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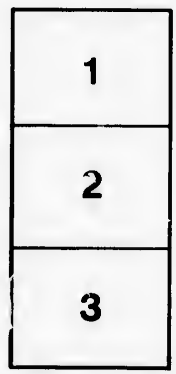

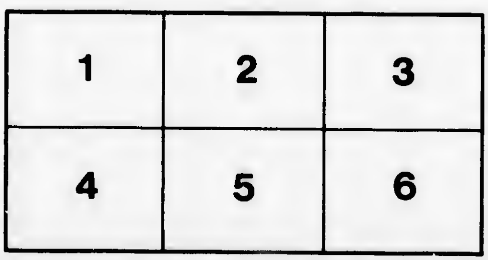

HANDBOOK

OF

ZOOLOGY

WITH EXAMPLES FROM

CANADIAN SPECIES, RECENT AND FOSSIL,

BY

SIR J. WILLIAM DAWSON, LL.D., F.R.S., &c.

THIRD EDITION, REVISED AND ENLARGED.

MONTREAL:
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1886.

PREFACE.

The object of this manual is to furnish to students, collectors, and summer tourists in Canada an outline of the classification of the animal kingdom, with examples taken, as far as possible, from species found in this country. This method has the double advantage of combining a knowledge of local Zoology with general principles, and of enabling the reader to procure and study for himself, either in nature or in public or private collections accessible to him, specimens illustrative of the various groups.

Fossil animals are included, as well as those which are recent, because many types not represented in our existing fauna occur as fossils in our rock formations; and because one important use of the teaching of Zoology is that it may be made subsidiary to geological research.

Directions for collecting and preparing specimens are appended, and references are given to some of the more important special works relating to the several classes of animals.

While it is necessary, in the interest of the systematic student, to state and define technical terms, readers desirous to avoid these can do so, and may nevertheless be able to use the book with advantage as a popular guide to Canadian Zoology, in which they will find many facts derived from original observation and not otherwise accessible.

For several of the illustrations I am indebted to the memoirs of Mr. Billings in the publications of the Geological Survey, and also to the papers of Mr. D'Urban, Mr. Whiteaves and Dr. Packard in the "Canadian Naturalist." Such other illustrations as are not original are credited to their authors.

JULY 1st, 1886.

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ZOOLOGY.

Preliminary Definition.

Zoology is the name under which we arrange our knowledge of animals, considered as objects of natural history study—that is, as objects of observation, comparison, and classification. The elements of the subject may be grouped under the following heads :—

1. *The general nature of the animal—its constituent tissues and its functions.*

2. *The principles of classification as applied to the animal kingdom.*

3. *The detailed description of animals, in connection with their classification, and distribution in geological time.*

The first of these subjects may be named *Physiological Zoology ;* the second, *Zoological Classification ;* and the third, *Descriptive and Palæontological Zoology.*

We shall consider these in their order, devoting, however, only a few pages to the first and second subjects, and entering at greater length into the third, or Descriptive Zoology, which necessarily includes the larger part of Zoology proper. In this we shall employ, as far as possible, Canadian examples, and shall notice fossil as well as recent forms, so as to introduce the reader to Palæontology, or the study of fossil animals. The greater part of our space will thus be occupied with Descriptive Zoology, more especially with that of the lower forms of animal life, the knowledge of which is most important in the Palæontology of Canada, and with reference to the systematic knowledge of the animal kingdom and the thorough understanding of its affinities and place in nature.

CHAPTER I.

PHYSIOLOGICAL ZOOLOGY.

I. General Introduction to the Subject.

The Sciences which relate to living beings are now usually grouped under the name Biology.[1] Under this general designation, that science which relates to the classification and structures of plants is Botany or Phytology[2]; that which relates to animals is Zoology.

Living bodies are distinguished from others by the following properties: (1) Origination by reproduction from other living beings, no method of abiogenesis or spontaneous generation being yet known to science. (2) Composition principally of albuminoid, amylaceous, and oily substances. (3) Organization by cell structures and the possession of special organs for definite functions. (4) Nutrition, or the power of adding to and renewing the matter of the body.

The distinction between animals and plants is easily recognized in their higher forms, though it becomes difficult in the lower types, in consequence of their simplicity and minuteness and of the obscurity of their functions.

The most general and important distinction is, that plants subsist on mineral or inorganic food, which by processes of deoxidation they convert into albuminous

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[1] **βίος—life, λογος—discourse.** [2] **Φυτον—plant,** [3] **ζωον—animal.**

and amylaceous matters, while they emit free oxygen. Animals consume and oxidise amylaceous and albuminous substances, absorbing oxygen and exhaling carbonic acid. This difference implies the possession of certain higher functions by the animal, which it maintains by its consumption and oxidation of organic food. The plant thus accumulates organic food materials, the animal expends these or the energy stored in them. It is possible that in some of the lowest forms of life both vegetable and animal functions may be performed in different parts or at different stages.

The animal in its more complete forms manifests four leading functions or capacities :

1. *Sensation*—carried on by means of a nervous system and special senses.

2. *Voluntary motion*—by means of the muscular and nervous systems.

3. *Nutrition*—by means of a stomach and intestines, with absorptive, circulatory and respiratory apparatus.

4. *Reproduction*—by ova and sperm-cells.

The first and second, with the organs concerned in performing them, may be said to be confined to the animal. The third and fourth it possesses in common with the plant, but they are carried on in a different manner and by organs of somewhat different composition and structure.

In every animal, even the simplest, these functions are in greater or less perfection performed, though sometimes in a very elementary and imperfect manner ; and it is the presence of the aggregate of these functions or the organs proper to them that enables us to call any organism an animal. It is important to carry with us this definition of the animal:—first, as indicating the limits of the creatures which the zoologist has to classify; and, secondly, as pointing out to us the nature of the characters on which we must rely in our classification.

It is further to be observed that the two functions special to the animal, its sensation and voluntary motion, are, in connection with its habits and intelligence, those which fix its purpose or use in nature, and, therefore, those which must be most important in its rational study. It is well also to observe that though there are some creatures of low organisation, respecting which doubts may exist as to their animal or vegetable nature, we shall find that, in the humblest animals of which we have satisfactory knowledge, the powers of feeling and voluntary moving are manifested with sufficient distinctness, and their nutrition and reproduction are also akin to those of higher animals rather than to those of plants.

The animal being thus defined, we may ask, what can be known of it within the department of Zoology, and what portions of this we may most usefully take up in the elementary study of the subject.

The leading divisions of Physiological Zoology in their relations to the other departments of the science, and to allied sciences, may be arranged as follows:

1. Microscopic Structure of Animal Tissues (Histology),[1]

2. Organs built up of the Tissues (Morphology).[2]

3. Functions of Animals (Physiology proper).[3]

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[1] ἱστος—web, tissue. [2] μορφή—form. φυσίς—nature.

Of these subjects it will be necessary to notice the first, as giving us the materials of which animals are built up. The second and third we shall take up very generally in this chapter, and more in detail in the Descriptive Zoology, in which we shall endeavor to illustrate every leading group of the animal kingdom by some characteristic example.

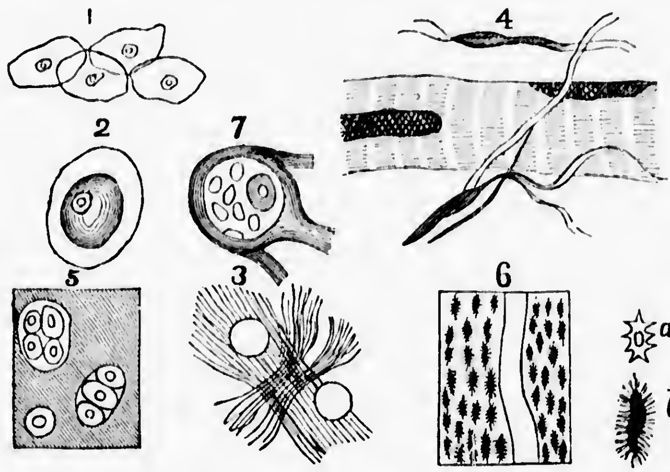
II. Tissues of the Animal.

The animal tissues are known to us principally by means of the microscope; and Animal Histology, or the study of animal tissues, has, in modern times, grown to be an extensive and most important branch of investigation, affording to the microscopist some of the most interesting as well as intricate subjects of observation, and yielding the most important results with reference to the principles of Physiology.[1]

The essential material of the animal tissues is albumen, sometimes called protoplasm, a substance with which we are familiar as white of egg, and which, with slight modifications and addition of mineral matter, is capable of furnishing the material of all the organs of animals. Albumen is a strictly organic substance, occurring only as a component of living beings, and produced in the first instance in the cells of plants. It is a compound of carbon, oxygen, hydrogen, and nitrogen, with a minute proportion of sulphur. In consequence of the prevalence

1 The teacher should, if possible, illustrate the several tissues by specimens seen under the microscope.

of albumen and albuminoid substances in the animal tissues, the animal may be regarded, in a chemical point of view, as consisting principally of protoplasmic matter. This may, however, occur in different states, as pabulum or food matter, as actively living matter, as formed tissue, or as effete or dead matter. Under the present heading we are concerned chiefly with the living and formed tissues.



Figs. 1 to 7 represent Tissues highly magnified.

Fig. 1.—Cellular Tissue—Showing Nuclei and Nucleoli,
Fig. 2.—Young Blood-Cell, (after Beale).
Fig. 3.—Fibrous Tissue and Fat-cells.
Fig 4.—Striated Muscular Fibre with Nerve-Fibres and Nuclear matter—(after Beale).
Fig. 5.—Cartilage, showing groups of cells with Nuclei.
Fig. 6.—Bone, showing cells and Haversian Canal; (*a*) Young Bone-Cell; (*b*) Mature Bone-Cell
Fig. 7.—Nerve-Cell and Nerve-Fibres—(after Beale).

1. Cellular Tissue.—The simplest kind of animal tissue is that to which we give the name cellular. It usually consists of cells or sacs, with albuminous walls, and containing a semi-fluid form of albumen or protoplasm named sarcode, with a central mass, usually granular in aspect, called the nucleus, and which is also albuminous. The nuclear matter would seem to be that which is most active in vital processes. It appears to precede the formation of the complete cell, and is most abundant in young cells. Animal cells tend to increase in dimensions up to a certain point, but they are usually microscopic in size. They also have the power of multiplying rapidly, new cells being produced from those previously existing. Cells may be free, as in the case of those of blood, or they may be aggregated as tissues. Large portions of the bodies of many of the lower animals are composed entirely of simple cellular tissue, and this often very imperfect in its structure from the absence of definite walls. Some animals seem to consist of only a single cell, and all may be said to originate in single embryonic cells. Cellular tissue also exists largely in the higher animals, in the epidermis and other membranes, glands, cartilages, &c. It is very abundantly present in all animals in their earlier embryonic stages. All cells, so far as known, originate in other cells by division of the cell or of its contents. On the other hand cells become, in the processes of growth, changed into, or give origin to, other tissues.—(Figs 1—2.)

2. **Fibrous or Connective Tissue.**—This is composed either of gelatine or of albumen, and presents the aspect of fibres, either parallel or interlaced, and often with intervening mucous or gelatinous substance. The dermis or true skin, and the finer membranes which pack and connect or give form to the different organs of the body, consist of it; and it forms also the tendons or cords

connecting the muscles with the parts which they act upon, and the ligaments which bind together the bones or other hard parts. The gelatinous form of fibrous tissue is white and inelastic, and can be boiled into glue or tanned into leather. The albuminous form is yellow and elastic; it constitutes the elastic ligaments and enters into the coats of the larger arteries. In the lower animals cellular tissue often serves instead of the fibrous, and sometimes intermediate forms occur. (Fig. 3.)

3. **Cartilaginous Tissue** is in a general sense a form of connective or supporting tissue, consisting of cells which develope between them either a dense gristly substance called chondrine (ordinary cartilage) or a mass of fibres (fibro-cartilage). Cartilage serves in animals as a substitute of bone, or as a more elastic supporting substance where bone would be too rigid, and by deposition of grains of calcium phosphate in its structure it passes into bone. (Fig. 5.)

4. **Osseous or Bony Tissue.**—Bone consists of gelatinous animal matter in which are imbedded granules of calcium phosphate. It is not absolutely solid, but filled with microscopic spaces or *lacunæ*, from the sides of which ramify numerous *canaliculi* or minute tubes connecting the lacunæ with each other, and with minute canals traversing the bone (the Haversian canals), which carry the blood-vessels that nourish it. These vessels open upon the surface of the bone, and unite with those of the periosteum, a strong membrane covering its surface. Bone is most frequently developed from cartilage. In

the ossification of the cartilage, the intercellular matter is hardened by deposition of mineral granules, and the cells become the lacunæ of the bone. In some animals the skeleton remains permanently cartilaginous; and in all, the extremities of many bones remain capped with cartilage. The substance of teeth is a modification of bone. In ivory the Haversian canals are absent, and the bone-cells are drawn out into narrow contiguous tubes. Enamel, which is the hardest kind of bony tissue, consists of solid bony prisms placed side by side. In the lower animals, shell, crust, corneous matter, etc., are used as supporting tissues instead of bone, and will be noticed in the descriptive part. (Fig. 6.)

5. **Muscular or Contractile Tissue.**—This, like the last, is fibrous, but it is composed of the animal substance fibrine, a member of the albuminoid series. It is possessed of the power of shortening and thickening its fibres, and again lengthening them, in such a manner as to produce the effects of muscular contraction and relaxation, on which the greater part of animal motions depend. The muscular fibres of the ordinary muscles or flesh of the higher animals are transversely striated or divided into joints, which shorten when the fibre contracts. The ultimate fibrillæ are united into fibres, each enclosed in a delicate structureless membrane. These fibres are again bound up into larger bundles, enclosed in fibrous tissue; and these are collected into muscles of various form and size. Non-striated fibres occur in some of the involuntary muscles of the higher animals, and as voluntary muscles in the lower groups, and may be

regarded as elongated cells possessing contractile power. The cellular tissue and living protoplasm of animals, often possess a property of contraction and extension, which in the lower forms is a substitute for muscular power, though less definite in its action. (Fig. 4.)

6. **Nervous Tissue**.—This is of two kinds—nerve cells and nerve-fibres. The former occur principally in the brain, the spinal cord and the organs of sense, and constitute what is sometimes called grey nerve matter. They are the sources or storehouses of nervous power. They give off tubular prolongations of their walls, which connect the cells with each other, or form the roots of nerve fibres. These last in their more complete forms, consist of a central cord or axis cylinder, surrounded by a clear substance, and this by a more opaque coating enclosed in a structureless membrane, the *Neurilemma*. The animal matter constituting Nerve, consists of albuminous and fatty matter, and contains phosphorus as one of its essential elements, but the relation of its composition and structure with its function is not known. This fnnction is the most remarkable performed by any tissue, namely that of being the material medium of the proper vitality of the animal, as exhibited in sensation and voluntary motion. Without the action of nervous cells and fibres, we can have no perception of impressions from without, or of changes taking place within, the body; and without this action no muscular fibre can contract, and consequently no motion can take place. For this reason, the amount and perfection of the nervous system mark, more than anything else, the rank of the animal in nature,

and the plan of distribution of the nervous system is the surest index of its type of structure. (Figs. 4 & 7.)

The above tissues exist in their full development only in the higher animals; but, under various modifications and simplifications, they may be traced in all except the lowest forms of animal life.

III. FUNCTIONS OF THE ANIMAL.

In order to perform the functions of animal life, the tissues are built up into organs and systems of organs, to each of which certain functions are allotted. These functions may be roughly grouped under two heads. 1st. Those of the animal life proper, which are peculiar to the animal. 2nd. Those of the vegetative life, which are common to plants as well, though performed in these in a different way. The former are Sensation and Voluntary Motion. The latter are Nutrition and Reproduction. Of these functions we can give only a very general summary.*

I. SENSATION.

The organs of sensation are the Nervous System and Special Senses.

The Nervous System.

The nervous system always consists of nervous centres or groups of cells, and nervous fibres or connecting cords.

* These functions should be illustrated to the class, either by actual specimens of the organs referred to, or by models or good figures: e.g. Marshall's; Dep. Sci. & Art. England.

These may be arranged in various ways, and may be of very different degrees of complexity. There are principally five types.

1. *A true Brain and Spinal Cord.*—(**Myelencephalous.**)—This consists of a proper brain, placed over the gullet, with a dorsal spinal cord, from which all the nerves of the extremities branch off. The brain includes several

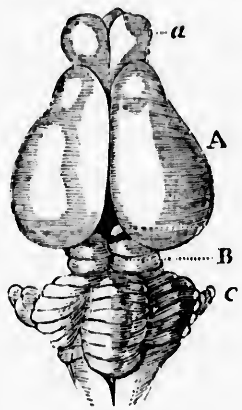


Fig. 8.

Brain of Opossum (after Owen), (*a*) Olfactory Lobes; (A) Cerebral Hemipheres; (B) Optic Lobes; (C) Cerebellum and origin of Spinal Cord.

pairs of lobes; viz: the olfactory, presiding over the sense of smell, the optic, relating to the sense of sight, the cerebral hemispheres, relating to the general sensation and intelligence, and a single posterior lobe, the cerebellum, presiding over voluntary motion. The parts of the brain are connected below with the spinal cord by a mass of fibres and cells called the medulla oblongata. The spinal cord is divisible into four columns, two posterior, and two antero-lateral, the former devoted to sensation, and the latter to voluntary motion, and the nerve fibres take their origin in part from each. The mammals, birds, reptiles and fishes have their nervous system constructed on this type (Figs. 8 & 9.)

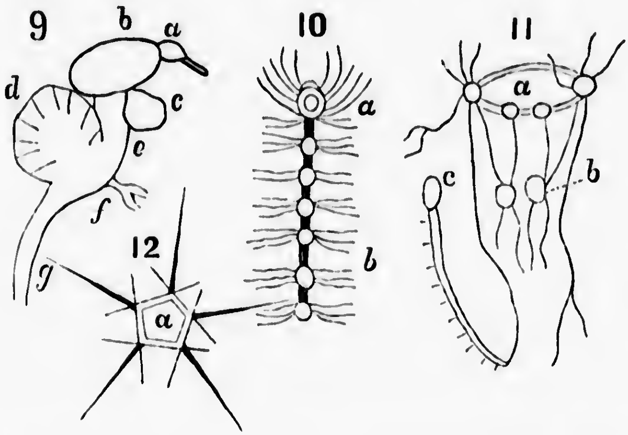


Fig. 9.—Diagram of Brain of Bird, (Myelencephalous.)—(*a*) Olfactory Lobes; (*b*) Cerebral Hemispheres; (*c*) Optic Lobes; (*d*) Cerebellum; (*e*) Medulla Oblongata; (*f*) Auditory nerves; (*g*) Spinal Cord.

Fig. 10.—Diagram of nervous system of a worm (Homogangliate); (*a*) Œsophageal ring; (*b*) Double abdominal cord with ganglia.

Fig. 11.—Diagram of nervous system of a Mollusk (Heterogangliate) (*a*) Œsophageal ring and ganglia; (*b*) Pedal ganglia; (*c*) Visceral ganglion.

Fig. 12.—Diagram of nerve system of a Star-fish; (*a*) Œsophageal ring.

2. *A nerve-ring around the gullet and abdominal nerve cord with ganglia.*—(**Homogangliate**.) In this type the principal nerve-centre consists of a ring surrounding the gullet or œsophagus, with a mass above (præ-œsophageal mass) giving off nerves of sensation, and a mass below (post-œsophageal mass) giving off a double abdominal cord, having ganglia or subordinate masses of nerve-matter at intervals. This is the nervous system of spiders, insects, crustacea and worms.—(Fig. 10.)

3. *Wide œsophageal ring with ganglia and irregular nerves.* (**Heterogangliate.**)—In this type the principal nervous masses are placed around a large œsophageal ring, and in the course of nerve-cords more or less bilaterally distributed to the different organs. The principal additional ganglia are the Pedal and Visceral. This is the nervous system of cuttle-fishes, land and water-snails, bivalve shell-fishes and their allies. (Fig. 11.)

4. *Nerve-ring with radiating nerves.* (**Nematoneurous or Radiated.**)—In this the centre of the nerve system consists of a simple ring, giving off radiating branches to the extremities of the body, and without distinct ganglia. This is the nervous system of star-fishes and their allies. (Fig. 12.)

5. In addition to these, there are in the lower forms of animal life detached nerve-cells and groups of such cells, with fibres variously disposed, which scarcely admit of arrangement under any of the above plans ; and in some of the simplest animals no distinct nervous system has been detected.

The nervous fibres subserve the two-fold function of carrying to the muscles the impulse by which they are excited to action, and of conveying to the brain sensational impressions from the extremities. Different fibres are supposed to be devoted to these separate uses. The function relating to muscular movement is known as the efferent or out-going function ; that relating to sensation as the afferent or in-coming influence. It is the latter that concerns us under the present heading, and in performing it the nervous system is connected with organs of sense, the general nature of which can alone be referred to here.

The External Senses.

The sense of **Touch** is distributed generally over the outer surface of the body, though with different degrees of intensity in different parts. In the higher animals this sense informs of resistance, character of surface and temperature, being acted on not only by objects in contact with the skin, but by radiant heat from bodies at a distance. In some of the lower animals with transparent bodies, it is probably acted on by light as well, being in all animals the most truly general sense. The structures connected with the sense of touch are the extremities of minute nerve-fibres, or loops of such fibres, disposed on the inner surface of a membrane. and thus protected from direct contact with external bodies. This sense is possessed by all animals. Sometimes the tactile organs are extended outwards as papillae, tentacles, antennae, tactile bristles, &c.

The sense of **Taste** resembles that of touch in the apparatus provided for its exercise; but the nerves appropriated to this sense are distributed to the papillae or prominences on the surface of the tongue, palate or other oral organs. These nerves, in addition to tactile properties and temperature, take cognizance of the sapid properties of bodies, and, in conjunction with the sense of smell, of flavours also. All animals appear to possess this sense, though in very different degrees, and with remarkable modifications as to the effects of different kinds of food. In the higher animals there are special nerves of taste, the glosso-pharyngeal.

The sense of **Smell** resides in the nerves distributed over a delicate moist membrane in the nostrils. In animals breathing air this membrane is affected by odorous particles diffusible in that medium. In animals living in water, by particles in suspension or solution in the water, or in the free oxygen contained in it. There is reason to believe that this sense is possessed in some degree by all animals, but the character of the impressions which it conveys must be very different in different creatures, and in many animals it is not connected with the organs of respiration. The sense of smell has in most animals a very direct relation to the choice of food. The olfactory lobes and nerves are provided for this sense.

The sense of **Hearing** relates to the vibrations of sonorous bodies; and in the higher animals the ear is a very complex apparatus, giving very distinct impressions of different qualities of sound. In animals of lower grade it is often simplified to a sac filled with fluid, and containing minute ramifications of the auditory nerve ending in rods or hairs, and often in connnection with small solid granules or concretions (otoliths), which concentrate the vibrations of the water or air.

The sense of **Sight**, the highest and most important of all, requires very complicated arrangements. In addition to the optic lobes and nerves, the retina of the eye,where the minute ramifications of the latter terminate, is the screen of a camera, provided with a highly perfect optical arrangement for throwing on it a minute picture of external objects. The varied colours and lights of this picture, acting on the cells of the retina and the optic nerve, give the power of vision. In the higher animals the optical apparatus consists of a doubly convex or globular lens imbedded in humours of different refractive owers. In insects and some other creatures, there are great numbers of minute tubular eyes centering in a common point (facetted or compound eyes). In animals of still lower grade, the eyes consist merely of a globular transparent sac filled with a clear refractive fluid, and having at the back a retina or optic nerve, and a coat of pigment cells for absorbing the light after it has acted on the nerve. These simple and often microscopic eyes are known as eye-specks.

2. Voluntary Motion and Support.

The motions of animals are effected by muscular contraction, except in the case of some minute aquatic animals, in which movable threads or ribbons named *Cilia*, serve as organs of locomotion, or in which spontaneous protoplasmic movements take the place of ordinary contractility. and act through sarcodic or protoplasmic extensions, named Pseudopodia (See Figs. 25, 26.)

Muscular tissue may be so arranged as to act without any hard parts, as in the swimming-bells of Medusae or Jelly-fishes, and the so called foot of Mollusks; but for their most effective actions they are attached to levers of bone or other hard material, constituting a skeleton which serves for support and protection as well as locomotion, and in its relation to protection is connected with the requirements of the plan of nervous system carried out in the animal. The skeleton may be either internal, relatively to the muscles that act upon it, or external, and connected with the cuticle or integument. Some animals are provided with both these kinds of skeleton, an endo-skeleton or internal skeleton for support and locomotion, and an exo-skeleton for defence; but usually only either one or the other is present.

1. The most perfect kind of internal skeleton is that known as the **Vertebrate**, in which the body of the animal is supported by a series of bones (vertebræ), articulated together, and having the principal nerve cord above their centres or surfaces of attachment, and the viscera below. The limbs do not exceed four. The whole skeleton is internal, relatively to the muscles that act upon it.

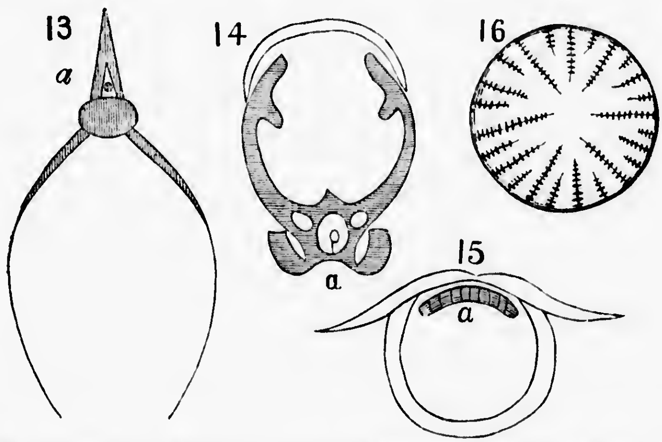


Fig. 13.—Section of Skeleton of a Fish (Vertebrate); (*a*) Spinal cord.
Fig. 14.—Section of Skeleton of a Crustacean (Annulose); (*a*) Abdominal nervous cord.
Fig. 15.—Section of mantle of a Cuttle-fish (Saccate or Molluscous); (*a*) Internal shell.
Fig. 16.—Section of Skeleton of a Coral (Radiate).

The mammals, birds, reptiles and fishes have a skeleton of this kind, which in its relation to protection and defence, is adapted to the requirements of the myelencephalus nerve system, and to the highest kinds of muscular action.

A less complex kind of internal skeleton, often composed of very numerous pieces, is found in some of the invertebrate animals, as in Cuttle-fishes and Star-fishes, but it has no close relation in point of plan with that of the vertebrates, (Fig. 15.)

2. The most perfect kind of external skeleton is that known as the **Articulate or Annulose**. In this, support and locomotion are provided for by a series of external rings, enclosing the body and limbs, and acted on by muscles placed within. This group coincides with animals having a homogangliate nervous system, and distinctly segmented bodies, and includes the spiders, insects, crustaceans and worms. (Fig. 14.)

3. The shells of certain mollusks may be regarded as a species of external skeleton, but it differs in plan from that of the Annulates. Some of the higher mollusks have also internal hard parts, cartilaginous or shelly. Even the hard parts of certain corals and the spicules of sponges constitute a kind of skeleton, either external or internal. (Figs. 15 and 16.)

4. A large number of animals, especially those of the lower aquatic types, are destitute of hard parts, or have shells and tests which are of less importance as not being connected so closely with the nervous and locomotive systems, and as being absent or present in animals closely

related to each other. In the greater part of the important group of mollusks or ordinary shell-fishes, the hard parts or shells, though largely developed and important for protection, are not directly connected with the locomotive system; and in other groups of invertebrates, the soft parts are supported by spicules, fibres, plates, tubes, cells, and other mechanical contrivances for supporting and protecting the soft parts, which must be described separately in the case of each group.

3. Nutrition.

The processes connected with this function may be comprehended under the headings of Digestion, Circulation, Respiration, Nutrition Proper, and Excretion.

Digestion.

In the higher animals the process of digestion requires: (1.) Organs of prehension and mastication, which are often of the highest importance as means of zoological distinction. In connection with these the salivary secretion affords the means of preparing the food for the processes to which it is subsequently subjected. (2.) Digestion proper, carried on in the stomach by the aid of the gastric juice, aided by the muscular motions of the stomach, dissolving the food and converting it into a grey semi-fluid mass known as chyme. The process is completed in the small intestines by the action of the bile and pancreatic juice, which causes the separation of a milky liquid (chyle) containing all the nutritive material of the food. (3.) Absorption by the villi or processes of the intestine, by which the fluid nutritive matters, the results of digestion, are removed from the intestinal canal and conveyed to the circulatory system by means of the lacteal vessels, being at the same time supplied with living protoplasmic matter, secreted by the mesenteric and other glands. (4.) Rejection of the matters not available for nutrition.

In animals lower in the scale these arrangements are variously simplified, until the whole of the apparatus and secreted fluids are concentrated in a simple sac; and in the simplest animals digestive cavities appear to be temporarily excavated in the soft substance of the body.

Circulation.

The process of circulation, whereby the blood, or corresponding fluid containing the products of digestion, is circulated throughout the body, is performed in the highest animals by a muscular heart of four cavities, with arteries for the outflowing, and veins for the inflowing, blood. In animals lower in rank the same purpose is served by a heart of three or two cavities, or even of one; and finally the blood is circulated without the action of a heart, by a network of vessels similar in function to those called capillaries in the higher animals.

Respiration.

In all animals the vital fluid requires aeration, or exposure to the action of oxygen. This may take place directly in the air by means of lungs or similar contrivances, or indirectly in water containing free oxygen in solution, by means of gills. In either case the essential condition is that the blood shall be carried by minute vessels along a moist membrane, separating it from the oxygen-bearing medium. In the higher animals there is a special circulation to the lungs or gills. In lower animals the respiration is often a mere incident in the general circulation, and in some of the lower forms of life, the general surface of the exterior or interior of the body is used as a means of respiration.

Nutrition proper and Excretion.

Nutrition proper is performed by the absorption of the materials required to form or repair the various tissues, from the blood or nutritive fluid; and in all animals these tissues, chemically changed by use in the production of animal force, are removed from the body by excretory processes, to which, in the higher animals, complicated organs, as the kidneys and perspiratory glands of the skin, are devoted.

4. Reproduction.

In all animals new individuals arise from the formation of ovarian or embryo cells, the fertilization of these by the introduction of the matter of another kind of cell, the sperm cell, and the subsequent development within the ovum, and from its substance, of a cellular embryo capable of advancing to the mature condition of its species. In some of the lower animals, however, in addition to this process of true sexual reproduction, we observe: (1.) Reproduction by spontaneous fission, or separation of the body of the animal into two distinct parts, each of which may become a complete animal. (2.) Reproduction by gemmation or budding, in which a process developed from the body of the parent becomes a separate individual. These modes, however, are usually characteristic of the immature or embryonic stages of animals, but they include many of the most interesting and complicated phenomena in the reproductive and embryonic history of some of the more simple creatures. The various phenomena of reproduction will be noticed in connection with the different groups of animals in the Descriptive Zoology.

CHAPTER II.

ZOOLOGICAL CLASSIFICATION.

1. General Principles.

No subject is at present more perplexing to the practical zoologist or geologist, and to the educator, than that of zoological classification. The subject in itself is very intricate, in consequence of the vast number of species to be arranged ; and the views given as to certain groups by the most eminent naturalists are so conflicting that the student is tempted to abandon it in despair, as incapable of being satisfactorily comprehended.

These difficulties arise largely from the desire of specialists to claim pre-eminence for the particular objects of their study, and from the tendency to seize upon some one part, structure or function, as the basis of a system, instead of giving proportionate value to the whole. In recent times a new element of confusion has been introduced by the determination of evolutionists to make classification subordinate to their views of the derivation of animals, and, as these views are often discordant and changeable, classifications based on them are very fluctuating. In these circumstances it will be best to retain as far as possible the older divisions based on plan of structure, but to notice such of the more modern arrangements as appear to be natural.

It may be premised here that any rational classification of the Animal Kingdom must be based principally on plan of structure, or type as it has been called. Such resemblance of plan is called *Homology*, and implies the persistence of the same principles of construction, even though the end to be served is different. Thus the arm of a man, the fore limb of a quadruped, the wing of a bat or of a bird, the paddle of a whale, though diverse in use, are constructed on the same general plan, and are said to be homologous. Animals thus resembling each other in plan of structure are said to be homologous or to have affinity with each other, whereas those resembling each other merely in function and not in plan are said to be analogous. Thus, though birds and insects have wings and are adapted for flight they are not homologous. In forming subordinate groups, however, we consider gradation of rank or of complexity; and similarity of embryonic development is justly regarded as a useful guide to the true affinities of animals.

It is evident that homology or affinity, if we can really detect it in nature, should be a primary ground in our arrangement; because, if we regard nature as an orderly system, and still more if we regard it as the expression of an intelligent mind, this must be the aspect in which we can best comprehend its scheme or plan of construction. Experience has shown that those naturalists who discard the idea of intelligent plan as embodied in nature, and who regard it as a mere chance product of conflicting forces and tendencies, necessarily arrive at irrational modes of classification.

In producing a classification it would be well to begin with individual animals and proceed from these to higher groups; but in stating the conclusions arrived at, the reverse order is most convenient.

2. Leading Divisions of Animals.

A primary and very important division of the Animal Kingdom and one still often used or referred to, is that of Lamarck into (1.) *Vertebrates*, or those having a skull and backbone, (2.) *Invertebrates*, those destitute of these structures. It is to be observed that the vertebrate skeleton not only defines and specialises the locomotive apparatus, but provides a separate lodgement in the skull and spinal column for the principal parts of the Nervous System, which in these animals is more highly developed than in the invertebrates.

The great range of structure observed in the second of these groups led to the fourfold division proposed by Cuvier into *Vertebrates*, *Articulates*, *Mollusks* and *Radiates*, which may still be regarded as of scientific value, though it has been variously modified in details. More especially it has been found useful to divide the Articulata of Cuvier into two groups and the Radiata into three or more.

In this way, for practical purposes, and as at least a useful provisional arrangement, we arrive at the groups represented in the following table :—

THE ANIMAL KINGDOM.

Cuvier's Provinces.	*Modern Provinces.*	*Examples.*
I. VERTEBRATA	1. VERTEBRATA	—Mammals, Birds, Reptiles, Fishes.
II. ARTICULATA	2. ARTHROPODA	—Spiders, Insects, Crustaceans.
	3. ANNULATA	—Worms and Worm-like Animals.
III. MOLLUSCA	4. MOLLUSCA	—Cuttle-fishes, Snails, Bivalves, &c.
IV. RADIATA	5. ECHINODERMATA	—Sea-urchins and Star-fishes.
	6. CŒLENTERATA	—Corals, Sea Jellies, &c.
	7. PROTOZOA	—Sponges, Animalcules, &c.

To these provinces nearly all animals can readily be referred. Those whose position is doubtful we shall have to notice as we proceed.

The seven primary groups above mentioned may be defined as follows :—

1. VERTEBRATA.

including Mammals, Birds, Reptiles, Amphibians and Fishes. All these animals are bilateral and symmetrical, have an internal vertebrate skeleton, a brain and a dorsal nerve-cord lodged in a special cavity of the skeleton. With reference to their general form, they may be termed doubly symmetrical animals ; with reference to their nervous system, Myelencephalous. (Fig. 17.)

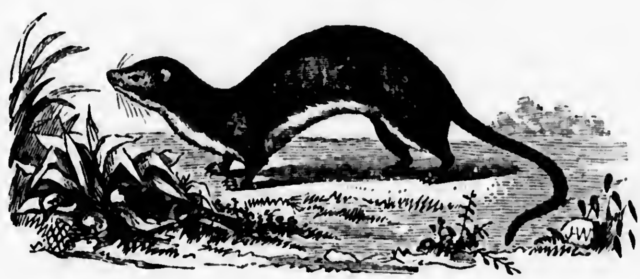


Fig. 17.—PUTORIUS.

2. ARTHROPODA.

including Insects, Myriapods, Arachnida, or spiders and scorpions, and Crustaceans. These animals are bilateral and symmetrical, with the body divided into unequal segments, and provided with jointed limbs. They have an external annulose skeleton, and a nervous system consisting of a ring and ganglia around the gullet, connected with a double abdominal nerve-cord. (Figs. 18–19.) (√ Homogangliate)

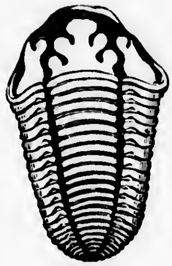


Fig. 18.—CALYMENE.

Fig. 19.—CALOSOMA.

3. ANNULATA.

including Worms, Entozoa and Rotifers. They have the body equally segmented or unsegmented, often supported by an annulate skeleton, but without jointed limbs. The nerve system in the more typical forms is homogangliate, with an œsophageal nervous ring and a double abdominal cord, and with ganglia corresponding to each segment. (Fig. 20.)

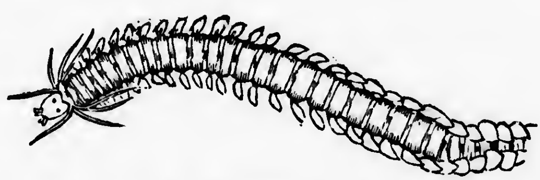


Fig. 20.—PHYLLODOCE.

4. MOLLUSCA.

including Cuttle-fish and their allies; Gastropods or univalve shell-fishes and their allies ; Lamellibranchiate or bivalve shell-fishes, &c. ; Brachiopods and their allies. They are bilateral but not always symmetrical, have no skeleton, and an œsophageal nervous ring, with nerve-fibres and ganglia not symmetrically disposed. They are otherwise named *Saccata*, or animals enclosed in mantles. (Fig. 21.)

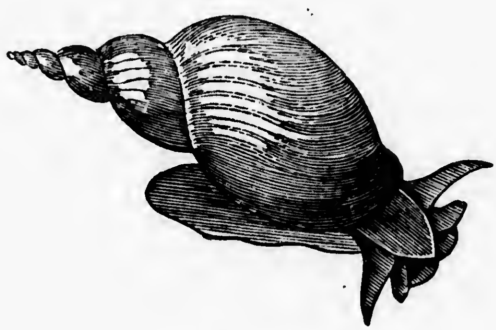


Fig. 21.—LYMNEA.

The Brachiopods, Tunicates and Bryozoa may be regarded as Mollusks of low grade, and are usually placed in a subdivision of Molluscoidea.

5. ECHINODERMATA.

including Sea-urchins, Star-fishes, Sea-cucumbers, &c. They have the parts usually arranged radially, and in fives or multiples of five. The skin is hardened by calcareous deposits, and often bears spines. They have a distinct digestive canal and vascular and water vascular apparatus. Their nervous system is nematoneurous. (Fig. 22.)

Fig. 22.—PALÆASTER.

6. CŒLENTERATA.

including Coral-animals, Sea-mosses, Sea-jellies, &c. They have usually a radially symmetrical body composed of cells. They have a body cavity, which serves both for circulation and digestion, and tentacles furnished with urticating organs. The nerve system is nematoneurous or indiscernible. (Figs. 23, 24)

Fig. 23.—HELIOPHYLLUM.

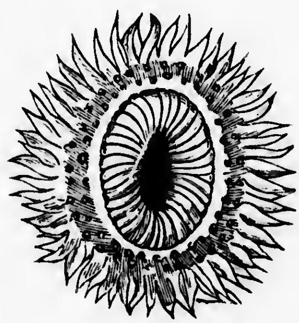


Fig. 24.—ACTINIA.

7. PROTOZOA.

including Sponges, Infusoria, Rhizopods, &c. Body sarcodous or imperfectly cellular, radiate or spiral, or amorphous. Motions by cilia or pseudopodia. No distinct internal digestive cavity, no discernible nerve system or external senses. (Figs. 25, 26)

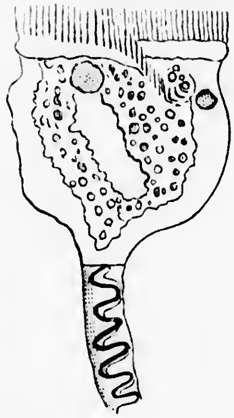


Fig. 25.—VORTICELLA.

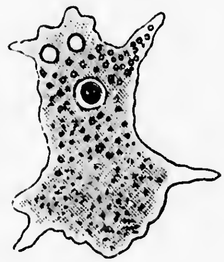


Fig. 26.—AMOEBA.

NOTE.—The Sponges are by many Zoologists placed in the previous group of Cœlenterata, but the balance of their affinities seems to incline to Protozoa.

3. DIVISION OF PROVINCES INTO CLASSES, &C.

These divisions are used analytically in distinguishing species, which we refer first to their provinces, then to their classes, &c. But in framing the classification we begin with individual specimens, group these in species, then in genera, and so on in a synthetical manner. They are the following :—

B

1. Class.

In each province we may find certain subdivisions characterized by subordinate differences in plan of structure and of adaptation to external nature. These we call Classes. The familiar division of the Vertebrata into Mammals, Birds, Reptiles and Fishes is an example of the formation of classes.

2. Order.

In the animals of any class we may recognize gradations of rank or of complexity connected with subordinate diversities of structure and adaptations to modes of life. These we call orders. In the birds, for example, the division into Birds of Prey, Perching Birds, Wading Birds and Swimming Birds is an example of ordinal division.

4. Family.

In certain orders we may recognize a further subdivision into groups characterized by a general resemblance of form and habit; as in the Birds of Prey we have the Families of the Hawks, the Owls and the Vultures.

5. Genus.

Genera are subdivisions of orders or families based on close relationship in plan of structure, as for instance among the Hawks we may separate the Eagles, the Falcons and the Buzzards as distinct genera.*

*In recent times there has been a tendency to subdivide genera very much, or to establish sub-genera; and large orders and families are often divided into sub-orders and sub-families.

6. Species.

Species is the smallest group furnished to us by nature; every distinct kind of animal reproducing itself continuously, and consisting of individuals identical in all their essential characters, being a species. Thus among the Eagles, the Golden Eagle and the White-headed Eagle are distinct species,* not intermixing or passing into each other, though within each species there may be minor differences depending on age, sex, condition, or accident.

There may always be more or less permanent *Races* or *Varieties*, though these usually occur in domestication or other abnormal conditions, and tend when external pressure is removed, to return to the normal form, which in the species represents the state of stable equilibrium of all the organs and functions.

In studying animals we study species, of which individuals are the embodiments in time. Individual specimens or such number of specimens as may serve to exhibit the peculiarities of age, sex and varietal forms, constitute for scientific purposes adequate representatives of the species.

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*The Eagles now constitute a sub-family, and the species above named are usually placed in distinct genera.

CHRONOLOGY OF THE ANIMAL KINGDOM.

As reference will be made in the following pages to the history of animal life in Geological time, the following table is given for reference :—

Geological periods and systems of formations, with their characteristic animals, in ascending order, or beginning with the oldest.

PERIODS.	SYSTEMS OF FORMATIONS.	CHARACTERISTIC ANIMALS.
EOZOIC	Laurentian. Huronian.	Age of Protozoa.
PALÆOZOIC	Cambrian. Siluro-Cambrian. Silurian.	Age of Invertebrates.
	Erian or Devonian. Carboniferous. Permian.	Age of Fishes and Batrachians.
MESOZOIC	Triassic. Jurassic. Cretaceous.	Age of Reptiles.
KAINOZOIC	Eocene. Miocene. Pliocene. Pleistocene. Modern.	Age of Mammals and of Man.

Details as to the above systems of formations, their local distribution and the fossil animals occurring in each, may be found in "Dana's Manual of Geology," The "Reports of the Geological Survey of Canada," and the Author's "Acadian Geology" and "Chain of Life."

CHAPTER III.

DESCRIPTIVE ZOOLOGY.

PROVINCE I.—PROTOZOA.

The Protozoa are the simplest in structure of all animals. Their bodies are composed of a thin apparently structureless protoplasm, often of a granular character, which has been named "Sarcode," and the only proper tissues associated with this are of a cellular nature. They possess a reproductive organ of the nature of an embryo cell, and called the *Nucleus*, and a circulating or excretory organ, styled the *Pulsating Vesicle*. Digestion takes place in *Vacuoles* or extemporised stomachs in the sarcode mass. The locomotive and prehensile apparatus in some consists of extensions of the sarcode substance known as *Pseudopodia*. In others locomotion is performed, or currents of water produced by microscopic vibratile threads, *Cilia*. These organs are seen in Figs. 25 and 26. Most of the Protozoa are of minute size, though some grow to large dimensions by indefinite multiplication of similar parts. Their reproduction takes place when immature by fission and gemmation, when mature in so far as known by germ-cells or granules, developed from the nucleus. Simple though the Protozoa are, they admit of subdivision into classes, differing materially in structure, function and grade of complexity.

The classes of the Protozoa are the following :—

1. *Rhizopoda*—Jelly animalcules, Foraminifera and their allies.
2. *Infusoria*— Infusorial Animalcules and their allies.
3. *Porifera*— Sponges and their allies.

(The *Gregarinida*—Microscopic insect parasites, are also usually included with the Protozoa.)

CLASS I.—RHIZOPODA.

Sarcodic or protoplasmic animals, destitute of a mouth, moving and feeding by means of extensions of the sarcode of the body in lobes or threads known as pseudopodia. Some are naked ; others are provided with calcareous or silicious or arenaceous tests of one or several chambers.

ORDER 1. AMOEBINA OR LOBOSA.

We may take as a type of this group the *Amoeba*, a microscopic creature frequently found in ponds containing vegetable matter. It occurs in Canada, and may readily be procured by the microscopist, by searching among the decaying vegetable matter or living water-weeds of stagnant waters. Different species have been described, but they are very similar to each other. When placed under a microscope, a living specimen appears as a flattened mass of transparent jelly ; the front part moving forward with a sort of flowing motion, and jutting forth into lobe-shaped or finger-like pseudopodial prolongations ; the hinder part appearing to be drawn after it, and presenting fewer irregularities. In its interior are seen a nucleus, minute granules which flow freely within its substance, and one or more vesicles which alternately expand and become filled with a clear fluid, and contract and disappear. Often also there are certain spaces or vacuoles, in which may be seen minute one-celled plants or other particles of food which the creature has devoured, and which are in process of digestion. The outer portion of the substance of the Amoeba (the Ectosarc) appears to be more transparent and dense than the central portion (Endosarc) which is granular. So soft is the tissue that the creature seems to flow forward like a drop of some semi-fluid substance moving down an inclined surface; but as the Amoeba can move forward on a horizontal plane or up an incline, it is obvious that its movement proceeds from a force acting from within, and probably of the nature of contraction and relaxation of the protoplasmic substance. Nor are there wanting indications that these motions are voluntary and prompted by the appetites and sensations of the animal (Fig. 27). Nourishment is taken by means

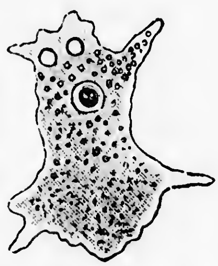


Fig. 27.—AMOEBA PROTEUS, Magnified.

