referring to muscles in clams which draw the shells together.

Albumen. (Lat. *albus*, white.) Resembling the white of an egg.

Alveolus. A hollow cavity forming a socket for the teeth.

Ambulacrum. (Lat. from *ambulare*, to walk, a garden-walk.) The perforated spaces in the shell of Echinus.

Ametabolic. (Gr. α, without; μεταβολή, change.) Referring to insects and other animals which do not undergo a complete metamorphosis.

Amœba. (Gr. ἀμοιβή, a change.) One of the Rhizopods that is continually changing its shape.

Amphibia. (Gr. ἀμφί, both; βίος, life.) A class of vertebrates, breathing in water while young and in air when mature. The term amphibious is applied to fishes, mollusks, etc., that are capable of changing the nature of their respiration at will.

Amphicœlous. (Gr. ἀμφι, both; κοίλος, hollow.) Vertebræ with a cup at either end.

Amphioxus. (Gr. ἀμφί, both; ὀξύς, sharp.) The Lancelot, which tapers to either end of its body.

Amphipoda. (Gr. ἀμφί, both; πούς, foot.) An order of Crustacea, whose feet serve both for walking and swimming.

Anchylosis. The union of the two surfaces of a joint by bone, so that all movement is lost.

Annulosa. (Lat. *annulus*, a ring.) Ringed animals.

Anthropoid. The highest order of apes.

Anthozoa. (Gr. ἄνθος, a flower; ζῶον, an animal.) A class of Cœlenterata generally termed Actinozoa.

Anura. (Gr. α, without; οὐρα, a tail.) An order of Amphibia, including frogs and toads.

Apoda. (Gr. α, without; πούς, foot.) Fishes that have no ventral fins.

Apodous. Footless.

Aptera. (Gr. α, without; πτερόν, wing.) The wingless insects.

Arachnida. The spiders.

Archæopteryx. A fossil bird which possessed a tail of true vertebræ.

Arthropoda. (Gr. α, without; ἄρθρος, a joint; πούς, ποδός, foot.) Articulata with jointed feet, as crabs, insects, etc.

Artiodactyla. (Gr. ἄρτιος, even; δάκτυλος, finger or toe.) Even-toed Ungulates.

Asexual. A term applied to animals, as Aphis, in which the reproductive organs are imperfect, and the young are produced by budding.

Auricle. (Dim. of *auris*, an ear.) The cavity of the heart which receives the blood and transmits it to the ventricle.

Avicularium. (*Avicula*, dim. of *avis*, a bird.) Peculiar little processes found in many of the Polyzoa, shaped like a bird's beak.

Bacterium. (Gr. βακτήριον, a staff.) Minute filamentous organisms found in decomposing infusions of organic matter.

Balanidæ. The acorn-shells, a family of Cirripedia, or barnacles.

Batrachia. Applied to frogs, toads, and salamanders.

Belemnite. A fossil genus of Cephalopoda.

Bivalve. (Lat. *bis*, twice; *valvæ*, folding-doors.) Shells with two valves.

Branchiæ. (Gr. βράγχια, gills.) Breathing-organs of fishes, etc.

Byssus. (Gr. βύσσος, flax.) Silk anchor-threads of the mussel, etc

Cavicornia. (Lat. *cavus*, hollow; *cornu*, horn.) Ruminants with hollow horns.

Cephalopoda. (Gr. κεφαλή, the head; πούς, foot.) The highest class of Mollusca.

Cestraphori. A family of Elasmobranchii, or sharks.

Cetacea. The whales.

Chiroptera. The bats.

Chelæ. The prehensile claws terminating the limbs of some Crustacea—e. g., the lobster.

Chelonia. An order of Reptilia.

Chilopoda. An order of Myriopoda.

Chitine. (Gr. χιτών, a coat.) The horny covering of insects, etc.

Chrysalis. The pupa state of an insect.

Chyle. (Gr. χυλός, juice.) The milky fluid which results from the digestion of food.

Chyme. (Gr. χυμός, juice.) An acid, the result of the action of gastric juice on food.

Cilia. (Lat. *cilium*, an eyelash.) Hair-like organs of Infusoria.

Cirripedia. (Lat. *cirrus*, a curl; *pes*, a foot.) A group of Crustacea.

Cæcal. Ending blindly.

Cæcum. A blind sac.

Cœlenterata. The sub-kingdom of Invertebrata, comprising Hydrozoa and Actinozoa.

Coleoptera. (Gr. κολεός, a sheath; πτερόν, a wing.) The beetles whose anterior wings protect their posterior.

Condyle. The articular surface of a bone, especially of the occiput.

Crinoidea. (Gr. κρίνον, a lily; εἶδος, form.) An order of Echinodermata.

Crustacea. (Lat. *crusta*, a crust.) Applied to lobsters, crabs, etc.