The outer clear portion is the Ectosarc, which sends out processes or pseudopods, the inner granular portion the Endosarc. In the latter are seen the nucleus and two pulsating vesicles.

of the pseudopodia which surround or press into the interior of the body minute one-celled plants, and other substances suitable for food. These are usually taken in at the anterior extremity of the body, and the undigested remains ejected posteriorly, but there is no alimentary canal, digestion taking place in temporary vacuoles. The adult *Amoeba* becomes encysted by the formation around it of a membranous sac, and within this the nucleus subdivides, and the whole mass of the parent animal seems to be reduced into germs. Amoeba is the type of the order *Amoebina*, in which, however, some of the genera have membranous or sandy cells for protection. (*Arcella, Difflugia &c.*)

Descriptions and figures of many species of American fresh-water Rhizopods will be found in Leidy's Report on Fresh-water Rhizopoda, published by the United States Geological Survey of the Territories. In collecting these animals the fine flocculent surface matter of the bottom of ponds may be taken up with a dipper attached to a stick, or water-weeds and Sphagnum may be squeezed and the water flowing from them gathered in a watch-glass and examined.

ORDER 2. HELIOZOA.

In the same places with Amoeba may be found specimens of the genus *Actinophrys*, in which the outer coat of the body often has a vacuolated or frothy structure, and the form is globular with radiating slender pseudopods. There is a pulsating vesicle and nucleus.

It is the type of the second order, *Heliozoa*. (Fig. 28.)

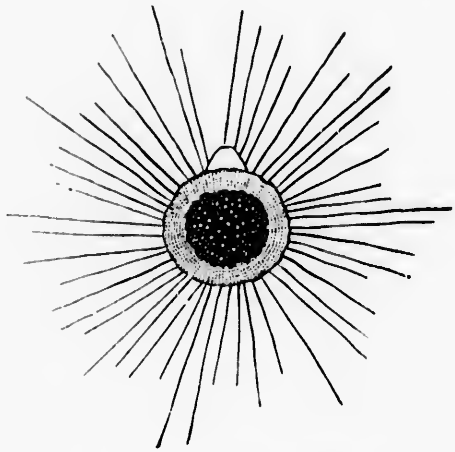


Fig. 28.—ACTINOPHRYS SOL, Magnified.

The Ectosarc is thick and with minute cavities. The pulsating vesicle is external. The pseudopods are slender and thread-like.

ORDER 3. FORAMINIFERA.

In the ocean we find other Rhizopods, distinguished by having pseudopodia thread-like and often reticulating with one another, and by the formation of calcareous or sandy tests, having one opening for the emission of pseudopods (*Imperforata*) or perforated with numerous minute pores (*Perforata*). Sometimes these shells are of one chamber only, but more frequently of several chambers arranged in a regularly spiral or alternate manner, so as to form beautiful chambered shells (Fig. 29). These

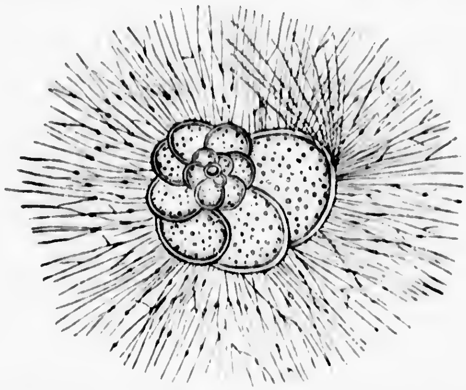


Fig. 29.—NONIONINA, a modern Foraminifer, showing its chambered and punctated test and nettled pseudopodia.—After Carpenter.

constitute the order *Foraminifera*, the specie of which occur in immense abundance in the waters o ocean, and in its deeper parts their calcareous shells accumulate in extensive beds. According to Messrs. Parker and Jones, from 80 to 90 per cent. of the matter taken up by the sounding lead in deeper parts of the Atlantic, is composed of their remains, and the dredgings of the Challenger expedition have shown that the bottom of the deeper parts of the ocean is largely composed of this "Globigerina ooze," as it has been called from the name of one of the more common forms found in it. In like manner, in the sea bottoms of former geological periods, were accumulated, by the growth and death of Foraminifera, the great beds of chalk and of Nummulitic and Miliolite limestone. In the older formations also, these creatures are found to have attained to gigantic size as compared with living species. A foraminiferal organism of dimensions unequalled in the modern seas (Eozoon Canadense, Figs. 40, 41) occurs in the Lower Laurentian, and is the oldest form of animal life known to us. The forms figured (Figs. 30 to 39), are some of the most numerous in the Gulf of St. Lawrence, and in the Pleistocene clays of the St. Lawrence Valley. They are all highly magnified.

The Foraminifera are usually divided into two orders, in accordance with the character of their tests. These are *Imperforata* (Fig. 30); *Perforata* (Figs. 31 to 39).

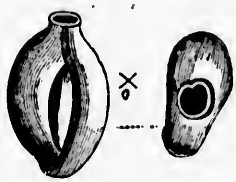


Fig. 30.—Quinqueloculina seminulum (Gulf St. Lawrence).

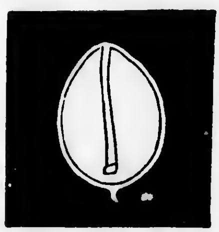


Fig. 31.—Entosolenia globosa Section (Gulf St. Lawrence)

Fig. 32.—Entosolenia costata (Gulf St. Lawrence).

The species represented in Figures 30 to 39 inclusive are found fossil in the Pleistocene clays of Canada, as

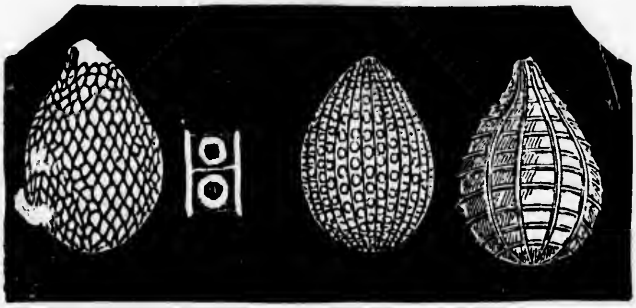


Fig. 33.—Entosolenia squamosa, three varieties (Gulf St. Lawrence), and Sculpture of one variety.

Fig. 34.—Polymorphina lactea (Gulf St. Lawrence).

well as living in the Gulf of St. Lawrence.

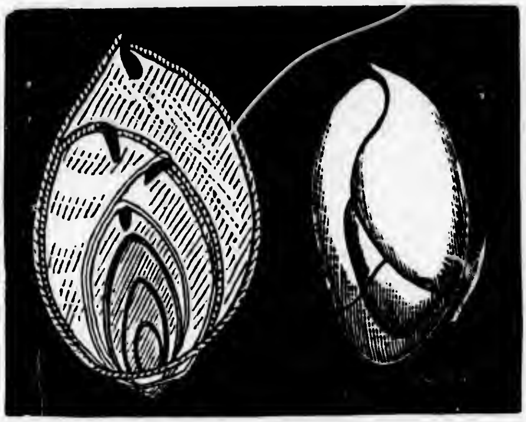


Fig. 35.—Bulimina presli, Section and Exterior (Gulf St. Lawrence).

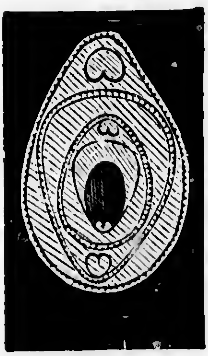


Fig. 36.—Biloculina ringens Section (Gulf St. Lawrence).

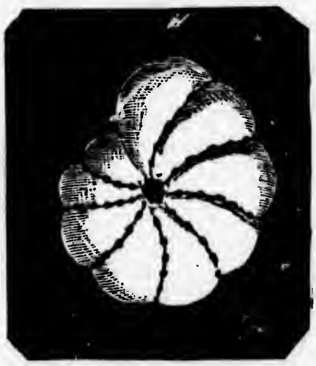


Fig. 37.—Polystomella crispa (Gulf St. Lawrence).

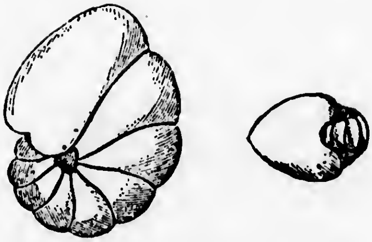


Fig. 38.—NONIONINA SCAPHA—VAR LABRADORICA (Gulf St. Lawrence).

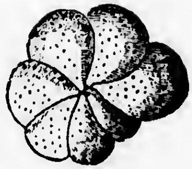


Fig. 39.—TRUNCATULINA LOBULATA (Gulf St. Lawrence). A Sessile Species.

The singular Laurentian form known as *Eozoon Canadense* presents in its succession of calcareous walls perforated with ramifying canals, (Figs. 40, 41) a close resemblance to the structure of modern Foraminifera, and especially to such sessile forms as the Polytrema, which occurs in patches on dead coral; though in details it shows many peculiarities, allying it with several modern groups. The *Stromatoporæ* or layer-corals, or at least some of their forms, resemble large Foraminifera, and there are minute species found fossil from the Silurian upwards.

Fig. 40.—EOZOON CANADENSE—Dawson. Laurentian System, Canada. Section of a small specimen natural size.

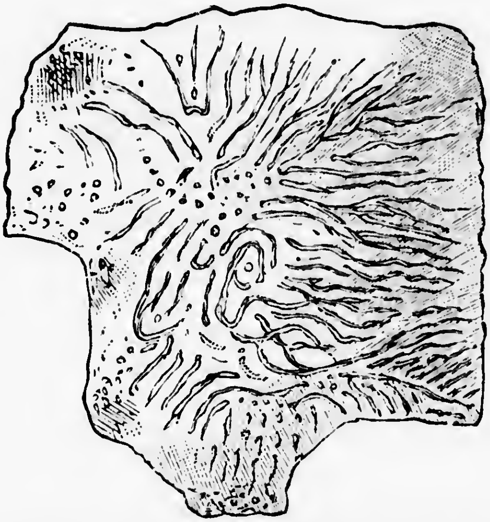


Fig. 41.—Section of Eozoon highly magnified, showing the Canals.

Foraminifera may be obtained from the mud taken up in dredging in deep water, and also from the Pleistocene clays containing marine shells. They are most easily collected by drying the deposit and then crumbling it and stirring it in water. The minute shells float to the surface, and may be skimmed off. Fossil Foraminifera occur in large quantities in certain cretaceous marls of the North-western Territories, in which the forms are similar to those of the English chalk. Reference—Carpenter on Foraminifera, Publications of Ray Society.

ORDER 4. RADIOLARIA.

Another oceanic group is that constituting the order *Radiolaria*, in which the body is more complex than in Foraminifera, containing a central capsule holding vacuoles and granules with oil globules and a nucleus or nuclei. The skeleton is silicious, and consists of little radiating spicules or a perforated glassy test, often of great beauty. *Acanthometra* of our seas, is an example of the spicular skeleton, and has a globular sarcodic body supported and protected by fine silicious needles, or spiculæ radiating from the centre.

The Polycistina have the skeleton in form of a test. The Polycistina are almost equally widely diffused in the sea, though less abundant than the Foraminifera, and their silicious skeletons are often of great beauty and symmetry. Fig. 42 represents two species obtained from a depth of 313 fathoms in the Gulf of St. Lawrence, by Capt. Orlebar, R.N.

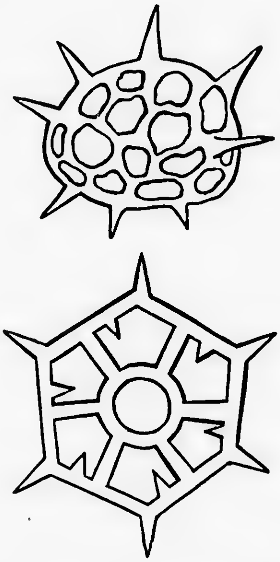


Fig. 42.—CERATOSPYRIS and DICTYOCHA ACULEATA?; Silicious tests. (Gulf St Lawrence, 313 fathoms.)

Acanthometræ may sometimes be taken in great numbers in a gauze or muslin tow-net, especially on the margin of the Gulf Stream on the Banks of Newfoundland. Polycistina occur in the deeper parts of the Gulf of St. Lawrence, and fine preparations of their skeletons are made from a white silicious earth found in the Island of Barbadoes, and which is in great part composed of these organisms. Reference—Carpenter on the Microscope.

CLASS II. INFUSORIA.

[*Protozoa having an oral and often an anal aperture, and an integument of cellular tissue enclosing the sarcode mass, and furnished with cilia, flagella or suckers.*]

Examples of these creatures may be found in stagnant water, or in any vegetable infusion which has been exposed to the air. Some are locomotive, and others fixed. As a type of the first, the genus *Paramœcium* may be taken (Fig. 43). The species of this genus are very

Fig. 43.—PARAMŒCIUM—Magnified, showing ciliated surface, ectosarc and endosarc, and pulsating vesicles in the former. The mouth is seen at one side.

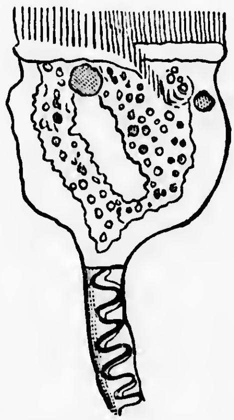


Fig. 44.—VORTICELLA, same parts as in Fig. 43, with nerve mass near mouth and contractile stalk.

common in infusions. They are oval in form. with a minute slit or depression at one side, which is the mouth. The surface is covered with vibratile cilia, by the motion of which the animals can swim rapidly. Within the ciliated cuticle is a cortical layer of dense sarcode, with the pulsating vesicles, and the interior is occupied with soft sarcode like that of an Amoeba, in which may be perceived a nucleus or reproductive organ, and vacuoles or cavities filled with food. The animals of the genus Vorticella afford an example of fixed or attached Infusoria. They are conical or cylindrical in form, with the upper surface alone ciliated, and attached at the base by a cord or stalk, in which is a spiral contractile thread, enabling the animals suddenly to retract themselves on the approach of danger. The Vorticellas are found in stagnant water, aquaria and similar places. (Fig. 44.)

The reproduction of the Infusoria takes place by spontaneous fission, by gemmation or budding, and by a process of encysting followed by subdivision into minute embryos. This last is probably a true reproductive process, and in some species reproduction takes place by the formation of embryos in the nucleus without encysting. By these various means of multiplication the Infusoria are enabled to increase with wonderful rapidity, and thus most efficiently perform their office of scavengers in places where organic matters are in process of decay. Their embryos also are not only present in all natural waters, but are able to float in the air, so that it is very difficult to prevent them from finding access to any infusion.

A great number of species of Infusoria have been described by microscopists, but it is possible that many of these are embryonic states of other animals, or even minute plants or spores of plants. The grouping of the species in families is, as yet, by no means certainly ascertained.

The Infusoria may be divided into orders as follows :

Order 1. *Flagellata* (Fig. 45), having one or more whip like threads or flagellae at the extremity of the usually oval or rounded body. This order includes the Monads, among which are some of the smallest of animals, and which appear in vast abundance in organic matters decaying in water. Certain marine Infusoria, as

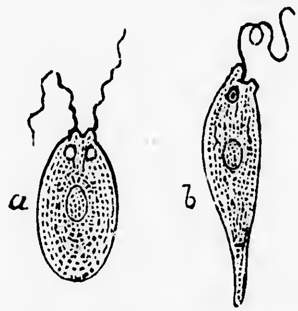


Fig. 45.—FLAGELLATA (highly magnified).

(*a*) *Monas termo*, after Dallinger, showing two flagellae, two pulsating Vesicles and Nucleus.

(*b*) *Euglena Viridis*, after Claus, showing Flagellum, pulsating Vesicle and Nucleus.

Noctiluca, remarkable for its luminosity at night, are also included in this order. It seems difficult to distinguish from the flagellate Infusoria those minute organisms known as Bacteria and Microbes, which are connected with putrefaction and diseases of animals, and which are by many regarded as plants. They certainly have spontaneous motions which appear to be carried on by flagella. Their study has become of the utmost practical importance in connection with the germ theory of diseases.

The Monas termo is stated by Dallinger to be the 1/24,000 of an inch in diameter. The germs [illegible] the animal are not killed by boiling. The [illegible] consuming decaying animal matter, [illegible]

Order 2. *Ciliata* (Figs. 43, 44). These are more or less covered with cilia, by which they move, or when sessile form vortices to collect food. They have a mouth and arms, and not only an endosarc and ectosarc, but the latter is often cellular in structure. They have also a nucleus and contractile vesicle.

Order 3. *Suctoria.* These are destitute of cilia, and have instead processes which act as suckers, and are used both for protection and absorbing food. They are comparatively rare.

Infusoria of various kinds may be found in most stagnant waters in which organic matters are going to decay. Water in which cut flowers have been kept or in which a few fragments of vegetable matter have been left for a few days, will afford several common species. Fragments of fish or flesh or almost any other organic matter placed in water and exposed to the air for a few days, usually swarm with the smaller forms, especially the Flagellata. Reference: Carpenter on the Microscope; Griffith & Henfrey's Micrographic Dictionary; Kent, Manual of Infusoria.

Class III. Porifera.

Animals having the sarcode usually supported on a corneous, silicous or calcareous skeleton of fibrous or spicular structure, and traversed by canals through which water is drawn by cilia. This class is that of the Sponges, sometimes named Polystomata, on account of their numerous incurrent pores, which are not however true mouths.

Of this group any of the sponges, whether those foreign ones used by us for washing purposes, or those occurring on our own coasts, rivers and lakes, may be taken as examples.

In some the skeleton or framework is wholly of corneous fibres; in others partly corneous and partly of silicious

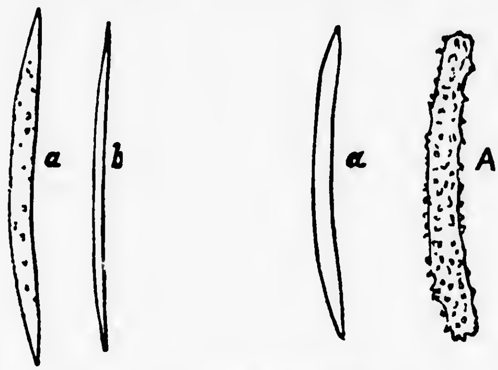


Fig. 46.—SPICULES OF SPONGILLA.
(*a b*) Skeleton spicules of *Spongilla stagnalis*, Dn.
(*a A*) Skeleton and Ovarian Spicules of *Sp Ottawaensis*, Dn..
These species are closely allied to *Sp. fluviatilis* and *Sp. fragilis*, or may be varieties.

spicules or needles; in others wholly silicious. In a few the spicules are calcareous. In the living condition this skeleton supports a soft or more dense mass of sarcode, similar to that found in the Amoeba, but perforated by numerous canals and cavities through which water freely percolates, and is kept in motion by cilia placed on cells or on minute bodies (*Spongozoa*), resembling flagellate infusoria, on the sides of the canals. The currents thus produced, entering by the smaller pores on the surface, and passing out by openings called Oscula, carry into the organism the microscopic organic matters on which it feeds, and subserve also the purpose of respiration.

Of the numerous species of sponges found in our waters a few only can be noticed. A species of silicious sponge first dredged in deep water at Portland, has been named by Dr. Bowerbank, *Tethea Hispida*. A closely allied species from the Post-pliocene clays, and probably still living in deep water, has been named by the writer, *T. Logani*, in honor of the late distinguished head of the Geological Survey of Canada (Fig. 50). Several species of fresh-water sponges of the genus *Spongilla* and its allies, are found in the rivers and lakes of Canada, where they grow on stones, shells or sub-aquatic stems (Figs. 46, 49). Two of the most common species on our shores are the beautiful funnel shaped or cup sponge of the lower St. Lawrence (*Isodictya*), Fig. 47, and the pal-

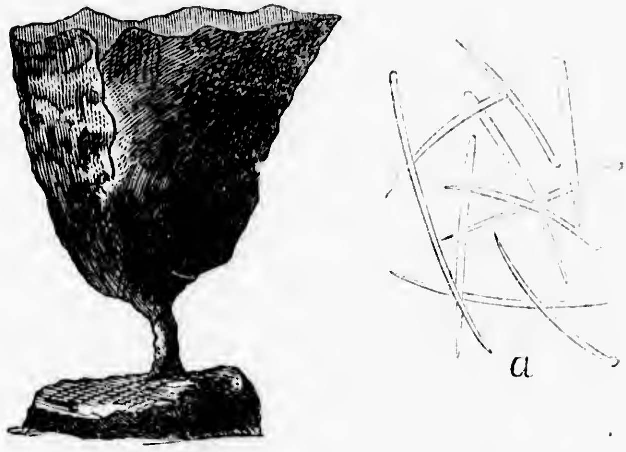


Fig. 47.—ISODICTYA, INFUNDIBULIFORMIS, Bk., Murray Bay. (*b*) general form, reduced; (*a*) Spicules, highly magnified.

mate sponge of the Atlantic coast, *Chalina oculata*. Another very common species found attached to sea-weeds, is the close-grained and shapeless "crumb-of-bread sponge" (*Halichondria*) and less common are the dense yellow sponges of the genus *Suberites* or sea-cork. Dead shells are often found to be burrowed by minute yellow sponges of the genus *Cliona*, which have the power of dissolving away the shell and forming cavities for themselves.

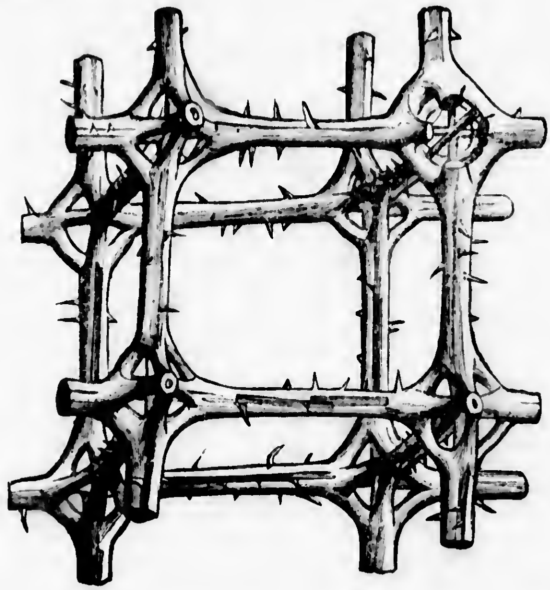


Fig. 48,—Spicules of Hexactinellid Sponge, after Zittel, Magnified.

The sponges are by some zoologists regarded as a humble group of Cœlenterata; but inasmuch as they all, as far as known, consist of amœboid sarcode or ciliate cells united together and fed by currents of water produced by cilia, while the food is introduced into the general mass and not into any central cavity, they should be regarded as Protozoa. Nevertheless owing to their aggregative character the walls of a sponge consists of three parts, an ectosarc, mesosarc and endosarc. Of these the first and last correspond to the ectosarc of the lower Protozoa, and the mesosarc to the endosarc. The germs of the sponges are ciliated and locomotive, and in many cases are produced in spicular or membranous ovaria or gemmules, which are especially complete in some of the fresh-water sponges, the germs of which they serve to protect during winter. (Figs. 46, 49.)

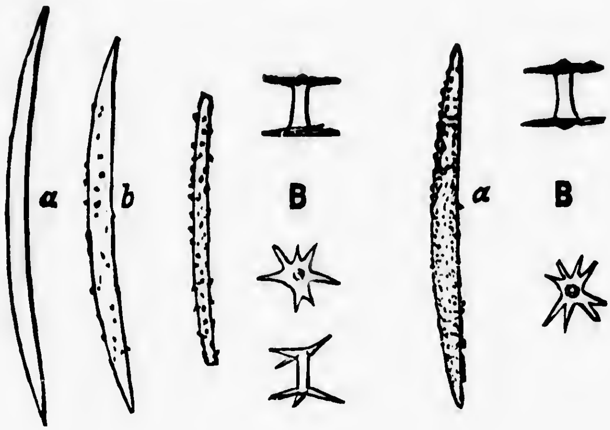


Fig. 49.—SPONGILLA STAGNALIS.
(*a b*) Skeleton Spicules, (*B*) Birotulate Ovarian Spicules, Mag.

SPONGILLA ASPERRIMA.
(*a*) Skeleton Spicule, (*B*) Birotulate Spicules, Mag.
May be a varietal form of *Sp. Fluviatilis.*

Fresh-water sponges may be collected in rivers and lakes when the water is low, and the marine species abound in many parts of the sea, and are not infrequently drifted on shore in storms. The silicious spicules may be obtained by treating fragments of the sponge with nitric acid, which destroys the animal matter, the spicules falling to the bottom. They may be collected, washed and mounted in balsam (Figs. 46, 49). These spicules are much more important than the general form in determining the genera and species.

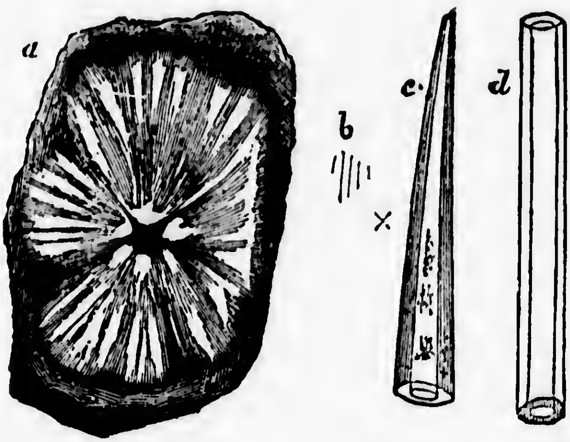


Fig. 50.—TETHEA LOGANI, Pleistocene; (*a*) specimen in clay; (*b*, *c*, *d*) Spicules.

Fossil sponges (*Protospongia*) occur in the Acadian group of the Cambrian in Southern New Brunswick. Others occur in the lower Silurian *e.g.* in the Utica shale formation, and globular and conical species, *Astylospongia*, &c., in the Niagara limestone. All of these appear to have had silicious spicules, closely resembling in form and arrangement those of modern species of that group with six-rayed silicious spicules, known as Hexactinellid sponges (Figs. 48, 53). The curious fossils of the genus *Receptaculites* are also supposed to be the skeletons of Protozoa allied to the sponges (Figs. 51, 52).

The species *Tethea Logani*, whose spicules are sometimes abundant in the Pleistocene clays, has already been mentioned (Fig. 50).

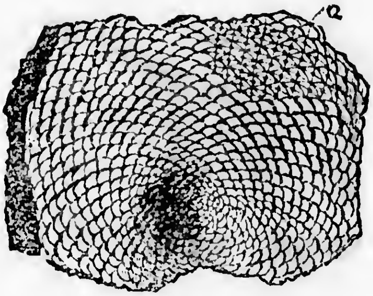


Fig. 51.—RECEPTACULITES OCCIDENTALIS, Salter.
(*a*) Portion of surface removed, showing interior structure.

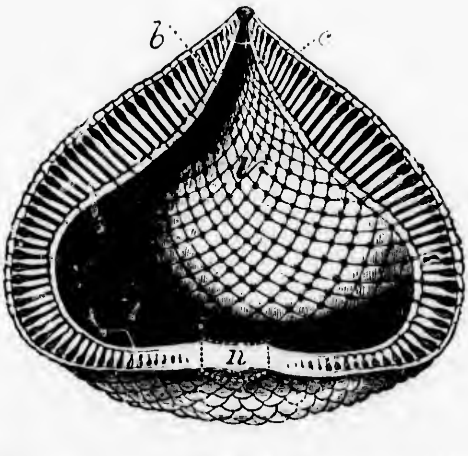


Fig. 52.—RECEPTACULITES, restored—after Billings.
a—Aperture. *b*—Inner integument. *c*—External integument.
n—Nucleus. *v*—Internal cavity.

The sponges may be classified as follows :—

Order 1. *Myxospongiæ.* Soft gelatinous species without any skeleton. Ex. *Halisarca.*

Order 2. *Ceratospongiæ.* Supported by a framework of horny or corneus fibres, Ex. *Euspongia*, a genus which includes the common washing sponges.

Order 3. *Halichondriæ.* Skeleton of simple silicious spicules with corneus matter. Ex. *Isodictyia*, *Chalina*, *Spongilla.*

Order 4. *Hyalospongiæ.* Skeleton wholly silicious, Ex. *Tethea*, *Euplectella*, *Hyalonema.* The most perfect forms have six-rayed spicules often very beautifully arranged, and are named Hexactinellida (Figs. 48, 53). Most of the species of our Silurian rocks belong to this group.

Fig. 53.—Astylospongia præmorsa—Silurian. With Framework of Spicules Magnified.

Order 5. *Calcispongia*, with skeleton of calcareous spicules. Ex. *Grantia.*

CHAPTER IV.

DESCRIPTIVE ZOOLOGY—*Continued.*

Province II.—Cœlenterata.

These are the animals formerly called "Zoophytes," because so many of them by aggregation of individuals on a common stem or branches assume plant-like forms. Nothwithstauding this, however, and the fact that many of them are, in adult life, permanently fixed to the sea bottom, they present much higher structures than those of the Protozoa. Their bodies are composed of definite cellular tissues, and in some cases present muscular and nerve cells and fibres, and are hollow so as to constitute an internal digestive and circulating cavity. In very many of them distinct organs of external sense appear. They are generally furnished with hollow muscular tentacles, armed with poison-bearing "thread cells," (nematocysts), which are very characteristic of these animals. Their embryos resemble Protozoa in the presence of an internal protoplasmic mass, with an outer layer of ciliated cells ; but as they develope, a portion of the outer cellular membrane is turned inwards by a process of invagination, and becomes the lining of the internal cavity, while the internal sarcode becomes an intermediate layer or mesoderm. This is the so-called "gastrula" stage, in which the animal presents a cellular ectoderm with cilia, and a cellular endoderm lining an internal digestive cavity. The Cœlenterata often form by budding and fission polyp-stocks or polyparies, including numerous individuals, and in which are developed hard parts or coralla, either calcareous or corneous. The arrangement of parts in the individual animal is radiated, and in fours and sixes, and multiples of these numbers.

The classes of Cœlenterata are as follows :—

1. *Acalephæ* or *Hydrozoa*.—Hydræ and Sea-jellies.

2. *Anthozoa*.—Sea Anemones, Coral Animals, Sea fans, &c.

3. *Ctenophora*.—Cydippe, Beroe, &c.

To these are usually added, for certain fossil corals which cannot as yet be placed in the other classes :—

4. *Rugosa*.—Fossil Rugose Corals.

5. *Tabulata*.—Fossil Tabulate Corals.

CLASS I.—ACALEPHÆ OR HYDROZOA.

Body naked or in an external tube or sheath ; locomotive or fixed ; digestive cavity of an outer and inner chamber, the latter communicating with a more or less complex vascular system—tentacles hollow with dart or thread cells ; Reproductive organs external.

The Acalephæ are by most naturalists regarded as of lower grade than the next class, in consequence of their apparently less complex internal structure, especially in the lower groups. But to counterbalance this, we have in the higher members of the present group a much greater development of locomotive and sensorial powers. In other words the Anthozoa excel in the complexity of the organs of *vegetative* life: the higher Acalephæ, in those of *locomotion* and *sensation*. Hence, the same grounds which would in the vertebrates induce us to give the birds a higher place than the reptiles, should place the Acalephæ higher than the Anthozoa. Still it must be admitted that the difference of rank, if any, is not great, and that the lower forms of Acalephæ are of very simple structure in comparison with the higher members of the same group, and therefore make the transition from the previous sub-kingdom to this more easy.

The Acalephæ resemble the animals of the next class in having a polyp-like form; but they have the digestive sac turned outward instead of being folded inward; so that there is an outer stomach or proboscis and an internal chamber or tube, in the higher forms communicating with a system of nutritive canals excavated in the wall of the body. Some of these animals are altogether soft, others have horny or calcareous skeletons, which are wholly sclerodermic, or belong to the ectoderm of the polyps. The lower Acalephæ multiply freely by gemmation and form complex communities. In the higher groups such multiplication takes place only in the immature states.

This class contains three orders:—

1. *Hydroida*, or Hydroid Polyps. Individual animals polyp-like, and either solitary or in communities. Body naked or inserted in a cell (Hydrotheca). Reproductive

organs attached externally to individual polyps, or developed in separate capsules, and often attached to free bell-shaped individuals differing much in form from the ordinary Hydroids. These are the Hydroid Polyps of the fresh waters and of the sea, the Millepore corals, &c. (Figs. 54, 55).

2. *Siphonophora.*—Free swimming hydra-stocks with flexible contractile stem or base, and furnished with swimming-bells (Nectocalyces or Floats). Polyps of three or four kinds on one stem or base. These are the Physaliæ or "Portuguese men of war" and their allies (Figs. 58, 59).

3. *Discophora.*—Individuals distinct and often of large size, free and oceanic, with the disc extending into a broad bell-shaped or umbrella-shaped swimming organ (Nectocalyx). Ova borne under the disc and developing into hydra-formed progeny. These are the Medusæ or jellyfishes and their allies (Fig. 60).

ORDER 1.—HYDROIDA.

The fresh-water Hydra, which is one of the simplest of these organisms, presents the appearance of a sac composed of an outer and inner layer. At the base is an adhesive disc or foot. At the summit is the proboscis or external stomach, around the neck of which are the tentacles, which, like those of Anthozoa, are furnished with urticating darts. The Hydra, though soft and gelatinous in texture, is carnivorous and very voracious; and though it usually remains fixed, it can move at will. Its ova are borne on the external surface of the body, and are hatched into ciliated embryos like animalcules. These creatures also increase by gemmation and have remarkable powers of repairing injuries, (Fig. 54).

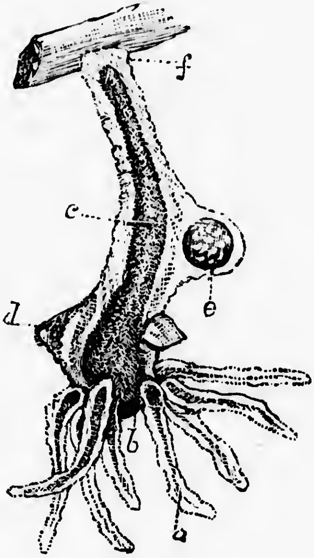


Fig. 54.—HYDRA VIRIDIS, hanging on a submerged twig and magnified.
a—Tentacle.
b—Mouth and probosis retracted.
c—Body cavity.
d—Male generative apparatus.
e—Ovary.

The type of structure exhibited by the Hydra is capable of a vast variety of modifications in its kindred inhabiting the sea. These modifications depend principally on the possession of hard investing organs, on aggregation of the cells into complex structures (hydrozoary), and on the production of different kinds of Polyps or Polypites;

some being stomach-bearing, others tentacle-bearing, others ovarian. By such modifications are produced the families noticed below.

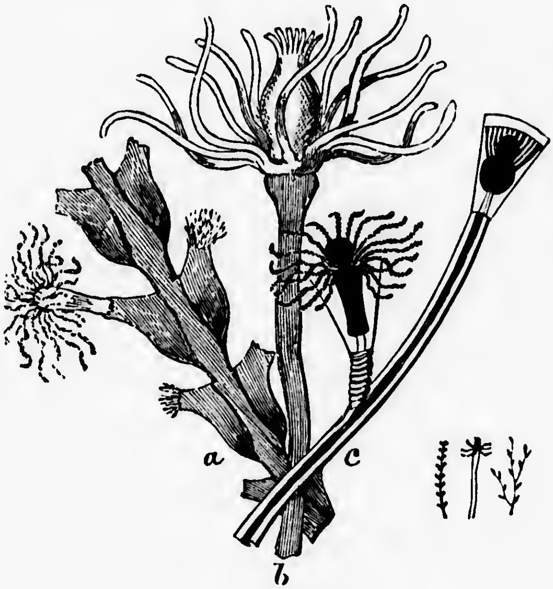


Fig. 55.

HYDROIDA, Gulf St. Lawrence, Nat. size and magnified, showing forms of polyps expanded and modes of aggregation.

(*a*) Sertularia (Dynamena) pumila. Lamx.
(*b*) Tubularia (Parypha) crocea Ag.
(*c*) Campanularia (Laomedea) amphora Ag.

Another remarkable point in the history of these oceanic forms, connecting them with the next group, is that many of them develop, by a process of gemmation, individuals provided with a swimming disc and not attached, and it is in these locomotive individuals that the ova are produced. This locomotive progeny of the hydroids constitutes the group of Naked-eyed-Medusæ, at one time regarded as a distinct order. Fig. 56 shows

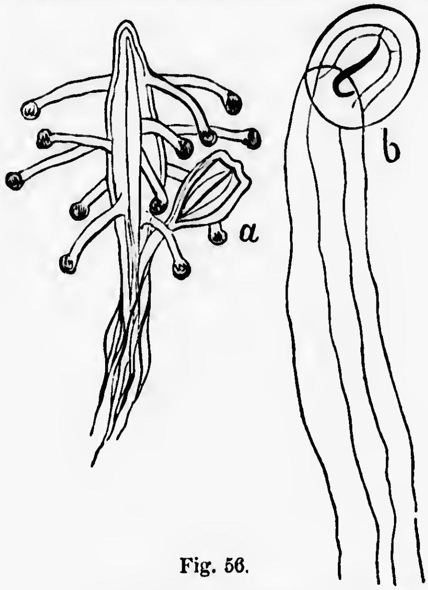


Fig. 56.

CORYNE MIRABILIS (after Agassiz) Magnified.
(*a*) Young Medusoid, attached to polyp.
(*b*) The same detached.

these two forms as they exist in one of our American species.

The following are the Families of Hydroids :—

1. HYDRIDÆ.—Polyps independent, locomotive, naked. Example, Hydra viridis (Fig. 54).

2. CORYNIDÆ.—Polyps independent or in communities. Tentacles in several series. Animals enclosed in tubular corneous cells. Example, Coryne mirabilis (Fig. 56).

3. TUBULARIADÆ.—Polyps solitary, in elongated corneous tubes and with two rows of tentacles. Example, Tubularia crocea (Fig. 55b).

4. EUCOPIDÆ.—Polyps in corneous conical cells at the extremities of the branches. Example, Laomedea amphora (Fig. 55c).

5. SERTULARIADÆ.—Polyps arranged in corneous cells on the sides of branching tubular stems. Example, Sertularia pumila (Fig. 55a).

6. PLUMULARIADÆ.—Polyps in single rows on one side of corneous branches. Example, Plumularia falcata.

7. HYDRACTINIADÆ.—Polyps sessile, with a spinous skeleton, attached to shells, &c., and of two sorts. Example, Hydractinia echinata.

8. MILLEPORIDÆ.—Polyps of different kinds, in cells of a stony coral. The cells divided by transverse tabulæ. Example, Millepora.

In or near this group may probably be placed some of the fossil tabulate corals referred to under the Anthozoa.

To these may be added the fossil family of *Graptolitidae*, characteristic of some portions of the Silurocambrian rocks. They are regarded by Professor Hall as allied to Sertulariadæ. (Fig. 57.)

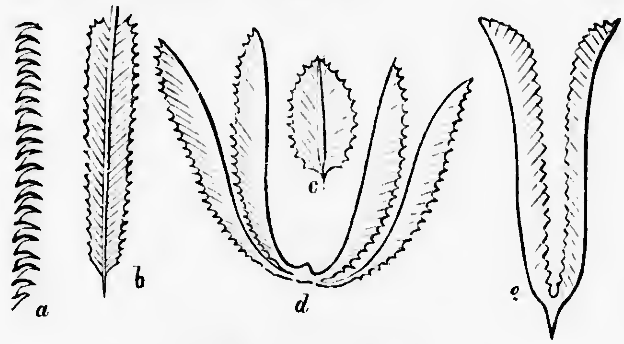


Fig. 57.—GRAPTOLITIDAE.
a—Graptolithus. *b—Diplograpsus.* *c—Phyllograpsus.*
d—Tetragrapsus. *e—Didymograpsus.*

ORDER 2.—SIPHONOPHORA.

These are oceanic and free swimming animals, living in communities which are attached either to a flexible thread or stalk, or to a float filled with air. The polyps, or zooids forming the community, are specialized into different kinds—feeding, reproductive and tentacular or prehensile, all of these co-operating for the nutriment and reproduction of the common stock. In some of the forms there is a fourth kind of polyp, constituting swimming bells, which, by their contraction and expansion, row the community through the water. *Halistemma carum* (Fig. 58) is an American example. In others

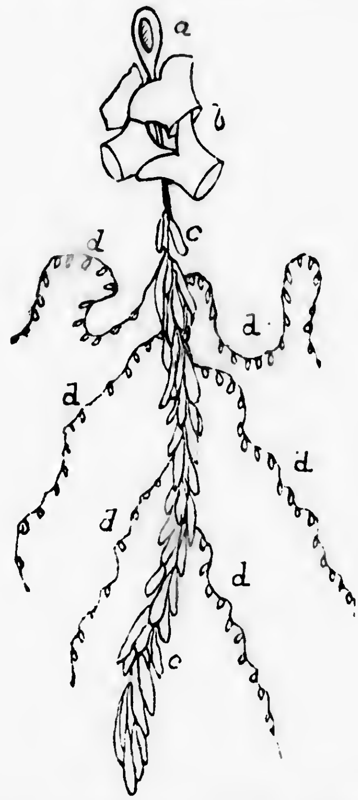


Fig. 58.—HALISTEMMA CARUM, Agassis.
a—Pneumatophore or Oil-cell. *b*—Nectocalyces or Swimming-bells.
c—Digestive polyps. *d*—Common tentacles with thread-cells.

there is an inflated swimming vesicle, to the base of which the polyps are attached. This is the case with the beautiful *Physalia Arethusa*, sometimes found on our coasts, and having a float resembling a purple bubble (Fig. 59). In others the float is a flat disc, as in

Fig. 59.—PHYSALIA ARETHUSA, reduced.

a—Crest. *b*—Pneumatophore. *c*—Polyps. *d*—Tentacles.

Porpita; and this is sometimes, as in *Velella*, provided with a vertical membrane acting as a sail. In accordance with these arrangements the Siphonophora may be divided into two families: (1) Calycophoridæ (Fig. 58), (2) Physophoridæ (Fig. 59).

ORDER 3.—DISCOPHORA.

One of the best representatives of this order on our coast is the great blue Jelly-fish, *Cyanea arctica* (Fig. 60),

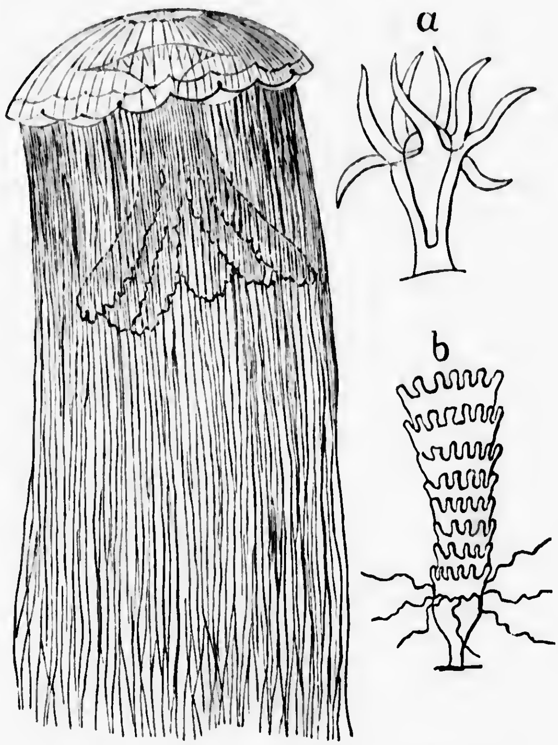


Fig. 60.—CYANEA ARCTICA, Per. and Les. reduced.
a—Hydroid progemy.
b—Strobila.

which is often found in the Gulf of St. Lawrence and on the Atlantic coast of Nova Scotia, a foot or more in diameter, and is said sometimes to attain the enormous diameter of seven feet. The most conspicuous part of this creature, as it floats in the sea, is its great violet-coloured disc, the edges of which are moved slowly up and down as it swims along. In the centre of this disc below, projects the proboscis or external stomach, furnished with a profusion of filmy fringes hanging at the extremities of the four lateral processes into which its free end is divided. From the margins of the disc float backward innumerable long reddish tentacles armed with urticating thread cells, which paralyze any little animal they may touch, and enable it to be drawn into the mouth. These tentacles are often several feet in length. Between the tentacles and the base of the proboscis, when the creature is mature, may be seen four great ovaries loaded with yellowish eggs. The eyes and ear-vesicles, each eight in number, are placed in notches in the margin of the disc, while circulation and respiration are provided for by a net-work of vessels ramifying through the disc. Though these animals are tenuous as jelly, and contain very little solid matter, their organs are of singular complexity, and the body consists of several layers of cellular and fibrous tissues. The reproduction of the Cyanea, as described by Agassiz, forms an interesting example of the changes through which animals of this type pass in attaining to maturity. The eggs are hatched into ciliated embryos which swim freely. These attach themselves to the bottom, and are developed into little hydroids, with tentacles in fours and multiples of four (Fig. 60 a), and which have the power of increasing by gemmation. From this stage the young animal passes by transverse fission into a sort of jointed form (the Strobila. Fig. 60 b), and this, breaking up into separate segments, produces free swimming discigerous animals, formerly known by the name of Ephyra, and which are the young of the Cyanea. Thus each animal passes through four definite stages before attaining the perfect form, and one ovum may produce several adult Cyaneas.

Another very common species on our coasts is the white or colourlesss Jelly-fish, *Aurelia flavidula.* It has four white or milky spots (the ovaries) seen conspicuously through its transparent body, and has short marginal tentacles.

The Discophora are divided into the following sub-orders or families :—

1. Rhizostomeæ, in which the proboscis is divided into a series of ramifying tubes, through which nutriment is absorbed. Some very large tropical Medusæ belong to this group, but none are known on our coasts.

2. Semaeostomeæ, in which the proboscis is divided into labial processes or oral tentacles. This group includes our commoner species above mentioned.

3. Haplostomeæ —Are simple-mouthed Medusæ, including the curious animals known as *Lucernaria*, a species of which is found in the Gulf of St Lawrence, adhering to sea-weeds or floating freely. It forms a curious link between the Polyp and Medusa forms, having a stalk for attachment developed in the middle of the disk.

The best descriptions and figures of the North American Acalephæ are to be found in Agassiz' Contributions to the Natural History of America, vols, 3 and 4. There is a good summary of the species in the Illustrated Catalogue of the Harvard Museum, by A. Agassiz, and the student will find the general characters of this and the following class well stated in Greene's Manual of Cœlenterata, London.

Class II.—Anthozoa, or Actinozoa.

Body naked or in a corallum, with a distinct internal cavity, divided by radiating partitions into chambers communicating with a central digestive sac. Tentacles with urticating organs. Reproductive organs internal.

The Anthozoa present a considerable advance in complexity of internal structure. Their parts are grouped around a central stomach or digestive sac, which is surrounded by a perivisceral space separating it from the outer body wall; and this space is traversed by radiating membranous plates or mesenteries connecting the wall of the stomach with the body wall. The tissues constituting these organs are membranous and muscular. The body of the individual Anthozoon thus presents in cross section the aspect of a wheel with radiating spokes. The stomach opens above in the centre of a disc, surrounded by hollow tentacles, provided with thread cells, capable of emitting spiral threads, provided with sharp spicules and covered with a poisonous secretion, by means of which the animal prey of these creatures is paralyzed when seized. When the tentacles are expanded they present a beautiful flower-like appearance, whence the name, Anthozoa The name, Actinozoa, is derived from their radiated structure, and that of Polypi or

Polyps, from their numerous tentacles (Fig. 61).