Cteñophora. An order of Actinozoa.

Cuticle. The outer layer of the skin.

Cyclostomi. An order of fishes, called Marsiopobranchii.

Cycloid. (Gr. κύκλος, a circle; εἶσος, form.) Applied to circular fish-scales.

Decollated. (Lat. *decollo*, I behead.) Univalve shells whose apex falls off during growth.

Dentirostres. (Lat. *dens*, a tooth; *rostrum*, a beak.) Perching birds with a toothed mandible.

Dentate. Furnished with teeth.

Didelphia. (Gr. δίς, two, or double; δελφύς, womb.) The sub-class of Marsupials.

Dipnoi. (Gr. δίς, double; πνοή, breath.) An order of Pisces.

Dipteria. (Gr. δίς, two; πτερόν, wing.) An order of Insecta.

Discophora. A group of jelly-fish.

Echinodermata. (Gr. ἐχῖνος, a hedgehog; δέρμα, skin.) The star-fishes, etc.

Echinoidea. An order of Echinodermata.

Ectoderm. (Gr. ἐκτός, outer, and δέρμα, skin.) The outer covering

Ectosarc. (Gr. ἐκτός, outer; σάρξ, flesh.) The outer layer of sarcode, as in the Amœba.

Elasmobranchii. (Gr. ἔλασμα, a strap; βραγχία, gill.) The sharks and rays.

Elytra. (Gr. ἔλυτρον, a sheath.) Horny wing-covers of beetles.

Embryo. (Gr. ἐν, in; βρύω, I swell.) The earliest period at which the young of animals is recognized.

Encysting. To become inclosed in a cyst or sac.

Entomostraca. (Gr. ἔντομα, insects; ὄστρακον, a shell.) A division of Crustacea.

Epipodite. (Gr. ἐπί, upon; πούς, foot.) An appendage of the basal joint of the limbs of Crustacea.

Equilateral. With equal sides.

Equivalve. Referring to shells which have two equal valves.

Exopodite. (Gr. ἔξω, outside; πούς, a foot.) The outer of the two secondary joints of the somite of a Crustacean.

Exserted. Protruded—the opposite of inclosed.

Fauna. (Lat. *fauni*, rural gods.) The native animals of a certain locality.

Flagellum. A whip. The appendage of some Protozoa.

Foraminifera. (Lat. *foramen*, a hole; *fero*, I bear.) Rhizopods with perforated shells.

Gallinacei. (Lat. *gallina*, a fowl.) An order of birds.

Ganoid. (Gr. γάνος, splendor.) Applied to certain fish-scales.

Gasteropoda. (Gr. γαστήρ, the belly; πούς, foot.) A class of Mollusca.

Glaucus. Bluish-green or gray.

Globigerina. (Lat. *globus*, a ball; *gero*, I carry.) A group of Foraminifera.

Grallatores. (Lat. *grallæ*, stilts.) Wading-birds.

Gregarinidæ. Lat. *grex*, a flock.) A class of Protozoans.

Halteres. (Gr. ἁλτῆρες, poisers.) The rudimentary hind-wings of Diptera.

Hemiptera. (Gr. ἡμι, half; πτερόν, wing.) An order of insects.

Heterocercal. The tail of fishes when the lobes are unequal, as the sharks.

Heterophagi. Birds whose young are born in a helpless state, as robins, etc.

Heteropoda. An order of Mollusca.

Hexapodus. Six-footed.

Holometabolic. (Gr. ὅλος, whole; μεταβολή, change.) Insects whose metamorphosis is complete.

Homocercal. Referring to fishes the lobes of whose tails are equal, as the perch.

Homology. Applied to parts which are structurally alike.

Hydridæ. An order of Hydrozoa.

Hydrozoa. A class of Cœlenterata.

Hymenoptera. (Gr. ὑμήν, hymen, or membrane; πτερόν, wing.) An order of insects having two pairs of membranous wings.

Hyoid. The bone which supports the tongue; so called from its resembling the letter U in man.

Ichthyosaura. An extinct genus of Reptilia.

Imago. (Lat. an image.) The perfect form of insects.

Inequilateral. Applied to shells having the two ends unequal.

Inequivalve. Having two unequal valves.

Infusoria. (Lat. *in*, on; *fundo*, I pour.) A class of Protozoa.

Isopoda. (Gr. ἴσος, equal; πούς, foot.) An order of Crustacea.

Labium. (Lat. lip.) The lower lip in the Arthropoda.

Labrum. (Lat. lip.) The upper lip in the Arthropoda.

Lamellibranchiata. (Lat. *lamella*, a leaf or sheath; *branchia*, gill.) Mollusks having large, leaf-like gills.

Larva. (Lat. a mark.) The second stage of an insect, as the caterpillar, etc.