Fig. 61.—ACTINIA (Rhodactinia) CRASSICORNIS, Gaspé.

Some of these creatures are altogether soft (Malacodermata). Others secrete hard parts or corals, which may be calcareous or corneous in their composition, and are either produced from the base of the Polyp merely (sclerobasic), or from the substance of its body wall as well (sclerodermatous).

The Anthozoa multiply freely by gemmation and fission; and in the case of those which have hard corals, this produces complex structures consisting of many individuals, having their skeletons united directly or by a common substance (cœnœcium). The individuals of these communities, are to some extent nourished in common. The reproductive apparatus of Anthozoa is attached to the mesenteries of the perivisceral cavity. The individuals are either diœcious or monœcious.

The existing Anthozoa may be divided into two orders.

1. *Zoantharia or Actinoids.*—These are either naked or provided with a sclerodermatous (rarely sclerobasic)

corallum, and have the tentacles simple, usually numerous and in multiples of six or of five. When the corallum is developed, it has radiating septa corresponding to the soft mesenteries. In this group are the Sea-anemones and their allies, and the Madrepores or reef-building corals. See Figs. 61, and 65 to 68.)

2. *Alcyonoria or Alcyonoids.*—These differ from the last in having the tentacles and mesenteries limited to eight in number, and the former fringed or provided with pinnate processes. The corallum is corneous or calcareons and sclerobasic, often with spicules of calcareous matter imbedded in the soft parts. In this group are the Alcyoniums, Sea-pens, Organ-pipe corals, Sea-fans, Red corals, &c. (See Fig. 69.)

In addition to these there are two orders of extinct or fossil corals, found more especially in the older rocks of the earth's crust. These differ materially in their structures from modern corals, and have been referred by some naturalists to the present class, by others to the last. I believe with Agassiz, that some of these corals are closely allied to modern corals of the last class; but there are others which present characters indicating that the animals, if known to us, would prove to be similar to those of Zoantharia, or intermediate between these and the Alcyonaria. These extinct corals are included in the following orders:

1. *Rugosa.*—In these the corallum is sclerodermic, with septa arranged in fours and multiples of four, and often with horizontal floors or tabulæ and a well developed external wall or theca. In some the septa and tabulæ

coalesce into a vesicular substance very unlike that of modern corals. (Figs. 62, 63.)

Fig. 62.—ZAPHRENTIS PROLIFICA—Billings—Devonian.

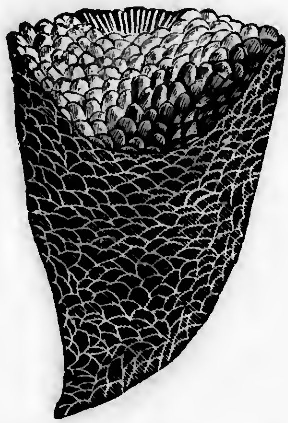


Fig. 63.—CYSTIPHYLLUM SULCATUM—Billings, Devonian—Section.

The late Count Pourtales dredged from a depth of 324 fathoms, off the Florida reef, a remarkable coral, *Haplophyllia paradoxa*, apparently closely allied to, if not a modern representative of the Rugosa. The animal was of a greenish colour, with a circle of about 16 tentacles, rather long and abruptly tuberculated at the tip; outside the tentacles was a membranous disc with radiating and concentric folds. This is the first indication of the occurrence of these remarkable corals in the modern seas.

2. *Tabulata.*—In these the corallum consists of simple, often hexagonal, tubes, without septa or with rudiments of septa, and with well marked horizontal tabulæ. Some of these corals approach very closely in their characters the Millepore corals belonging to the last class. Some of them have also been shewn to resemble in important points such modern corals as Heliopora among Alcyonoids, and Pocillopora among Actinoids—and they will, no doubt, be ultimately divided up among these different groups.

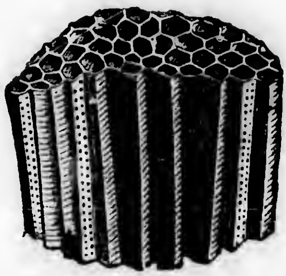


Fig. 64.—Favosites Gothlandica—Goldf.—Upper Silurian.

The orders Rugosa and Tabulata include nearly all the numerous fossil corals found in the limestones of Canada. (See Figs. on subsequent pages.)

Order 1.—Zoantharia or Actinoids.

The Actinias or Sea-anemones may be taken as the type of Zoantharia; and as an example of these the species named by Agassiz *Rhodactinia Davisii*, and which is the most common species on the north shore of the Gulf and River St. Lawrence, may be noticed here. It is probably a variety of *Actinia crassicornis* of the British coast. Externally, when expanded, it presents a cylindrical body attached at the lower extremity to a rock or stone, and at the upper having a crown of thick worm-like tentacles arranged in several rows, in the centre of which is the mouth. The external surface of the body, the tentacles and disc are often gaily coloured in shades of purple, crimson and flesh colour, though different individuals differ very much among themselves in this respect, and also in the smoothness or roughened character of the body. When fully expanded, the animal has the appearance of an aster or other stellate flower. When irritated or alarmed it withdraws its tentacles, contracts the body wall over the disc, and assumes the form of a flattened cone. Its food consists of such small animals as may be attracted by its gay colours, or may accidentally come within reach of its tentacles. To enable it to seize these it has in the substance of the tentacles an apparatus of extensile and retractile thread-cells, by means of which it can hold with some tenacity any object which touches the tentacles, and can also exert a benumbing influence tending to paralyze and subdue the resistance of its prey. The specimens figured (Figs. 61 and 65) were dredged in Gaspé Bay. Another variety or species found in the St. Lawrence differs from the above in being tuberculated on the surface, and resembles the rough variety of *A.* (*Urticina*) *crassicornis*, as ordinarily seen in Great Britain.

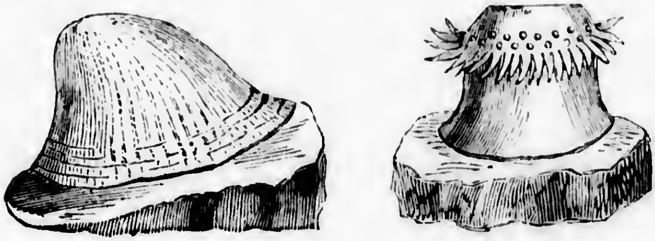


Fig. 65.—ACTINIA (Rhodactinia) CRASSICORNIS, contracted, and smaller individual expanded.

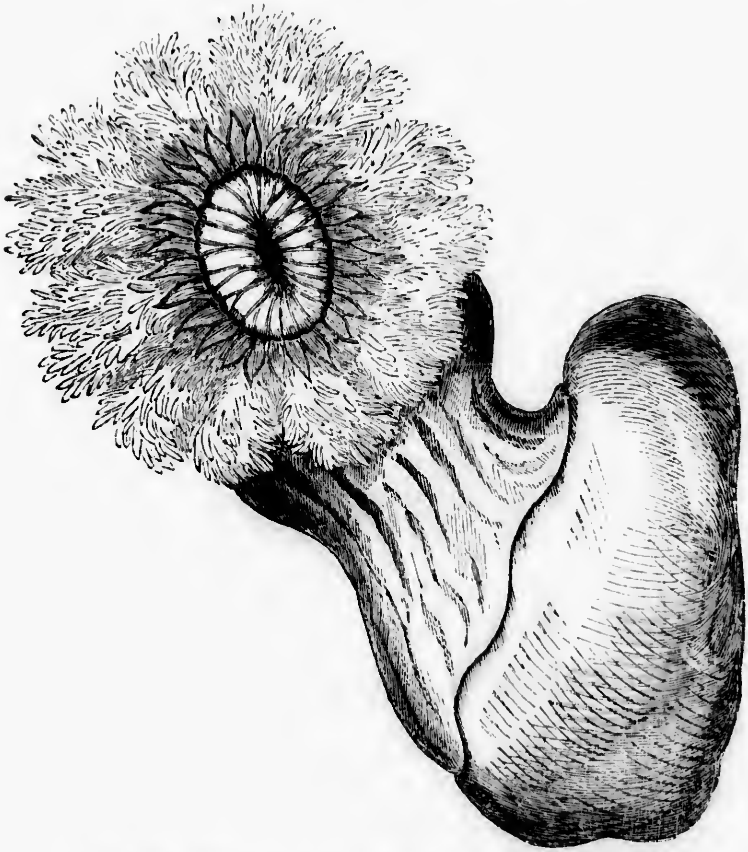


Fig. 66.—METRIDIUM MARGINATUM, Edw. & Haime (Gaspé).

A larger and often more beautiful representative of the Actinoids is the ***Metridium marginatum***, a species closely allied to the ***Actinia dianthus*** of Great Britain. It is found in great perfection at the mouth of Gaspé Basin, where the specimens represented of life size in the figures (Figs. 66, 67) were obtained. In this species the tentacles are in two series, the outer series being very numerous ard arranged on lobes of the edge of the disc.

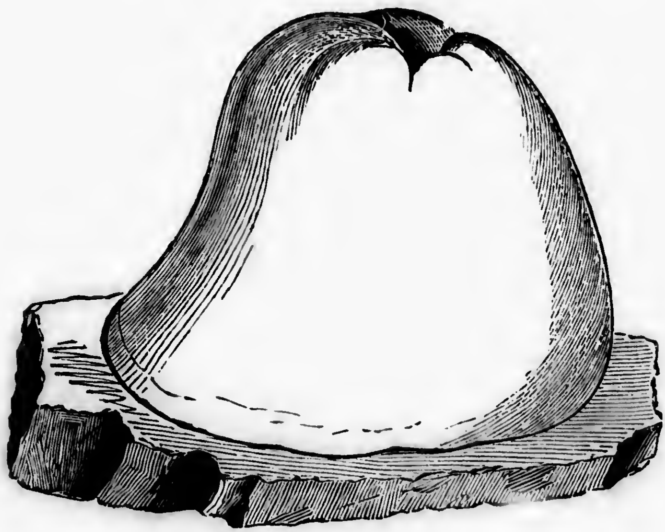


Fig. 67.—M. MARGINATUM, contracted.

In some Actiniæ rudiments of a nerve system are believed to have been detected, but though sensitive to light, they are not supposed to have organs of vision. They multiply by budding, and also by true ovarian reproduction, the ovaries being attached to the mesenteries.

The following are the principal families of Zoantharia:

1. ACTINIADÆ.—No Corallum. Polyps usually independent, attached by a broad base, but locomotive at will. Examples, Actinia, Rhodactinia, Metridium.

2. ILYANTHIDÆ.—No Corallum. Polyps independent, with rounded or tapering base. Examples, Ilyanthes, Cerianthes.

3. ZOANTHIDÆ,—Corallum spiculate. Polyps attached to a horizontal cœnosarc or common soft basis. Example, Zoanthes.

4. ANTIPATHIDÆ.—Corallum sclerobasic, having Polyps with six tentacles. Example, Antipathes.

5. FUNGIDÆ.—Corallum calcareous, septiform. Individuals mostly distinct and large, with numerous tentacles.

6. ASTREADÆ.—Septa numerous, cells attached, without cœnenchyma.

7. PORITIDÆ.—Corallum reticulate, cell-walls not distinct from surrounding cœnenchyma.

8. OCULINIDÆ.—Cœnenchyma abundant, compact, calcareous.

9. MADREPORIDÆ.—Corallum compact but porous, septa distinct.

The animals of the five last families are mainly instrumental in the accumulation of the great coral reefs of the intertropical seas. Only a few small species of these coral-producing Anthozoa, are found in the Northern seas. Fig. 68, taken from Dana, shews the appearance of one of the tropical species of *Astrea* when alive.

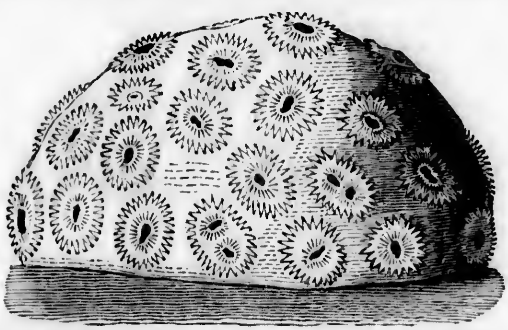


Fig. 68.—ASTREA PURPUREA, with polyps expanded—after Dana.

ORDER 2.—ALCYONARIA OR ALCYONOIDS.

As a native example of this group, we may take the *Alcyonium rubiforme* (Fig. 69), which is sometimes cast

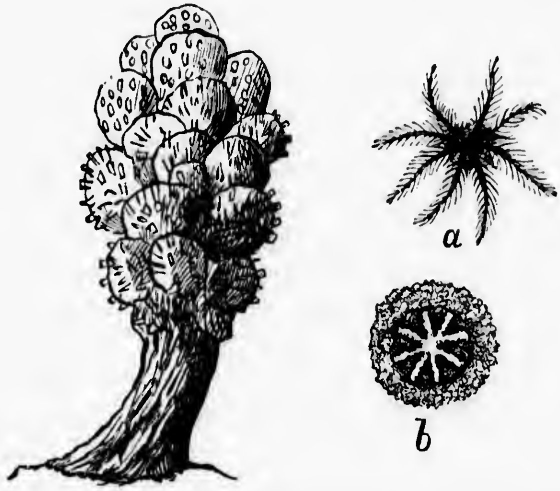


Fig. 69.—ALCYONIUM RUBIFORME, Dana (Gaspé), (a) Polyp expanded, (b) Polyp contracted.

up in storms on the shore of the Gulf of St. Lawrence, and may be obtained alive by dredging in deep water. It presents tuberculated yellowish or pinkish masses of a club-shaped form, from an inch to three inches in length, and of a spongy or firmly gelatinous structure. The surface is studded with round or star-shaped cells of small size, from which, when the creature is alive and undisturbed, delicate semi-transparent polyps protrude themselves and extend their tentacles. These little animals can be easily distinguished from those of the last group by their pinnate tentacles, eight in number. The corallum or skeleton is of a corneous and fibrous nature, and the animals are connected by numerous canals traversing its substance.

The families of Alcyonaria are the following:

1. ALCYONIDÆ.—The Alcyonia, which have a sclerodermic corallum, spiculous or fibrous, and when dry resemble sponges.

2. TUBIPORIDÆ.—The Tube-corals. The corallum is composed of a number of distinct calcareous tubes connected by horizontal plates.

3. PENNATULIDÆ.—The Sea-pens. In these the sclerobasic corallum is rod-like and free, or with its base immersed in mud at the bottom of the sea. The cells are placed on pinnate branches, and fortified with calcareous spicules.

4. GORGONIDÆ.—The Sea-fans and true red corals. In these the corallum is sclerobasic and either corneous or calcareous, and the fleshy matter enclosing it and in which the polyps are imbedded, is fortified with calcareous spicules.

ORDERS 3 AND 4.—RUGOSA AND TABULATA.

Figs. 70 to 77 and Figs. 62 and 63 represent Canadian

Fig. 70—HELIOPHYLLUM HALLI, Devonian.

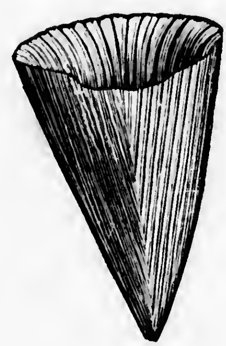
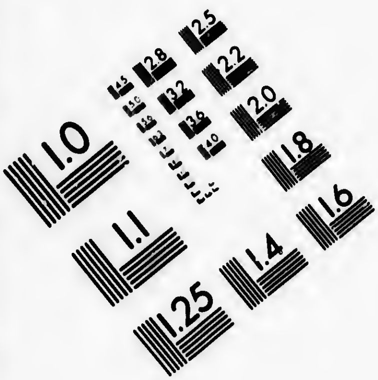
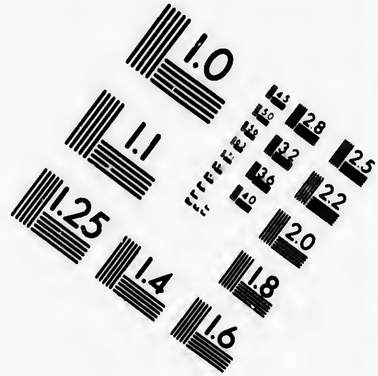


Fig. 71.—PETRAIA PROFUNDA, Hall, Siluro-cambrian.





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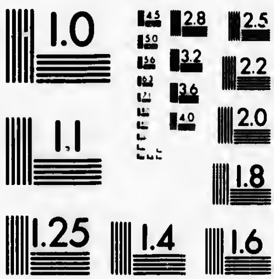
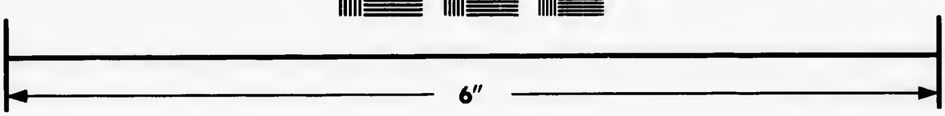
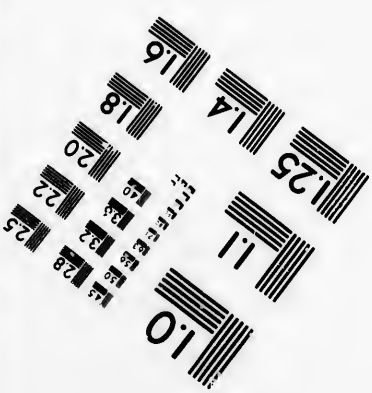
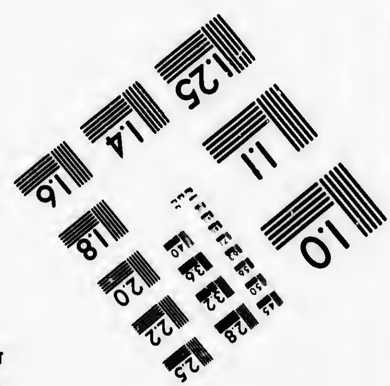








species of corals of the order Rugosa, and Figs. 74 to 77

Fig. 72. —CYSTIPHYLLUM AMERICANUM, E. & H., Devonian.

Fig. 73.—STROMBODES SIMPLEX, Hall, Devonian.

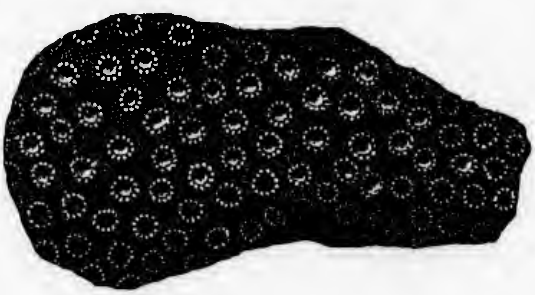


Fig. 74.—HELIOLITES SPECIOSUS, Billings—Silurian.

and Fig. 64 represent corals of the order Tabulata. All of these are fossil.

Fig. 75.
Syringopora Maclurei,
Billings—Devonian.

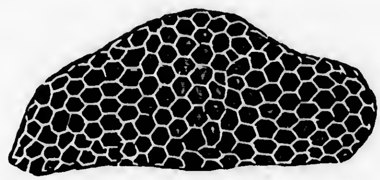


Fig. 76.
Columnaria alveolata,
Goldf.— Siluro-cambrian.

Fig. 77.—Halysites catenulatus, Silurian.

CLASS III. CTENOPHORA.

Body usually soft and translucent. Form usually spherical or oval. The organs of locomotion are eight comb-like frills at the sides of the body, and within there are eight water-vessels, communicating with the gastric cavity. The alimentary canal is central and the mouth opens anteriorly, and there are usually two tentacles provided with tentacular fringes, and lasso cells. The sense organs are placed at the posterior pole, opposite the mouth.

The Ctenophora are oceanic and free-swimming animals, and are independent, or not attached in communities, and appear to pass through no metamorphosis. They have a decided tendency to bilateral symmetry.

Pleurobrachia rhododactyla of Agassiz (Fig. 78) may be taken as a type of this group. As it occurs on the

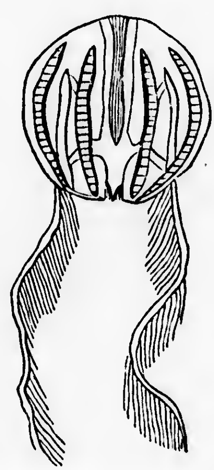


Fig. 78.—PLEUROBRACHIA RHODODACTYLA (after Agassiz).

Atlantic coast of New England, it is thus described by Madame Agassiz :—

"The body of the Pleurobrachia consists of a transparent sphere, varying, however, from the perfect sphere in being somewhat oblong, and also by a slight compression on two opposite sides, so as to render its horizontal diameter longer in one direction than in the other. This divergence from the globular form, so slight in Pleurobrachia as to be hardly perceptible to the casual observer, establishing two diameters of different lengths at right angles with each other, is equally true of the other genera. It is interesting and important, as showing the tendency in this highest group of Acalephs to assume a bilateral character. This bilaterality becomes still more marked in the highest class of Radiates, the Echinoderms. Such structural tendencies in the lower animals hinting at laws to be more developed in the higher forms, are always significant, as showing the intimate relation between all parts of the plan of creation. This inequality of the diameters is connected with the disposition of parts in the whole structure, the locomotive fringes and the vertical tubes connected with them being arranged in sets of four on either side of a plane passing through the longer diameter, shewing thus a tendency toward the establishment of a right and left side of the body, instead of the perfectly equal disposition of parts around a common centre, as in the lower Radiates.

"The Pleurobrachiæ are so transparent, that, with some preparatory explanation of their structure, the most unscientific observer may trace the relation of parts in them. At one end of the sphere is the transverse slit that serves them as a mouth ; at the opposite pole is a small circumscribed area, in the centre of which is a dark eye-speck. The eight rows of locomotive fringes run from pole to pole, dividing the whole surface of the body like the ribs on a melon. Hanging from either side of the body, a little above the area in which the eye-speck is placed, are two most extraordinary appendages in the shape of long tentacles, possessing such wonderful power of extension and contraction that, while at one moment they may be knotted into a little compact mass no bigger than a pin's head, drawn up close against the side of the body, or hidden within it, the next instant they may be floating behind it in various positions to a distance of half a yard and more, putting out at the same time soft plumy fringes along one side, like the beard of a feather. One who has never seen these animals may well be pardoned for doubting even the most literal and matter-of-fact account of these singular tentacles. There is no variety of curve or spiral that does not seem to be represented in their evolutions. Sometimes they unfold gradually, creeping out softly and slowly from a state of contraction, or again the little ball, hardly perceptible against the side of the body, drops suddenly to the bottom of the tank in which the animal is floating, and one thinks for a moment. so slight is the thread-like attachment, that it has actually fallen from the body; but watch a little longer, and all the filaments spread out along the side of the thread, it expands to its full length and breadth, and resumes all its graceful evolutions."

Agassiz divides these animals into the following families:—

1. EURYSTOMEÆ,—with large mouth, and no tentacles or lobes. Example, Idyia roseola Ag.

2. SACCATÆ,—with body more or less globular and long pinnate tentacles. Example, Pleurobrachia rhododactyla, Ag. (Fig. 78.)

3. TAENIATÆ,—with the body produced at the sides into two wide appendages. Example, Cestum Veneris.

4. LOBATÆ,—having the oral end of the body divided into two wide lobes. Example, Bolina alata, Ag.

Agassiz' "Contributions," Milne Edwards' Coralliaires, in the "Suites à Buffon," Greene's Manual of Cœlenterata, and Verrill on American Polyps, (Memoirs of Boston Society of Natural History,) may be consulted with advantage on this Province. American fossil species will be found in the reports of the Palæontology of New York and Canada, by Prof. Hall and Mr. Billings, and the general arrangement of the fossil forms in Nicholson's Palæontology.

CHAPTER V.

DESCRIPTIVE ZOOLOGY—*Continued.*

PROVINCE III.—ECHINODERMATA.

These creatures are the highest in rank of the old Cuvierian Radiata, and in their adult state and in their more typical forms, present very admirable examples of radial arrangement, though in some of the groups there is a decided approach to bilateral symmetry. With the exception of the lowest group, these animals are all free-moving, but not swimmers like the higher Acalephs. They have a nervous system, consisting of an æsophageal ring and radiating fibres. Organs of sense exist in some of the species. The alimentary canal is contained in a proper visceral cavity, and in some is tubular and convoluted. They have also a complex vascular system, including blood-vessels and aquiferous canals. Distinct respiratory organs exist only in the highest group. Their organs of sense are scarcely advanced beyond those of the Cœlenterata. All of these animals have a complex skeleton, quite distinct in character from that of any other animals, and consisting of numerous calcareous pieces articulated together, and composed of carbonate of lime arranged in a loose cellular manner, so as to combine great strength with lightness. This skeleton is properly internal to the muscles, but there are often added to it external spines or plates. The organs of locomotion are erectile thread-like organs with suctorial discs at their extremities (tube feet), placed in grooves or lines called ambulacra. There are also in many species minute stalked pincers for cleaning the surface of the body (pedicellariæ).

The reproduction of Echinodermata, in many of the groups, takes place by means of a free-swimming larva or pro-embryo of bilateral form, within which the young animal is developed; but in some species there is a direct development without metamorphosis, the eggs being protected in a marsupium.

The classes of Echinodermata are:—

1. *Crinoidea.*—Feather-stars and Encrinites.
2. *Ophiuridea.*—Serpent-stars, Sea Baskets.
3. *Asteroidea.*—Star-fishes.
4. *Echinoidea.*—Sea-urchins.
5. *Holothuridea.*—Sea-cucumbers, &c.

Class I.—Crinoidea.

These have a central body or disc, with or without articulated rays, and covered with an inflexible shelly case. The arms or rays when present are furnished with pinnate processes. Some of the species are attached for life by an articulated stem. Others are attached when young, free when adult.

In the absence of any known species of this group in our waters, the rosy Feather-star (*Antedon rosaceus*) of the European seas, may be taken as a type. In its earliest state it is an oval, gelatinous, locomotive creature, moving by bands of cilia. It then fixes itself and developes a jointed stem below, and a series of jointed and pinnated rays above, while the body becomes encased in delicate calcareous plates. After existing for some time in this state, it becomes loosed from its attachment, and appears as a locomotive Feather-star, with five pairs of beautiful

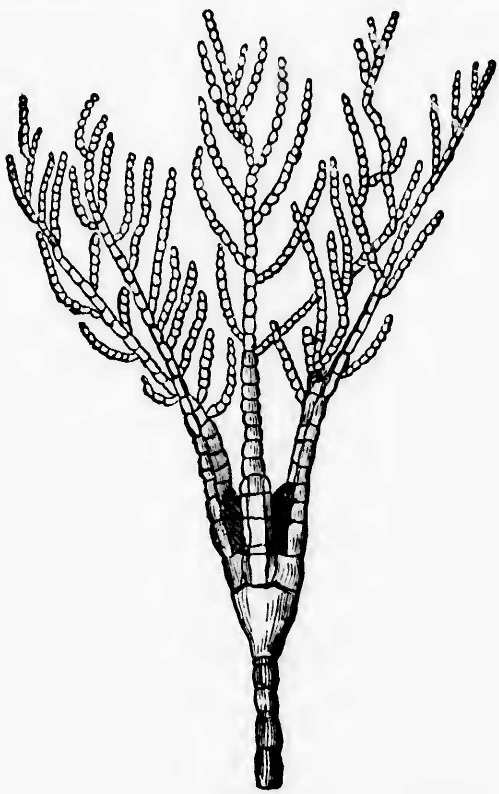


Fig. 79.—RHIZOCRINUS LOFOTENSIS (after Sars).

pinnate arms, on which are borne the reproductive organs in the form of small brownish spots; and which are also locomotive and prehensile organs. ***Antedon dentatus***, Verrill, the toothed feather-star, is found on the American coast, south of New England.

In the tropical seas there are a few larger species belonging to the genus Pentacrinus, which are attached when adult; and Sars has recently described a small species of a different genus (Rhizocrinus) from the coast of Norway (Fig. 79). A few others have been obtained in the deep sea dredgings of recent expeditions. These are the only living representatives of vast numbers of species of stalked crinoids, found abundantly

Fig. 80.—Pentacrinus caput-medusae.
West Indian seas, reduced, with articulating surfaces of joints.

as fossils in the rocks of the earth's crust, and sometimes constituting a great part of the substance of crinoidal limestones. Fig. 81 is a species of Glyptocrinus, from

Fig. 81.—GLYPTOCRINUS DECADACTYLUS, Siluro-cambrian. Body without arms or stalk.

the Siluro-cambrian. Fig. 82 is another Siluro-cambrian form.

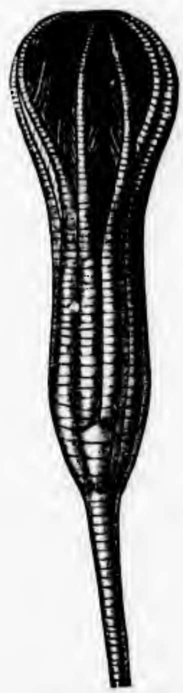


Fig. 82.—HETEROCRINUS SIMPLEX, Meck, Siluro-cambrian.

Besides the typical crinoids, there occur as fossils two other groups, known to us only by their skeletons, but included in this class. They are :—

Cystideæ.—Not divided in a quinate manner, but sac-like. Oral opening with valves. Arms few, and free or attached. The Cystideans are, as a whole, extinct, and belong to the Palæozoic rocks (Fig. 83), but a living

Fig. 83.—PLEUROCYSTITES SQUAMOSUS, Siluro-cambrian (after Billings).

species from Torres Strait has recently been described by Prof. Loven, under the name of Hyponome Sarsii.

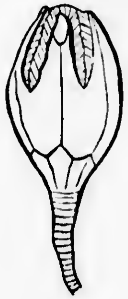


Fig. 84.—PENTREMITES PYRIFORMIS, Carboniferous, U States (after Dana).

Blastoideæ.—Body divided in a quinate manner, but without arms. These are the Pentremites. These creatures are all extinct, and are especially characteristic of the Carboniferous rocks in Western America (Fig. 84).

These groups are so distinct that they may be regarded as of ordinal value, and we may thus divide the Crinoidea into three orders—(1) *Brachiatæ*, or ordinary Crinoids with fully developed arms; (2) *Cystideæ*; (3) *Blastoideæ*.

Class II.—Ophiuridea.

These have a central disc protected by plates and furnished with tube-feet. The rays are simple or forked, and are supported internally by a series of articulated pieces, and in many protected externally by plates or by plates and spines. Fig. 85.

Fig. 85.—Ophiopholis aculeata, Lutken, Gaspé,—reduced.

This order is represented on our coasts by several beautiful species. *Ophiopholis aculeata*, the Daisy Brittle-star, *Ophioglypha robusta*, and *O. Sarsii*, may be obtained by dredging in many parts of the Gulf and River St. Lawrence, and the *Astrophyton*, of which two species are found in Canadian waters, is one of our finest Star-fishes, being sometimes eighteen inches in diameter, and its eight arms subdividing into many hundreds of filaments, each consistiug of a series of curiously-formed joints. This creature is known as the Sea-basket. *A. Agassizii* is our most common species.

Fig. 86 represents two of the calcareous joints of

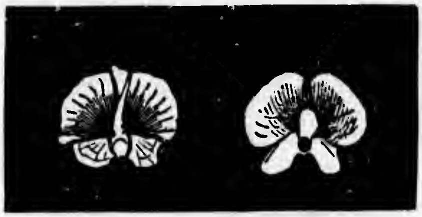


Fig. 86.—Joints of Ray of Ophioglypha Sarsii, Post-pliocene, magnified.

Ophioglypha Sarsii, a species found living at Gaspé and fossil in the Pleistocene clays.

The Ophiuridea may be divided into two orders, that of the *Ophiuridæ* proper with simple arms, and that of the *Euryalidæ* with branching arms, without protective plates on their surfaces.

Class III.—Asteroidea.

These have the disc and rays confluent, and the latter thick and traversed by ramifications of the digestive apparatus and generative organs, and furnished with rows of tube-feet along their lower sides.

As the type of this order may be taken *Asteracanthion*

(*Asterias*) *vulgaris* (Fig. 87). It is the representative on

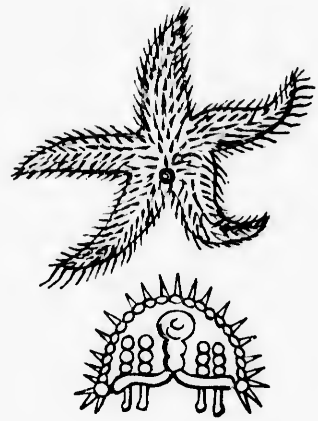


Fig. 87.—ARTERIAS VULGARIS, Stimpson, Atlantic Coast, reduced, and section of a ray showing tube-feet.

our coasts of the European *A. Rubens*, if not merely a variety of it. It is the common Star-fish, Sea-star, or Five-finger. Its upper surface is covered with calcareous spines, around the bases of which are little moveable pincers or pedicellariæ, useful in cleaning and defending the skin On the upper surface of the disc, but a little to one side, is a perforated plate, the madreporic plate, acting as a filter for enabling pure sea-water to enter the aquiferous system of the animal. At the end of the rays are minute purple specks, supposed to be the organs of vision. On the under side the mouth is situated in the centre, and is furnished with an extensile proboscis, which the creature uses to suck out the soft parts of the animals on which it feeds. Extending outward from the mouth, along the under sides of the rays, are the ambulacral grooves, each containing four rows of tube-feet and bordered by spines. In the interior, the centre of the disc is occupied by the stomach, which sends forth complicated ramifications into each ray. Below these are rows of sacs connected with the bases of the tube-feet without, and with the aquiferous system within. Around the mouth is the annular nerve-cord, and also the arterial ring, the principal organ of the circulation. The ovaries are placed around the oral opening. The eggs are hatched into oval ciliated swimming pro-embryos, which become developed in the first instance into bilateral gelatinous creatures with long ciliated processes, and totally unlike the adult, which is produced within the pro-embryo and subsequently escapes. The Star-fishes are slow in their movements, and destitute of offensive weapons. They are, however, carnivorous, and devour shell-fishes and other animals which come within their reach.

Several species of Star-fishes occur in Canada The *Asterias polaris* is the six-rayed Star-fish of the Lower St. Lawrence and Labrador. The Sun-star, *Solaster papposa* is a fine species, with a large disc and twelve to fourteen short rays. *Solaster endeca* has longer and less spinous rays, from nine to twelve in number. *Hippaster phrygiana* and *Ctenodiscus crispatus* are two pentagonal Star-fishes found on the coast of Nova Scotia. Another common species is the smooth, red Star-fish, *Cribrella sanguinolenta* Lutken.

A few species of fossil Star-fishes occur in the

Silurian rocks of Canada. Fig. 88 represents one of these.

Fig. 88.—PALÆASTER NIAGARENSIS, Hall—Upper Silurian

The Star-fishes may be divided into four orders :

1. *Asteriadæ* or typical star-fishes, with four rows of tube-feet in each ambulacral groove.
2. *Solastridæ*, with two rows of tube-feet in the ambulacral grooves.
3. *Astropectinidæ*, with conical and imperfect feet in two rows and no anus.
4. *Brysingidæ*, with slender rays, having only a narrow internal cavity in each.

CLASS IV.—ECHINOIDEA.

Rays obsolete, the skeleton a case or box enclosing the viscera, with spines articulated upon it, and tube-feet projected through rows of ambulacral pores.

The most common Sea-urchin of our coast is *Echinus* (*Toxopneustes**) *Drobachiensis*, so called from the port of

* *Eurechinus* of some authors.

Drobach in Norway, where it was first observed (Fig. 89.)

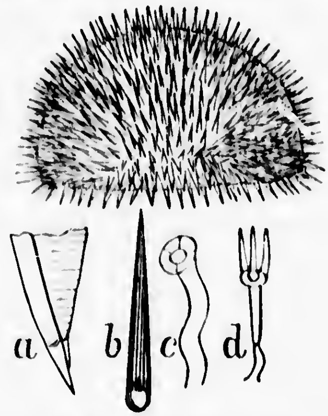


Fig. 89.—ECHINUS DROBACHIENSIS, Tadousac, reduced.
a—Portion of Jaw. b—Spine.
c—Tube-foot, enlarged. d—Pedicellaria, enlarged.

A second species or well-marked variety, *E. granulatus* of Lutken, is, however, also found on the coast of Nova Scotia. The first mentioned presents externally the appearance of a flattened sphere covered with sharp greenish spines, beyond which it can extend rows of long thread-like suckers or tube-feet, by means of which it drags itself along. Every spine of the hundreds which clothe the creature is articulated on a ball and socket joint, and moved by muscles in every direction, and the tube-feet are provided with complicated chains of little hooked bones, and with plates to extend the suckers at their extremities. There are also intermixed with the spines numerous three-pointed pedicellariæ. The mouth is at the base of the sphere, and is furnished with a singular apparatus of five jaws, each with a chisel-shaped tooth, the whole meeting in a point and worked by numerous muscles. The creature uses these teeth in browsing on the small sea-weeds that clothe the rocks and stones on the bottoms on which it feeds. In the common European species this dental apparatus is the so-called "Lantern of Aristotle," or more correctly the "Cresset" of the great Greek naturalist, who described it in his Zoology. In our species it is smaller but of similar structure. The anus, the five eye-specks, and the openings of the ovaries, are situated at the upper pole. The shell is composed of pentagonal plates which grow by additions to their edges. In the interior of the shell the principal organs visible are the intestinal canal, curved in a series of loops, and usually filled with pellets of comminuted sea weed; and the five large yellow ovaries, at certain seasons distended with ova. The only other species found on our coast is the Cake-urchin, flat or disc-like in form, and with very small spines. It is the *Echinarachnius parma*.

The Echinoidea may be divided into four orders:

1. *Palæchinida*, with more than twenty rows of plates and mostly fossil.
2. *Cidaridea* or ordinary sea-urchins, with central mouth and equal ambulacra.
3. *Clypeastridea*, with flattened shell, central mouth and very small tube-feet.
4. *Spatangidea*, heart shape in form, mouth and arms not central and no teeth or jaws.

The Echinoidea first appear in the Upper Silurian. *Palæchinus ellipticus* (McCoy), Fig. 90, is a carboniferous species.

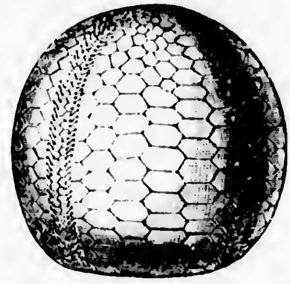


Fig. 90.—PALÆCHINUS ELLIPTICUS, McCoy, Carboniferous.

CLASS V.—HOLOTHURIDEA.

Body elongated and horizontal, sometimes bilateral, and covered above with spines or irregular plates. Though abberrant in form, some of these creatures are very complex in organization, and are furnished with special respiratory tubes. Some of the species resemble worms in their external form.

One of the best known representatives of this order on our coasts is the *Psolus* (*Cuvieria*) *Fabricii*. (Fig. 91.)

Fig. 91.—PSOLUS FABRICII, Gaspé,—reduced.

It is of a bright red colour and oval form, and covered with flat irregular scales, and when alive, can extend anteriorly a large proboscis divided into numerous processes. It creeps along the bottom by tube-feet protruding from the lower side, which is covered with a tough membrane. Specimens, from three to five inches in length, may be dredged in the Lower St. Lawrence and at Gaspé. It is called "Sea Orange" by the fishermen.

Another representative of this order is the Sea-cucumber (*Pentactes frondosa.*) It has spines instead of scales, and has five rows of tube feet, so that it may be compared to a rayless Star-fish greatly lengthened out.

To this group belong the great Sea-slugs of the Indian Ocean, eaten by the Malays under the name of Trepang.

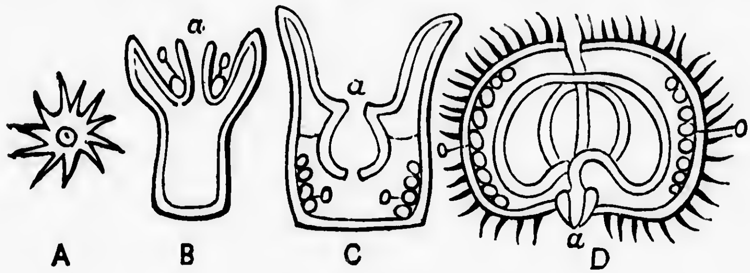
The Holothurians are usually divided into two orders :

1. *Apoda*, without ambulacral feet, and usually without distinct respiratory apparatus.
2. *Pedata*, with numerous ambulacral feet.

The Holothurians are not known as fossils, except in the more modern formations. Plates of a species of *Psolus* are found in the Pleistocene of Canada.

Note on Relations of the Three Lower Provinces of Animals.

Though I have adopted the new divisions of the old Cuvierian Radiata, it is certain that one great leading type or plan of structure prevades the whole, and distinguishes them from the other leading divisions. To illustrate this I reproduce four rough diagramatic figures from the first edition, and which show the relative



DIAGRAMS OF RADIATES.

A—Protozoan. B—Hydroid C—Anthozoon. D—Echinoderm.
a—Mouth. *o*—Ovary.

positions of the prehensile, digestive and ovarian systems in the Protozoa, Hydroids, Anthozoa, and Echinoderms. It will be seen from these that, while there is a progressive advance in complexity, there is a general identity of plan.

CHAPTER VI.

DESCRIPTIVE ZOOLOGY—*Continued.*

PROVINCE IV.—MOLLUSCA.

The typical Mollusca, of which the ordinary bivalve shell-fishes like the oyster and cockle, the univalve shell-fishes like the snails, whelks, &c., and the cuttle-fishes and their allies, may be taken as examples, are unjointed and unsegmented animals, having the body covered with a membranous and muscular sac called the mantle, and destitute of any true locomotive skeleton, though often protected with a calcareous shell or shelly valves. The greater part are like the animals of the previous provinces,—aquatic; but a few are adapted to life in the air, and to aerial respiration. In addition to the more typical members of this province, there are three groups, the *Polyzoa*, the *Brachiopoda*, and the *Tunicata*, which though wanting in some of the characteristics of Mollusca proper, have usually been placed in this division, and may be provisionally retained in it, constituting a low and imperfect group to which the name *Molluscoidea*, or Mollusk-like animals has been applied.

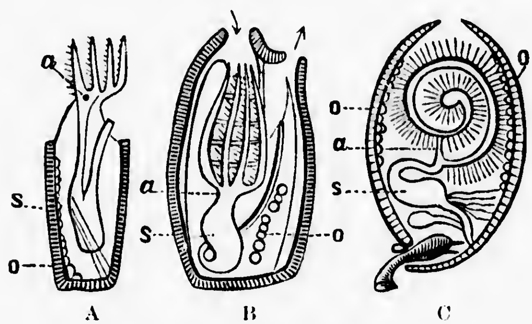
The classes of the Mollusca will thus be four, as follows :—

1. *Molluscoidea*, including Polyzoa, Bryozoa, or Moss-animals; Brachiopods or Lamp-shells and Tunicates.

2. *Lamellibranchiata*, including the ordinary bivalve shell-fishes.
3. *Gastropoda*, including the univalve shell-fishes and their allies.
4. *Cephalopoda*, including the Cuttle-fishes, Nautili, and allied animals.

Class I.—Molluscoidea.

Animals mostly attached, and often aggregative in communities; destitute of organs of special sense. Heart simple or at once systemic and branchial. No special respiratory organs. Food obtained by ciliated tentacular organs.



DIAGRAMS OF MOLLUSCOIDEA.

Fig. 92.—A—Polyzoon. B—Tunicate. C—Brachiopod.
a—Mouth. *s*—Stomach. *o*—Ovaries.

The simplest of these Molluscoids, the moss animals or Bryozoa or Polyzoa, are scarcely above the cœlenterates in grade of complexity, yet are distinct from them in plan of structure, in which they rather resemble embryo or undeveloped mollusks, and are also connected with the other molluscoids. The other groups of this class, the Tunicates and Brachiopods, seem to connect the Bryozoans with the typical Mollusks, but along two different lines of development. The Tunicates present the greatest development of the merely nutritive organs, the Brachiopods that of the muscular and circulating systems; but both, as the position of the class would imply, are deficient in nervous and sensory apparatus, though in the former the Brachiopods appear to be decidedly superior. The orders of Molluscoidea may be defined as follows :—

Order 1. *Polyzoa or Bryozoa.*—Nutrition by means of ciliated tentacles—animals often aggregated and enclosed in a Polyzoary. These are the Sea-mats and their allies; creatures popularly confounded with Sea-weeds and with Sertularians, &c. They are principally marine, but some live in fresh water. (Fig. 92 A.)

Order 2. *Tunicata.*—Body unsymmetrical; integument an uncalcified tunic having two openings and lined by the mantle. Cilia for producing currents of water disposed on an inner tunic or band representing the tentacles. These are the Ascidians and their allies, sac-shaped or bottle-shaped Mollusks. The Tunicates are all marine. (Fig. 92 B.)

Order 3. *Brachiopoda.*—Body symmetrical; shell dorso-ventral; mantle in two lobes adhering to the shell. Tentacles two, fringed, usually spiral. Shell usually with supports for the arms or tentacles. These are the Lamp-shells and their allies, curious little bivalves differing much from the ordinary bivalve shell-fish, and few in species in the modern seas, but very abundant as fossils. Their name is derived from the two long ciliated arms attached to the sides of the mouth, and serving to bring within reach of the animal the minute organisms on which it feeds. The Brachiopods are all marine. (Fig. 92 C.)

Order 1.—Polyzoa or Bryozoa.

Any one who has visited the sea-coast must have observed, attached to sea-weeds, thin whitish crusts, which, when carefully examined, are seen to consist of little oval cells often with delicate spines at their extremities. These are the skeletons of Bryozoa of the genus *Membranipora*. If taken from the sea alive and kept in a glass of sea-water, the microscope will show that each cell is inhabited by a separate animal of somewhat complex structure.

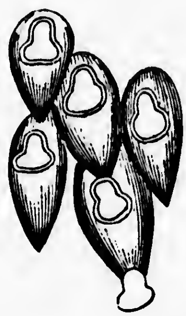


Fig. 93.—Membranipora solida, Packard, Gulf St. Lawrence, (Magnified.)

The cell is lined by a thin inner membrane. Within this is seen a clear fluid having minute granules floating in it, and in the centre is seen the stomach, floating freely, except that it is attached below to the bottom of the cavity by muscular bands. The stomach is usually of a dark brownish colour, and is bent upon itself; one arm, the œsophagus, opening in the centre of a disc (lophophore) surrounded by processes provided with cilia; the other arm, the intestine, opening outside the disc. In the upper part of the stomach is seen a muscular gizzard for the trituration of the food. Each of these little animals can extend its tentacles and create brisk currents of water, or retract itself wholly into its cell. The ovaries are contained within, in the perigastric space, and the germs are free and ciliated in the marine forms. In the Membranipora they are hatched in a sort of hood or ovicapsule

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Fig. 94.—LEPRALIA PERTUSA Johnston—Gulf St. Lawrence.

Fig. 95.—L. HYALINA Lin—Gulf St. Lawrence.

attached to the cell. The animals multiply by gemmation so as to spread in a crust over the surface, and there is a communication between the perigastric spaces of the individuals, so that nutriment may be conveyed from one to another.

The *Membranipora* above referred to is only one of many forms of Bryozoa found in our waters. On stones and dead shells other encrusting forms, (*Lepralia*, *Hippothoa*, Figs. 94 to 99) may be found; other species

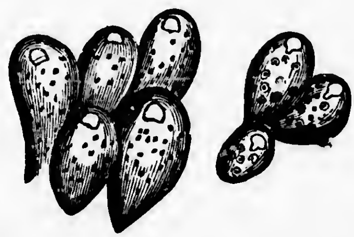

Fig. 96.—L. PRODUCTA, Packard,—Gulf St. Lawrence.

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Fig. 97.—HIPPOTHOA CATENULATA, Fleming.
Fig. 98.—H. DIVARICATA, Lm.
Fig. 99.—TUBULIPORA FLABELLARIS, Fabricius. (All magnified.)

build their cells in slender branches or broad leaves, either soft or flexible (Figs. 100 and 101) or hard and

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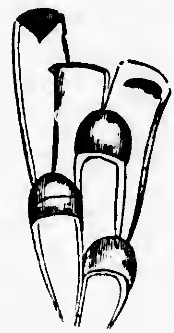


Fig. 100.—MENIPEA FRUTICOSA, Packard, Gulf St. Lawrence.

Fig. 101.—HALOPHILA BOREALIS, Packard, Gulf St. Lawrence.
(Both magnified.)

stony (Fig. 102). Some of the latter have the aspect of

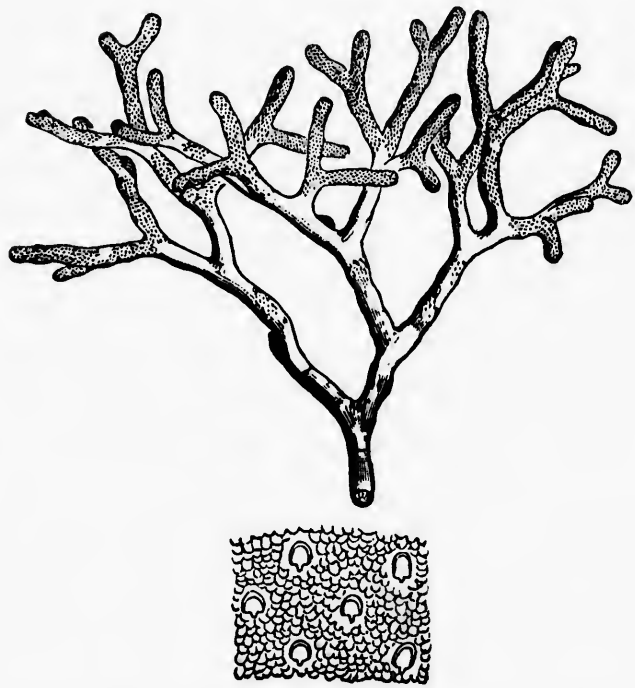


Fig. 102.—MYRIOZOUM SUBGRACILE, D'Orbigny, Gulf St. Lawrence, natural size.
a—Cells of the same magnified.

small corals. Other species (*Halodactylus*) are imbedded in a dense mucilaginous substance arranged in thick branches, in which the coloured stomachs of the animals are seen as little specks. In the fresh water there are many interesting forms which constitute gelatinous masses or are found in slender groups of membranous or corneous cells attached to aquatic plants and other bodies in streams, ponds and lakes. The fresh-water species produce curious winter eggs (statoblasts), which perpetuate their existence through the winter months when the adults have perished. In the limestones of the Silurian, Devonian and Carboniferous periods, many species are found fossil, of the genera Ptilodictya, Fenestella, &c. (Figs. 103 and 104). Several species are also fossil in the Post-pliocene clays (Fig. 105).

The animals in this order, while minute in size and very similar in the structure of the individuals, present a vast number of specific and generic forms, distinguishable from each other by the shapes and arrangements of the cells, and are consequently very curious objects of microscopic investigation.

The simplest mode of classification divides them into sub-orders, in accordance with the forms of the cells and the material of which they are composed, and with reference also to the habitat of the animal and the structure of its disc or Lophophore.

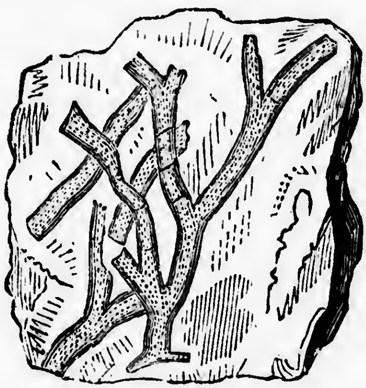


Fig. 103.—PTILODICTYA ACUTA, Hall,—L. Silurian.

Sub-order 1. CHEILOSTOMATA, or those with the mouth of the horny or calcareous cell in two lips, includes a great number of marine species belonging to the genera Lepralia, Hippothoa, Membranipora. Flustra, Cellularia, &c.

Sub-order 2. CYCLOSTOMATA, or those with circular mouths, includes the marine genera Tubulipora, Crisia, Idmonea. &c.

Sub-order 3. CTENOSTOMATA contains species with the mouth of the cell protected by a circle of moveable spines. Example, Bowerbankia.

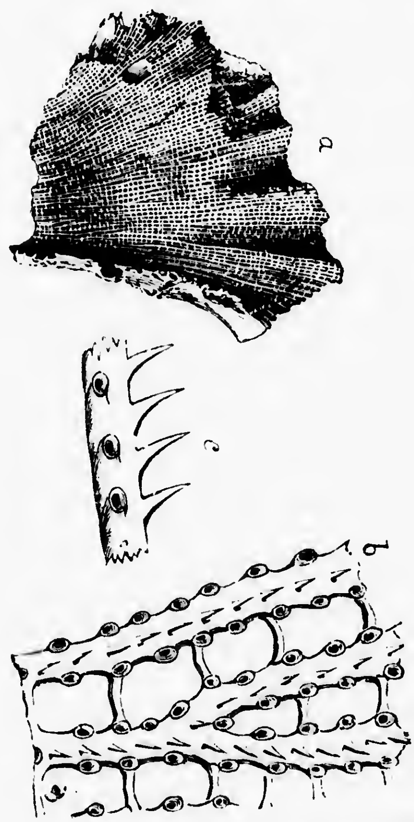


Fig. 104.—FENESTELLA LYELLI, Dawson,—Carboniferous.
b. c —Parts enlarged to show the cells.

Sub-order 4. PEDICELLINEA. In these the cells are supported on a stalk or pedicel. Example, Pedicœllina.

Sub-order 5. LOPHOPHEA. These are fresh-water species having the disc or Lophophore divided into two branches like a horse-shoe, and the investing substance gelatinous. Example, Fredericella, Pectinatella, Cristatella.

Sub-order 6. PALUDICELLEA. These are fresh-water species like the above, but with the disc circular. Example, Paludicella.

The curious *Urnatella gracilis* of Leidy, is by some regarded as the type of a separate group. It is a fresh-water species found in the Schuylkill River.

The first four groups are the *Phylactolæmata* of Allman, having an epistome at the mouth. The two last are *Gymnolæmata*, having no epistome.

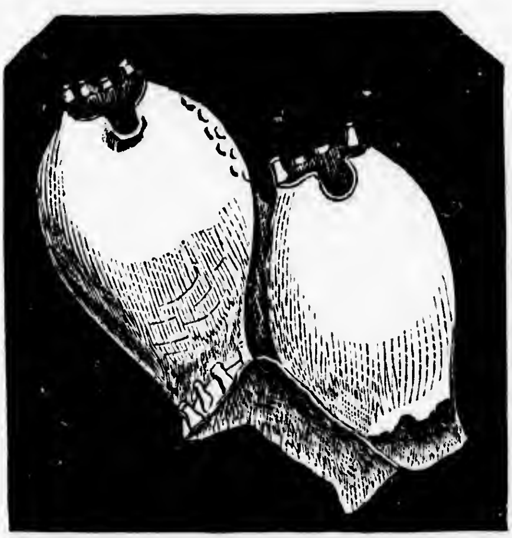


Fig. 105.—LEPRALIA QUADRICORNUTA, Dawson, Post-pilocene, Montreal.

ORDER 2.—TUNICATA.

Externally these creatures are among the most uninteresting of the Mollusks, their whole bodies being enclosed in a uniform sac-like coat. A species of *Boltenia*, (*B. Bolteni*, Lin.) presenting externally the appearance of a leathery sac, supported on a stalk, is not uncommon on our coasts (Fig 106). The sac has two

Fig. 106.—BOLTENIA BOLTENI, Lin., Gulf St. Lawrence. Young specimen.

apertures (incurrent and excurrent), and when the animal is alive, the sea-water is drawn into one of these and expelled from the other by the alternate contraction and expansion of the sac. On dissecting the outer tunic, this is found to be lined with a muscular sac, which is the true mantle, and by the contraction of which water is expelled from the interior, while it is re-admitted by the elastic expansion of the outer tunic. Within the muscular sac is a delicate membranous ciliated organ, the respiratory sac, along the surface of which the water entering by the entrant aperture is carried by the motion of the cilia, and the nutritive matter which it contains wafted toward the mouth which lies near the bottom of the sac. The intestine doubles round and empties at the excurrent aperture, toward which also the opening of the ovarian ducts is directed. The creature, thus constituted, remains attached at the bottom of the sea, and its actions are limited to the rythmical contraction and expansion of the tunic, by which water is continually introduced, and brings with it microscopic organisms on which the tunicate feeds.

The same action subserves the function of respiration.

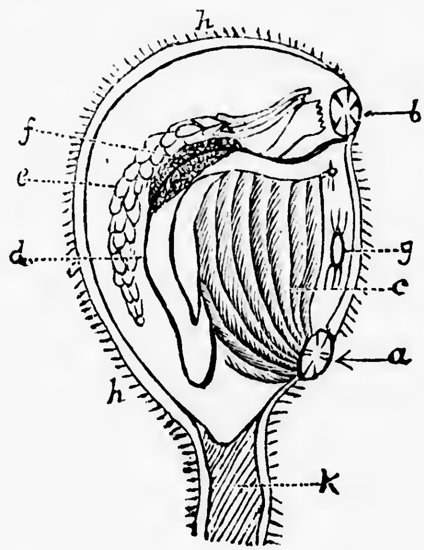


Fig. 107.—BOLTENIA, diagrammatic section.

a—Incurrent aperture. *b*—Excurrent aperture. *c*—Respiratory sac. *d*—Stomach. *e*—Ovary. *f*—Liver. *g*—Nerve mass. *h*—Tunic. *k*—Stem.

In addition to the Boltenia, we have several species of *Cynthia* and *Ascidia*, one of which, *Cynthia echinata*, is remarkable for its covering of stiff branching bristles. Another species, *Didemnium roseum* exists in compound communities, encrusting sponges and sea-weeds. Packard has dredged it at Hopedale, Labrador; and at Eastport, Maine; and Whiteaves has found it at Gaspé.

There are other species of smaller size, some of them highly coloured, and others perfectly pellucid, so that the internal organs are distinctly visible through the tunic, but all may be distinguished by the sac-like tunic and the two apertures.

All the species found on our coast belong to the first sub-order of Tunicates, that of the *Ascidiae*, which also includes the remarkable *Pryosomidae* of the warmer seas, freely moving forms in which the animals are grouped in radiating series in the walls of a hollow cylinder closed at one end, and said to be impelled by the reaction of the water sent forth from the excurrent apertures.

A second sub-order, *Biphora*, includes the *Salpidæ*, also inhabitants of the warmer seas, and floating in chain-like bands of individuals, which, however, produce ova from which solitary individuals are hatched, and these in turn develope within their bodies colonies of banded Salpae. The Salpas and the Pyrosomas are gifted with that luminosity in the dark which is the property of so many marine animals.

The nervous system in Tunicates is represented by a single ganglion usually placed in the vicinity of the apertures, or in the back of the respiratory sac, and giving off a number of minute nerves. There are pigment masses or eye-specks at the apertures, and in some there are auditory vesicles and olfactory pits.

The young of the Ascidians is provided with a swimming tail, having in it a gelatinous axis, and with a nerve fibre and muscles for locomotion. In this stage the larva resembles so closely the embryo of some fishes that it has been considered as a link connecting the Tunicates with the Vertebrates. It soon, however, loses the swimming tail, attaches itself by means of tubercles at the opposite extremity of the sac, and becomes developed into a fixed Ascidian.

ORDER 3.--BRACHIOPODA.

Of these curious and rare bivalve shell-fish, only a few species are found on our coasts. The most common is *Rhynchonella psittacea*, the parrot's-bill Rhynchonella (Fig. 108). It is a little horny bivalve shell, with one

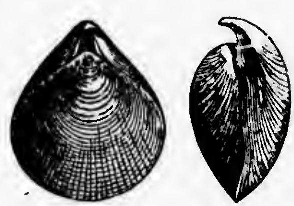


Fig. 108.--RHYNCHONELLA PSITTACEA, Lin. Gulf St. Lawrence.

valve, the dorsal, smaller than the other, the beak of which projects and has a notch (foramen) below, through which passes a stalk or pedicel for attachment. The interior of the shell is lined with the two valves of the mantle, and is occupied principally with the two fringed and ciliated arms coiled like cork-screws (Fig. 109). At the base of these is the mouth leading to a small stomach

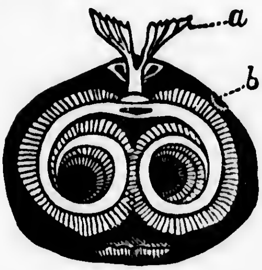


Fig. 109.—RHYNCHONELLA PSITTACEA.
Interior of dorsal valve, showing (*a*) adductor muscles, and (*b*) spiral arms : drawn from a specimen dredged at Gaspé, — natural size.

and short intestine. It has a more complicated nervous and circulating system than that of the Tunicates, and has several pairs of muscles placed near the hinge for opening and closing the shell and regulating the movements of the creature on its pedicel. The Rhynchonella is found attached to stones and dead shells in moderately deep water.

In addition to this species we have on our coasts *Terebratulina septentrionalis*, of more elongated form than the above-named species, ribbed longitudinally, with a round perforation at the beak, instead of a notch, and with an internal shelly loop. Other species found on our coasts are *Waldheimia cranium* and *Terebratella Spitzbergensis*, a northern form found in Labrador, and also fossil in the post-pliocene clay of Rivière du Loup. *Waldheimia cranium* has as yet been found only on the coast of Nova Scotia, by Willis. It has been ascertained that the young of some Brachiopods much resemble Polyzoa in form and structure. (Morse.)

Though recent Brachiopods are few in species, vast numbers are found fossil. Mr. Billings' catalogues include nearly 100 species, from the lower Silurian alone, in Canada; and Dr. Bigsby in his Thesaurus Siluricus, enumerates 429 species from the Silurian of America, whereas less than 100 living species are known in the whole world at present.

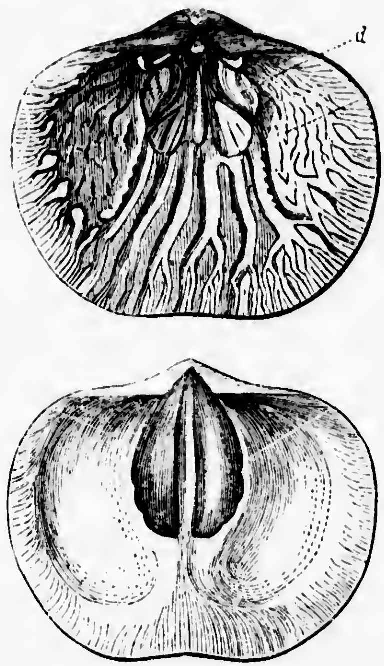


Fig. 110.—ORTHIS STRIATULA, after Woodward.

(A) Dorsal valve, showing the muscular impressions at (*d*); also the vascular impressions of the mantle, and the notch, tooth and brachial processes in the hinge.

(B) Ventral valve, showing the impressions of the hinge and pedicel muscles.

Many of the fossil Brachiopods differ considerably from those that are recent, and are placed in different families. We can recognize their general resemblance to the modern forms by the impressions of the mantle and muscles on the valves. Fig. 110 represents the interior of the dorsal and ventral valves of an Orthis, showing the muscular and mantle impressions, teeth and foramen.

The families of Brachiopods are the following, the greater part being now extinct :—

1. TEREBRATULIDÆ.—Shell minutely punctate ; ventral valve perforated and with two curved hinge teeth, dorsal valve with a cardinal process between the dental sockets, and a shelly loop supporting the arms. Recent and fossil. Examples,—Terebratula, Waldheima, Terebratella, Rensellæria (Figs. 111, 112).

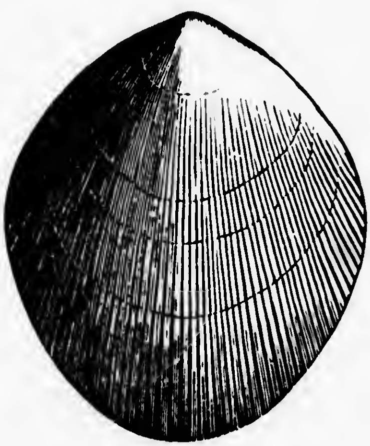


Fig. 111 —RENSELLÆRIA OVALIS, Hall, Devonian.

Fig. 112.—TEREBRATULA SACCULUS, Martin,—Carboniferous, with interior showing the loop.

2. SPIRIFERIDÆ.—Shell with two spiral shelly supports in the interior. Dorsal valve with a notch. Hinge line often long and straight. Fossil Examples: Spirifer, Athyris (Figs. 113, 116).

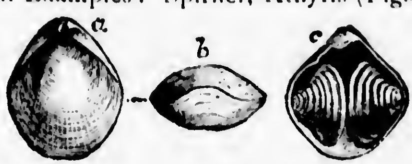


Fig. 113.—ATHYRIS SUBTILITA, Hall,—Carboniferous, with interior (c) showing spiral supports for the arms.

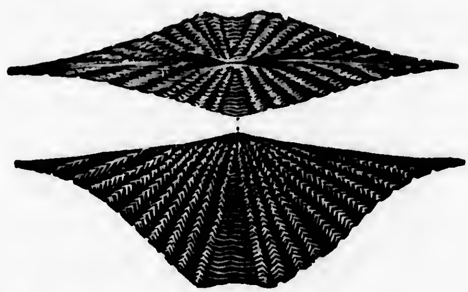


Fig. 114.—SPIRIFER MUCRONATUS, Hall, Devonian,

Fig. 115.—SPIRIFER VARICOSA, Hall, Devonian.

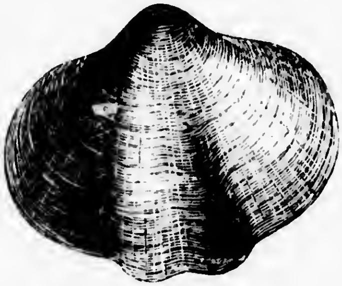


Fig. 116.—SPIRIFER GLABER, Martin, Carboniferous.

3. RHYNCHONELLIDÆ.—Shell not punctate, hinge line curved, Foramen under beak. Supports short or rarely spiral. Recent and fossil. Examples: Rhynchonella, Atrypa, Pentamerus. (Figs. 117 to 121, also Figs. 108, 109.)

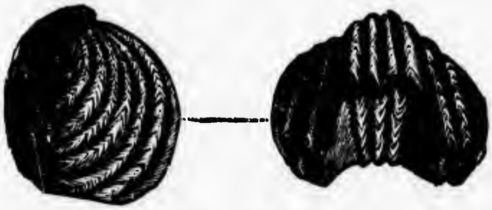


Fig. 117.—RHYNCHONELLA INCREBRESCENS, Hall.—Siluro-cambrian.

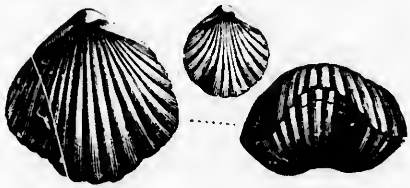


Fig. 118.—RHYNCHONELLA ACADIENSIS, Davidson,—Carboniferous.

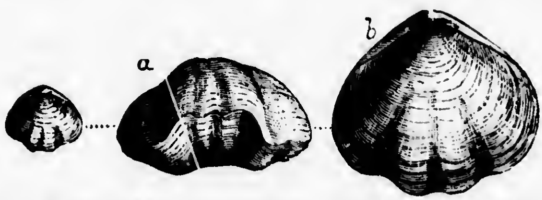


Fig. 119.—RHYNCHONELLA DAWSONIANA, Davidson, Carboniferous.

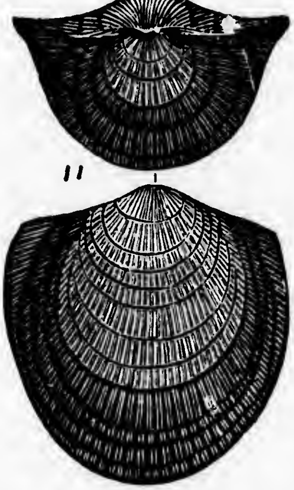


Fig. 120.—Atrypa reticularis, Lin,—Silurian.

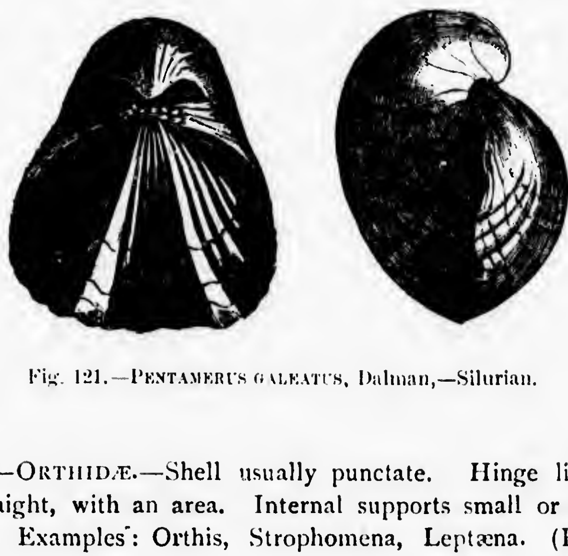


Fig. 121.—Pentamerus galeatus, Dalman,—Silurian.

4.—Orthidæ.—Shell usually punctate. Hinge line wide and straight, with an area. Internal supports small or wanting. Fossil. Examples: Orthis, Strophomena, Leptæna. (Figs. 122 to 127.)

Fig. 122.

Fig. 123.

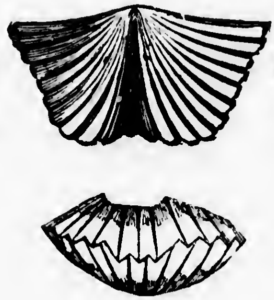


Fig. 124.

122. Orthis testudinaria, Dalman,—Siluro-cambrian.
123. O. lnyx, Eich,—Siluro-cambrian (with front view).
124. O. pectinella, Conrad,—Siluro-cambrian.

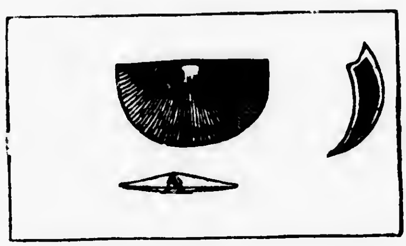


Fig. 125.—Leptæna sericea, Sow,—Siluro-cambrian. With diagram of hinge area and notch, and cross section showing the convex and concave sides.

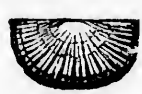


Fig. 126.—Orthis Billingsi, Hartt,—Cambrian.

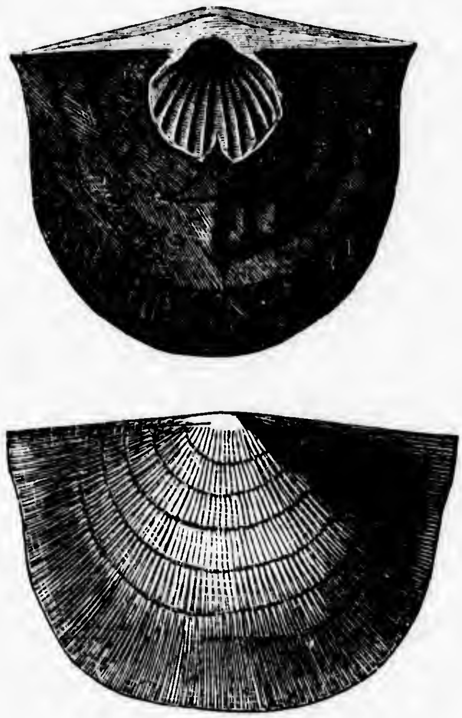


Fig. 127.—STROPHOMENA FILITEXTA, Hall. Siluro-cambrian, interior, showing muscular impressions, and exterior.

5. PRODUCTIDÆ.—Shell concavo-convex. Hinge line straight. Tubular spines on the surface. Fossil. Examples: Productus, Chonetes (Figs. 128, 131).

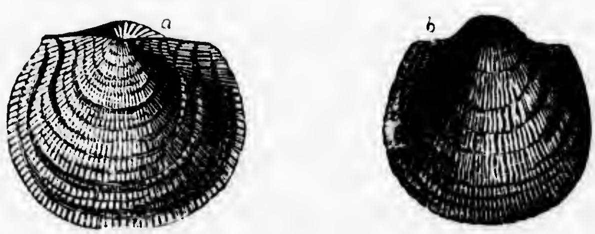


Fig. 128.—PRODUCTUS CORA, D'Orbigny,—Carboniferous.

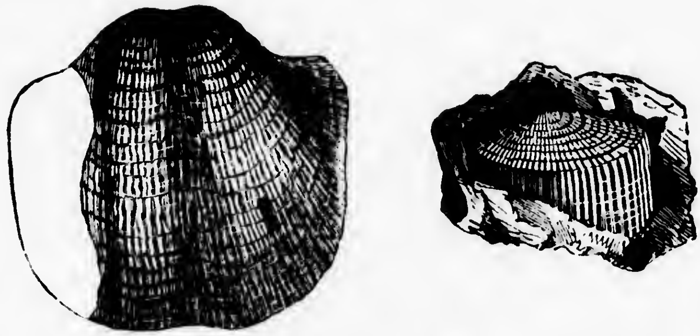
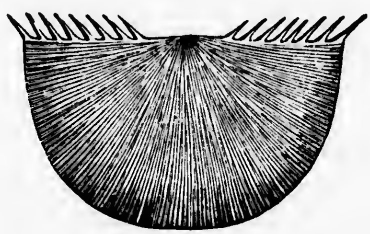


Fig. 129.—PRODUCTUS SEMIRETICULATUS, Martin.—Carboniferous.

Fig. 130.—CHONETES NOVASCOTICA, Hall, Silurian. with sculpture and spine magnified.



Fig, 131.—CHONETES, Sp., showing the spines.

6. CRANIADÆ.—Shell rounded, hingeless, usually attached by the ventral valve. Dorsal valve shaped like a limpet. Recent and fossil. Example: Crania (132).

Fig. 132.—CRANIA ACADIENSIS, Hall, Silurian. Ventral valve, natural size and magnified.

7. DISCINIDÆ.—Resembling Crania, but attached by a peduncle passing through a foramen in the ventral valve. Recent and fossil. Examples: Discina, Trematis (Fig. 133).

Fig. 133.—DISCINA CIRCE, Billings,—L. Silurian.

Fig. 134.—LINGULA QUADRATA, Eich,—L. Silurian.
Fig. 135.—LINGULELLA MATHEWI, Hartt,—Primordial.

Fig. 136.—LINGULA ANATINA,—modern, with flexible peduncle.

8. LINGULIDÆ.—Shell sub-equivalve with a long peduncle passing between the valves. Texture horny, minutely tubular. Material, phosphate of lime. Recent and fossil. Examples: Lingula, Obolus, Obolella (Figs. 134, 135).

On Brachiopoda the student may consult Woodward's Manual of Mollusca; Davidson's Fossil Brachiopoda in Pubs. of Palæont Society. For Canadian Fossil Brachiopods, Billings in Reports of Canadian Survey; Hall's Palæontology of New York; Dawson's Acadian Geology.

CLASS II.—LAMELLIBRANCHIATA.

Body bilaterally symmetrical, with a dextro-sinistral bivalve shell; mantle lining the shell, more or less closed; mouth with two pairs of labial appendages; heart of two or three cavities; gills lamelliform, in two pairs. Embryo usually swimming by a ciliated velum; adult creeping or burrowing by muscular foot or destitute of locomotive organs.

The Lamellibranchiates are the ordinary Bivalve Shellfish, as the Oyster, Clam, Cockle, &c. Their shells are not dorso-ventral, as in the Brachiopods, but placed on the sides of the body. Hence they are usually equivalve, and not equilateral; though there are not a few exceptions to this. They have no orifice at the beak for attachment, and very rarely any internal processes.

The animal has the two leaves of the mantle more or less closed. The mouth is furnished with four labial processes not ciliated. The gills are arranged in four lamellæ or plates, and not only serve for respiration, but, by the currents of water produced by their cilia, to waft food to the mouth. They also serve as a convenient hatching-place for the ova. The heart consists either of one auricle and one ventricle or of two auricles and one ventricle, and is systemic, that is, it drives the blood into the general circulation and receives it back from the gills. The nervous system consists of three pairs of ganglia—one pair at the sides of the mouth (cerebral), another at the base of the foot (pedal), and a third near the posterior adductor muscle (visceral). These are connected by nervous fibres. There are auditory vesicles near the pedal ganglia, and eye-specks which in some of the burrowing species are placed at the ends of the respiratory tubes, and in others are on the edge of the mantle. A few lamellibranchiates are viviparous and in the greater number the young, which have no proper metamorphosis, are nursed for a time in the gills of the parent. Most Lamellibranchiates are diecious. The foot, above mentioned, is a fleshy or muscular organ capable of being used for locomotion or for burrowing. In some genera

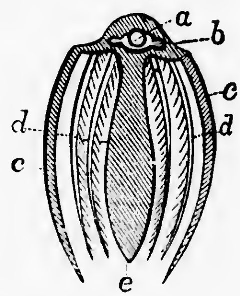


Fig. 137.—Section of a Lamellibranchiate.

a Alimentary Canal. b—Heart. c—Mantle. d—Gills. e—Foot.

it is absent. The adductor muscles are strong bands of muscular fibre serving to close the shell, which is opened, not by muscular effort, but by the elasticity of a pad or internal ligament placed in the hinge. The general arrangement of parts in a lamellibranchiate may be represented by a diagram of the cross section. (Fig. 137.)

The shell of animals of this class is composed of three coats or layers. (1) The Epidermis, of a horny consistency, and serving as an external coating or varnish. (2) Prismatic shell, composed of six-sided prisms of carbonate of lime, placed at right angles to the plane of the shell, and cemented with animal matter. (3) Lamellar shell, composed of laminæ of carbonate of lime and animal matter, and lining the interior. This last kind of shell, when the laminæ are very thin, becomes pearly; and the lustre is sometimes enhanced by the

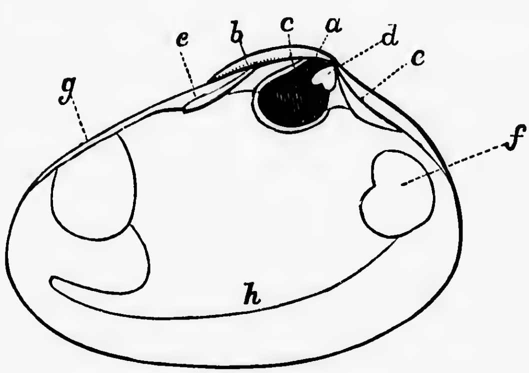


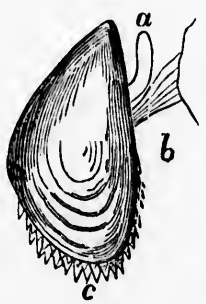
Fig. 138.—Interior of shell of Mactra.

a—Umbo. *b*—Exterior Ligament. *c*—Interior Ligament. *d*—Hinge tooth. *e*—Lateral teeth, *f*—Anterior adductor. *g*—Posterior adductor. *h*—Pallial impression, with sinus between it and posterior adductor. In this figure the hinge is somewhat exaggerated for the sake of distinctness.

corrugation of the laminæ. Pearls are concretions of lamellar shell formed in the mantle in consequence of injury or disease. The mantle not only lines the interior of the shell but is the organ by which it is deposited. The Lamellibranchiates are sometimes named *Conchifera.*

The parts recognised in the shell of a Lamellibranchiate, and the terms used in their description are indicated in the diagram (Fig. 138).

The Lamellibranchiates may be conveniently divided into (1) Asiphonida, or those which have no tubes or siphons. (2) Siphonida, or those which have two tubes or siphons serving for the entrance and emission of water. These last are the most numerous, and usually burrow in sand or other substances, using their siphons, which are sometimes very long, to admit water to the gills. Figs. 139, 140 show the appearance of an asiphonide and a siphonide species.



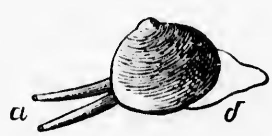


Fig. 139.—MYTILUS EDULIS, Lin.. *a*—Foot. *b*—Byssus. *c*—Margin of mantle.
Fig. 140.—TELLINA GROENLANDICA, Beck. *a*—Siphons. *d*—Foot.

The Lamellibranchiates may be arranged in the following families :—

(*Siphonida, sinu-pallialia.*)

PHOLADIDÆ—Example: Pholas, Teredo. The shells of the genus Pholas are remarkable as burrowers in stone and hard clay. Our species is *P. crispata*. The species of *Teredo* burrow in sunken timber, and are very destructive to piles and shipping. The animal is worm-like, and the valves appear to be constructed for boring rather than for protection.

GASTROCHAENIDÆ—Example: Gastrochaena. Burrowers, with the valves sometimes united into a shelly tube. No Canadian species.

ANATINIDÆ—Example: Anatina, Pandora. Shell thin, nacreous, often inequivalve, with a small free ossicle connected with the internal cartilage, *Pandora trilineata*, *P. glacialis*, *Thracia Conradi*, *Pandorina arenosa*, are Canadian species.

MYACIDÆ Ex.: Mya, Saxicava, Glycimeris. Shell coarse and wrinkled, gaping posteriorly. Animal with closed mantle, small foot and united siphons. *Mya arenaria* is the common sand clam, *Mya truncata* is more rare and in deeper water, *Saxicava rugosa*

Fig. 141.—SAXICAVA RUGOSA, Lin.

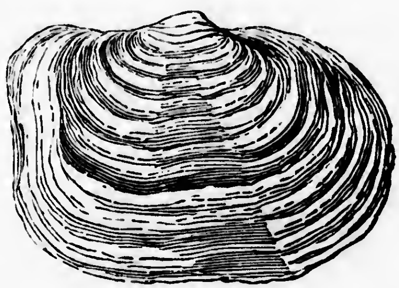


Fig. 142.—MYA TRUNCATA, Lin.

abounds on rocky coasts, and burrows in limestone (Figs. 141 to 143).

Fig. 143.—MYA ARENARIA, Lin. *a*—Process for internal ligament.

SOLENIDÆ—Example: Solen, Machaera. Shells elongated, gaping at both ends. The common "razor-fish" *Solen ensis*, is a typical example.

TELLINIDÆ—Example: Tellina, Sanguinolaria, Donax. Shell compressed, usually closed and equivalve. Animal with mantle widely open in front, foot tongue-shaped, siphons long and separate (Fig. 140). *T.* (*Macoma*) *Groenlandica* and *T.* (*M.*) *proxima* are common species. Figs. 144, 145.

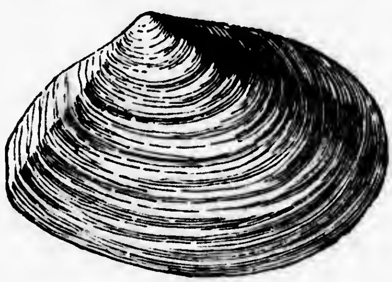


Fig. 144.
TELLINA PROXIMA (sabulosa, Spengl.)

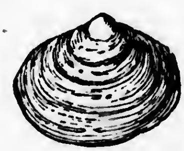


Fig. 145.
T. GROENLANDICA, Beck.

MACTRIDÆ—Example: Mactra, Gnathodon. Shell equivalve, triangular. Internal ligament in a deep triangular pit. Two diverging cardinal teeth, and two lateral (Fig. 138). *Mactra solidissima*, the great clam, is the largest bivalve found on our coasts.

VENERIDÆ.—Example: Venus, Cytherea, Petricola. Shell regular, closed, sub-orbicular or oblong, ligament external; hinge with usually three diverging teeth in each valve. The most common species on the Atlantic coast is *Venus mercenaria* the Quahaug or Wampum shell. *Venus (Tottenia) gemma* abounds at Gaspé.

(Siphonida, integro-pallialia.)

CYPRINIDÆ.—Example: Cyprina, Astarte, Cardita. Shell regular, equivalve, oval, solid; epidermis thick and dark, cardinal teeth one to three, and usually a posterior lateral tooth, *Cyprina Islandica* is our largest species; and we have several species of *Astarte* and *Cardita borealis.* (Figs. 146 and 147.)

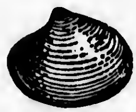


Fig. 146.
ASTARTE STRIATA, Leach.

Fig. 147.
A. LAURENTIANA –Post-pliocene.

CYCLADIDÆ.—Example: Cyclas, Cyrena, Pisidium. Fresh and brackish-water shells, sub-orbicular, closed, with thick horny epidermis and cardinal and lateral teeth. Several small shells of

Fig. 148.
SPHÆRIUM RHOMBOIDEUM, Say.

Fig. 149.
S. SOLIDULUM, Prime.

the genera *Sphærium* and *Pisidium* are found iu our streams and ponds. (Figs. 148 to 154.)

Fig. 150.
S. Sulcatum, Lam, (*Cyclas similis*) Say.

Fig. 151.
S. Transversum, Say.

Fig. 152.
Sphærium Securis, Prime.

Fig. 153.
Pisidium Virginicum, Brongt.

Fig. 154.—P. altile, Anthony.

Lucinidae—Example : Lucina, Corbis, Kellia.—Shell orbicular, closed, interior dull, obliquely furrowed. *Thyasira Gouldii*, a pretty little rounded shell with a flexure on the margin, is our most common species.

Cardiadae—Example : Cardium, Serripes.—Shell regular, equivalve, cordate, with radiating ribs, and peculiar sculpture on posterior side. Two cardinal and two lateral teeth in each valve.

Cardium Islandicum is the common cockle of the Gulf St. Lawrence, and *Serripes Groenlandica* is also frequent. Fig. 155.

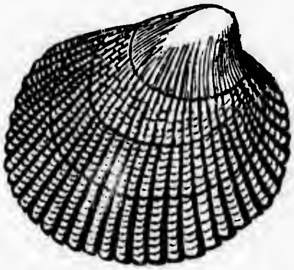


Fig. 155.—CARDIUM ISLANDICUM, Lin.

TRIDACNIDAE.—Example: Tridnacna, Hippopus. Shell regular, equivalve, truncated in front. *Tridacna gigas* is the largest of bivalves. No species occur in Canada.

HIPPURITIDAE.—Example: Hippurites, Radiolites. Fossil in the Cretaceous rocks; remarkable for the great and abnormal thickness of the right valve.

CHAMIDAE.—Example: Chama, Diceras.—Shell inequivalve, attached, with spiral beaks. Tropical seas and fossil, especially in the mesozoic.

UNIONIDAE.—Example: Unio, Anodon, Alasmodon. Fresh-water shells, regular, equivalve, closed. Epidermis thick, shell nacreous within, ligament large, external. These are the fresh-water

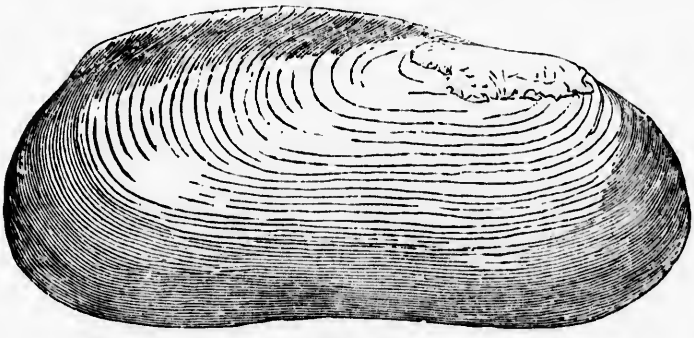


Fig. 156.—ALASMODON, (Margaritana) MARGARITIFERA.

mussels, and are very abundant in our streams and lakes. *Unio complanatus* is the most common species, *Alasmodon* (*Margaritana*) *margaritifera* is the Pearl-Mussel, and affords pearls sometimes of considerable beauty and value. Fig. 156.

TRIGONIDAE.—Example: Trigonia. Shell equivalve, trigonal, with umbones directed backward; ligament external, with few diverging teeth, interior pearly. No living species in Canada; but the genus Lyrodesma of the Silurian is supposed to belong to this family.

ARCADAE.—Example: Arca, Cucullaea, Nucula, Leda. Shell regular, equivalve, with a long row of teeth in each valve. Several species of *Nucula* and *Leda* occur in our seas. (Figs. 157, 158.)

Fig. 157.—LEDA MINUTA, Mull.

Fig. 158.—LEDA (YOLDIA) TRUNCATA, Pleistocene.

MYTILIDÆ.—Example: Mytilus, Modiola, Lithodomus. Shell equivalve, edentulous, oval or elongated, closed, umbones anterior. epidermis thick, attached by a byssus. The common mussel is *Mytilus edulis*. (Fig. 159.) The horse mussel is *M. modiolus*.

Fig. 159.—MYTILUS EDULIS, Lin.

AVICULIDÆ—Example: Avicula, Meleagrina, Pinna. Shell inequivalve, very oblique, hinge-line straight and eared or winged posteriorly; attached by a byssus. We have no modern species, but several in the Palaeozoic rocks (160, 161).

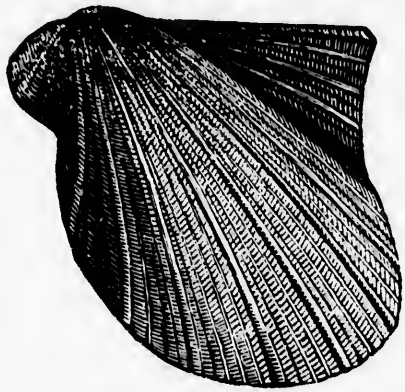


Fig. 160.—AVICULA FLABELLA; Vanuxem, Devonian.
Fig. 161.—A. HONEYMANI, Hall, Silurian.

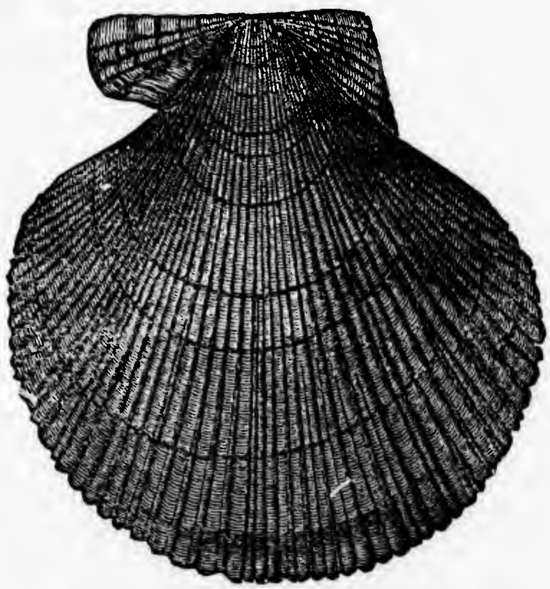


Fig. 162.—PECTEN ISLANDICUS, Chemnitz.

OSTREADÆ—Example: Ostrea, Aromia, Pecten, Spondylus, Plicatula. Shell inequivalve, free or adherent, resting on one valve. Beaks central, straight, ligament internal, adductor impression single, hinge usually edentulous. The common oyster, *Ostrea Virginica*, amd the Pectens or Scallops are well-known examples. (162).

The following figures represent fossil Lamellibranciates found in Canadian rocks, but which, for the most part, can be only doubtfully referred to any of the above families. (Figs. 163 to 173.)

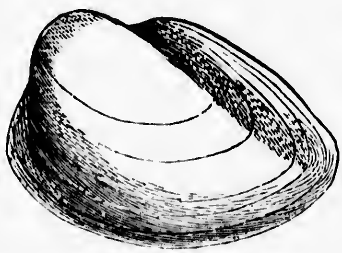


Fig. 163.—CYRTODONTA SIGMOIDES, Billings,—M. Silurian.

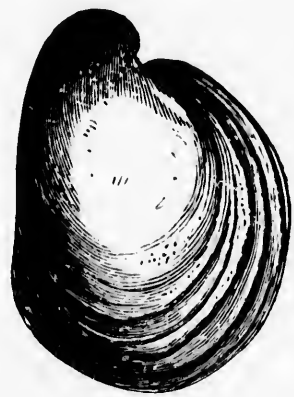


Fig. 164.—CYRTODONTA UNDULATA, Billings,—M. Silurian.

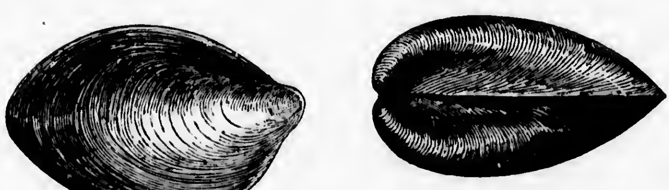


Fig. 165.—MEGAMBONIA NITIDA, Billings,—M. Silurian.

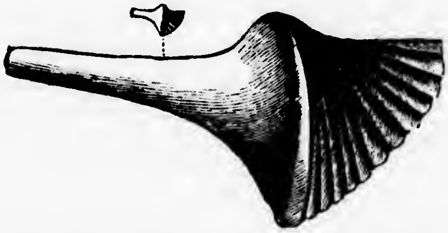


Fig. 166.—CONOCARDIUM ACADIANUM, Hartt.—Carboniferous.

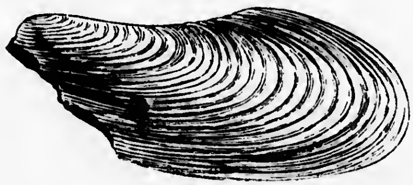


Fig. 167.—CYPRICARDIA INSECTA, Dawson.—Carboniferous.

Fig. 168.—EDMONDIA HARTTI, Dn.—Carboniferous.

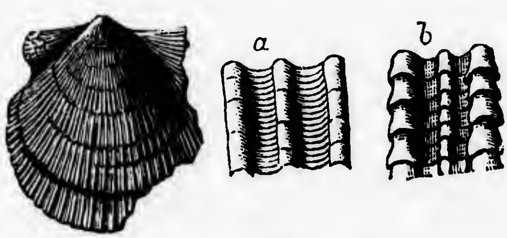


Fig. 169.—AVICULOPECTEN LYELLI, Dn. —*a*, *b*— sculpture—Carboniferous.

Fig. 170.
NAIADITES CARBONARIUS, Dn.—Carb.

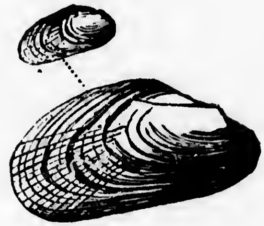


Fig. 171.
N. ELONGATUS, Dn.—Carb.