Lepidoptera. An order of insects.

Lithocysts. The sense-organs of certain jelly-fish.

Longipennata. (Lat. *longus*, long; *penna*, wing.) A group of birds.

Lucernarida. (Lat. *lucerna*, a lamp.) An order of Hydrozoa.

Lumbar. (Lat. *lumbus*, a loin.) Belonging to the loins.

Macrura. A group of decapod crustaceans.

Madreporic. Containing many pores or cells.

Mandible. (Lat. *mandibulum*, a jaw; fr. *mando*, I chew.) The upper jaw of Insecta; the lower jaw of Vertebrata.

Marsupium. A pouch.

Marsupialia. (Lat. *marsupium*, a pouch.) An order of Mammalia.

Maxillipedes. (Lat. *maxillæ*, jaws; *pes*, foot.) The modified limbs of Crustacea, used as masticatory organs.

Megalops. One of the stages of the young crab.

Merostomata. An order of Crustacea.

Mesenteries. (Gr. μέσος, the middle; ἔντερον, an intestine.) The vertical partitions which divide into chambers the intervening space between the alimentary tube and the body-wall of a sea-anemone.

Mesothorax. The middle segment of the thorax in insects.

Monad. (Gr. μονάς, a unit.) A minute Infusorian.

Moners. A class of Protozoans.

Monodelphia. (Gr. μόνος, single; δελφύς, womb.) The division including all the higher orders of Mammalia.

Monœcious. (Gr. μόνος, single; οἶκος, house.) Applied to animals in whom the two sexes are united in one individual.

Monotremata. (Gr. μόνος, single; τρῆμα, an opening.) An order of Mammalia having the intestine and the ducts of the urinary and genital organs open into a common cloaca.

Myriapoda. (Gr. μυρίος, ten thousand; πούς, a foot.) A class of Arthropoda.

Natatores. (Lat. *nare*, to swim.) An order of birds.

Nectocalyx. (Gr. νήχω, I swim; κάλυξ, a cup.) The swimming-bell of a jelly-fish.

Nematocyst. (Gr. νῆμα, a thread; κύστις, a bladder.) The stinging organs or thread-cells of Cœlenterata.

Neuroptera. (Gr. νεῦρον, a cord; πτερόν, a wing.) An order of insects.

Noctiluca. A giant monad.

Notochord (Gr. νῶτον, back; χορδή, a string), or *chordad orsalis.* A primitive backbone.

Nudibranchiata. An order of Gasteropoda.

Octopoda. (Gr. ὀκτώ, eight; πούς, foot.) A group of Cephalopoda.

Odontophore. (Gr. ὀδούς, a tooth; φέρω, I carry.) The lingual ribbon, or tooth-bearer, of the higher Mollusca.

Œsophagus. (Gr. οἰσός, a reed; φαγεῖν, to eat.) The gullet.

Operculum. (Lat. *operio*, to cover.) The bony covering of the gills of fishes; the horny foot of univalves.

Ophiura. An order of Echinodermata.

Opisthocœlous. (Gr. ὄπισθε, behind; κοίλος, hollow.) Vertebræ with bodies convex in front and hollow behind.

Ornithodelphia. (Gr. ὄρνις, a bird; δελφύς, womb.) Sub-class of mammals and order Monotremata.

Orthoptera. (Gr. ὀρθός, straight; πτερόν, wing.) An order of insects.

Otoliths. (Gr. οὖς, ear; λίθος, stone.) Small calcareous particles found in the auditory sacs of invertebrates.

Oviparous. (Lat. *ovum*, an egg; *pario*, I bring forth.) Applied to animals which produce eggs instead of living young.

Ovipositor. (Lat. *ovum*, an egg; *pono*, I place.) In insects an organ by which eggs are deposited in wood, etc.

Ovisac. The bag-like membrane which contains the eggs.

Ovoviviparous. A term applied to animals which retain the eggs within their bodies until they are hatched.

Pachydermata. An order of Mammalia.

Pallium. (Lat. a cloak.) The "mantle" of mollusks.

Palpi. (Lat. *palpo*, I touch.) Organs of touch connected with the mouth appendages of Arthropoda.

Pedicellariæ. (Lat. *pedicellus*, a louse.) Curious appendages attached to the sea-urchins.

Pelagic. Living on the high-seas in mid-ocean.

Perennibranchiata. (Lat. *perennis*, perennial; *branchia*, gill.) Batrachians retaining their gills during life.

Perissodactyla. (Gr. περισσός, uneven; δακτῦλος, finger.) Uneven-toed ungulates.

Peritonæum. (Gr. περί, around; τείνω, I stretch.)

Phyllopoda. An order of Crustacea.

Pinnigrada. A group of Carnivora.

Plagiostomi. An order of fishes.