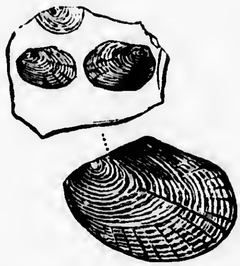


Fig. 172.—N. LAEVIS, Dn.—Carboniferous.

Fig. 173.—MACRODON HARDINGI, Dn.—Carboniferous.
a—Cast. b—Exterior.

The student will find the families of Lamellibranchiata admirably described in Woodward's Manual of the Mollusca. For Canadian species reference may be made to Gould's Invertebrates of Massachussets, and to the Papers by Packard, Whiteaves, Bell, and others, published in the *Canadian Naturalist.* Fossil species will be found in Memoirs by Billings and Whiteaves in Reports of Canadian Survey, and in Dawson's Acadian Geology.

CLASS III.—GASTROPODA.

Encephalous; body symmetrical or spiral with or without a shell, which is usually univalve and spiral; mouth with teeth and a lingual ribbon; nerve system with four pairs of ganglia, those of the head large; respiration by gills or an air-sac; foot along the ventral aspect of the body; young in aquatic species usually having a ciliated stage with velum.

A typical Gastropod, such as one of the whelks, periwinkles or snails, has a manifest head, in which are grouped its organs of sensation. Its locomotion is performed by a muscular organ placed on the ventral aspect of the body, and termed its foot. The body is usually elongated and generally spiral, and the most common covering is a univalve calcareous shell. The nervous system and circulating apparatus are more compact and highly developed than in the last class, and the locomotive energies are greater. The eyes are probably sufficient for distinct vision, and are usually attached to the tentacles, which are important as organs of touch. There are two auditory sacs (otocysts) placed near the pedal ganglia, and in some olfactory organs have been recognised near the gills. The concentration of the eyes, principal nerve ganglia, and oral organs in one mass gives rise to a head, hence these animals are known as Encephalous, as distinguished from the lower mollusks (Acephala). Respiration is performed either by gills or by a pulmonary sac. The mouth is destitute of tentacles, but is furnished with a tongue or lingual ribbon beset with teeth, which, in the herbivorous species, serves to rasp vegetable substances, and in those that are carnivorous, to abrade holes in the shells of other mollusks. The embryo, in some cases, especially in the terrestrial species, is precisely like the adult; but in most of the marine species it is a free-swimming larva, with two large ciliated lobes (the velum), by which it swims and which disappear when the abdominal foot becomes developed. Some of the Gastropods are diœcious, others are hermaphrodite. Fig. 174 shows the arrangement of the

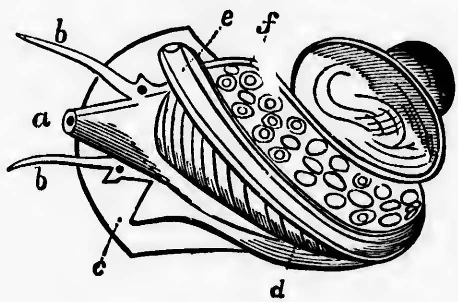


Fig. 174.—ANIMAL OF PALUDINA, after Woodward.

a—Mouth. *b*—Tentacles and Eyes. *c*—Foot. *d*—Gills. *e*—Intestine. *f*—Ovary.

principal organs in a fresh-water snail of the genus Paludina. The shell of the Gastropods is constructed of the same materials with that of the last class, and is deposited by the mantle. It is never bivalve, but is often provided with a horny or calcareous operculum or lid developed from the foot, and which closes the shell when the animal is retracted. The different parts of a univalve shell are indicated in Fig. 175.

Fig. 175.—Univalve shell (Sipho).

a—Apex.
b—Spire, showing sutures at union of the turns, also ribs or varices and revolving lines.
c—Outer lip and aperture.
d—Anterior canal. *e*—Body whirl. *f*—Inner lip or columella.

The Gastropods present a greater variety of organisation than the Lamellibranchiata, and may therefore be somewhat minutely divided into orders. The following are the orders generally received; but there are good grounds for considering that the Dentalia or tooth-shells, and the Chitons should be separated from Order 4th to form separate orders. A new classification has also been proposed on the ground of the forms and arrangements of the teeth on the lingual ribbon; but this seems a character too limited to give a natural arrangement.

Order 1. *Pteropoda.*—These are oceanic and free-swimming, and are distinguished by two fins or swimming organs developed from the sides of the neck or head. Some have shells, others are naked. The latter only have distinct heads.

Order 2. *Heteropoda* or *Nucleobranchiata.*—These are also pelagic animals, and swimmers; but their swimming organ is a fin-like tail, furnished with a sucker for attachment, and represents the foot of other Gastropods. The greater part have shells, which are, however, in many of the typical forms, as Carinaria, too small to cover more than a few of the more important organs.

Order 3. *Opisthobranchiata.*—Some of these can swim, but are all furnished with an ample foot for creeping. They derive their name from the position of the gills, which are placed toward the posterior part of the body, and are either covered by the mantle (Tectibranchiata) or naked (Nudibranchiata). A few of the former have shells.

Order 4. *Prosobranchiata.*—These are sea-snails proper, though a few occur in fresh water. They are all protected by shells. They breathe by gills which are placed toward the front of the body, and within the mantle. They are the most numerous and typical of the Gastropods, and are nearly all creepers by means of a muscular foot.

Order 5. *Pulmonifera.*—These are land and fresh-water snails and slugs, and are distinguished by the possession of an internal pulmonary chamber or air-sac by which they breathe air. The greater part have spiral shells, and all are creepers.

ORDER I. PTEROPODA.

On the coast of Labrador the tow-net sometimes secures great numbers of the little creature represented in Fig. 176 (*Clione limacina*, Phipps, *C. borealis* of Brugière).

Fig. 176.—CLIONE LIMACINA.

It is about an inch in length, semi-transparent, and of a roseate hue ; moving through the water by the flapping of its ample fins, and preying on minute crustaceans and other creatures by means of a formidable apparatus of suckers and shear-like jaws in front of its head. This little creature is so abundant in some parts of the Greenland seas that it is said to form a considerable part of the food of the great whalebone whales. Another still more beautiful Pteropod has been procured by Mr. Packard on the same coasts. It is the *Limacina helicina*, a little creature contained in a small snail-like spiral shell of almost inconceivable thinness, and extending from the front of its body two delicate and beautiful fins, which may almost be compared to the wings of an insect, with which it moves gaily through the water. These are the only Pteropods of which I have seen specimens from Canadian waters. The genus *Conularia* of our Carboniferous and Silurian limestones, and the genera *Theca*, *Pterotheca* and *Salterella* of the Silurian and Cambrian, are supposed to belong to this order (Fig. 177).

Fig. 177.—CONULARIA PLANICOSTATA, Dawson,—Carboniferous.

ORDER 2. HETEROPODA.

In the modern world these are for the most part inhabitants of the warmer seas; and the only species as yet known to us in Canada are those found fossil in our

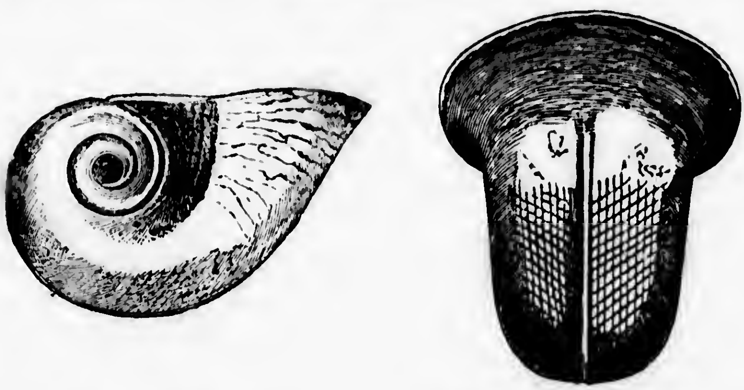


Fig. 178.—BELLEROPHON SULCATINUS,—Billings, Siluro-cambrian.

limestones. Of these, the most characteristic are those of the genera *Bellerophon* and *Cyrtolites*, species of which are found from the Lower Silurian to the Carboniferous inclusive (Fig. 178). The curious and somewhat anomalous shells of the genera *Maclurea* and *Ecculiomphalus*, are also supposed by some palæontologists to belong to this order. The *Ianthinæ* or violet snails are regarded as an aberrant family of this order. They have spiral shells and float by means of a modified cellular operculum which buoys them up. They are mostly tropical ; but shells of *Ianthina fragilis* are sometimes cast on our Atlantic coast (Fig. 179).

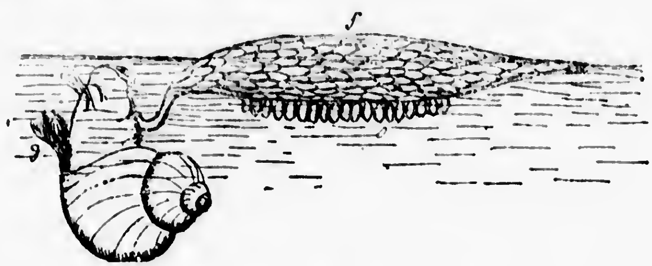


Fig. 179.—IANTHINA FRAGILIS.
f—Float. *g*—Gills. *o*—Ova.

ORDER 3. OPISTHOBRANCHIATA.

The Nudibranchiate, or naked-gilled division of this order, is represented on our coasts by many species of sea-slugs with soft slimy bodies and destitute of shells. Many of them are curious and beautiful when alive, but they lose all their charms when seen as museum specimens. I figure as an illustration *Doris planulata* (Stimpson), from the Bay of Fundy. It is a little creature about half an inch long, with a broad depressed body, covered with minute tubercles, and white, with a row of yellow spots along each side. Its gills, composed of delicate radiating plumes, are seen behind, and its two screw-like tentacles in front (Fig. 180).

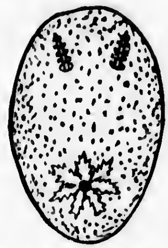


Fig. 180.—DORIS PLANULATA, Stimpson.

The most interesting of the Tectibranchiates are the *Bullæ* or bubble-shells and their allies. These have, enclosed in the mantle, a delicate and beautiful spiral shell. Several species, all of small size, occur on our coast (Fig. 181).

Fig. 181.—CYLICHNA ALBA, Brown.

ORDER 4. PROSOBRANCHIATA.

These are represented by very numerous species in our salt and fresh waters. For convenience they may be divided into two sections :—(1) *Holostomata*, or those which have the shell usually spiral and univalve, sometimes tubular or conical or multivalve, and have the aperture of the shell entire. They have no siphon, or the organ is very rudimentary. They are mostly vegetable feeders, though some are carnivorous. (2) *Siphonostomata,* with the shell spiral and notched or produced into a canal in front, to accommodate the respiratory tube or siphon.

In the first named of the above sections are the following families :—

CHITONIDÆ.—Having the body covered with a multivalve shell in eight pieces, giving the creature the aspect of an articulated animal, though truly a mollusk. *Chiton marmoreus*, the spotted or marbled Chiton, is the most common species (Fig. 182). The

Fig. 182.—CHITON EMERSONII, two of the valves.

Chitons are destitute of eyes and tentacles, and in the segmented form of the body resemble worms. They have a lingual ribbon.

DENTALIADÆ.—Long tubular shells, living in deep water in muddy bottoms. *Dentalium* (*Entalis*) *striatum* is found on our coasts. Dentalium agrees with the other Gastropods in having a head, lingual ribbon, muscular foot, and univalve shell ; but is regarded as a very rudimentary form.

PATELLIDÆ. Shells conical, animals clinging to or creeping on stones. *Acmaea testudinalis*, the common limpet of our coasts, is an example. *Lepeta cæca* (Fig. 183) is less common.

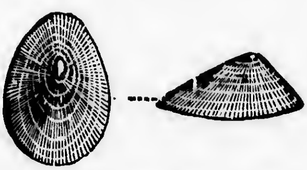


Fig. 183.—LEPETA CÆCA, Mull.

FISSURELLIDÆ.—The "Key-hole" or perforated limpets. One little species, *Cemoria Noachina*, is found on our coasts.

HALIOTIDAE.—The Sea-ears are beautiful pearly shells not represented in this country, except on the Pacific coast.

TURBINIDÆ.—These are the Top-shells and "silver willies." Their shells are turbinated or short conical and pearly within. *Trochus occidentalis* is found in our seas, and several species of *Margarita*.

The genus *Platychisma* of the carboniferous limestone perhaps belongs to this family (Fig. 184).

Fig. 184.—PLATYSCHISMA DUBIA, Dn.—Carboniferous.

NERITIDÆ.—The Nerites are not represented in our seas.

CALYPTRAEADÆ.—The Slipper Limpets and the "Cup and Saucer Limpets." *Crepidula fornicata* is our common Slipper Limpet.

TURRITELLIDÆ.—These, as their name imports, are long turreted shells with rounded aperture, and often of very graceful

Fig. 185.—SCALARIA GROENLANDICA, Parry.

form. They are marine. *Turritella erosa* is not uncommon, and *Scalaria Groenlandica* (Fig. 185) though rare, is one of our most beautiful shells.

LITTORINIDÆ—These are the most common little univalves of the sea-beach, swarming on stones, and feeding on sea-weeds. *Littorina rudis* and *L. palliata* are our most common species. The little banded sea-snail, *Lacuna vincta*, also belongs here, as do the almost microscopic shells of the genus *Rissoa*.

PALUDINIDAE—These are fresh water shell-fish, with conical or globular shells, having a rounded entire aperture. *Paludina decisa* is common in our large rivers, as also are certain curious little shells of the genus Valvata (Figs. 187, 188).

Fig. 186.
AMNICOLA PORATA, Say.

Fig. 187.
VALVATA TRICARINATA, Say.

Fig. 188.
V. PUPOIDEA, Say.

MELANIADAE—These, like the Paludinas, are fresh-water shells, common in our rivers. They differ from Paludina in their more elongated forms and tendency to a channel or notch in the front of the aperture. The most abundant species in the St. Lawrence is *Melania depygis*. The little shells of the genus *Amnicola* belong to this family. (Fig. 186.)

CERITHIADÆ—These differ from other members of this group in having a canal in front of the shell, and when adult the lip is often expanded. Our finest species is the Western "Spout-shell," *Aporrhais occidentalis*.

PYRAMIDELLIDAE—These are long shells like the Turritellas, with small aperture, and often plaits on the Columella. *Menestho albula* is a very pretty little species.

NATICIDAE—These have globular few whirled shells. The animal has a very large rounded foot. *Natica* (*Lunatia*) *heros* is one of our largest univalves, and very common on sandy shores, where it deposits its spawn in a flat sandy ribbon moulded on the foot. We have several smaller species of *Natica* and two of *Velutina*. (Figs, 189 to 191.)

Fig. 189.
NATICA HELICOIDES,
Johnston, Pleistocene

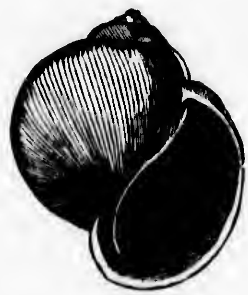


Fig. 190.
N. CLAUSA,
Brod and Sow.

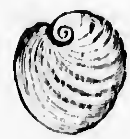


Fig. 191.
VELUTINA ZONATA,
Gould.

The second section (*Siphonostomata*) includes the following families.

CYPRÆADÆ—The Cowrie shells are inhabitants of the warmer seas and not represented with us.

VOLUTIDÆ—The Volutes are also tropical and sub-tropical shells, often of great beauty.

CONIDÆ—The proper Cone-shells belong to the warmer latitudes; but several beautiful little shells of the genus *Bela* are found in deep water on our coasts. They have the aperture long and narrow, with a notch in the back or upper end.

BUCCINIDÆ—These are the whelks and their allies, represented on our coast by the common whelk, *Buccinum undatum*, (*undulatum*, Stimpson,) and several other shells of this genus and of the genera *Nassa*, *Purpura*, &c. The masses of tough leathery egg-cases of the Buccinum are very common on our shores. (Fig. 192.)

MURICIDÆ—These have a straight inferior canal, often of considerable length. They are represented on our coast by species of

Fig. 192.—BUCCINUM UNDATUM, Lin., Variety.

Fusus, *Trophon*, and *Trichotropis*, mostly deep water shells. (Figs. 193, 194.)

Fig. 193.
FUSUS TORNATUS, Gould.

Fig. 194.
ADMETE VIRIDULA, O. Fabricius.

STROMBIDÆ.—These are tropical and subtropical shells. The great *Strombus gigas*, or conch of the West Indies, is well known everywhere, and is used in the manufacture of the commoner kinds of cameos.

The eight families last mentioned are carnivorous and have a retractile proboscis, often with a prehensile spinous collar.

The fossils of the genera *Murchisonia* and *Pleurotomaria* (Fig. 195), are abundant in our Palæozoic rocks, but are of uncertain affinities. These shells may be distinguished by a notch in front of the lip.

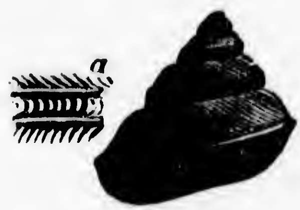


Fig. 195. PLEUROTOMARIA SYBILLINA, Billings.—M. Silurian.
a—Sculpture and notch.

The genera *Loxonema* and *Euomphalus* also include fossils of uncertain affinities (Figs. 196, 197).

Fig. 196.
EUOMPHALUS EXORTIVUS, Dn.
Carboniferous.

Fig. 197.
LOXONEMA ACUTULA, Dn.
Carboniferous, magnified.

ORDER 5. PULMONIFERA.

Though, from the dryness of its summers and the coldness of its winters, Canada is by no means favourable to the land and fresh-water snails, yet we have numerous species, some of which are very common. They belong to the following families:—

AURICULIDÆ.—The shells of the genus *Auricula* (sub-genera *Melampus*, *Alexia*) have the aperture guarded by processes, and inhabit salt marshes and similar places, thus connecting in their habitat the fresh-water and sea snails.

LIMNAEADÆ.—Here we have the Limneas and Physas or spiral fresh-water snails, and the discoid snails belonging to the genus *Planorbis*. Allied to the former is the curious genus *Ancylus*, with a conical shell, like that of a limpet. Figs. 198, to 210 show some

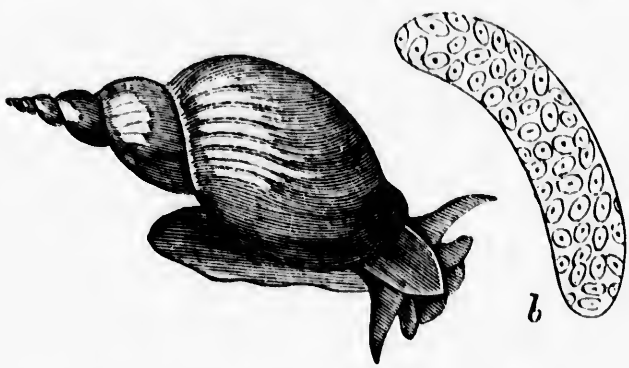


Fig. 198.—LIMNÆA STAGNALIS, Lin. Shell and Animal. *b*—Mass of Eggs magnified.

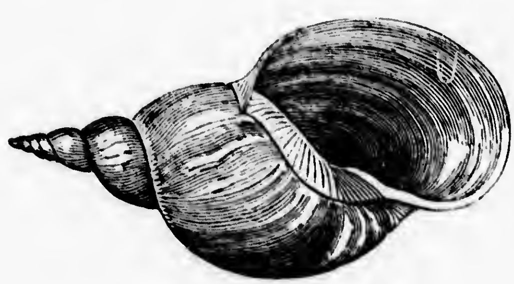


Fig. 199.—LIMNÆA STAGNALIS, Lin.

common species. All these creatures, though living in water, breathe air; and they are especially interesting to students residing in inland regions remote from the sea. Specimens may be found

Fig. 200.—Limnæa ampla, Mighels. Fig. 201.—Limnæa elodes, Say.

Fig. 202.—Planorbis macrostomus, Whiteaves.

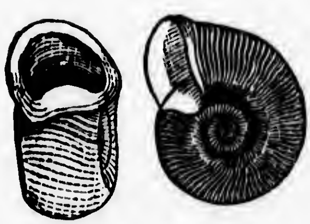


Fig. 203.
Planorbis trivolvis, Say.

Fig. 204.
P. Lentus, Say.

in nearly all ponds and streams, and if kept in an aquarium, afford a convenient opportunity of studying the forms and habits of gastropods.

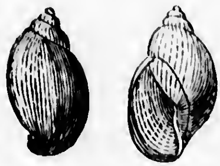


Fig. 205.
PHYSA HETEROSTROPHA, Say.

Fig. 206.
ANCYLUS RIVULARIS, Say.

Fig. 207
A. FUSCUS, Adams.

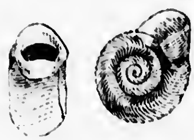


Fig. 208.
PLANORBIS CAMPANULATUS, Say.

Fig. 209.
P. DEFLECTUS, Say.

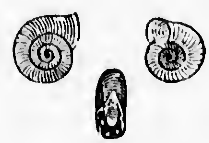


Fig. 210.
P. ARMIGERUS, Say.

LIMACIDÆ.—Our most common—gardeners may suppose too common—representative of this family, is the slimy garden slug, protected only by its membranous mantle, though it has a concealed rudimentary shell. Several species occur in this country. The common one in gardens is *Limax agrestis*. *L. campertris*, a smaller species, is found in fields and woods. These creatures are remarkable for the large quantity of tenacious mucus secreted from glands in the mantle, and which greatly contributes to their protection.

HELICIDÆ.—Here we have the ordinary land snails of the genus *Helix*, the Amber-snails of the genus *Succinea*, and the long land snails of the genera *Pupa* and *Bulimus*, and their allies (Fig. 211 to 213).

Fig. 211.—HELIX ALBOLABRIS, Say.

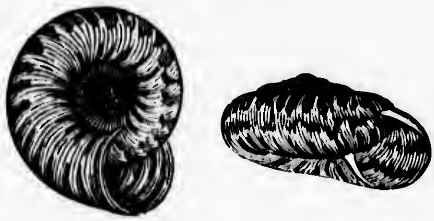


Fig. 212.
HELIX ALTERNATA, Say.

Fig. 213.
HELIX MONODON, Rackett.

Our oldest known Pulmonates are *Pupa vetusta* and *Conulus*

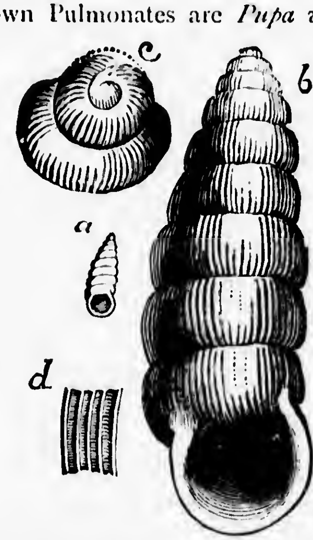


Fig. 214.—PUPA VETUSTA, Dawson.—Carboniferous.
a—natural size. *b*—magnified. *c*—apex. *d*—sculpture.

priscus from the Coal formation of Nova Scotia (Figs. 214, 215).

Fig. 215.—Conulus priscus, Carpenter. Carboniferous. *a* magnified. *b* sculpture.

SIPHONARIA.—These are marine snails, breathing air, and with limpet-like shells.

CLASS IV.—CEPHALOPODA.

Encephalous; body symmetrical; locomotive and prehensile organs attached to the head, and usually with suckers; mouth with a horny beak and lingual ribbon; eyes, auditory capsules and brain large and well developed; a rudiment of a skeleton in some; dioecious and ametabolian.

The Cephalopods occupy the highest place in the Province Mollusca. The foot is brought to the front of the body, and is divided into a number of arms furnished with an apparatus of suckers, and sometimes with hooks also. The mouth is provided with a horny beak, and the organs of sense are highly developed, while the circulation and respiration are very complete and vigorous.

Locomotion is performed by the arms, and in some by caudal or lateral fins, and also by the reaction of the water ejected from the respiratory chamber through the "funnel," from which also can be ejected in some species a pigment for darkening the water, secreted in a glandular apparatus, the "ink bag." Some are protected by an external shell. In others, the shell, or its rudimentary representative, is internal. These creatures are active and predaceous, and in the seas of warm climates some of them attain to gigantic dimensions and are formidable to man and to the larger fishes. They have two sexes, and the young undergo no metamorphosis.

They are divided into two orders:

Order 1. *Tetrabranchiata.* In which there are four gills, numerous arms, and an external chambered shell, the inner chambers of which are empty, and serve as a float to render the animal independent of gravity, by accommodating its weight to the specific gravity of the sea water. These are the Nautili and their allies.

Order 2. *Dibranchiata.* In which there are two gills, eight or ten arms, an ink gland, and *no external shell*, except in a few species. These are the Cuttle fishes and their allies.

ORDER I. TETRABRANCHIATA.

No living species of this order belongs to our country. The modern Nautili inhabit warmer regions, and are limited to a very few species, of which the Pearly Nautilus, *N. pompilius* is the most common. Its shell is distinguished by its numerous partitions, dividing it into air chambers through which passes a siphuncle or tube, communicating with the body of the animal. But though we

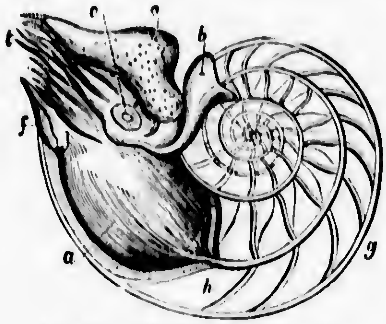


Fig. 216.—NAUTILUS POMPILIUS.

a—Mantle. *b* Dorsal fold of Mantle. *c*—Hood. *d*—Eye
t—Tentacles. *f*—Funnel. *g*—Air chambers. *h*—Siphuncle.

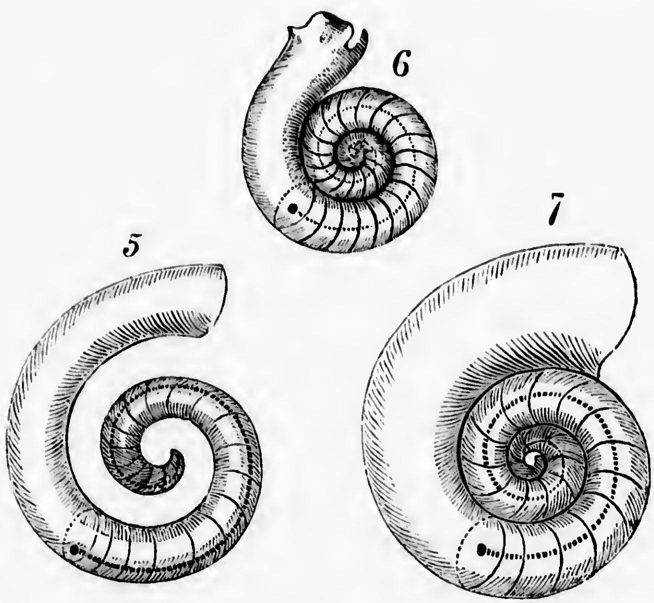


Fig. 217.—LITUITES—6. GYROCERAS—5. NAUTILUS—7.

have no modern shells of this order, numerous species are found fossil in our limestones; and it is in the rocks of the earth that we must seek for the greater number of species of Tetrabranchiates, which seem to have attained to their highest developement in number, size and complexity in former geological periods. The species are usually arranged in three families, though from our ignorance of the animals of the fossil species, it is not always possible to be certain that our arrangements are natural.

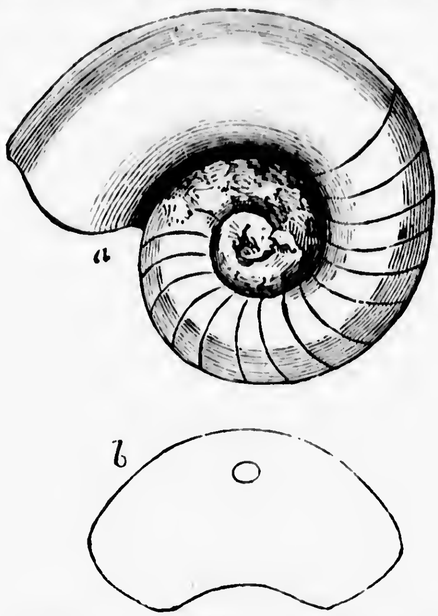


Fig. 218.—NAUTILUS AVONENSIS, Dawson,—Carboniferous.
b—Section showing position of Siphuncle.

Fig. 219.—DISCITES HARTII, Dn.—Carboniferous. External chamber only.

NAUTILIDÆ.—The type of this family is the *Nautilus pompilius*. In our Silurian and Devonian rocks we have species of the allied genera *Lituites* and *Clymenia*, and a fine *Nautilus* occurs in the Carboniferous (Fig. 218).

ORTHOCERATIDÆ—These are all extinct. They differ from the Nautili in having the shell often straight, or merely curved ; in the smallness of the last chamber for containing the body of the animal, and in the aperture being contracted. Many of them have the siphuncle or tube leading through the chambers singularly complicated. Some of the species were of very great size, the shells

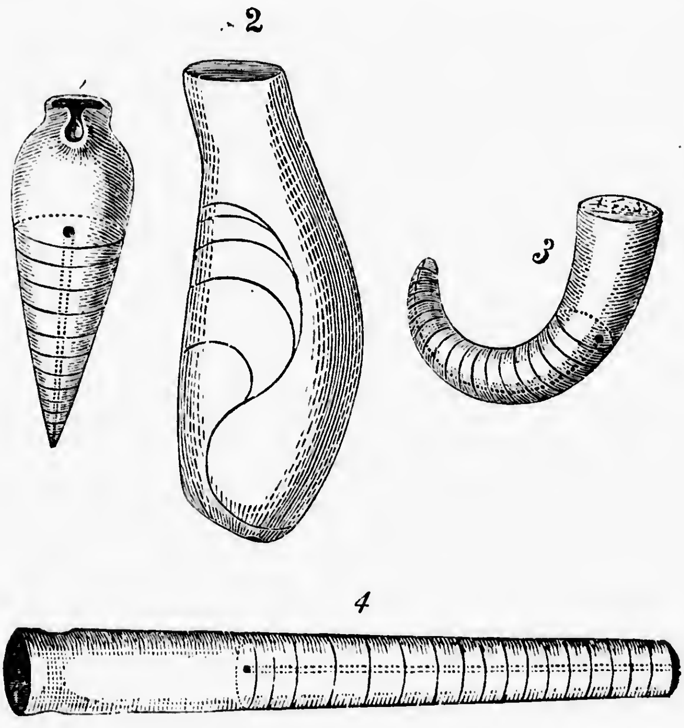


Fig. 220.—1—GOMPHOCERAS. 2—ASCOCERAS. 3—CYRTOCERAS. 4—ORTHOCERAS, after Bllings.

being several feet in length. Several genera of this family are represented in the Palaeozoic rocks of Canada. (Figs. 220, 221.)

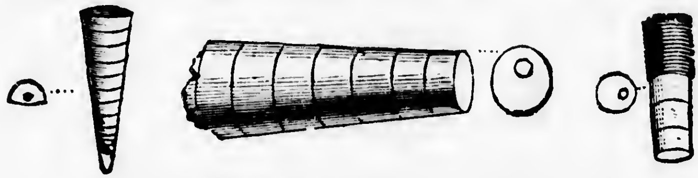


Fig. 221.—Orthoceras dolatum, Dn.—Carboniferous.
O. Vindobonense, do. do.
O. Perstrictum, do. do.

Ammonitidæ—In these the body-chamber is elongated and guarded by processes and closed with an operculum or lid. The

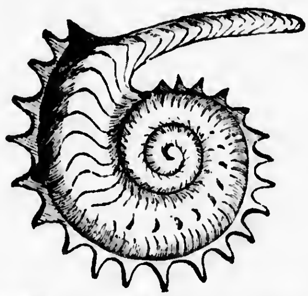


Fig. 222.—Ammonites jason, Reinecke,—Oxford Clay, England.

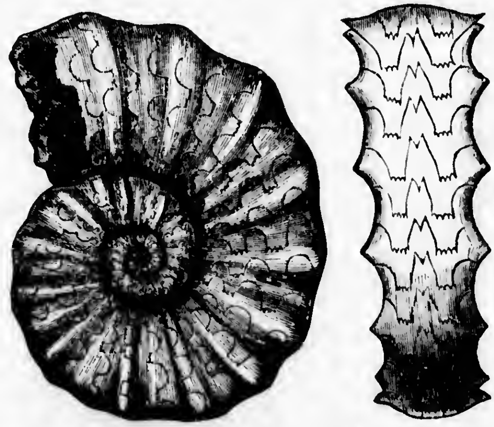


Fig. 223.—Ceratites nodosus, Schlot,—Triassic formation, showing the waived partitions.

partitions of the chambers are waved or lobed, and the siphuncle is at the back or outer curve of the shell. They are all extinct; but numerous fine species occur in the cretaceous formation of Western Canada (Fig. 222). The genus *Goniatites* is represented in the Devonian and Carboniferous.

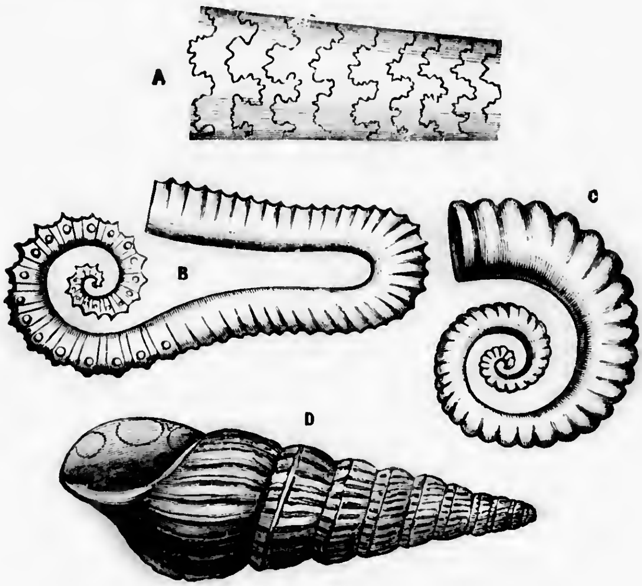


Fig. 224.—AMMONITIDÆ of the Cretaceous period.
a—Baculites. *b*—Ancyloceras. *c*—Crioceras. *d*—Turrilites.

ORDER 2. DIBRANCHIATA.

The common squids, of which two species occur in our seas, are our only known Canadian representatives of this order, if we except the curious little *Spirula fragilis* of which the shells have been found by Mr. Willis on Sable Island and the gigantic squids of the Newfoundland Coast.

The Dibranchiates may be conveniently divided into two groups or sub-orders, the *Decapoda* or ten-armed, and the *Octapoda* or eight-armed. The four first of the following families belong to the first sub-order, the two last to the second.

TEUTHIDÆ—This family includes several genera, two at least of which are found in our seas. *Loligo* includes the Calamaries or pen-bearing squids, so named from their having a rudimentary internal shell of cartilaginous consistency and shaped like a pen or feather. A species of Loligo is found in the Bay of Fundy.

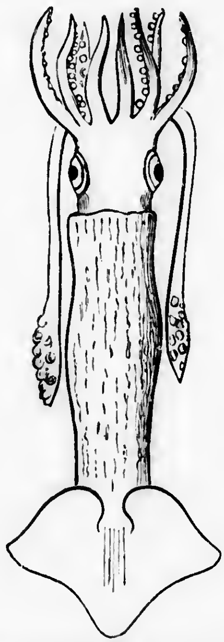


Fig. 225.—OMMASTREPHES ILLECIBROSA, LeSueur.

Ommastrephes includes those which have an elongated narrow pen, with a conical hollow extremity. *O Illecibrosa* occurs in the Gulf of St. Lawrence and is known as the squid. (Fig. 225.) Our squids are of small size and are much used as bait by fishermen ; but some of the largest and most formidable cephalopods of the tropics, belong to this family, as do also the giant Cephalopods of the coast of Newfoundland, belonging to the genus Archaoteuthis.

BELEMNITIDÆ—These are extinct Cephalopods belonging to the Mesozoic period of geology. They were allied to the last family, but possessed a curious and complicated internal shell, in part chambered (Fig. 226). No Canadian species are known.

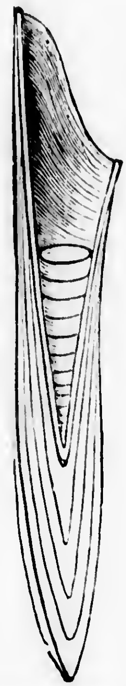


Fig. 226.—BELEMNITES, section, after Phillips.

SEPIADÆ—These are the Cuttle-fishes. They have a more compact form than the squids, and the internal shell (cuttle bone) is hard and calcarous. No Canadian species are known.

SPIRULIDÆ—These are small cephalopods with an internal spiral chambered shell. *S. fragilis* is sometimes carried northward by the gulf stream, and cast on our shores.

OCTOPODIDÆ—The Octopus or Poulpe of the Mediterranean is the type of this family, in which the shell is entirely rudimentary, the arms eight in number and connected by a web at the base, and the body usually short and compact. Some small species occur on the Atlantic coast, and larger ones on the Pacific coast in our latitudes.

ARGONAUTIDÆ—These are Octopods, of which the females are protected by a delicate shell, not divided into chambers, and enclosed in two of the arms, which are flattened at the extremity. The "Paper Nautilus," *Argonauta argo*, is the most common representative of this family in collections. These animals swim by ejecting water from the funnel, and creep on the bottom by means of the arms. The poetical fancy of their using their shells as boats has no foundation in fact.

For the Cephalopoda the student may be referred to the works already mentioned under the Lamellibranchiates. Many fossil Canadian species have been described and figured by Billings and Whiteaves in the Reports of the Geological Survey of Canada.

CHAPTER VII.

DESCRIPTIVE ZOOLOGY—*Continued.*

PROVINCE V.—ANNULATA OR VERMES.

The plan embodied in the structure of the typical Annulata is that of a series of rings, or somites as they have been called, articulated to each other and constituting a chain of segments, in which in the higher form we recognize upper and under and side pieces, and to which bristles (Setæ) or setigerous feet are often attached. In the ordinary worms this structure is simple and nearly uniform, from front to rear of the animal. In the cross section of the body, the alimentary canal occupies the centre; above it is the elongated heart or dorsal vessel; below is the principal nerve-cord. The bilateral symmetry is perfect; but in all the members of this group the nutritive fluid appears to be contained in the general visceral cavity, as well as in the vessels when these exist.

There are, however, a number of low forms of Annulates, in which the typical characters become obscure, and in some of which the organism descends almost to the level of the Protozoa. Of this character are the *Entozoa* or intestinal worms, and the *Turbellaria* or ciliated worms.

The link of connection between these low forms and the ordinary worms, is established only through the embryonic stages of the latter, which in the absence or slight development of the rings, aud their movement by means of cilia, at once recall some of the lower forms mentioned. It must, however, be admitted that the group of Entozoa, as at present held by naturalists, is rather one of convenience, depending upon the peculiar habits of these creatures, than of natural arrangement, since they differ very much among themselves both in plan and degree of complexity.

The above considerations lead us to divide the Annulata into classes as follows:—

1. *Platyhelmintha.*—Ciliated Worms, Flukes and Tape Worms, &c.
2. *Cœlelmintha*—Round intestinal Worms, Trichinæ, Hair-worms, &c.
3. *Rotifera.*—Wheel-Animalcules.
4. *Annelida.*—Earth-worms, Leeches, Sea-worms, &c.

Class I.—Platyhelmintha.

More or less flattened worms. The body often unsegmented. Head or anterior segment, often with hooks or suckers or both. Alimentary canal absent, or forked or branched. Nerve system usually a single ganglion. Some forms remarkable for producing numerous reproductive joints. Many are internal parasites, and hence named Entozoa.

The internal parasitic worms belonging to this class may be represented by the common tape worm, *Tænia solium*, of the human intestines (Fig. 227). This creature

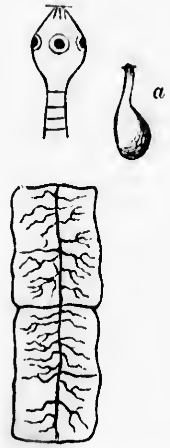


Fig. 227.—TÆNIA SOLIUM—Head or Scolex and two joints, with Larva or Cysticercus—*a*.

in its adult state consists of a head or *Scolex*, having four suckers on the sides and a circle of sharp spines for attachment; appended to this are very numerous quadrate flat joints, each containing an ovarian apparatus, so that these creatures are chiefly remarkable for the great development of their generative apparatus. Otherwise their structures are very simple, and they appear to feed by absorption into a series of tubes excavated in the cellular substance of the body. The eggs of the tapeworm, when discharged from the intestine of its host, may be taken by other animals along with their food. They are hatched in the stomach into a microscopic scolex, which penetrates into the tissues and is capable of multiplying by fission. This scolex finally establishes itself as a pupa or resting scolex, and assumes the form represented in Fig. 227*a*, in which state it is the kind of parasite termed *Cysticercus*, and which causes the disease known as "measles" in the domestic hog, an animal which, from its habits of life, is peculiarly liable to become the host of these parasites. The circle of change is completed when the Cysticercus is transferred alive from the flesh of the hog into the human stomach. Many other species of tape worm exist, and pass through similar changes; the young inhabiting the flesh of various animals, and the adults appearing in the intestines of carnivorous species which may happen to feed on the infected flesh.

A second group of Entozoa included in this class is represented by the genus *Distoma* and its allies. These creatures are oval in form and have one or two suckers for attachment. They have a mouth and an alimentary canal, which bifurcates, and has no posterior aperture. These are the "Flukes," two species of which are found in the human liver (*D. hepaticum* and *D. lanceolatum*), and they also occur in domestic animals, more especially in the sheep.

The last group of these worms is that of the *Planariæ*, which are minute oval worms occurring both in fresh water and in the sea, resembling the Distomas in form, but having a more complex internal system of nutritive canals, and having the surface covered with cilia, by means of which they swim. They are not internal parasites. The whole of these creatures may thus be grouped in the following orders:—

Order 1. *Planariæ.*—Free-living, flat, one-jointed ciliated worms, found in both salt and fresh water.

Order 2. *Trematoda* or Flukes.—Parasites, one-jointed, but with suckers for attachment.

Order 3. *Cestoda.*—Tape-worms and their allies, elongated and segmented parasitic flat worms, without mouth or alimentary canal, and with sucker or suckers and hooks for attachment.

Class II.—Cœlelmintha.

In these the alimentary canal is suspended in an abdominal cavity, and the sexes are distinct, which is not the case in the previous group. The common round worms of the human intestines (*Ascaris*) belong to this order. A still more dangerous though microscopic parasite is the *Trichina spiralis* (Fig. 228), which inhabits the

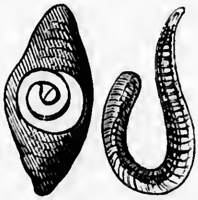


Fig. 228.—Trichina spiralis, in the cyst, magnified; and specimen removed from its cyst, farther magnified.

muscles of the domestic hog, and when transferred from these to the human stomach, multiplies rapidly, and penetrates the tissues, causing great and sometimes fatal irritation. It finally forms a sac or cyst, in which it remains in a quiescent condition, unless transferred into the alimentary canal of some new host, where the same course is again pursued.

Another curious worm belonging to this group, is the hair-worm (*Gordius*). These creatures are internal parasites in the larger aquatic insects, from which, when mature, they come forth as extremely long and slender worms, of a whitish or brown colour, which swim freely in the water of pools and there deposit their eggs. From their sudden appearance in great numbers in such places, arises the popular superstition that they are animated hairs. Our common species is probably *G. lacustris*, Fabr.

A humble group of parasites usually placed in this class is that of the *Acanthocephala*, represented by the *Echinorhyncus gigas* of the intestines of the hog. They are of elongated form, and the anterior extremity is armed with a formidable proboscis furnished with hooked spines at the sides. They have no mouth or digestive canal.

With reference to the relation of parasites to the animals on which they prey, it may be stated that these creatures are usually destructive only under circumstances of unnatural or unsuitable habits of life. In the human subject, their introduction is due in most cases to the use of imperfectly cooked food, of raw vegetables not properly cleansed, and of stagnant impure water ; or to filthy habits in the keeping and preparation of food.

The Cœlelminths may be divided into the following orders :—

Order 1. *Acanthocephala.*—Parasitic worms without alimentary canal, and with spinous proboscis. Example: Echinorhynchus.

IMAGE EVALUATION
TEST TARGET (MT-3)

6"

Order 2. *Gordiacea.* — Body slender. Alimentary canal without vent. Example: Gordius, Trichina.

Order 3. *Nematoidea.* —Body elongated. Alimentary canal with both mouth and vent. Example: Ascaris.

The curious little marine worms with a well-marked head and fin-like expansions of the skin, giving them the aspect of fishes, and which belong to the genus *Sagitta*, are by some naturalists included in this group as one of its orders.

CLASS. III.—ROTIFERA.

These are microscopic animalcules, at one time included with the Infusoria, but now known to be of much more complex structure. They derive their name from ciliated lobes placed on the head, and which, in some species, from the motion of the cilia, have the appearance of rotating wheels. These ciliated lobes serve to create currents to bring food to the mouth, and also for locomotion. The alimentary canal has, in the better developed examples, an outer stomach or crop, a gizzard with apparatus for triturating the food, and a proper intestinal canal. There is also a vascular system, with a pulsating sac. In the body wall there are distinct muscular fibres, and the posterior part is more or less articulated or jointed, and in many species furnished with claspers for attachment, while others are protected within a case or cell of gelatinous consistency. Though microscopic in size, the Rotifers are more highly organized than the members of the preceding classes; they are found in great numbers in stagnant water, aquaria, &c.; and form very interesting subjects of microscopic study.

The Rotifera are bisexual, and the males are of smaller size and more simple structure than the females. The young are produced from proper ova. Nervous ganglia have been observed in some species, and eyes are also believed to have been detected. The Rotifers are very tenacious of life, specimens have been desiccated and moistened again, several times in succession, without perishing; and after being kept dry for years, they have revived on being put into water.

The following division of the Rotifers, though probably not natural, is useful in distinguishing these creatures under the microscope :—

Monotrocha.—With a continuous single ring of cilia. Example, Conochilus.

Schizotrocha.—With the ciliary apparatus notched or lobed. Example, Floscularia.

Polytrocha.—With several wheel-like organs. Example, Hydatina.

Zygotrocha.—With two wheel-like organs. Example, Rotifer.

On intestinal worms the student may consult Von Beneden, "Vers Intestinaux," (Supplement to Comptes Rendus), and Cobbold on Entozoa; and the more common Rotifers will be found described and figured in Griffith & Henfrey, Micrographic Dictionary.

CLASS 4.—ANNELIDA.

The highest group of Annulata, the Annelids or worms proper, includes a vast number of species, the classification of many of which is difficult or uncertain. De Quatrefages divides the whole assemblage into three groups, which he regards as classes; the Leeches, the Earthworms, and the Sea-worms; and the latter is subdivided into two groups or orders of vagrant worms (*Errantes*) and sedentary worms (*Sedentaires*). Others form two groups based on the presence or absence of Setæ or bristles, which are wanting in the leeches, but present in the other groups. We may however retain the older and more common subdivision into four orders, as follows:

Order 1. *Suctoria.*—Body destitute of setæ or feet. Locomotion by suckers at the extremities, alimentary canal attached to the integument. These are the leeches and their allies.

Order 2. *Terricola.*—Body cylindrical, with setæ or bristle-like organs on the rings; alimentary canal attached by bands to the integument. Earth worms and their allies.

Order 3. *Tubicola.*—Body rings with tubular setigerous feet, gills placed near the head. Marine worms inhabiting tubes. These are the Serpulæ and their allies.

Order 4. *Errantia.*—Body with numerous setigerous feet; external gills in most. These are the Vagrant Sea-worms or Sea-centipedes and their allies.

Order 1.—Suctoria.

The ordinary medicinal leech, which is everywhere well known, is a typical worm of this group. Its anterior sucker is furnished with three saw-like teeth, with which it punctures the integument of the animal on which it is to feed. It has an immense sacculated stomach, a dorsal, abdominal and two lateral circulating vessels, and a complex nervous system of the homogangliate type, with ten minute eyes on the front margin of the body. In each ring of the body there are two apertures leading to mucous glands, and serving also as openings for the discharge of the ova. The Medicinal Leech is *Hirudo* (*Sanguisuga*) *medicinalis.*

The Tortoise Leech of our creeks and ponds, (*Clepsine parasitica*, Say) is another example. It is oval and flat in form, with the posterior sucker very large and the body mottled with green and black. The ova are hatched under the body of the parent animal, and attach themselves to vessels in the abdomen, apparently obtaining

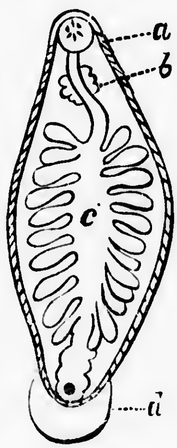


Fig. 229.—CLEPSINE PARASITICA.

Young specimen magnified, showing internal organs. *a*—Anterior sucker and eyes. *b*—Oesophagus and Salivary Gland. *c*—Stomach. *d*—Posterior Sucker.

nutriment in the first instance from the parent; but when still very small they swim freely and begin to suck the blood of other animals, sometimes of other species of leech. Fig. 229. represents a very young tortoise leech, magnified, showing its sacculated stomach as it appears when distended with food, with its eyes and suckers, the anterior one in this genus being little developed.

Order 2.—Terricola.

The earth-worms of the genus Lumbricus are the most typical representatives of this order, though it also includes some aquatic worms (*Nais* and allied genera.) The common earth-worm, *L. Terrestris*, breathes by pores in the sides, and creeps and burrows by the aid of setæ or bristles in the rings. It feeds on particles of organic matter present in the soil, and swallows with its food much fine earth, which it rejects in cylindrical castings at the mouth of its burrow. The earth worm is of value to the agriculturist in turning up the soil, especially in pasture lands, and it has been ascertained in some instances to have turned over more than a foot of soil in 80 years. Earth-worms also serve as food to many birds and other animals.

Order 3.—Tubicola.

These worms are inhabitants of the sea, forming tubes of various material, from the opening of which they exsert their gills, which are often beautiful in form and colouring. The following may serve as examples of our tubicolous worms. Fig. 230 represents the tube of *Vermilia serrula*,

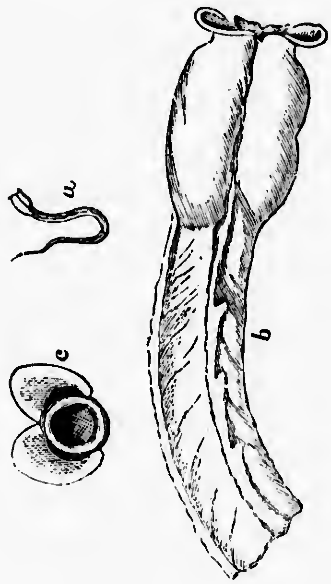


Fig. 230.—VERMILIA SERRULA, Stimpson.

a—Natural size. *b*—Magnified. *c*—Aperture magnified, showing ovarian pouches.

Stimpson, which is frequent on shells and stones. The anterior part, when complete, has two auriculate expansions at the sides, apparently to accommodate the ova. *Serpula vermicularis*, which has a round tube of similar size, is apparently less common. Several species of *Spirorbis* occur on shells, stones and sea-weeds, and are distinguished from the last mentioned species by their regularly spiral forms. *S. borealis* is common on sea-weeds, and has a round tube. *S. lucida* is smaller and coiled in the opposite direction or reversed. *S. vitrea*, Fig. 231, is

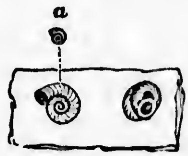


Fig. 231.—SPIRORBIS VITREA, natural size and magnified.

also a reversed species, of a semi-transparent texture. *S. granulata* has three sharp ridges on the upper side, and *S. cancellata* (Fig. 232) is our most ornate species.

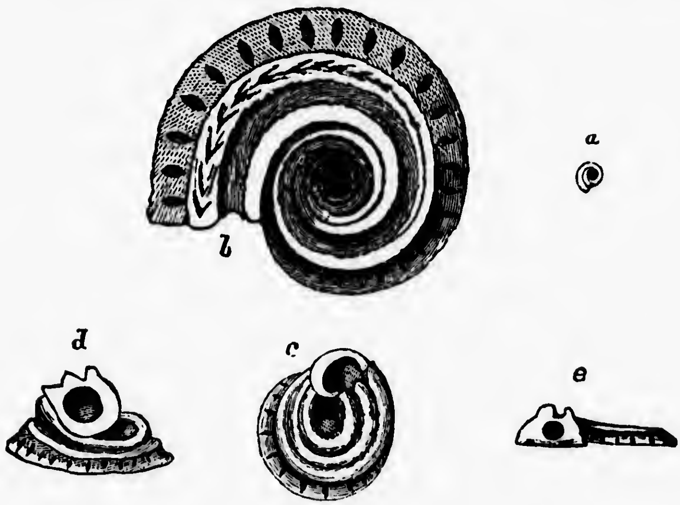


Fig. 232.—SPIRORBIS CANCELLATA, Fabr.

a—Natural size. *b*, *c*, *d*, *e*—Magnified.

It was first described by Fabricius, from Greenland, but is not uncommon on the coast of Labrador and of Gaspé. *S. porrecta* is loosely coiled and resembles a Serpula, and may be the adult state of *S. lucida*; and our largest species, *S. glomerata*, also becomes somewhat irregular in its coils at the end. *

Another group of tube-dwellers, abundantly represented on our coast, construct their tubes of grains of sand neatly cemented together. Our common species seems to be ***Pectinaria annulata.*** Lastly there are several species which inhabit membranous tubes, buried in or coated with mud or fine sand. One of these dredged at Murray Bay is represented in Fig. 233 as it appeared when alive.

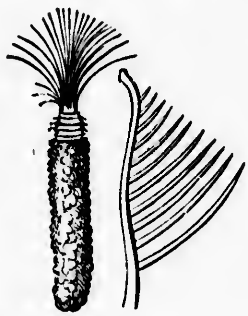


Fig. 233.—Sabella zonalis, Stimpson.
Upper part, natural size ; and branchial process magnified.

It is a Sabella, probably *S. zonalis*, Stimpson. It extends from the mouth of its tube about sixteen beautifully pectinate fibres, which are its gills, and which it can expand and retract with a very graceful movement.

Order 4.—Errantia.

It is difficult to select from the numerous species of naked sea-worms and sea-centipedes contained in this group. Perhaps the most typical species are those

* See a paper on these shells by the author, Canadian Naturalist Vol. V.

of the genus *Nereis*, in which the body is greatly elongated, with very numerous joints, having setaceous feet on each joint, to which are added flattened appendages for swimming. These also appear to serve as gills. The mouth is armed with a pair of strong mandibles. These worms abound under stones on muddy shores, and in similar places. *N. pelagia*, Lin., *N. grandis*, St., and other species, are found on our coast. *Phyllodoce catenula*, (Fig. 234) is one of the smaller species.

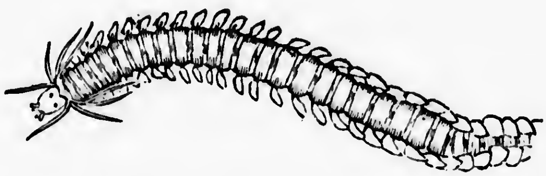


Fig. 234.—PHYLLODOCE CATENULA, Verrill.
Anterior segments enlarged.

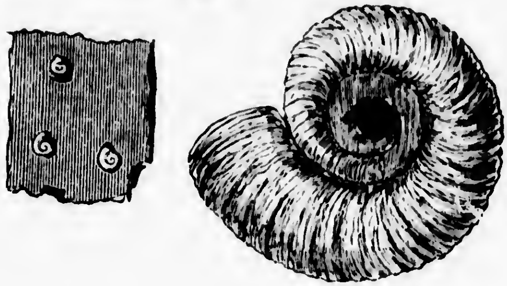
A less typical but very curious species is *Aphrodite aculeata*, an oval creature, sometimes five inches in length, and more than two broad. Its back is covered with wrinkled plates, which are its respiratory organs, and clothed with felt-like hair; and on its sides are great numbers of bristles, which shine with the colours of the rainbow. It is the Sea-mouse of the fisherman. Another very common worm of this group. *Lepidonotus squamatus*, Lin., may be recognized by its double row of rounded scales on the back.

The marine worms are of great geological antiquity; impressions of their tracks, and shells of tubicolous species, being found in very ancient rocks. Figs. 235 to 236 represent species of tubicolous worms from the Carboniferous of Nova Scotia.

Fig. 235.

Fig. 236.

Fig. 237.



235.—SERPULITES ANNULATUS, Dn.—Carboniferous.

236.—S. HORTONENSIS, Dn.—Carboniferous.

237.—SPIRORBIS CARBONARIUS,—Carboniferous. Natural size, attached to a fossil plant, and magnified.

CHAPTER VIII.

DESCRIPTIVE ZOOLOGY—*Continued.*

Province VI.—Arthropoda.

The animals of this Province conform in general plan to those of the last, and this was the ground on which Cuvier placed them along with it in his sub-kingdom Articulata. They differ in the inequality of the several somites of the body, and in the presence of jointed limbs. It is to be observed, however, that some of the Arthropods are in their immature condition scarcely distinguishable from worms, and that some as the Myriapods have an equality of the body somites and a minuteness of the limbs, which gives them even in the adult state a worm-like aspect. There is thus a great natural principle embodied in the Cuvierian Province Articulata, which should not be overlooked.

The Arthropods may be divided into four classes, as follows :—

1. *Crustacea.*—Shrimps, Lobsters, Crabs, &c.
2. *Myriapoda.*—Centipedes and Gally-worms.
3. *Insecta.*—Six-footed Insects.
4. *Arachnida.*—Mites, Spiders, and Scorpions.

It is to be observed, however, with respect to the rank of these classes, that while the more perfect Arachnida are in some respects higher in rank than the true insects, they also approach in other respects more nearly to the Crustacea, and that while the lower Myriapods present many resemblances to worms, they are very near to the Hexapod Insects in the character of their respiration.

CLASS I.—CRUSTACEA.

Body with articulated limbs, and divisible into cephalo-thorax and abdomen. Respiratory organs branchial. Head with jointed antennæ.

The crustaceans are the soft shell-fishes, of which the Crab, Lobster, Crayfish and Shrimp, may be taken as examples. They are characterized by the division of the body into two portions, the cephalo-thorax and abdomen, and by the possession of proper jointed limbs, and gills as organs of respiration. By these characters they may be distinguished from the worms on the one hand and

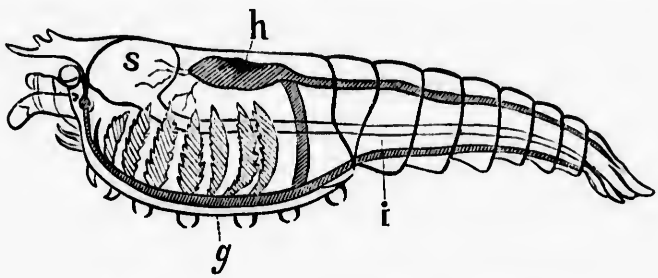


Fig. 238.—DIAGRAM OF A DECAPOD CRUSTACEAN.

s—Stomach. *h*—Heart. *g*—Gills. *i*—Intestine.

the insects and arachnidans on the other. The front part of the cephalo-thorax corresponds to the head, and is furnished with jointed antennæ, eyes and other organs of sense, and organs of mastication, usually in several pairs. The cephalo-thorax contains the stomach, heart and gills, arranged as in the diagram (Fig. 238). To the cephalo-thorax are also attached the proper feet. The abdomen is muscular, and usually furnished with swimming apparatus. Most of the crustacea are aquatic, and those that live on land, nevertheless, breathe by means of gills.

The Crustacea may be divided primarily into two sub-classes:—

1. *Entomostraca*, including a great number of species, with various numbers of feet and without swimming feet on the abdomen. The integument in these species is also composed of the substance named chitine, whereas in the higher groups it is often strengthened with calcareous matter. These are the Water-fleas, Barnacles, King-crabs, Cyprids, Trilobites, &c. The animals of this group appear very early in geological time, and some of the fossil forms are so markedly distinct from those of later formations and modern times, that it has been proposed to divide the group into Neocarida or modern Entomostracans, and Palæocarida, or ancient Entomostracans. Without insisting on this sub-division, we shall arrange the orders in this manner, beginning with the Palæocarida.

2. *Malacostraca*, with seven or five pairs of legs and thoracic segments, and six abdominal segments. They

may be divided according to the number of limbs into (1) *Tetradecapoda*, or those with the feet in seven pairs, and appendages on the abdomen. These are the Oppossum shrimps, Sand-fleas, Sow-bugs, &c. (2) *Decapoda*, with five pairs of feet. These are the Lobsters, Crabs, &c.

SUB-CLASS 1.—ENTOMOSTRACA.

The orders in the sub-division of Palæocarida are the following :—

1. *Xiphosura.*—The King-crabs or Horse-shoe Crabs. *Limulus polyphemus*, the American King-crab, or Horse-shoe crab, is found as far north as the coast of Maine, but does not extend into British America. These

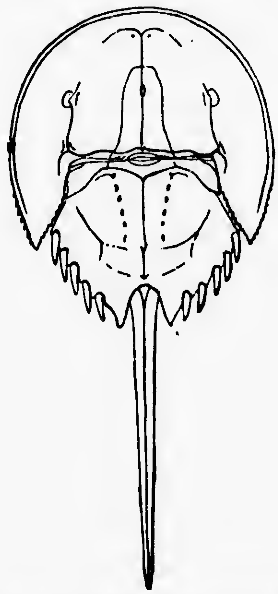


Fig. 239.—LIMULUS POLYPHEMUS, or Horse-shoe Crab, reduced.

creatures have the cephalo-thorax of semi-lunar form, and the abdomen reduced to two pieces, one of them being a sharp defensive appendage (Fig. 239).

2. *Trilobites*—These are extinct crustaceans characteristic of the Palæozoic rocks. The anterior segment of a trilobite is the largest, and is known as the *buckler.* It is divided by two longitudinal furrows into the side areas or *cheeks,* which bear the eyes, and a central area, the *glabella.* The body segments are usually numerous, and each divided into three lobes. The last segment which is usually similarly lobed, is named the *pygidium.* The feet of Trilobites appear to have been small and probably soft, but they are not certainly known, except in a few species (Fig. 240). The markings on rocks known as

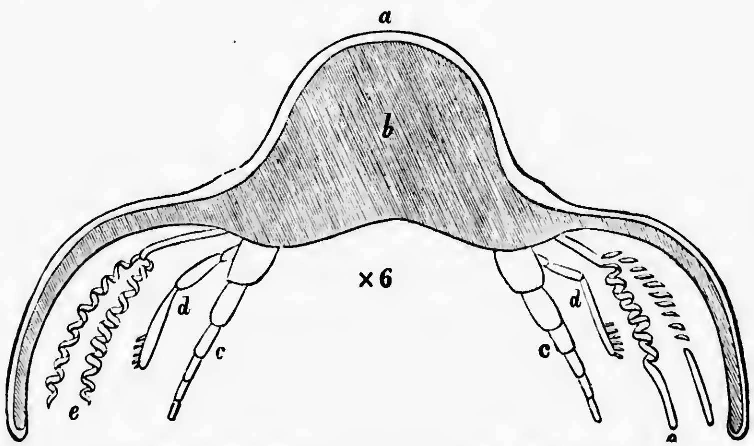


Fig. 240.—Transverse section of CALYMENE, after Wolcott.
a—Dorsal shell. *b*—Visceral cavity. *c*—Legs. *d*—Epipodite, gill cleaner or palp. *e*—Gills.

Rusichnites, *Protichnites*, and *Climactichinites*, are supposed to be burrows and tracks of Trilobites or similar animals.

Many species of Trilobites occur in Canadian rocks. (Figs. 240 to 244.)

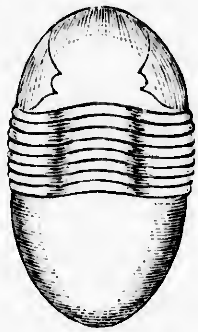


Fig. 241.—Asaphus notans, Billings.—Middle Silurian.

Fig. 242.—Dalmania logani, Hall (Head & Pygidium), Silurian

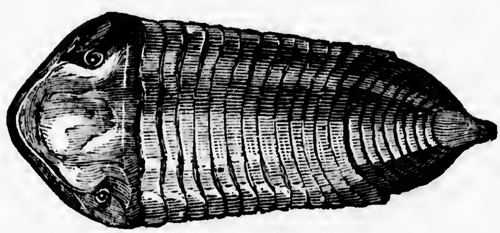


Fig. 243.—Homalonotus delphinocephalus, Green.—Silurian.

Fig. 244.—Phillipsia howi, Billings (Pygidium),—Carboniferous.

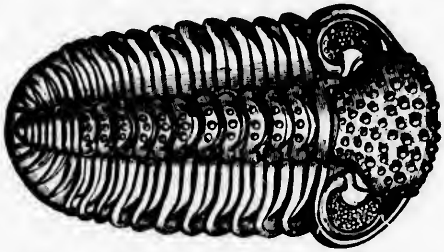


Fig. 245.—PHACOPS LATIFRONS, Devonian.

3. *Eurypterida.*—This order includes the largest known Entomostraca. The species all belong to the Palæozoic period of Geology, and are known to us only as fossils. In Canada and Nova Scotia, their remains are found in the Upper Silurian, Devonian and Carboniferous rocks. They resemble the Trilobites and King-crabs in the form of the short head or cephalo-thorax, but

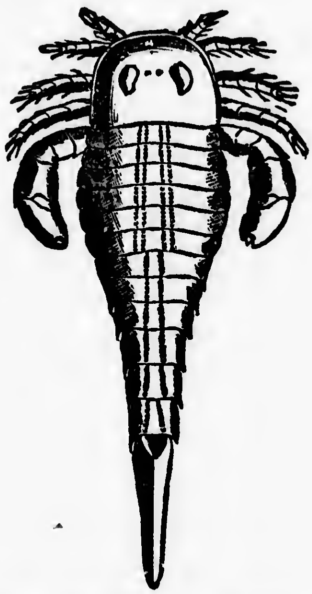


Fig. 246.—EURYPTERUS REMIPES, Dekay, restored,—Upper Silurian.

differ in the great development of the abdominal segments, which some authors regard as divisible into two series, one thoracic and the other abdominal. There are twelve of these segments with a telson or tail piece in addition. There are five pairs of appendages round the mouth, which appear to have combined, as in Limulus, the functions of jaws and limbs. Fig. 246 represents a restoration, by Prof. Hall, of *Erypterus remipes*, a species found in the Upper Silurian of Western Canada. Other genera of this order are *Pterygotus* and *Slimonia*.

The orders in the sub-division of Neocarida are the following :—

1. *Phyllopoda.*—These are small crustaceans of shrimp-like form, with very numerous leaf-like feet and elongated bodies. Some of the species swarm in fresh-water ponds in spring and in summer. Fig. 247*b* represents a com-

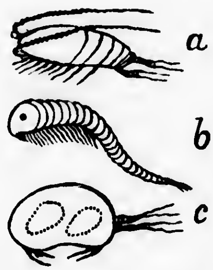


Fig. 247.—ENTOMOSTRACA. *a*—ANOMOLOCERA, sp.—magnified. *b*—BRANCHIPUS VERNALIS, Verrill. *c*—CYPRIS AGILIS, Haldeman, magnified.

mon species of *Branchipus*, found in Canada, *B. vernalis*, Verrill. In these creatures the eyes are sometimes consolidated into one mass. The limbs serve for gills as well as for locomotive organs. To this group or the next are also referred a number of curious bivalve crustaceans of the Palæozoic rocks, belonging to the genera *Leperditia*, *Beyrichia*, *Estheria*, *&c.* (Figs. 248, 249.)

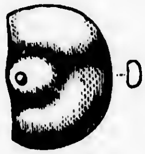


Fig. 248.
BEYRICHIA JONESII, Dn.
Carboniferous.

Fig. 249.
B. PUSTULOSA, Hall.
Upper Silurian.

2. *Ostracoda.*—In these the body is more completely covered with a bivalve carapace, which sometimes resembles the shell of a bivalve mollusk. The limbs are suited for swimming and the eyes are confluent. Fig. 247 c. represents a species of *Cypris* common in fresh-water pools and ditches, and resembling, if not identical with, *C. agilis*, Haldeman. Fig. 250 represents *Cytheridea*

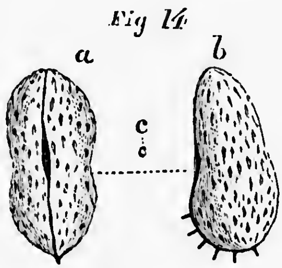


Fig. 250.—CYTHERIDEA MULLERI, Munst. *a*—Front. *b*—Side. *c*—Nat. size.

Mulleri, one of several marine species found in the Gulf of St. Lawrence, and also in the Post-pliocene clays. Several species of Ostracods are found in the coal-formation rocks, and referred to genera *Cythere*, *Cytherella* and *Bairdia*. (Fig. 251.)

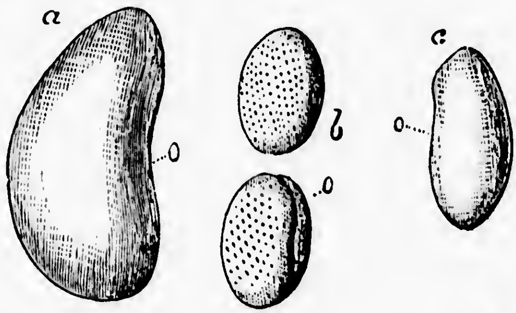


Fig. 251.—ENTOMOSTRACA—Carboniferous. *a*—BAIRDIA. *b*—CYTHERELLA INFLATA. *c*—CYTHERE.

3. *Cladocera.*—In this order the body is usually short, and the carapace or covering of the cephalo-thorax is in two valves. The limbs are lamelliform and branchial, and the eyes usually confluent. The water fleas of the genus *Daphnia* belong to this order.

4. *Copepoda.*—In these the body is shrimp-like though minute, and distinctly articulated, with many pairs of swimming limbs. The females are remarkable for their large pendant ovisacs. Species of *Cyclops* are very common in the fresh water, and many other forms occur in the sea. The species of *Anomalocera* represented in Fig. 247*a*, is remarkable for its luminosity at night, often causing great breadths of the Gulf of St. Lawrence to be phosphorescent.

5. *Cirripedia.*—These are the Barnacles and Acorn-shells, creatures which in their young state resemble ordinary entomostracans, but when adult are included in peculiar shelly coverings, giving them a very anomalous

appearance. The genus Balanus contains the common beach acorn-shell, *B. crenatus*, which appears abundantly on all rocky coasts. The genus *Coronula* includes the large whale-barnacles, which grow parasitically on the skins of whales. *C. diadema* is common on whales caught on the Labrador coast. The genus *Lepas* includes stalked species, the barnacles proper. Fig. 252 repre-

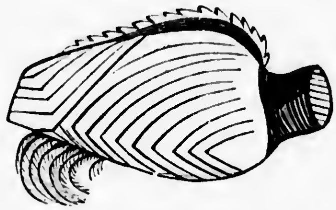


Fig. 252.—LEPAS DENTATA, Gould.

sents *L. dentata*, a species common on the Atlantic coast, and which may be a variety of *L. anatifera*. The valves which cover these creatures are five in number;

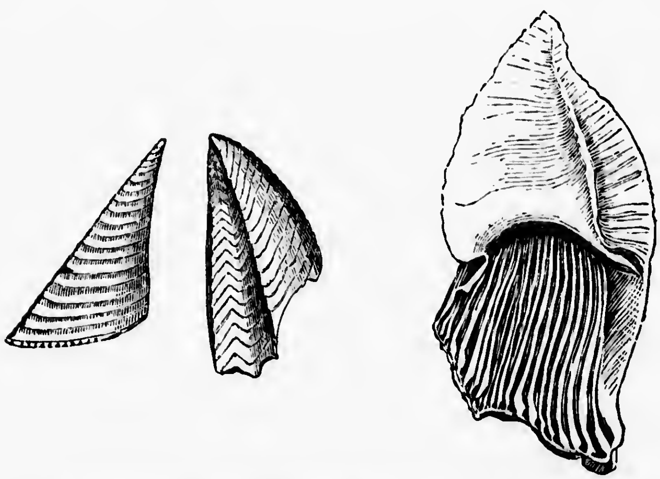


Fig. 253.—BALANUS HAMERI, Opercular valves and Body valve.

the two larger are the Scuta, the two smaller the Terga, and the single piece along the back the Carina. The latter is the only part corresponding to the conical case of the acorn-shells. The scuta and terga correspond to the "opercular valves" of the latter. Fig. 253 represents portions of our largest acorn shell.

6. *Epizoa.*—The Epizoa are a group of depauperated and parasitic crustaceans, which in their young state swim freely and resemble the young of ordinary Entomostraca; but when adult they attach themselves, either by a suctorial mouth, by mandibles furnished with hooks, or by suckers attached to the limbs, to the skin, eyes or gills of fishes, and other aquatic animals. The females carry a pair of pendant ovisacs, and the males are animals of much smaller size and of different form. The Epizoa are curious objects for examination under the microscope, owing to their singular forms and the readiness with which their viscera can be seen through their transparent bodies. They have been divided into the following sub-orders or families:—

1. *Cephaluna*, or those attached directly by the head.
2. *Brachiuna*, or those attached by suctorial arms.
3. *Onchuna*, or those attached by hooks.

Sub-class 2.—Malacostraca.

Division 1.—*Tetradecapoda.*

This group includes an immense number of species of the smaller crustaceans, agreeing in the number of thoracic limbs, though in some cases these are merely rudimentary, but differing very much among themselves in details of structure. The orders of Tetradecapoda are four, as follows :—

1. *Læmodipoda.*—In these the abdomen is rudimentary, and the thorax is elongate, with limbs having hooks or claws, and others that are vesicular and branchial. A common species in the Gulf of St. Lawrence is *Caprella septentrionalis*, the *Squilla lobata* of Fabricius, who describes it admirably. It is a grotesque looking creature, half an inch long, found on sea-weeds and zoophytes. It walks by bending and lengthening its body like a looper caterpillar, and when seeking for food attaches itself by its hind legs and bends and vibrates its body and antenæ with great agility, grappling with its fore limbs anything that may come within its reach.

2. *Isopoda.*—The Isopods have the abdomen somewhat similar to the cephalothorax, and the body usually flattened, the thoracic limbs subequal, the abdominal branchial, and in the female plates for sheltering the spawn on the abdomen. The genus *Asellus (A. Communis*, Say, Fig. 254) is found in our fresh-water streams,

Fig. 254.—Asellus communis, Say.

under stones and chips, and may be regarded as a typical isopod. On the sea coasts species of *Idotea* and other genera are found in sand and mud, and among sea weed. Species of *Cymothea* are found attached to cod and other sea fishes, on which they are parasitic, and the little *Limnoria terebrans* is remarkable for the rapidity with which its almost countless hosts burrow into and devour the woodwork of bridges and wharves. A species of *Limnoria* has been found at Gaspe by Mr. Whiteaves. The genus *Oniscus* includes the common sow-bug or slater, a terrestrial species, living in cellars and damp places; and is interesting as an example of a crustacean capable of breathing in air, though by means of gills. It feeds on decaying vegetable matter, and is harmless to man.

3. *Amphipoda.*—These have the thoracic limbs unequal, and with vesicular branchial organs at their bases. The abdomen is terminated by appendages for swimming or leaping. The body is usually compressed laterally and curved. The Amphipods are the "beach-fleas," "sand-hoppers," &c., and are very numerous on the

Fig. 255.—Mysis spinulosus. *b*—Gammarus minor.

borders of the sea and also in some fresh-water streams. *Gammarus locusta* is found along the coast almost everywhere, among sea-weeds ; and an allied species, *G. Minor* (Fig. 255*b*) is an inhabitant of streams and ponds. The sand-fleas of the genera *Orchestia* and *Talitrus* are also common on sandy beaches. *Diplostylus Dawsoni* of the coal-formation of Nova Scotia is supposed to be an Amphipod (Fig. 256).

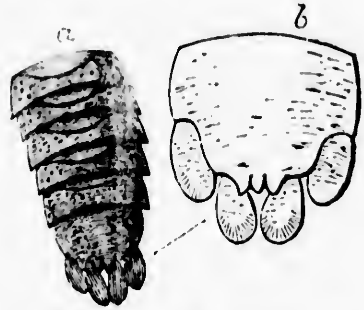


Fig. 256.—DIPLOSTYLUS DAWSONI, Salter—Carboniferous.
a—Abdominal segments. *b*—Tail magnified.

4. *Stomapoda.*—In these the eyes are borne on stalks, the thoracic region is protected by a carapace, the gills are free and exposed, and the anterior feet are turned toward the head. The tail and abdominal feet are adapted for swimming. The larger species of Stomapods are found in the waters of the warmer regions of the world. Those of our coasts are small, though often in great numbers. *Mysis spinulosus* (Fig. 255*a*) is abundant along the Atlantic coast, and has been called "opossum shrimp," from a pouch under the thorax in which the young are carried for a time. *M. oculatus* is a second and more northern species, found on the north shore of

the Gulf of St. Lawrence. Fossil crustaceans, supposed to be allied to Stomapods, are found in the coal formation and Devonian of Nova Scotia and New Brunswick. One of these is *Amphipeltis paradoxus*, Salter.*

The Stomapods closely connect the Tetradecapods with the next division.

Division 2.—Decapoda.

This group includes the highest and most perfect crustaceans, characterized by having feet in five pairs and the eyes mounted on stalks, with the body definitely divided into cephalo-thoracic and abdominal regions. The gills are lamellar, attached to the sides of the thorax, and always enclosed in a special branchial cavity. Fig. 238 illustrates the arrangement of the more important organs as seen in the common lobster. The Decapods may be divided into three groups, which are perhaps of ordinal value.

1. *Macroura*, or long-tailed crustaceans. These have the abdomen long, with lamellar swimming feet, which also, in the female, serve to carry the spawn. The abdomen is terminated by a swimming organ, and is furnished with powerful muscles for striking the water with the caudal fin. The most important representative of this group is the common lobster, *Homarus Americanus*. The fresh-water cray-fish, *Astacus Bartoni*, also belongs to it, as well as great numbers of shrimp-like creatures found in the salt water. One of the most abundant of

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* Acadian Geology, second edition.

these is that represented in Fig. 257, *Crangon vulgaris*,

Fig. 257.—CRANGON VULGARIS, Fabr.

a species very plentiful on both sides of the Atlantic. Other species, very abundant in the Gulf of St. Lawrence, and distinguished by a dentated rostrum, belong to the genera *Hippolyte* and *Pandalus*.

2. *Anomoura.*—This group is characterized by a long abdomen destitute of natatory organs. The most remarkable representatives on our coasts are the hermit crabs, of which there appear to be several species, not as yet very well distinguished from each other. Our most

common species appears to be *Eupagurus Bernhardus.* It has a naked abdomen, furnished at the end with prehensile hooks, and shelters itself in the cast-off shells of univalve mollusks.

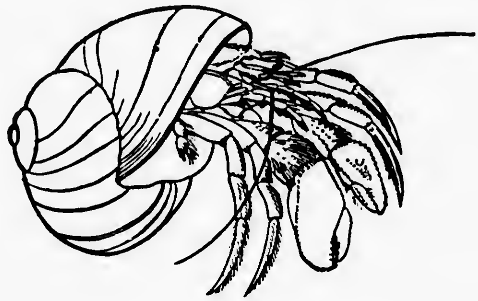

Fig. 258.—EUPAGURUS POLLICARIS, after Morse.

To this group belong also the "soldier crabs," of the intertropical regions, which are capable of living on land.

3. *Brachyura.*—In these the tail is rudimentary and bent under the thorax, and the antennæ are short. These are the crabs proper. *Cancer borealis* is our common crab, which is very abundant on all sandy and muddy shores. The smaller "spider crab," *Hyas aranea*, is found in water a little deeper ; and the great spider crab, which is our largest species, sometimes measuring eighteen inches in extreme breadth, occurs in still deeper water. It is *Chionectes opilio* of Fabricius.

The tropical Land-crabs (*Gecarcinus*) and Tree-crabs (*Birgus*) belong to this group. Their gills are furnished with a special apparatus for containing water to keep them moist in the air ; some of these creatures are of large size, and of great strength and swiftness.

On the Crustacea the student may consult Milne Edwards' "Crustaces" in the "Suites a Buffon," and Owen's Lectures on the Invertebrata; and for American species, De Kay's Report on the Crustacea of New York, and papers by S. J. Smith, in Reports of United States Fishery Commission. Canadian species of Trilobites and other fossil crustacea will be found described by Billings and Jones in the Reports of the Geological Survey. See also Hall's Palæontology of New York.

CLASS II.—MYRIAPODA.

Somites of thorax and abdomen continuous and similar, often very numerous. Each somite with one or two pairs of feet. Respiration by tracheæ or air-tubes.

The Myriapods constitute at present only a small and not very diversified class, but they appear to have culminated in the Palæozoic period, so that they are probably a survival of a group at one time more important. A tropical genus *Peripatus* connects the Myriapods very closely with the worms, and is regarded as the representative of a separate order. The Myriapods of Canada may all be included in two orders, as follows:—

Order 1. *Chilognatha.**—Head composed of one segment, two pairs of feet on each segment of the body. These are the Gallyworms or Millepedes.

Order 2. *Syngnatha.*†—Head composed of two segments, one pair of legs on each segment of the body. These are the Centipedes.

These creatures differ so greatly from the typical insects that many naturalists regard them as a separate

* Diplopoda, Blainville. † Chilopoda, Latreille.

class. In their general form of body, and in their developement by increase in the number of their segments, they resemble the worms; but in their internal structures and in the possession of limbs they approach to the insects, of which, on the principles of classification followed in this manual, they must necessarily form the lowest or most degraded group, corresponding to the scolecida among the worms. The chilognatha or gallyworms are represented in this country by several species, of which one of the most common is apparently *Iulus venustus*, Wood (Fig. 259). It lives among decaying

Fig. 259.—Iulus venustus, Wood,

vegetable matter, on which it feeds, and when disturbed curls itself up. Of the other division one of our common representatives is *Lithobius Americanus* (260). The

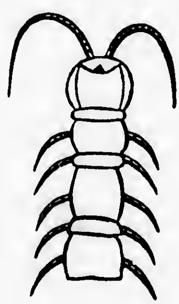

Fig. 260.—Lithobius americanus, Newport.—Anterior segments enlarged.

centipedes, of which this creature is an example, are carnivorous and active in their habits, and furnished with poisoned fangs. Some of the tropical species attain to a great size and inflict formidable bites.

The earliest known Myriapods have been found in the Devonian of Scotland, and the Carboniferous period seems to have been more favorable to the herbivorous myriapods than the modern time. In the coal-formation of Nova Scotia, six species have been found. One of these *Xylobius sigillariæ*, is represented in Fig. 261 *a* and

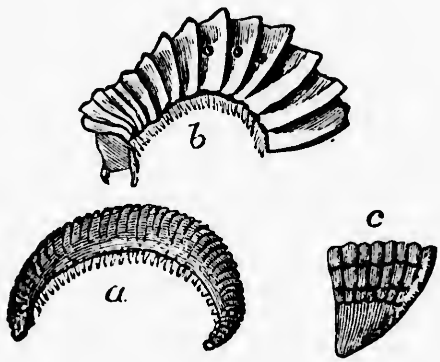

Fig. 261.—Carboniferous myriapods.

a—Xylobius sigillariæ, Dn.
c—Posterior Segments enlarged.
b—Archiulus xylobioides, Scudder.

c, and another *Archiulus xylobioides* in Fig. 261 *b*. Several very large forms occur in the Carboniferous of Illinois.

CLASS III.—INSECTA.

Skeleton chitinous, with articulated limbs; and in the typical orders, a distinction into head, thorax and abdomen; head with jointed antennae. Respiration tracheal. Wings in most; limbs normally in three pairs.

In the insecta the body is divided into three great regions, the head, thorax and abdomen. The rings of the body in the insects are more complex than in the previous classes, being each divided into a tergum or back piece, two side pieces and a sternum or head piece, and in the thoracic part at least, these portions are again subdivided.

The head in the typical insects is regarded by most entomologists as composed of several rings or segments consolidated together. Its appendages may be divided into sensory and oral. The first are the eyes and antennæ or tactile organs, and probably organs of taste and smell. The eyes in adult insects are in two masses or compound eyes, consisting of numerous simple eyes, each having a hexagonal or quadrangular cornea, a crystalline lens and a division of the optic nerve imbedded in pigment. Besides these there are separate ocelli, usually three in number, on the top of the head. Some uncertainty exists as to the hearing in most insects, but in some, as in the locust, there are auditory sacs in the basal joint of the abdomen.

The oral organs are the labrum or upper lip, which forms the roof of the mouth, the two mandibles, which are often powerful hooks or jaws, the two maxillæ or inner jaws, and the labium or lower lip, which is furnished with palpi or feelers. In the suctorial insects the oral organs are variously modified into lancets or suckers, for obtaining liquid food.

The appendages of the thorax are, in the most perfect forms, two pairs of wings above, and three pairs of legs below. The thorax is divided into three segments, the pro-, meso- and meta-thorax. Each has a pair of feet, and the wings, when present, are attached to the meso- and meta-thorax. The wings are each composed of a double membrane, strengthened by tubular nervures. The wings may be coriaceous or membranous, and naked or covered with scales, and their venation affords important characters for distinguishing the orders, families and genera. The abdomen is destitute of appendages, except the ovipositor, sting or other apparatus which may be attached to its extremity. Each thoracic leg consists of five joints :—(1) the Coxa, consisting in some orders of two pieces; (2) the Trochanter; (3) the Femur; (4) the Tibia; (5) the Tarsus, usually consisting of five subdivisions, and terminated by a pair of claws, between which is a cushion-like sucker which aids the insect in walking on vertical and overhanging surfaces.

The insects are remarkable, among the invertebrates, for the perfect structure and arrangement and great energy of the muscular system. The muscles concerned in locomotion are chiefly concentrated in the thorax and its appendages. The nervous system consists of a double abdominal cord, with a ganglion at each segment, from which the nerves of that segment are given off. The abdominal cord consists of an upper series of fibres without ganglia, and an under series on which the ganglia are placed. In the head the nerve cord expands into an œsophageal ring, with a considerable mass of nerve matter above the gullet, giving off the nerves of sense. The digestive organs consist of the œsophagus, crop, gizzard, true digestive stomach and intestines. The heart is an elongated dorsal vessel with a series of valves, and propelling the blood from back to front. The respiration of insects is carried on by tracheæ or air-tubes, kept open by a delicate thread of chitine spirally coiled in their walls, and opening by spiracles or breathing pores in the thorax and abdomen. The tracheæ penetrate through all parts of the body, and blood-vessels are abundantly distributed on their surfaces. The expulsion and admission of air are effected by the alternate contraction and dilatation of the abdominal segments. In larvæ and pupæ inhabiting water, the respiration is effected by gill-like expansions of the crust of the body, containing air-tubes and apparently absorbing the air mechanically suspended in the water. (See Fig. 262.)

Insects are bisexual and reproductive by eggs, and many of their most curious instincts are connected with oviposition and provision for their young. The egg in the higher insects developes a worm-like *Larva*, and this passes into a torpid *Pupa*, within which the parts of the *Imago* or perfect insect are developed, until it emerges full grown from the pupa case. In some insects, however, this metamorphosis is imperfect, the larva and pupa resembling the perfect insect, except in the absence or rudimentary state of the wings ; and in some wingless insects there is no metamorphosis. Insects are thus *Metabolian*, *Hemi-metabolian* or *Ametabolian.*

Fig. 262.—ANATOMY OF SPHINX LIGUSTRI—after Newport.

a—Maxillæ or Tongue.
b—Labial Palpi.
c—Super-œsophageal Ganglion or Brain.
m, i, g—Principal Nerve-cord and Ganglia.
d—Nerves of muscles of flight.
n, o, p—Nerves of muscles of the legs.
h—Crop.
e, f—Heart or Dorsal vessel.
j—Digestive Stomach,
g—Intestine and urinary vessels.
k, l—Generative organs.

The numerals indicate the segments of the body, 8 to 10 being thoracic, and 11 to 20 abdominal.

Several kinds of peculiar organs of secretion are observed in insects. Of this kind are the silk-glands for secreting that material, the odoriferous glands secreting pungent odoriferous substances, and poison glands connected with stings or lancets.

SUB-CLASS HEXAPODA.

Order 1. *Aptera.*—These are destitute of wings, and undergo no metamorphosis, or are *ametabolian.* They are the Lice and Spring-tails. By some modern systematists this order is broken up—the Lice being placed with the order Hemiptera, and only the Spring-tails and their allies retained in this order.

Order 2. *Aphaniptera.*—These have rudiments of wings, and undergo a complete metamorphosis, or are metabolian. They are the Fleas and their allies. In some modern systems this order is united with the next.

Order 3. *Diptera.*—The insects of this order have only two wings, on the meso-thorax; the second or posterior pair being rudimentary and named halteres or poisers. They are metabolian and their larvæ are footless. These are the Flies and Gnats.

Order 4. *Lepidoptera.*—These have four wings, usually of ample dimensions, clothed with coloured scales. They are metabolian, and the larvæ have rudimentary limbs. They are the Butterflies and Moths.

Order 5. *Hymenoptera.*—These have four wings, membranous and few veined, and the basal joint of the abdomen united with the thorax. They are the most perfectly metabolian of all insects. They are the Bees, Wasps and Ants.

Order 6. *Hemiptera.*—These have four wings, the first pair wholly or partly leathery or coriaceous. They have an imperfect metamorphosis or are hemimetabolian, the larvæ having six feet and the thorax and abdomen distinct. They are the Bugs, Water-boatmen, Plant-lice, &c.

Order 7. *Neuroptera.*—These have four membraneous veiny wings. They are hemi-metabolian, the larvæ being hexapod and often aquatic. They are the Dragon-flies, May-flies, &c.

Order 8. *Orthoptera.*—These have four wings, the front pair coriaceous but nerved, the second pair folded longitudinally in the manner of a fan. They are hemi-metabolian, the larvæ being like the imago but without wings. They are the Grasshoppers and Cockroaches.

Order 9. *Coleoptera.*—These have four wings, the first pair being hard *elytra* or covers to the under pair, which are folded transversely. These are intermediate between the hemi-metabolian and metabolian insects, the larvæ being worm-like but six-footed. They are the Beetles.

Of the above orders the first six have their mouth organs for the most part adapted for suction, (haustellate) the last three have the mouth adapted for biting (mandibulate).

The families and genera of insects are so numerous that it will be necessary in this manual merely to illustrate each order by a few typical species, leaving the student to refer for further information to more detailed works, to be mentioned in the sequel.

ORDER 1.—APTERA.

We figure as an illustration of this order the too well-known *Pediculus humanus* (Fig. 263) an external parasite

Fig. 263.—PEDICULUS HUMANUS CAPITIS, De Geer.—magnified.

on the human head, where it subsists by sucking blood by means of its minute beak or haustellum. It deposits its eggs upon the hair. The Poduræ or Spring-tails are remarkable for the presence of a moveable bifurcate organ at the extremity of the abdomen, by means of which they can leap with great agility. In the genus *Lepisma* the body is covered with shining scales which are interesting microscopic objects. These creatures are often found in damp lumber-rooms and similar places.

ORDER 2.—APHANIPTERA.

The Fleas, of the genus *Pulex*, are remarkable for their leaping powers, and the highly irritating nature of the poison which they inject into the minute wounds inflicted by their sharp lancet-like mandibles. The eggs of the fleas are deposited in dust and organic matters lying in dry places, and are hatched into worm-like larvæ. In some of the species the larvæ spin a silken cocoon in which they pass the pupa state. The largest species known is *Pulex gigas*, described by Kirby, found in the northern part of British America, in Lat. 65°. It is two lines in length.

Order 3.—Diptera.

The principal families of the two-winged insects are :—

The *Hippoboscidæ* or Forest-flies, Sheep-ticks and Bird-ticks, some of which are wingless.

The *Oestridæ* or Bot-flies, whose larvæ inhabit the stomachs of horses and other animals, *Oestrus*, &c.

The *Muscidae* or ordinary House-flies, *Musca domestica*, &c.

The *Tabanidae* or biting Horse-flies, *Tabanus*, &c.

The *Tipulidae* or Harry-long-legs and Wheat-flies, *Tipula*, *Cecidomyia*, &c.

The *Culicidae* or Mosquitoes and Gnats, whose larvæ live in water, and the adult females are very troublesome by their irritating bites. *Culex pipiens* is the European species, and there are said to be thirty species known in North America.

As an illustration of the Diptera we may take the *Cecidomyia tritici*, Kirby, which under the name of "wheat midge" and "weevil" * has been so destructive

* The latter name is incorrect, the true weevils being Coleoptera.

to the wheat crop in America. The imago and larvæ are shown in Fig. 264. The animal deposits its eggs in

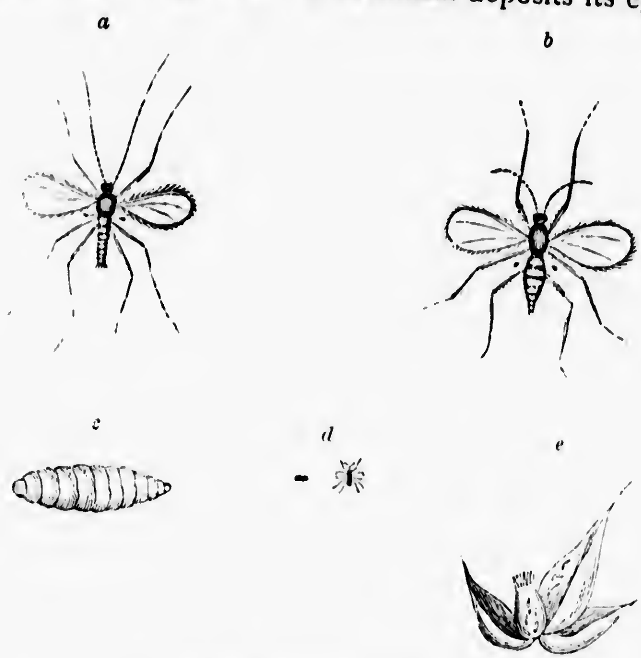

Fig. 264.—CECIDOMYIA TRITICI, *Kirby*.
a—Male, magnified. *b*—Female, magnified. *c*—Larva magnified.
d—Imago and Larva, natural size. *e*—Kernel of wheat with larvæ.

the ears of wheat when in blossom. The minute yellow larvæ hatched from these eggs feed on the juices of the young grain, and when mature drop to the ground, into which they burrow and remain torpid during the winter, making their way to the surface in spring to assume the imago condition and to renew their depredations. The best remedy for their attacks is to cut and house the grain before the larvæ have dropped, and to destroy these when the grain is threshed. The "Hessian Fly," an allied species (*C. destructor*) deposits its eggs on the straw of wheat, and the larvæ suck the juices of the stem. Two broods are produced in the year. This species is represented in Fig. 265. A proper rotation of crops is the surest remedy for the ravages of the Hessian fly.