Planarida. (Gr. πλάνη, wandering.) A group of Turbellaria.

Plesiosaurus. An extinct order of Reptilia.

Pluteus. The larval form of Echinoidea.

Pneumatocyst. The float of certain Hydrozoa.

Podophthalmia. An order of Crustacea.

Polype. (Gr. πολύς, many; πούς, foot.) Separate coral animals.

Polyzoa. (Gr. πολύς, many; ζῶον, an animal.) A class of worms.

Protoplasm. (Gr. προτος, first; πλάσμα, from πλάσσω, I mold.) The primitive basis of organic tissue.

Protozoa. (Gr. προτος, first; ζῶον, an animal.) The lowest forms of animal life.

Pseudopodia. (Gr. ψεῦδος, false; πούς, foot.) Temporary foot-like processes of Protozoans.

Pteropoda. (Gr. πτερόν, wing; πούς, foot.) A class of pelagic mollusks.

Pupa. The third stage in insects.

Ratitæ. (Lat. *ratio*, a raft.) Birds with unkeeled sterna; ostriches, etc.

Rhizopoda. (Gr. ῥίζα, root; πούς, foot.) Protozoans with root-like processes.

Rodentia. (Lat. *rodo*, I gnaw.) An order of Mammalia.

Rotiferera. (Lat. *rota*, a wheel; *fero*, I bear.) A class of worms.

Ruminantia. The cloven-footed quadrupeds.

Selachia. The family of sharks.

Septa. (Lat. partitions.) Applied to the walls of the chambers of the nautilus, etc.

Setaceous. (Lat. *seta*, a bristle.) Bristle-like.

Sertrilarida. An order of Hydrozoa.

Siphonostomata. A division of Gasteropods.

Sirenia. An order of Mammalia.

Spicula. (Lat. *spiculum*, a point.) Applied to the pointed bodies found in sponges.

Spiracle. (Lat. *spiro*, to breathe.) The lateral breathing pores of insects.

Stigmata. (Gr. *στίγμα*, a mark.) A synonym of spiracle.

Stomapoda. An order of Crustacea.

Tæniadæ. (Lat. *tænia*, a tape.) The tape-worms.

Teleostei. An order of fishes.

Telson. (Gr. *τέλσον*, from *τέλος*, end.) The rudimentary terminal segment of the abdomen of arthropods.

Tergum. (Lat. back.) The dorsal region of crabs and insects.

Tetrabranchiata. (Gr. *τετρᾶς*, four; *βράγχια*, gills.) An order of Cephalopoda.

Test. (Lat. *testa*, a shell.) Applied to the calcareous covering of tunicates.

Thorax. (Gr. *θώραξ*, a breastplate.) The chest of vertebrates, the middle portion of insects, etc.

Thysanura. (Gr. *θυσανοί*, fringes; *οὐρᾶ*, tail.) An order of insects.

Trachea. (Gr. *τραχεῖα*, the rough windpipe.) The tube which connects the lungs with the mouth.

Trematoda. (Gr. *τρῆμα*, a pore or hole.) An order of worms.

Trichina. One of the nematoid worms.

Trichocephalus. One of the nematoid worms.

Trichoptera. An order of insects.

Trilobita. An extinct order of Crustacea.

Truncated. Cut squarely off.

Tuberculose. Covered with tubercles.

Tunicata. (Lat. *tunica*, a cloak.) The primitive vertebrates.

Turbellaria. (Lat. *turbo*, I disturb.) An order of worms.

Umbo. (Lat., the boss of a shield.) The back of a bivalve shell.

Ungulata. (Lat. *ungula*, a hoof.) The hoofed animals.

Univalve. (Lat. *unus*, one; *valvæ*, folding-doors.) A shell composed of a single piece.

Urodela. (Gr. *οὐρᾶ*, tail; *δῆλος*, visible.) An order of Batrachians.

Vacuole. (Lat. *vacuus*, empty.) Cavities in the bodies of Protozoans.

Ventral. (Lat. *venter*, the stomach.) Belonging to the lower surface of the body.

Ventricle. One of the cavities of the heart.

Vertebra. (Lat. *verto*, I turn.) One of the bones of the spinal column.

Vesicle. (Lat. *vesica*, a bladder.) A little sac or bladder.

Viscera. (Lat. *viscus*.) The internal organs of the body.

Viviparous. (Lat. *vivus*, alive; *pario*, I bring forth.) Applied to animals which produce their young alive.

Zoöid. (Gr. *ζῶον*, animal; *εἶδος*, form.) The separate organisms of a compound animal, such as many of the Cœlenterata.

Zoöphyte. (Gr. *ζῶον*, animal; *φυτόν*, plant.) Applied to the animals which resemble plants, such as the sea-anemones, sponges, etc.

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