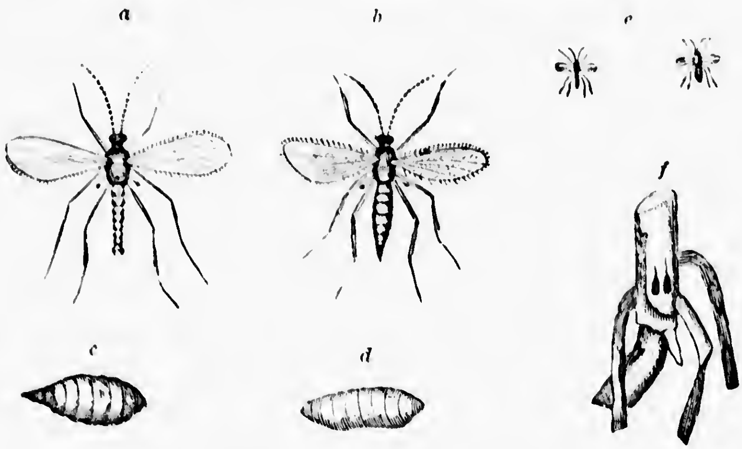

Fig. 265.—CECIDOMYIA DESTRUCTOR, Say.

a—Male, magnified. *b*—Female, magnified. *c*—Larva, magnified. *d*—Pupa, magnified. *e*—Imago, natural size. *f*—Joint of wheat with larvæ.

ORDER 4.—LEPIDOPTERA.

The Butterflies and Moths are the gayest of insects in the imago state, and their larvæ or caterpillars are among the most destructive of pests. They are remarkable for the perfection of the silken cocoons formed by some species, to which we owe the beautiful and useful material silk. The scales of the wings are among the most interesting of microscopic objects. The Lepidoptera may conveniently be divided into three groups. (1)

Butterflies, or diurnal species with knobbed antennæ (rhophalocera) and carrying the wings erect when at rest. (2) Hawk-moths, or sphinxes—crepuscular species, having the antennæ thickened in the middle, and carrying

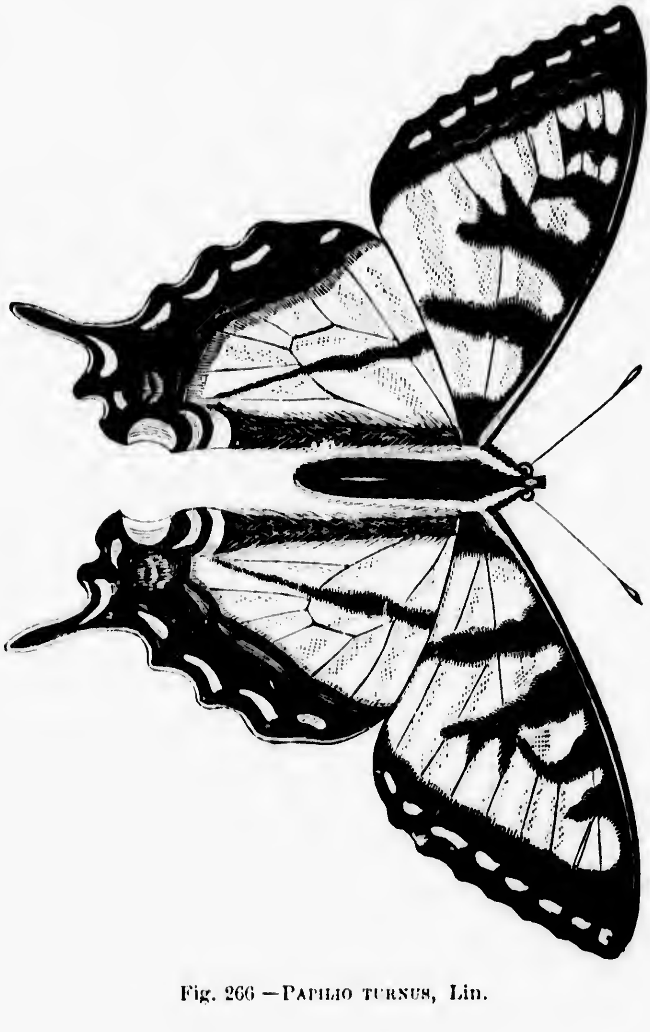

Fig. 266.—Papilio turnus, Lin.

the, often narrow, wings flat when at rest. (3) Moths, or nocturnal species, having the antennæ filiform or pectinated (heterocera) and the wings carried flat when at rest.

One of our finest butterflies is *Papilio Turnus* (Fig. 266), the Yellow Swallow-tail. The eggs are deposited on cherry, plum and other trees, on the leaves of which the larva feeds. It is solitary, and remains by day on a silken platform spun by itself and stretched between the edges of a leaf. It feeds at night. When ready to become a chrysalis, it suspends itself by a button of silk at the tail, and a loop supporting the back (Fig. 267).

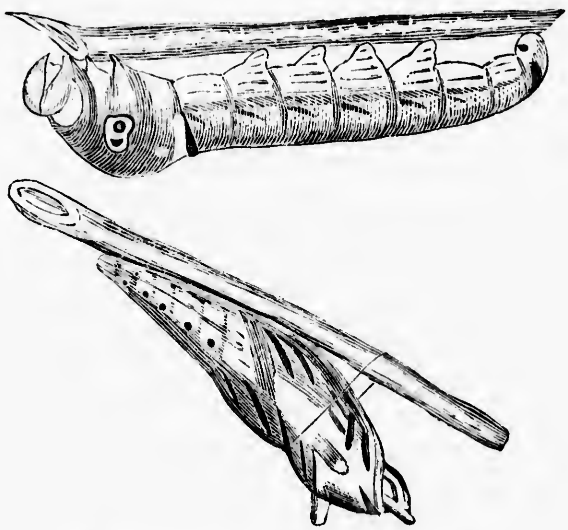

Fig. 267.—PAPILIO TURNUS, Larva and Pupa.

Another common and beautiful species is the "Camberwell Beauty" (*Vanessa Antiopa*) whose spiny caterpillars feed on elm and other trees (Fig. 268). The "Clouded

Fig. 268.—VANESSA ANTIOPA, Lin.

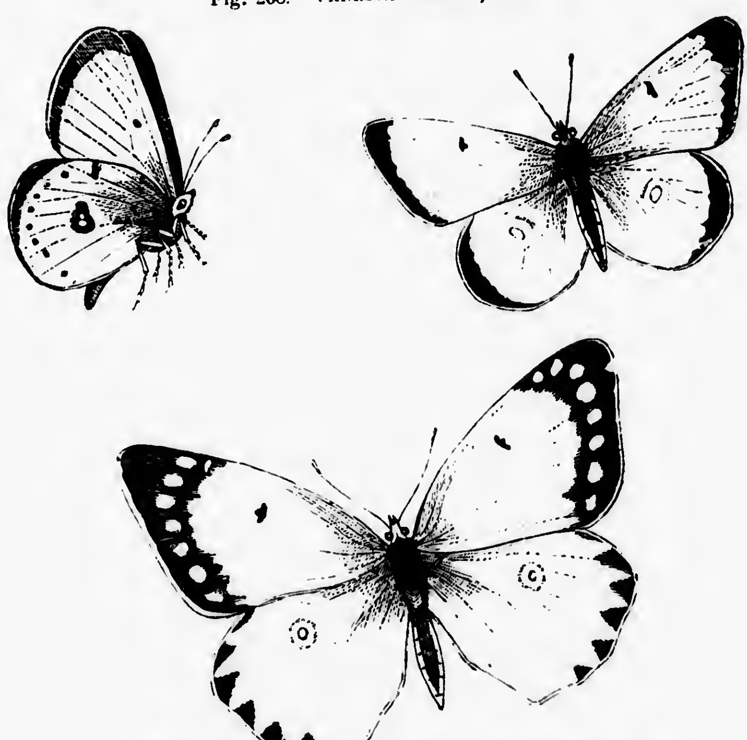

Fig. 269.—COLIAS PHILODICE, Godart.—male and female.

Sulphur" (*Colias philodice*) is one of our most common butterflies by road-sides in summer. The caterpillar is greenish, with yellow and black markings, and feeds on clover (Fig. 269). The small white butterflies of the genus *Pieris* are more troublesome, the caterpillar of *P. rapæ* being very destructive to cabbages and similar plants. This is an introduced species. A native species (*P. oleracea*) has similar habits but is less destructive.

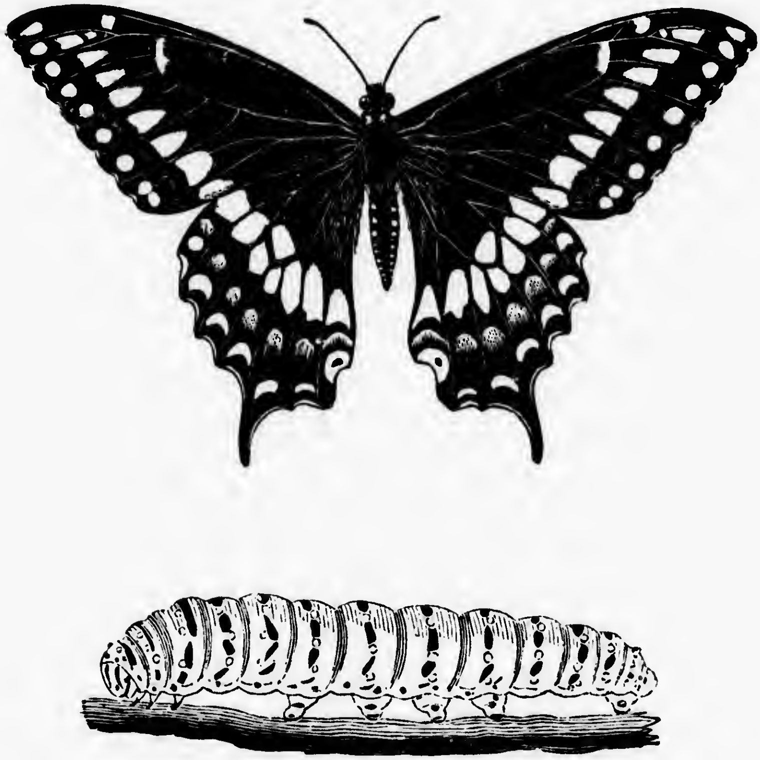

Fig. 270.—Papilio asterias.—male and larva.

Of the Sphingidæ and their allies one of the largest is the *Sphinx quinquemaculatus*, the larvæ of which feed on the potato plant. Species of smaller size, but of rich colouring, belong to the genus *Smerinthus*.

The species of proper moths are exceedingly numerous. The giants of the tribe are the great Emperor Moths of the genus Attacus. *A. (Platysamia) cecropia* is the largest species, and *A. luna* is remarkable for its singular form and delicate green colour, as well as for its large size. *Clisiocampa Americana* is the tent-weaving moth, whose social caterpillars produce large silken webs in trees, and are very destructive. Several of these species are capable of yielding valuable silk. Fig. 271 represents a pretty

Fig. 271.—ALYPIA LANGTONII, Cooper.

little *Alypia*, described by Cooper in the "Canadian Naturalist," as a new species, under the name of *A. Langtonii*.

ORDER 6.—HYMENOPTERA.

This order includes three principal groups or sub-orders. (1) *Securifera* or the Horn-tails and their allies. These are furnished with a borer or awl, with which they make holes in wood, in which their larvæ live, and on which they feed. *Tremex columba* is a large and common species very destructive to timber trees. The sub-order (2) *Pupivora*, includes the Ichneumons and their allies, which deposit their eggs in the bodies of Larvæ, and are thus of great service in checking the ravages of many herbivorous species. I figure as an illustration a somewhat abnormal species, *Eurytoma hordei*, which bears the name of Joint-worm, as it infests the stems of wheat and barley, and is supposed to cause much damage to the crop (Fig. 272). More typical examples are furnished

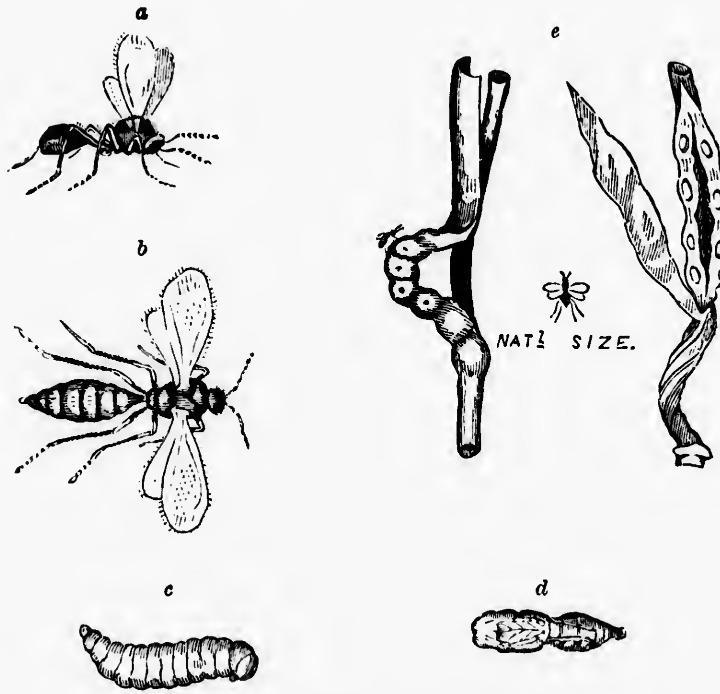

Fig. 272.—Eurytoma hordei, Harris.

a—Male, magnified. b—Female, magnified. c—Larva, magnified. d—Pupa, magnified. e—Injured stalk of grain.

by the minute insects of the genera *Platygaster* and *Macroglenes*, whose larvæ prey upon those of the wheat midges and similar insects (Figs. 273, 274).

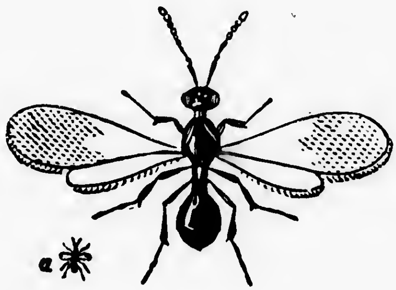

Fig. 273.—PLATYGASTER TIPULÆ, Kirby. *a*—Natural size.

Fig. 274.—MACROGLENES PENETRANS, Kirby.—Male and Female, magnified.

Fig. 275.—SAND-WASP, Pompila.

Sub-order (3) *Aculeata*, or those possessing stings, of which the Bees (*Apiariae*) and Wasps (*Vespiariae*) are the typical examples. The Ants (*Formicariae*) are an aberrant group. Fig. 275 represents one of the smaller species of Sand-wasps (*Pompilidae*) which make burrows in the ground, in which they deposit the bodies of spiders and caterpillars, as food for their young.

ORDER 6.—HEMIPTERA.

The Hemiptera include two great groups or sub-orders, the *Heteroptera* which have the wings coriaceous at the base, and the *Homoptera* which have the wings membranous throughout. In the former group are the Water-boatmen and Squash-bugs and their allies, and in the latter the Cicadas or singing locusts, and the Aphides or plant-lice. The Squash-bug (*Coreus tristis*,) De Geer, (Fig. 276) may be taken as an example of a large group of these insects living on plants and sucking their juices. *Notonecta undulata*, Say, (Fig. 277) is an example of the

Fig. 276.

COREUS TRISTIS, De Geer.

Fig. 277.

NOTONECTA UNDULATA, Say

active water-boatmen, which may be seen swimming and diving in pools by means of their oar-like hind feet. The beautiful little species *Erythroneura vitis* (Fig. 278)

Fig. 278. ERYTHRONEURA VITIS, Harris,—magnified.

is very destructive to vine leaves. In winter they shelter themselves under fallen leaves and in litter, and come forth in spring to deposit their eggs on the leaves, the juices of which they suck, both in the wingless larval state, and in that of the mature insect. In this group are also placed the troublesome Aphidæ or Plant-lice, and the Coccidæ or scale-insects of our fruit trees. In these families the females are wingless.

ORDER 7.—NEUROPTERA.

Among the most common insects of this order are the *Ephemeridae*, "May-flies" or "Shad-flies;" the larvæ of which live in water, and in summer emerge in countless swarms on our lakes and rivers, to fly for a few hours or days, and deposit the eggs of a new brood in the water. Fig. 279 represents one of our species.

Fig. 279.—EPHEMERID (Baetis.)

The larvæ of these creatures feed on vegetable matters in the bottom of the water, and themselves furnish much food for fresh-water fishes. To the same order belong the Dragon-flies, (*Libellula*, &c.) which are highly carnivorous and predaceous, catching other insects on the wing. Their larvæ and pupæ live in water. The Corydalids or horned May-flies are large broad-winged insects, remarkable for their long jaws or mandibles. To this order also belong the curious Caddice-flies (*Phryganidæ*) whose larvæ construct tubes in which they live in the bottom of pools and streams. In the same family is the genus *Helicopsyche*, whose, larvæ construct spiral cases of sand, resembling small snail-shells.

Several insects found in the Devonian and Carboniferous of New Brunswick and Nova Scotia, belong to this order. (Figs. 280 to 282.)

Fig. 280.—XENONEURA ANTIQUORUM, Scudder,—Devonian.

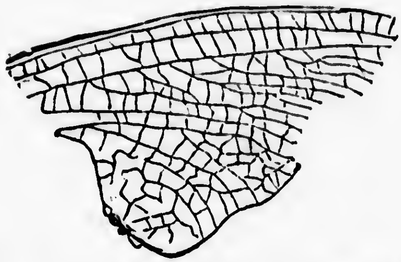

Fig. 281.—PLATEPHEMERA ANTIQUA, Scudder,—Devonian.

Fig. 282.—HAPLOPHLEBIUM BARNESI, Scudder,—Carboniferous, Wing in shale, with a fern leaf.

Order 8.—Orthoptera.

The Locusts, Grasshoppers and Crickets are well-known representatives of this order. One example is the familiar red-legged grasshopper, *Caloptenus femur-rubum* of Harris (Fig. 283,) but there are numerous

Fig. 283.—Caloptenus femur-rubum.

species of these insects, belonging to different genera. One of the most curious and anomalous is the "Walking-stick," *Diapheromera femorata*, Say; a sluggish creature, living in the woods and altogether wingless, and depending for its safety on its resemblance to a dead twig. The noises produced by the insects of this order depend on a membrane or drum on the wings, or on the friction of the hind legs on the margin of the wings.

To this family belong the cockroaches of the genera *Blatta* and *Ectobia*, which infest houses; and species of the same group have been found fossil in the coal formation. (Fig. 284.)

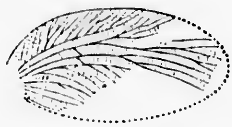

Fig. 284.—Archimulacris acadicus, Scudder,—Carboniferous.

ORDER 9.—COLEOPTERA.

The beetles are the most numerous of insects in regard to species, and very varied in their habits of life; but with the exception of a few aberrant types, they may all be recognized by the horny upper wings or elytra, which give them a very distinct appearance from other insects. To the family of the *Cicindelidæ* belong the beautiful green and spotted Tiger-beetles, so common in sandy places, and so brilliant in colour and swift in motion. The family of the *Carabidæ* includes hunter-beetles, of which *Calosoma calidum* (Fig. 285) is one of the most common species, and very serviceable as a destroyer of noxious insects. The *Dytiscidæ* are the water beetles, one of which is, perhaps, our largest species. The larvæ of the species of Dytiscus are very active and carnivorous, and are known as "Water-tigers." The black-and-yellow carrion beetles belong to the family *Silphidæ*; and the bacon beetle of larders, which also devours specimens of natural history, to the *Dermestidæ*. The *Scarabæidæ* are the "Shard-beetles" or ground beetles, the larvæ of many of which are injurious to plants. The *Lampyridæ* are the curious fire-flies, so brilliant in summer evenings, emitting a phosphorescent light from the joints of the abdomen. The *Meloidæ* are the blistering beetles, including the blue oil beetles of our woods, which are remarkable for the rudimentary condition of the wings. The *Curculionidæ* are a troublesome family, including the Pea-weevil, Plum-weevil, and other species, which commit depredations on cultivated plants. The *Cerambicidæ*, or capricorn-beetles, also include destructive species, one of which, the *Saperda Candida* (Fig. 286) is, in its larval state, the "Appletree-borer," and another *Stenocorus villosus*, is the "Oak-pruner," whose name indicates

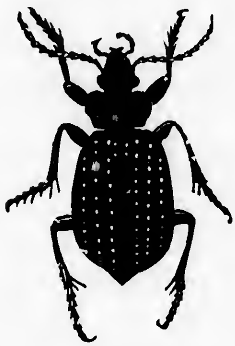

Fig. 285.
CALASOMA CALIDUM.

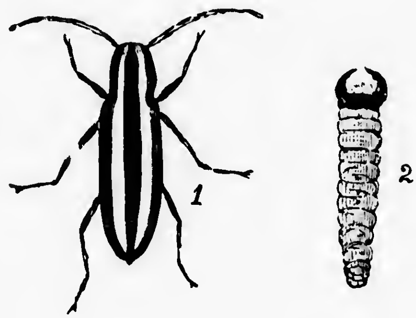

Fig. 286.
SAPERDA CANDIDA, Fab.
1—Imago. 2—Larva.

its work in breaking off the twigs of trees by the boring action of its larvæ. *Monohammus confusor** (Fig. 287), the Pine-boring Beetle is also a very destructive species; its larvæ destroying great quantities of pine timber. The *Chrysomelidæ*, notwithstanding the golden colour of some species, are also devourers of our crops. The yellow-striped Squash-beetle is a well-known example, and an allied species is the Potato-beetle (*Doryphora*). Lastly, the *Coccinellidæ*, or "Lady-bugs," are not only pretty little creatures, but very useful as devourers of plant-lice, on which they subsist both in the larval and perfect state.

Important catalogues of several orders of American insects have been published by the Smithsonian Institution; Packard's Guide to the Study of Insects, is a valuable introduction to the subject of

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*See a paper by Billings, *Canadian Naturalist*, vol. vii.

Entomology, and contains notices of nearly all the common American species. Harris' "Insects Injurious to Vegetation," and "Saunders on Canadian Insects injurious to Vegetation" are also very valuable.

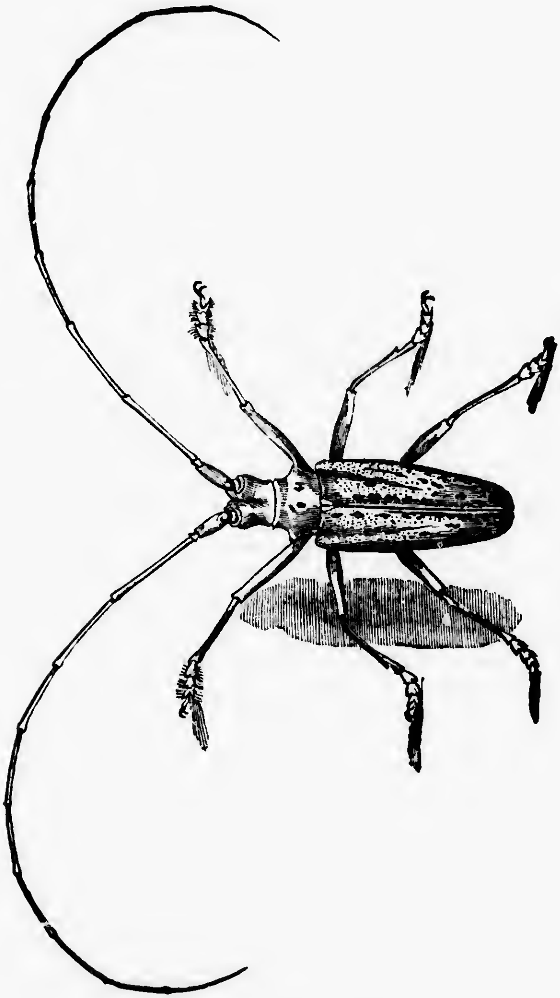


Fig. 287.—MONOHAMMUS CONFUSOR.

CLASS IV.—ARACHNIDA.

Head usually confluent with thorax; respiration tracheal or pulmonary; antennæ rudimentary or mandibuliform. No wings; legs in four pairs. Ametabolian.

In the Arachnidans the body is divided into two distinct regions, the one (cephalo-thorax) corresponding to the head and thorax in insects, the other to the abdomen. The eyes are simple and two to eight in number, the tenacles are short and often modified for prehension as well as for tactile uses. The nervous system and the dorsal vessel are more condensed than in the insects, and in the higher groups there is more varied adaptability and instinct. None of the Arachnidans have wings, and, like the cephalopods among the mollusks, they undergo no metamorphosis. In the union of the head and thorax, they resemble crustaceans, but differ in their respiration, which is never by gills. They are at once separated from insects, not only by the union of the head and thorax but also by the possession of four pairs of limbs.

The Arachnidans may be divided into the following orders, which whether absolutely natural or not, with reference to their limits of separation, no doubt express pretty accurately the grades of complexity of the group.

Order 1. *Dermophysa.*—These are degraded or depauperated species, without distinct respiratory organs, and with the limbs or abdomen rudimentary.

Order 2. *Acarina.*—These have the cephalo-thorax in one or two joints, and respire by tracheæ. They are the Mites and Ticks.

Order 3. *Araneida.*—These have the cephalo-thorax and abdomen unarticulated and separate. They breathe by lamellated pulmonary sacs, in some aided by tracheæ. They are the Spiders.

Order 4. *Scorpionidea.*—These have the abdomen and cephalo-thorax separate, and the former articulated. They respire by pulmonary sacs furnished with lamellæ. They are the Scorpions and their allies.

ORDER 1.—DERMOPHYSA.

As an example of these creatures, we may take the *Demodex folliculorum*, belonging to the family Nulligrada, which burrows in the hair follicles of the skin of the human face. It is of elongated form with eight very short legs. Its mouth is suctorial, and it appears to subsist on the fatty and other matters secreted by the follicles in which it lives. Similar creatures have been found in the skin of mangy dogs. In the same group are placed a number of other minute and rudimentary mites, living in mosses and damp places, to which little attention has yet been given in this country. They constitute the family of the Tardigrada. In this order are also usually arranged certain marine species resembling spiders, found among weeds on the shores, and sometimes in moderately deep water. A small species found in the River St. Lawrence at Murray Bay, and also on the Labrador coast, is appropriately called the "Sea Spider." It is the *Nymphon grossipes* of Fabricius, and has a slender body, sometimes half an inch in length, and very long slender limbs. These marine species constitute the family Levigrada of some authors. By others they are regarded as crustaceans.

ORDER 2. ACARINA.

The animals of this order are very diverse in form and habits, but the greater part of them belong to the group of Mites proper, of which the flour and cheese mites are examples, and which have the cephalo-thorax and abdomen condensed into one mass. As an example of this ordinary type of mite, the sugar mite, *Acarus sacchari*, may be taken (Fig. 288). It abounds in the more impure

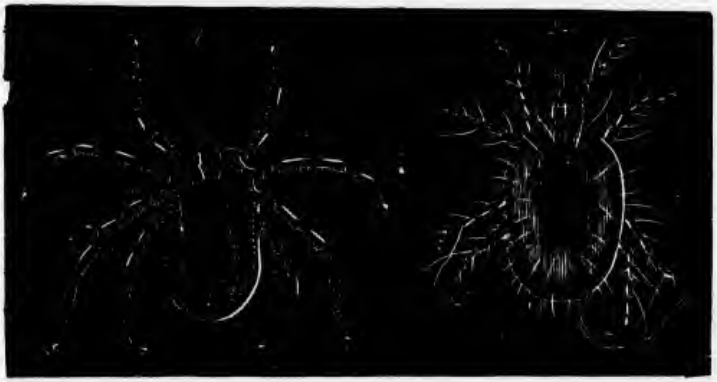


Fig. 288.—ACARI, after Packard.
1—IXODES BOVIS, Riley. 2—ACARUS (Tyroglyphus) SACCHARI. – Magnified.

varieties of raw sugar, on the foreign organic matters present in which it feeds. It is capable, like some other species, of burrowing into the skin, and is supposed to produce the disease known as grocers' itch in the skin of persons who handle sugar containing these animals. A species of the genus *Sarcoptes* (*S. galei*) is the immediate cause of the common itch. The mites of the genus *Ixodes* are the ticks which infest the skin of many animals. They are furnished with a pair of serrated or hooked mandibles which they bury firmly in the skin, and suck its juices by their serrated labrum. *Ixodes albipictus*, Packard, is a species found on the moose, and a very similar species is abundant on the American hare. Fig. 288 represents *I. bovis* which is the common cattle-tick of the Western and Southern parts of North America. Mites of the genus *Hydrachna* occur in fresh-water ponds and attack the animals inhabiting such places. The "red spiders" (*Tetranychus*,) also belong to this order. The mites in their larval state have only six legs, thus approaching to the hexapod insects.

Along with the mites we include in this order the animals of the genus *Phalangium*, the long-legged spiders or "harvest men" and the curious scorpion-crabs of the genus *Chelifer*, found among books and in dusty corners. They are carnivorous in their habits and are useful as destroyers of vermin.

ORDER 3. ARANEIDA.

The true spiders differ from the mites in thedistinct separation of the thorax and abdomen, and also in the presence of pulmonary sacs. They are provided with strong fangs perforated at the point, and secreting a highly poisonous fluid, which is injected into the wound which they produce. The fangs are regarded not as proper mandibles but as modified antennæ, being placed above the mouth. The abdomen, in most of the species, has two breathing pores or spiracles, leading to the pulmonary sacs, and in some species there is a second pair of spiracles leading to tracheæ. The pulmonary sacs are opened and closed by the muscles of the pericardium or membrane covering the dorsal vessel. In the abdomen are also the glands which secrete the silken material of the web. This is poured out in a liquid state through numerous pores pierced in cylindrical or conical spinnerets. at the extremity of the abdomen. As an example of a typical spider we figure *Epeira vulgaris*, the common geometrical spider of Eastern America, with some of its organs. (Fig. 289).

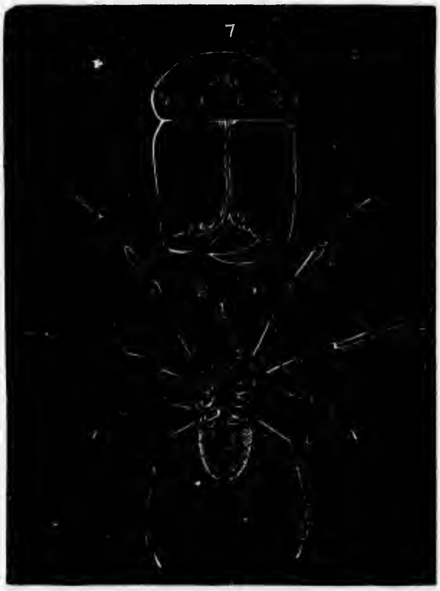


Fig.—289. EPEIRA VULGARIS, Hentz, after Emerton.

1—Eyes and Mandibles, magnified. *c*——First Joint of Mandible, *a*—Point of Mandible.

2—Underside, *a*—Legs, *b*—Palpi, *c*—Mandibles, *e*—Spinnerets and above these the Stigmata

The spiders of this country have as yet been little studied; but though not generally liked, these animals present many of the most curious traits of instinct and habit to be observed among the lower animals, and their structures are very interesting objects of microscopic investigation. With reference to their habits the spiders may be divided into three groups. 1.—The water-spiders, which live in pools, carrying down a bubble of air on the abdomen for respiration, and constructing sub-aquatic webs. 2.—The sedentary spiders, constructing webs and watching on them for their prey. 3—The vagrant, leaping and hunting spiders, which pursue or dart upon the insects on which they feed. It is at present, however, usual to arrange them, primarily, according to the number of the eyes, into *Octinoculina* or eight-eyed; *Sexoculina* or six-eyed, and *Binoculina* or two-eyed, the greater nunber of spiders belonging to the two former groups, and especially to the first, which includes all the ordinary spiders. Those of the second group are small spiders with elongated bodies, and most of them hunting their prey and making little silken cells in crevices of rocks and the bark of trees.

ORDER 4. SCORPIONIDEA.

This group includes the Scorpions and the Phrynidæ, a group resembling spiders in form, but having chelicers or prehensile arms in front, like the scorpions. The chelicers are enlarged palps, and in the scorpions they are strong and of formidable power. In the scorpions the cephalo-thorax consists of several joints, and graduates into the abdomen, which is long and slender, and terminates in a sting—which discharges a highly poisonous fluid. They use this weapon both for attack and defence, and the larger species inflict painful wounds, even on man. Like the spiders, these animals are carnivorous and prey on insects. They are not represented in the fauna of Canada except as fossils. Remains of Scorpions occur in the Carboniferous of Nova Scotia and of Illinois (Fig. 290) and species referable to this group have been

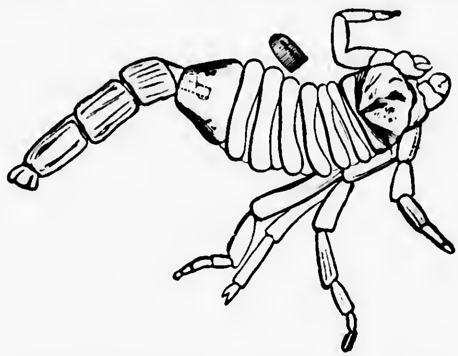


Fig. 290. —Eoscorpius carbonarius Meek, A Scorpion from the carboniferous of Illinois

found both in Europe and America in the Silurian.

Blackwell's "British Spiders" gives a very full account of this class; and there is a very interesting work on British Spiders by Miss Stavely. The only descriptions of American species known to me, are those of Hentz in the Journal of the Boston Natural History Society. A very good summary of American forms is given by Packard in the end of his "Guide to the study of Insects."

CHAPTER IX.

DESCRIPTIVE ZOOLOGY—*Continued.*

PROVINCE VII.—VERTEBRATA.

The Vertebrates are distinguished from other animals by having a central cartilaginous cord (notochord) or series of bony vertebral joints, dividing the body into an upper and lower region. The former (neural) contains the brain and spinal cord. The latter (hæmal or enteric) contains the heart and alimentary canal. The vertebræ when developed consist of bodies or centra, by which they are attached to each other, with processes above forming an arch for the protection of the nerve system, and often lateral or inferior processes for protecting the viscera. The vertebral column also forms the basis of support and for attachment of the limbs, which when present are usually in two pairs.

The nervous system in all Vertebrates is myelencephalous, or consists of a brain and dorsal nerve cord. The heart is compact and muscular, with two, three or five chambers. The blood is red. The respiratory organs are connected with the pharynx. The jaws move vertically.

The classes of Vertebrates are the following :—

1. *Pisces*—The Fishes.
2. *Amphibia* or *Batrachia*—Frogs, Newts and their allies.

3. *Reptilia*—Lizards, Serpents, Tortoises and their allies.

4. *Aves*—The Birds.

5. *Mammalia*—The Mammals or ordinary quadrupeds and their allies, including man.

The Vertebrata, though regarded as one of the Provinces of the animal kingdom, are relatively so important and so closely related to man, that they merit a more full treatment than the other Provinces. We shall, however, have to confine ourselves to definitions, classification, and Canadian examples, referring to special works for the details of the orders, families, genera and species.

Jordan's Manual of the Vertebrata of the United States will be found useful for reference, and an extended list of books useful for special groups is given in Kingsley's Naturalists' Assistant.

CLASS I.—PISCES.

Heart of two cavities; respiration by gills; locomotion by the movement of the vertebral column, with the aid of fins; body naked or covered with scales or plates. Reproduction oviparous, rarely ovo-viviparous.

We may take as the type of this class an ordinary fish, as the Cod, the Perch, or the Herring, having in mind, however, that the range of structure included under the general name Fish, within the Vertebrate Province, is very large. The general form of the body is elongated and tapering to either extremity, on lines fitted to allow the easiest possible passage through the water. The head is articulated directly to the body without the intervention of a neck. The limbs are represented by the pectoral and ventral fins, which are in pairs, and are supported by bones named rays. Besides these, there are median fins, the dorsal above and the anal below, and the caudal or tail fin, which is the most important of all in propelling the fish forward by its sculling motion. The caudal fin is in general equally two-lobed (homocercal), but in many fossil fishes and some recent species the upper lobe is larger (heterocercal). Fig. 291.

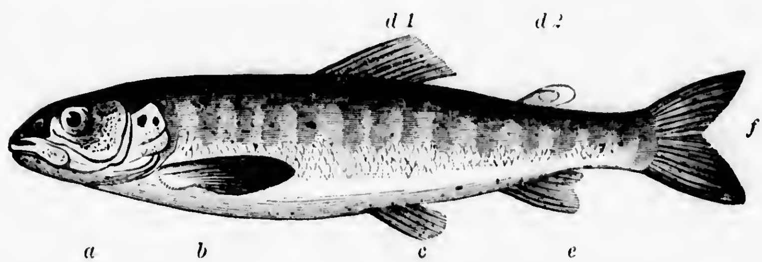


Fig. 291.—PARR OR YOUNG SALMON.

a—Gill cover. *b*—Pectoral fin. *c*—Ventral fin. *d 1*, *d 2*—First and second dorsals. *e*—Anal fin. *f*—Caudal fin.

The skeleton of fishes is either bony or cartilaginous. When bony the skull is composed of a great number of easily separable pieces. The vertebrae are biconcave, with spines above (neural spines) protecting the spinal cord and hæmal spines or ribs below. There are also interspinous bones fixed in the flesh to support the median fins.

Besides the proper internal skeleton, fishes have usually an outer or dermal covering of scales or plates.

In the ordinary fishes the scales are horny and imbricated or overlapping, and are either circular in form (cycloid) or divided into tooth-like processes (ctenoid). In other fishes there are hard bony points set in the skin (placoid) or flat bony plates or scales, often shining or enamelled at the surface (ganoid).

The brain of fishes is smaller than that of other Vertebrates, and with its parts arranged lengthwise and not condensed into a rounded mass. The eyes are well-developed, with a dense globular lens, fitted for vision in water, and without external lids. The ears are wholly internal and provided with hard stony otolites to condense and intensify vibrations. The nostrils are excavated in the front of the head, and are not connected with respiration, but subserve the olfactory function only. The senses of taste and touch are less perfect than in most other Vertebrates.

The circulation of the blood is performed by a heart of one auricle and one ventricle. The auricle receives the blood from the general circulation and transmits it to the ventricle, by which it is driven through the gills, and then finds its way to the general circulation without returning to the heart. The gills are placed on the sides of the head, and are supported on cartilaginous arches, covered by the operculum or gill-cover, and so arranged that they are constantly bathed with the water entering by the mouth and passing out under the gill-covers.

In most fishes there is an air-sac or swimming-bladder under the backbone, which serves to balance the body in the water, and, in some fishes, aids as a rudimentary lung in the æeration of the blood. The viscera in fishes are placed on the anterior part of the body, so as to leave space behind for the great muscles which bend the tail in the process of swimming.

Fishes are diœcious and oviparous, producing great numbers of ova or spawn. The ovary of the cod is said to contain more than a million of eggs.

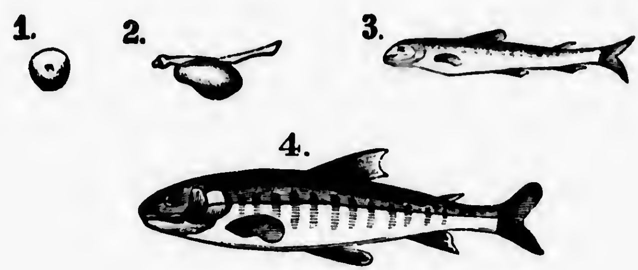


Fig. 292.—Development of Salmon.

1—Ovum. 2—Embryo, with yolk attached. 3—Embryo, after absorption of yolk. 4—Young Parr.

The class Pisces, in its widest sense, includes the following orders :—

Order 1.—Pharyngobranchii.

This order includes only two known species, the *Amphioxus* or Lancelet (Fig. 293), and an Australian fish (*Epigonichthys*).

The *Amphioxus* is of the greatest possible interest as illustrating the simplest condition of Vertebrate life. Some zoologists are disposed to put this animal into a

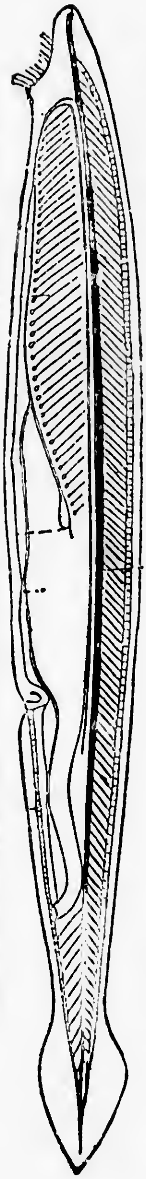


Fig. 293.—Amphioxus lanceolatus, enlarged two and a half times. The dark line above is the Notochord. In front below is the mouth with cirri; behind this the branchial sac with numerous blood vessels; and behind this the stomach and intestine.

separate class or even to create a special Province for it; but as its plan is essentially that of a fish, this seems quite unnecessary. The *Amphioxus* is destitute of scales, and its only fin, the caudal, is simply membranous without rays. The mouth has no jaws, but is a slit or opening provided with cirri. The gills are represented by a wide branchial sac, which opens posteriorly by a pore in the abdomen. The backbone consists only of a cylindrical cartilaginous cord (notochord). There is no skull, and the spinal nerve-cord is scarcely dilated in the brain. The heart is of a single cavity. There are four eyes, and a groove in front which is probably an organ of smell. The Lancelet is an oceanic fish, found on both sides of the Atlantic, and in the Pacific and Indian Oceans.

Order 2.—Marsipobranchii.

This order includes the Lampreys, Lamperns and Hags, which occur both in fresh waters and in the sea. They are destitute of true fins and scales, have a circular or oval mouth without jaws, and have the gills in little pouches opening by lateral slits. Their skeleton is wholly cartilaginous. *Ichthyomyzon argenteus*, the silvery Lamprey or Lampern, is found in our lakes and streams.

ORDER 3.—TELEOSTEI.

This order includes the typical or ordinary fishes, with well-developed bony skeleton, and the other characters already referred to as belonging to the fish proper. It is usually divided into sub-orders, based on the structure of the fins and other peculiarities. The greater part of our common fishes belong to two of the sub-orders, the *Malacopteri* or soft-finned, and the *Acanthopteri* or spiny-finned. In the first, all the fins are supported by flexible jointed rays. In the second, some of them have stiff spinous supports. The Cod, the Salmon and the Herring are examples of the first of these groups, the Perch and the Bass of the second. The curious Pipe-fishes (*Syngnathus*) remarkable for their elongated snouts and attenuated bodies, and for their tufted gills, belong to the sub-order *Lophobranchii*. The File-fishes (*Balistes*) are examples of another group named *Plectognathi*, from the fact that the teeth are united into two or four masses.

ORDER 4 —GANOIDEI.

The fishes of this order have the body protected by bony scales, and have the swimming bladder largely developed and aiding in respiration. The bony Pike or Gar-fish of the St. Lawrence (*Lepidosteus*) the Sturgeon (*Accipenser*), and the Mud-fish (*Amia*) are living Canadian examples of this order, and of types characterized by somewhat different arrangement of the scales. A few other species exist in other parts of the world, but they are much less numerous than the ordinary fishes (Fig. 294).

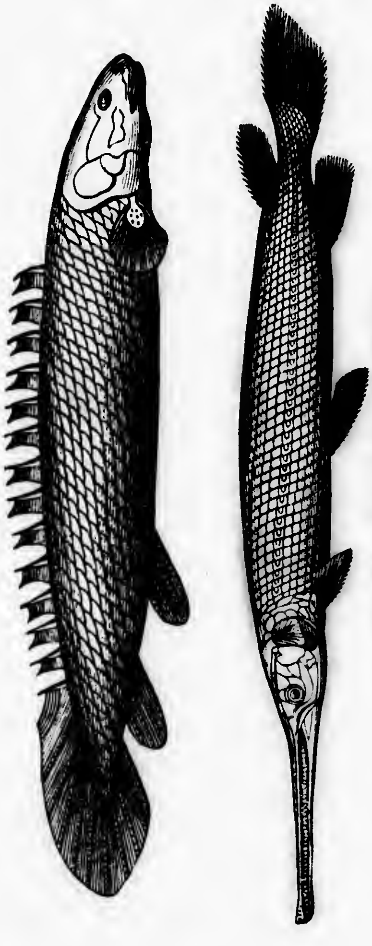


Fig. 294.—Modern Ganoid Fishes.

The upper figure represents the *Polypterus* of the Nile. The lower the *Lepidosteus* of the North American rivers. In both these species the body is covered with hard bony scales of rhombic form.

The Ganoids culminated in the later Palæozoic Period of Geology, and many species are found fossil in our

Erian and Carboniferous rocks (Fig 295 to 297). One

Fig. 295.—PALÆONISCUS ALBERTI, a Ganoid of the lower Carboniferous.

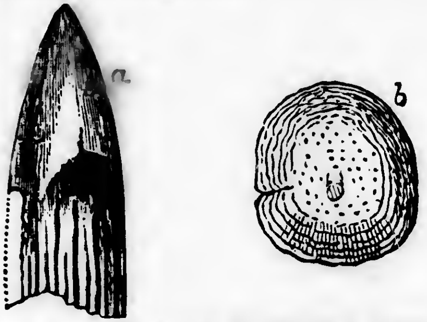


Fig. 296.—RHIZODUS LANCIFER, a large Ganoid of the coal-formation period. *a*—tooth. *b*—bony scale.

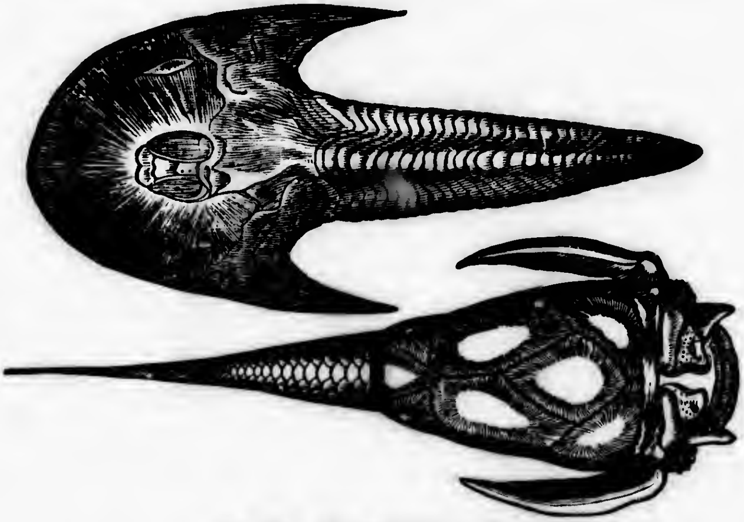


Fig. 297.—ERIAN PLACOGANOIDS.
The upper *Cephalapis Lyelii;* the lower *Pterichtys cornutus.*

remarkable group characteristic of the Erian Period, is that of the Placoganoids, in which the body is boxed up in hard bony plates (Fig. 296).

Some of the Ganoids, as Lepidosteus, have well-ossified skeletons. Others, as the Sturgeon, have the skeleton cartilaginous.

ORDER 5.—ELASMOBRANCHII.

These are the Sharks, Dog-fishes and Rays or Skate-fish. The Sharks are the largest and most formidable of fishes. One species found on our coasts, the basking Shark, sometimes attains a length of thirty feet. The skeleton is cartilaginous or very imperfectly ossified, but the teeth are hard and trenchant in most of the species, though in some they are flattened into pavement-like surfaces for crushing. The skin is protected by small placoid bony scales. This group of fishes, while well represented in the modern seas, extends back as far as the Silurian period.

ORDER 6.—DIPNOI.

This is in the modern world a small group occurring only in the streams and lakes of South America, Africa and Australia (Fig. 298), and we have no Canadian examples; but species referable to this group are found fossil in our Palæozoic rocks. Some of those found in the Erian formation of the United States, were very large and formidable fishes. Others furnished with flat teeth probably, like the modern Ceratodus or Baramunda of Australia, fed on aquatic plants.

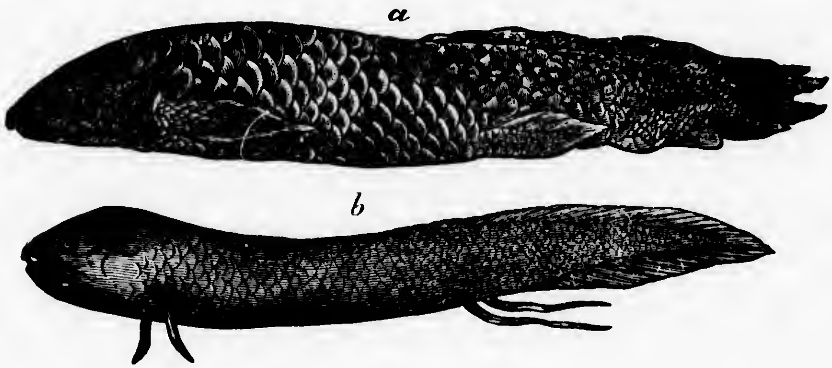


Fig. 298.—Fishes of the order Dipnoi.
a—Ceratodus of Australia.
b—Lepidosiren of Africa.

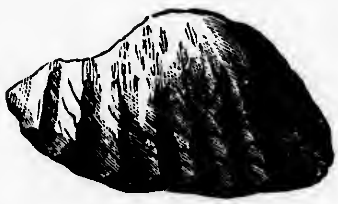


Fig. 299.—Tooth of *Couchodus plicatus*, a fish allied to the Ceratodus of Australia.—Coal formation of Nova Scotia.

For Canadian fishes see Richardson's Fauna Boreali Americano ; Jordan's Catalogue of fresh-water fishes, Gill, Catalogue of fishes of East coast of North America.

Class II.—Amphibia.

Vertebrates breathing by gills when young, but acquiring lungs when adult, and having a heart of three cavities;

limbs when present in two pairs, and not of the nature of fins; skin naked in the modern species; skull articulated to neck by a double condyle.

The Amphibians connect the fishes with the true reptiles, being fish-like and having gills and a two-chambered heart in the immature state, but acquiring lungs and a three-chambered heart, and usually well-developed limbs when mature. The modern Amphibians occupy a very humble position, but in former geological periods they were large and abundant, and some of the extinct forms were of higher rank than their modern successors.

ORDER 1.—OPHIOMORPHA.

This includes species having a snake-like body destitute of limbs. They are the Cecilians or blind-worms. They are not as yet known in our fauna.

ORDER 2.—URODELA.

These are the tailed or lizard-like Batrachians, the Newts or water-lizards. They are usually divided into two groups, those with permanent gills remaining through life, and those which lose their gills when mature (perennibranchiate and caducibranchiate forms). Some species, however, seem capable of retaining or parting with their gills according to the circumstances in which they are placed. *Necturus* (*Menobranchus*) *lateralis* the water-lizard or mud-puppy, is a common representative of the permanently gilled type, and is found in many lakes and streams. *Diemyctylus viridescens*, the spotted newt of our ponds, and the Salamanders (*Plethodon*, *&c.*) are examples of the forms which part with their gills when adult. In this country these animals are usually called lizards, but do not really belong to that group, which is truly reptilian.

ORDER 3.—ANURA.

These are the tailess Batrachians, which are destitute of swimming-tails, and have large and well-developed limbs. They are represented in Canada by three generic groups, the ordinary frogs (*Rana*), the tree-frogs (*Hyla*), living in woods and having suctorial discs on the toes to aid them in climbing, and the toads (*Bufo*) a terrestrial group, nocturnal in habit and destitute of teeth.

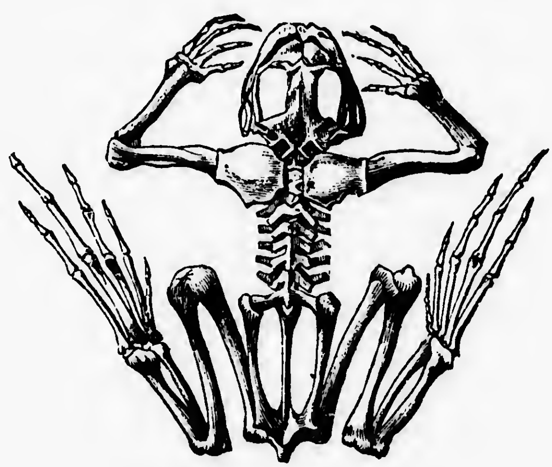


Fig. 300.—SKELETON OF A FROG.

In the Carboniferous rocks of Nova Scotia, the remains of several species of Batrachians are found, some of them of large size. The larger belong to the group of *Labyrinthodontia*, the smaller to that of *Microsauria.*

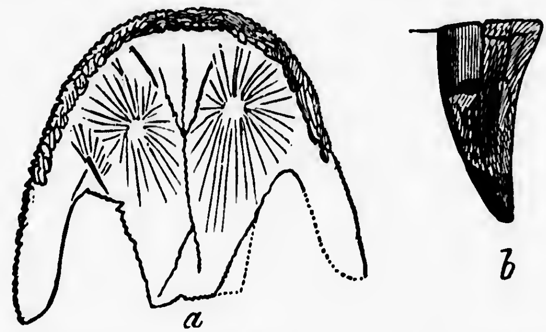


Fig. 301.—BAPHETES PLANICEPS, Owen, a Labyrinthodont from the coal-formation of Nova Scotia.
a—Anterior portion of the skull reduced. *b*—Tooth, natural size.

CLASS III.—REPTILIA.

Heart ordinarily in three cavities (two auricles and one ventricle); respiration by lungs; limbs, when present, usually adapted for motion on land; skin protected by scales or plates; reproduction oviparous or ovo-viviparous.

The reptiles differ from the Amphibians in not undergoing any metamorphosis, but are produced from the egg at once as air-breathing animals. In connection with this, their eggs are of larger size than those of fishes or batrachians, and the embryo is provided with special structures suited to the requirements of hatching in the air (Amnion or water-sac, and Allantois or urinary-sac). In this respect the reproduction of the reptile resembles that of the bird. The reptiles have scaly skins and a single occipital condyle, and like the birds have the lower jaw not directly articulated to the skull, but by an intermediate quadrate bone. The reptiles are at present for the most part inhabitants of the warmer climates, and are few and poorly developed in comparison with their predecessors in the middle portion of the earth's geological history, which was emphatically the "Age of Reptiles." Of nine orders into which the reptiles are usually divided, five are extinct, and only two are represented in the modern fauna of Canada.

Order 1.—Chelonia.

The turtles and tortoises constitute this order. The former are marine species, with fin-like feet adapted to swimming rather than to walking. The latter have walking feet. There are, however, intermediate forms, usually inhabiting fresh water. The sculptured tortoise *Chelopus insculptus*, the painted pond tortoise *Chrysemys picta*, and the snapping turtle *Chelydra serpentina* are Canadian examples. *Chelone midas*, a marine species found in the West Indies, is the epicure's turtle, and *Chelone imbricata* the tortoise-shell turtle.

In the Chelonia the skeleton is remarkably modified, so that the ribs and backbone unite above to form a carapace, and the breast-bone is enlarged to form a plastron, while the whole is covered with a more or less dense horny coating, either continuous or in separate scales.

Order 2.—Ophidia.

These are the Serpents and Snakes, distinguished by the enormous length of the vertebral column and the great number of ribs, and by the absence of limbs. In this country we have two families, the *Coluberidae* or harmless snakes, and the *Crotalidae*, with erectile poison fangs. To the former belong all our ordinary snakes, as the water-snakes (*Tropidonotus*), the garter-snakes (*Eutenia*) and the milk-snakes (*Ophibolus*). To the latter belongs the venomous rattle-snake (*Crotalus horridus*), found only in the southern or western borders of Canada.

Order 3.—Lacertilia.

This includes the Lizards properly so called, which constitute a numerous and varied group in the warmer regions of the world, but are not represented in the fauna of Canada, except perhaps in the extreme south-west, where the so-called "horned toads" (*Phrynosoma*) or the Northern Skink (*Eumeces*) may occur locally.

Order 4.—Crocodilia.

The Crocodiles and the Alligators are the largest and most formidable of modern reptiles, and the most advanced in the character of their circulation, but are not found in the temperate latitudes.

The following orders are extinct, and occur chiefly in the Mesozoic rocks. Examples of some of them are found in the Cretaceous rocks of our Western Territories :—

Ichthyopterygia.—Fish-lizards, *Ichthyosaurus*, &c. Marine saurians of great size, with paddles and elongated snouts and tails.

Sauropterygia.—Also a group of marine reptiles, with smaller heads, larger paddles, and shorter and more compact body (Fig. 302).

Fig. 302.—PLIOSAURUS, Jurassic of England.

Pterosauria.—Winged Lizards, as Pterodactyles and their allies (Fig. 303).

Fig. 303.—RHAMPHORHYNCHUS, a Pterosaur from the Jurassic, reduced, with a tooth natural size.

Anomodontia.—Beaked reptiles.

Theriodontia.—Reptiles with several orders of teeth like the carnivorous mammals.

Dinosauria.—Reptiles often of gigantic size, and in some respects approaching to the structures of birds, and often bipeds. *Dinosaurus*, *Hadrosaurus*, &c. (Figs. 304, 305.)

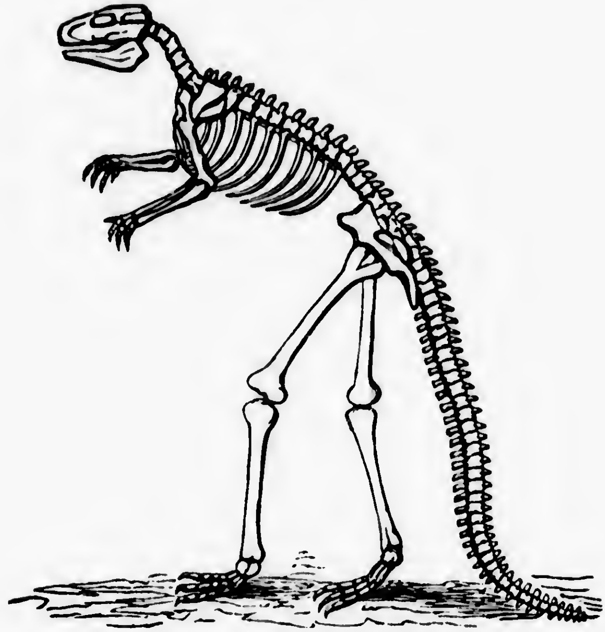


Fig. 304.—HADROSAURUS, a Dinosaur of the Cretaceous. Skeleton, much reduced.

Fig. 305.—BATHYGNATHUS BOREALIS, Leidy. A Dinosaur from the Trias of Prince Edward Island. Part of lower jaw reduced, and tooth natural size.

CLASS IV.—AVES.

Heart in four cavities; respiration by lungs; anterior limbs modified for flight; clothing, feathers; reproduction, oviparous.

The birds represent the special modification of the vertebrate type for life in the air. The head is small and light, with a horny beak and well-developed brain and organs of sense; the neck long and flexible. The trunk is compact, with the sternum or breast-bone large, and usually provided with a keel for the attachment of the great pectoral muscles which move the wings. The fore-limb is so modified that it serves as a support for the pinions which provide for flight. The bones are thin-walled and hollow. The circulating and respiratory organs are of a high degree of perfection, the heart being strong and muscular, and of four cavities, and the lungs attached to the back of the chest and communicating with accessory air-cavities. The clothing of feathers admirably combines warmth, resistance to external agencies, and adaptation for flight. The voice of birds is of great force and compass, and is provided for by a cavity or syrynx at the base of the windpipe, and furnished with vocal cords. The birds present the highest type of oviparous reproduction, accompanied with many curious instincts as to nidification, which are rendered necessary in connection with the hatching of a warm-blooded animal. The following figure (Fig. 306) shows the external parts most important in the description of birds, in the sub-science of Ornithology.

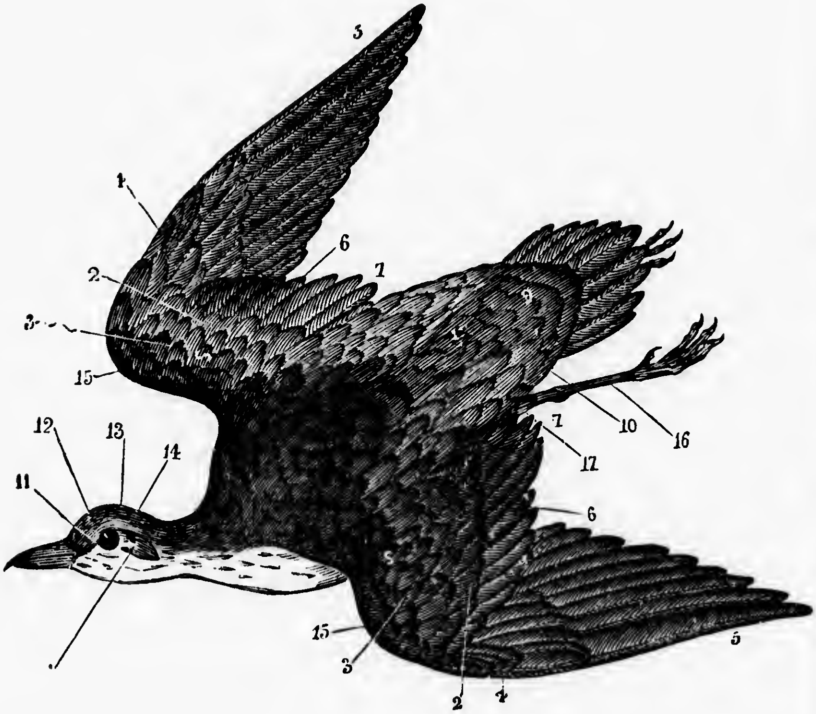


Fig. 306.—EXTERNAL PARTS OF A BIRD.

1—Ear Coverts.
2—Greater Wing Coverts.
3—Median Coverts.
4—Bastard Wing (alula).
5—Primaries.
6—Secondaries.
7—Tertiaries.
8—Scapulars.
9—Tail Coverts.
10—Under Tail Coverts.
11—Lore.
12—Forehead.
13—Crown.
14—Hind-head.
15.—Lesser Coverts and angle of wing.
16—Tarsus.
17—Tibia.

Birds may be primarily divided into the sub-classes of *Ratitæ* (Ostriches and other birds with rudimentary wings) and *Carinatae* (birds with keeled sternum and developed wings). All the birds of Canada belong to the latter group, and may be arranged in the following orders :—

ORDER 1.—NATATORES.

Swimming birds with palmated or lobed feet, set far back ; examples of these are the families of the Ducks and Geese (*Anatidae*), Gulls (*Laridae*), Cormorants (*Pelecanidae*) Grebes (*Podocepidae*).

ORDER 2.—GRALLATORES.

Long-legged wading birds, including the Herons (*Ardeidae*), Plovers and Sandpipers (*Charadriadae*) Phalaropes (*Phalaropidae*), &c.

ORDER 3.—RASORES.

Scraping birds, with well-developed walking feet, and usually moderate powers of flight. They are represented in our fauna by the families of the Grouse (*Tetraonidae*) and the Pigeons (*Columbidae*).

ORDER 4.—INSESSORES.

These are the perching birds, a very numerous and varied group, including most of our small birds. Examples are, the Crows and Jays (*Corvidae*), the Sparrows and Finches (*Fringillidae*), the Thrushes (*Turdidae*), the

Flycatchers (*Muscicapidæ*), Swallows (*Hirundinidae*), and Woodpeckers (*Picidae*).

Fig. 307.—The Waxwing (*Ampelis*), a typical insessorial bird.

Order 5.—Raptores.

This order includes the Birds of Prey, of which there are three principal family groups, the Eagles and Hawks

(*Falconidae*), the Owls (*Strigidae*), and the Vultures (*Vulturidae*).

For the classification and determination of birds, reference may be made to Coues' Key to American Birds, or to Baird's Birds of America.

CLASS V.—MAMMALIA.

Heart in four cavities; respiration by lungs; limbs formed for walking or prehension or both; skin usually protected by hair; reproduction viviparous; young nourished by milk.

The distinguishing characteristic of this class, is the production of the young alive, and their nourishment by milk furnished by lacteal glands. The usual covering is hair, and the normal condition of the limbs adapted to walking or prehension, though in some, as the Bats, they are modified for flight, and in others, as the Whales, they become paddles for swimming. The skull is large, with a capacious brain-case, and the brain larger than in other animals, and in the higher types convoluted at its surface, so as to give a greater expansion to the cortical brain matter (Figs. 308, 309).

Except in a few species, the neck consists of seven vertebræ, the back is divided into dorsal and lumbar regions, and certain of the vertebræ are united to form a sacrum or support for the pelvis. The limbs present the typical vertebrate parts. In the fore-limb, beginning from above, these are the Scapula or shoulder blade, the Humerus or arm bone, the Radius and Ulna, the

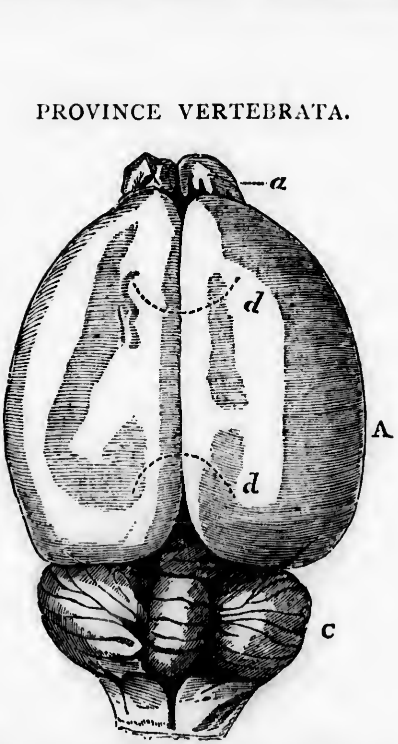


Fig. 308.—Non-convoluted Brain of Beaver.
a—Olfactory lobes. *c*—Cerebellum. *d*—Cerebral lobes.

Fig. 309.—Convoluted Brain of Chimpanzee.
A, C—Cerebral lobes.

Carpal or wrist, Metacarpal or hand, and Phalangeal or finger bones. In the hind limb, next to the pelvis, is the Femur or thigh bone, then the Tibia and Fibula, then the Tarsal, Metatarsal, and Phalangeal bones (Fig. 310).

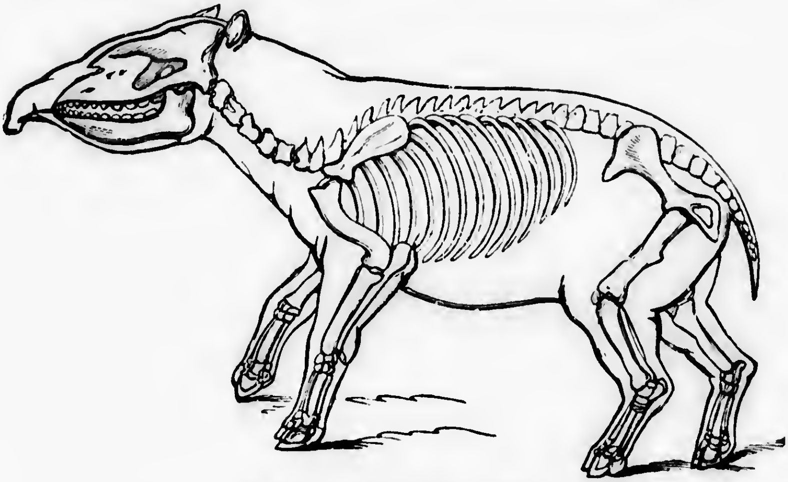


Fig. 310.—PALÆOTHERIUM, Eocene.
One of the most ancient types of mammalian skeleton.

The teeth are more complex than in other animals, often presenting complicated associations of enamel,

Fig. 311.—SKULL OF THE OTTER, showing carnivorous dentition.
a—Incisors. *b*—Canines. *c*—Pre-molars and Molars.

ivory and bone; and they are arranged in different sets, viz.: incisors, canines, pre-molars and molars. The diverse modifications of these relate to the food and habits of the animal, and are, therefore of great importance in classification.

The heart of the mammal is of four chambers, the lungs remarkable for their fine division into air-cells, and the chest is separated from the abdomen by a diaphragm or midriff.

The mammals may be divided into non-placental and placental, the latter having the more perfect arrangements for viviparous reproduction. The non-placentals are at present confined to the Australian Islands, and to the warmer parts of America, but in the mesozoic and tertiary periods they were much more widely distributed.

The orders of Mammals may be arranged as follows:

(*Non-Placental.*)

ORDER 1.—MONOTREMATA.

This order includes the duck-billed animal (*Platypus*) and the *Echidna* or spiny Ant-eater, both Australian animals, and in regard to their reproduction, exceptional in the fact that they produce eggs, though the young are nourished with milk.

ORDER 2.—MARSUPIALIA.

The Marsupials are so named from the fact that the young after birth are nourished for a time in a marsupium or pouch attached to the body of the mother. The

Kangaroos and other Australian mammals, and the Opossums of America, are examples of this order.

Fig. 312.—MYRMECOBIUS FASCIATUS, a small Australian Marsupial.

(*Placental.*)

ORDER 3.—EDENTATA.

These are the Sloths, Armadillos, Anteaters, &c., at present limited to South America and Africa. They have either no teeth or molars only.

ORDER 4.—RODENTIA.

These have incisors and molars only, and the former are large and chisel-shaped for gnawing. This order is well represented in Canada by the Beaver, Porcupine, Musk-rat, Squirrels, Gophers, Hares, &c.

ORDER 5.—INSECTIVORA.

These are small animals with sharp canines and trifid molars. They are the Moles, Shrews, &c. Though resembling the last order in size and form, they are quite different in dentition and habits.

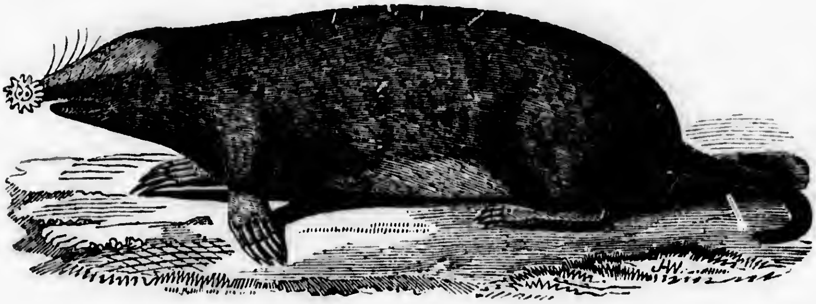


Fig. 313.—CONDYLURA CRISTATA, the Star-nosed Mole.

ORDER 6.—CHEIROPTERA.

These are closely allied to the last order, except that the anterior limb is converted into a wing by the curious elongation of the fingers, which are connected with each other and with the body by a delicate membrane. This is the order of the Bats.

ORDER 7.—CETACEA.

This includes the Whales, Dolphins, Porpoises, &c. They have smooth fish-like bodies with a horizontal caudal fin, and the anterior limbs, which alone are present, in the form of paddles. The nostrils are turned back, so as to appear as blow-holes on the top of the head. The teeth are either uniform and conical or are replaced by laminæ of whale-bone, which collect food as in a net. They may thus be divided into toothed whales and whale-bone whales. In the Gulf of St. Lawrence the great Rorqual or Finner whale and the Humpback whale represent the whalebone whales. The Black-fish, White Whale, Beluga and Porpoise are toothed cetaceans. The Sirenia or Dugongs constitute another order allied to the whales, but are not represented in our fauna.

ORDER 8.—UNGULATA.

These are the hoofed animals. They are divided into odd-hoofed (*Perissodactyle*) and even-hoofed (*Artiodactyle*). To the former belong the Horse, Rhinoceros and Tapir, as well as some extinct animals of our Tertiary rocks.

Fig. 314.—SKULL OF BRONTOTHERIUM, an extinct Ungulate of the Miocene Period.

To the latter belong the Bison, Deer, Antelopes, Musk-ox and other ruminants, which have well-developed molars, and incisors in the lower jaw only, and have the complicated structure of stomach connected with chewing the cud. These animals are also remarkable for the developement of horns or antlers as weapons of defence.

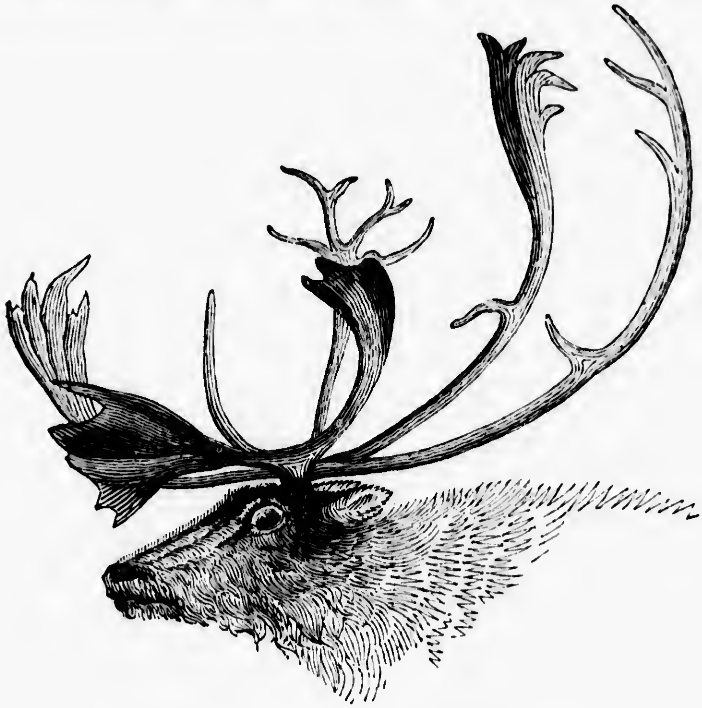


Fig. 315.—Head and Antlers of Barren Ground Caribou.
Tarandus arcticus.

ORDER 9.—PROBOSCIDEÆ.

The Elephants are not now represented in our fauna, but in the Pliocene and Post-glacial periods there were elephants of the two genera *Elephas* and *Mastodon*, in Canada, and their bones and tusks are not infrequently found in peat bogs and beds of gravel.

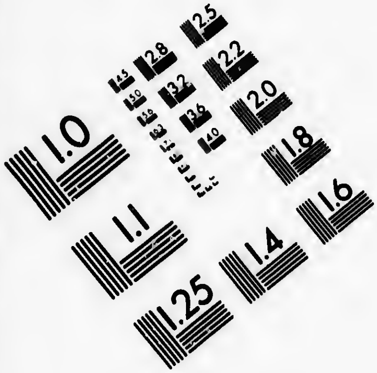
ORDER 10.—CARNIVORA.

The flesh eating mammals, or wild beasts properly so called, belong to this order. The Lynxes and the Puma (*Felidae*), the Dogs, Wolves and Foxes (*Canidae*), the Bears and Racoon (*Ursidae*), the Weasels, Martens and Otters (*Mustelidae*), and the Seals (*Phocidae*) belong to our fauna.

Fig. 316.—MUSTELA MARTES, the Sable.

ORDER 11.—QUADRUMANA.

In this order the fore and hind feet both serve as hands, fitting for prehension. They are frugivorous animals, not found in our fauna, being restricted to the warmer climates. The order includes the Apes, Monkeys and Lemurs.



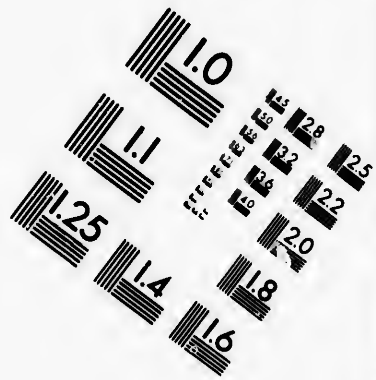
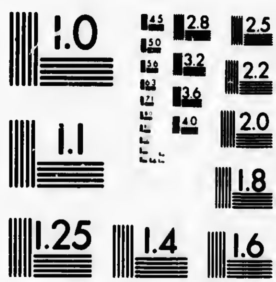
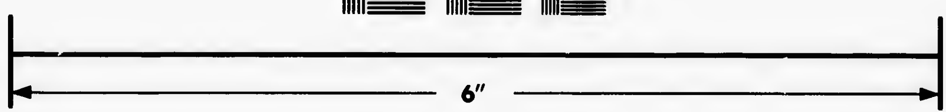
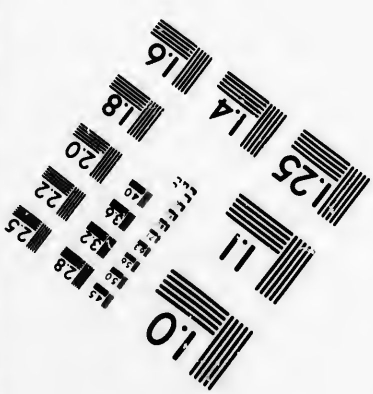
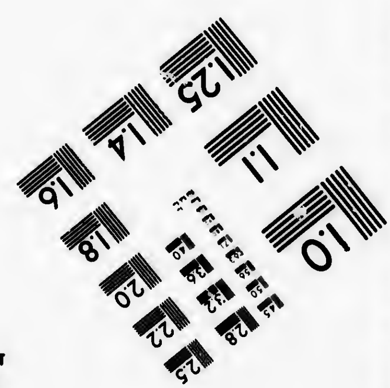


IMAGE EVALUATION TEST TARGET (MT-3)







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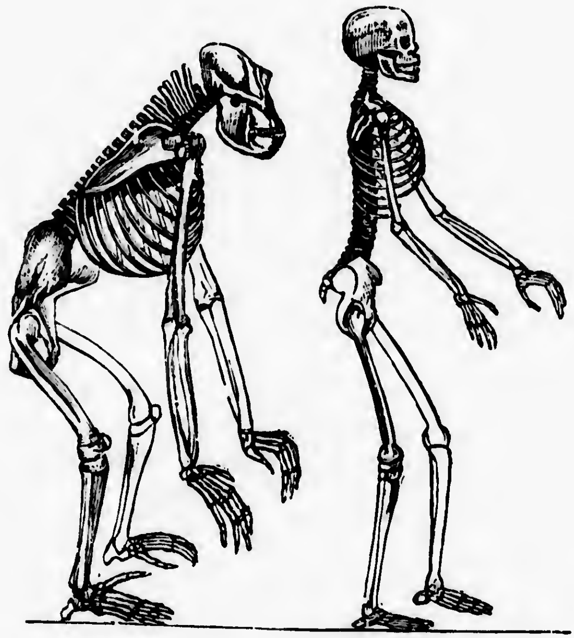


Fig. 317.—Skeletons of Gorilla and of Man (Quadrumana and Bimana).

ORDER 12.—BIMANA.

Man alone constitutes this order, and consists of a single species, though with several races or varieties. Some zoologists are disposed to include this and the last order in one, under the name *Primates*; but this is manifestly incorrect, since the physical characters of man, independently of his higher psychical endowments, separate him very widely from the Quadrumana. Among his peculiarities may be stated the following; (1) the great size of the skull and brain; (2) the balancing of the skull on median condyles instead of having these at the posterior end; (3) his doubly-curved and pillar-like spinal column; (4) his perfect hands and plantigrade arched feet; (5) his unspecialized dentition and skeleton generally,; (6) his want of natural clothing and of weapons of defence or attack. These specialties separate him as widely from any other orders of mammals as any of these are separated from each other, and their value in classification is increased by their manifest connection with mental endowments altogether different from those of animals. Nevertheless, in so far as his bodily frame is concerned, man is a member of the class Mammalia, and thus connected with the lower animals over which it is his province to rule.

Man is further characterised as being the only animal having power to understand the relations, uses and adaptations of other animals, and of the universe in general, and as thus being able to enter into and comprehend the plans of the Creator. He is also distinguished as the only animal having that inventive ingenuity which enables him to deal with materials and forces as an inventor and creator, and thus to build up the frame of a rational civilization. He is further distinguished by that instinctive belief in immortality and spiritual existence, and those capacities for distinguishing right and wrong which make him a moral, religious and responsible being.

PLATE I.

CORAL, GALAXEA (after Hyatt).

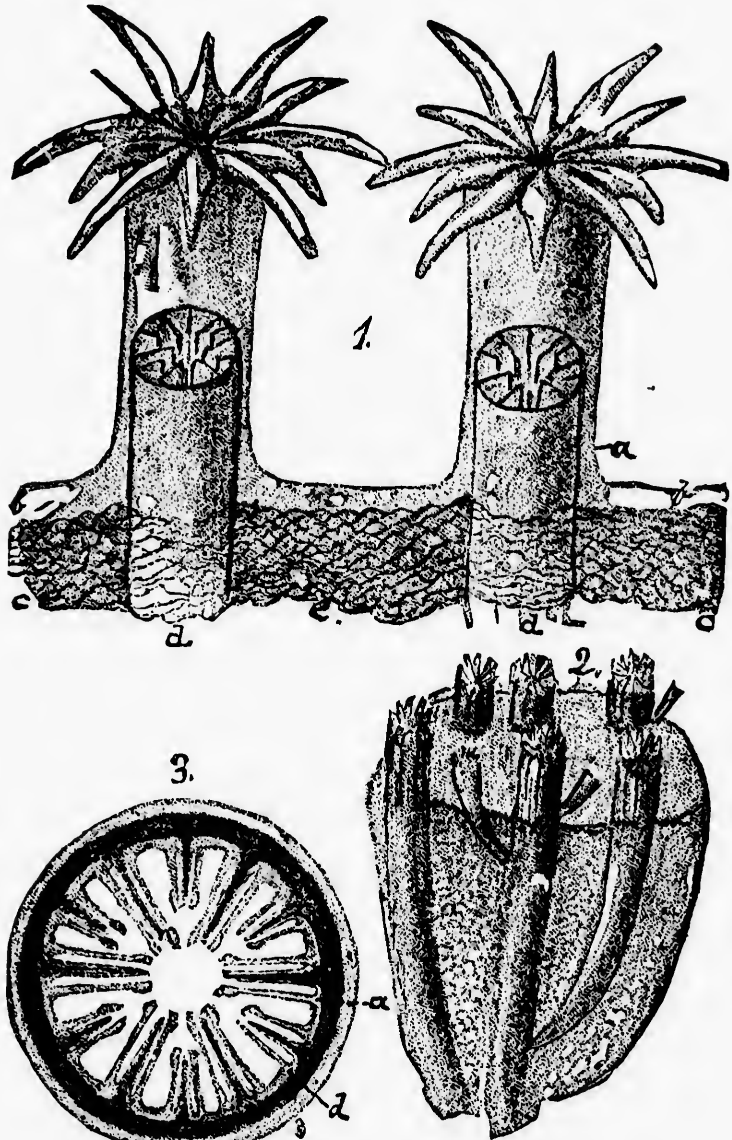
Illustrating a Coral-forming Cœlenterate.

Fig. 1.—Two Corallites enlarged. (*a*) Flesh of Polyps; (*b*) Common Flesh (Cœnosarc) ; (*c*) Common Skeleton (Cœnenchyma) ; (*d*) Individual Cells, with wall and radiating Lamellæ or Septa.

Fig. 2.—Portion of Corallum, natural size, with six full-grown cells and young budding cells.

Fig. 3.—Cross section of Polyp and cell enlarged. (*a*) Coral Wall and Endoderm ; (*d*) Endoderm lining Septa.

PLATE I.



Structure of a Cœlenterate.

PLATE II.

STAR-FISH—ASTERIAS RUBENS (after Rolleston).

Illustrating the structure of an Echinoderm.

I.—Ray cut open, showing complex extension of the digestive apparatus (upper part of figure).

II.—Ray with upper integument, showing its tubercles and spines.

III.—Ray with integument and sacculated extension of stomach removed to show the Ovaries (j^1, j^2), the central row of ambulacral Ossicles and some of the Sacs (Ampullæ) of the tube-feet.

IV & V.—From these most of the organs have been removed to show the Ampullæ (d^1, d^2), and the articulations of pairs of inter-ambulacral Ossicles (k^1, k^2).

(*a*) Intestinal cavity; (*b*) Divisions of digestive cavity; (*c*) Stomach; (*d*) Ampullæ; (*e*) Anus; (*f*) Exterior muscle of Ray; (*g*) Madreporic plate and tube; (*h*) Polian vesicles or muscular water-sacs; (*j*) Reproductive glands; (*k*) Ambulacral ossicles and arches.

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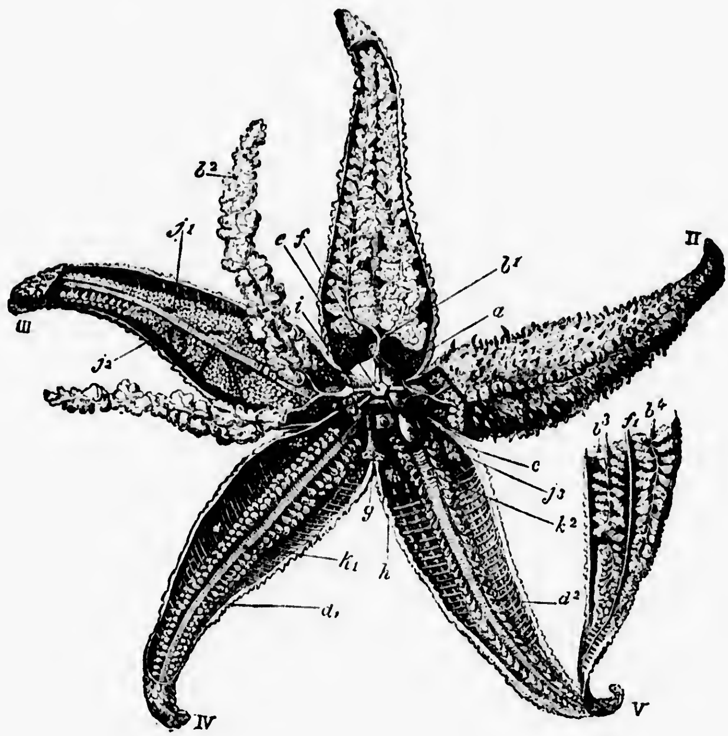


STRUCTURE OF AN ECHINODERM.

PLATE III.

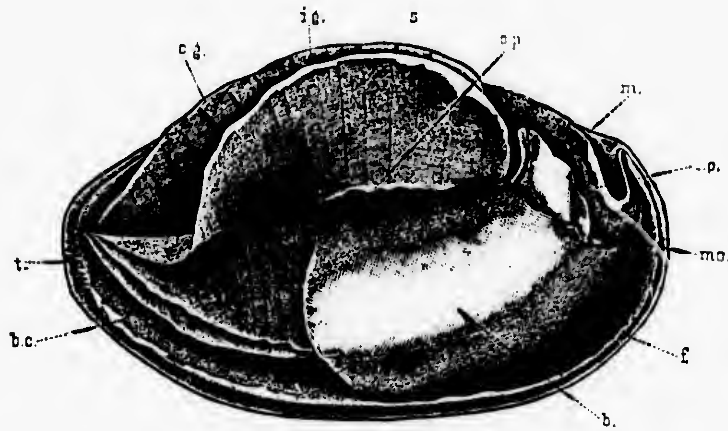
FRESH-WATER MUSSEL—ANADONTA FLUVIATILIS,

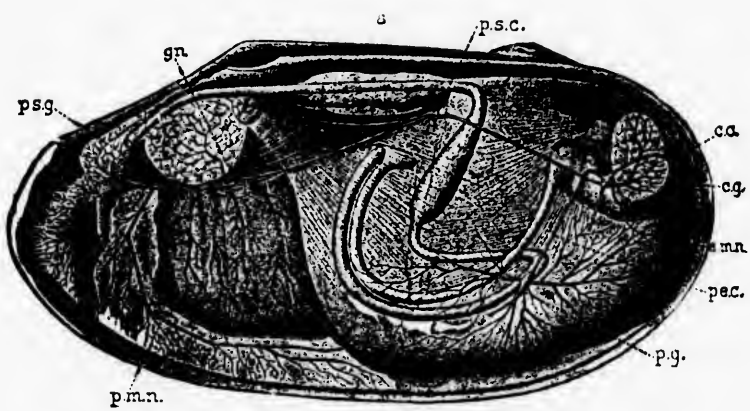
(After Simpson.)

The upper figure shows the mantle (m) and gills (i g, o g) thrown back, showing the foot (f), mouth (m o), one of the labial palpi (l p), the visceral mass (b), branchial cavity (b c), and siphon with tentacles.

The lower figure shows the two adductor muscles and the intestinal canal with the nervous system. (c g) Central ganglia ; (c c) Commissural cord ; (p g) Posterior ganglia and (psc) Commissural cord ; (p g) Pedal ganglia and (p e c) Commissural cord ; (a m n) Anterior mantle nerve ; (g n) Nerves of the gills.

PLATE III.





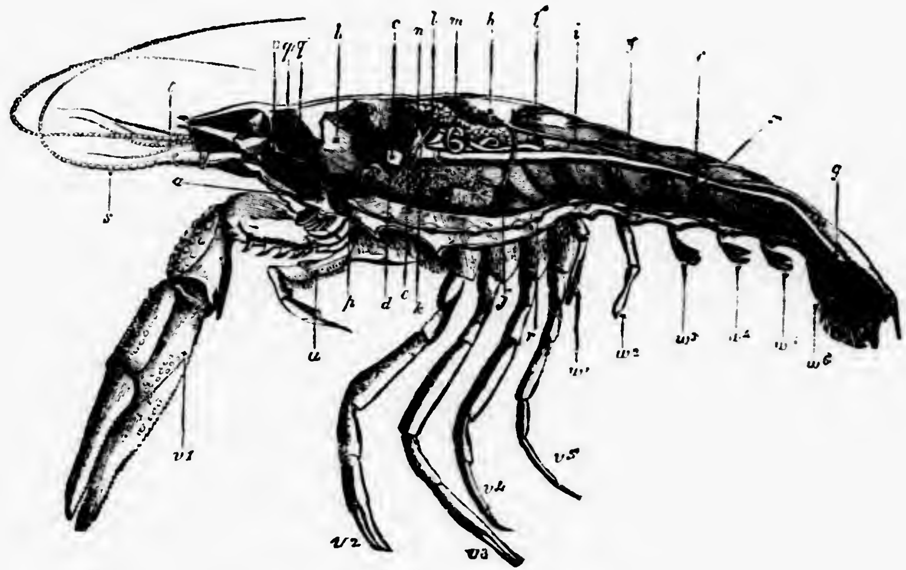
DIAGRAMS OF A LAMELLIBRANCHIATE.

PLATE IV.

CRAY-FISH—ASTACUS FLUVIATILIS (after Rolleston).

a—Oesophagus.
b—Cardiac portion of stomach.
c—Pyloric portion of stomach.
d—Hepatic lobes. *e*—Orifice of do.
f—Intestine. *g*—Anus.
h—Heart.
i, *j*, *k*—Arteries
l, *m*, *n*—Generative organs.
o—Super-œsophageal ganglia.
p—First pectoral ganglion, supplying oral organs.
q—Connecting nerves of head.
r—Ganglia on abdominal cord.
s, *t*—Antennæ.
u—Foot-jaw.
v^1 to v^5—Five pairs of feet.
w^1 to w^5—Five pairs of abdominal feet.
w^6—Telson and lateral appendages.
x—Flexor muscles of the tail.
y—Extensor muscles of the tail.

PLATE IV.



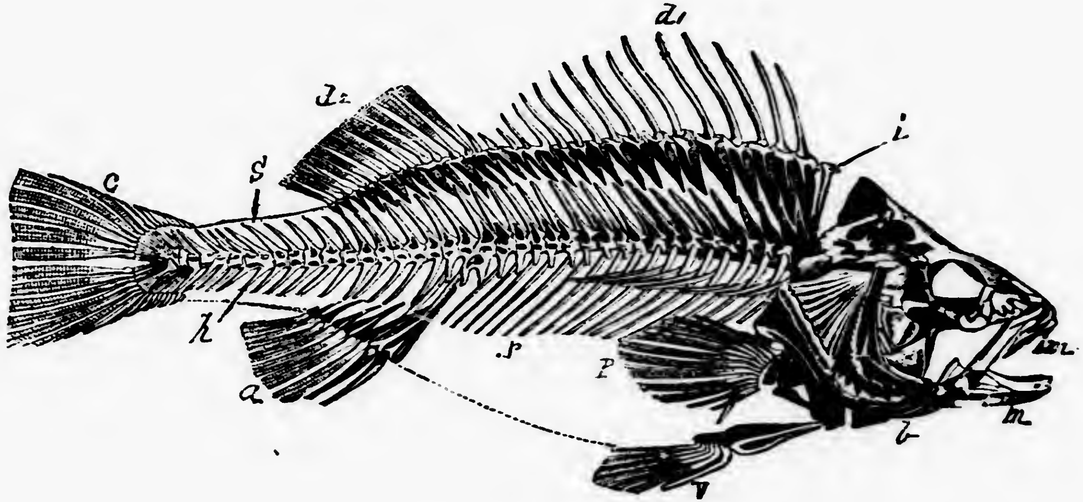
STRUCTURE OF A CRUSTACEAN.

PLATE V.

SKELETON OF PERCH—PERCA FLAVESCENS (after Owen).

(*m*) Mandible; (*im*) Intermaxillary; (*b*) Gill arches; (*i*) Interspinous bones; (d^1, d^2) First and second dorsals; (*p*) Pectoral fins; (*v*) Ventral fins; (*a*) Anal fin; (*c*) Caudal fin; (*r*) Ribs; (*s h*) Spinal column.

PLATE V.



SKELETON OF A FISH.

PLATE VI.

BROOK STICKLEBACK—GASTEROSTEUS (APELTES) GYMNETES, Dawson.

(Canadian Naturalist, Vol. IV, 1st series, 1859)

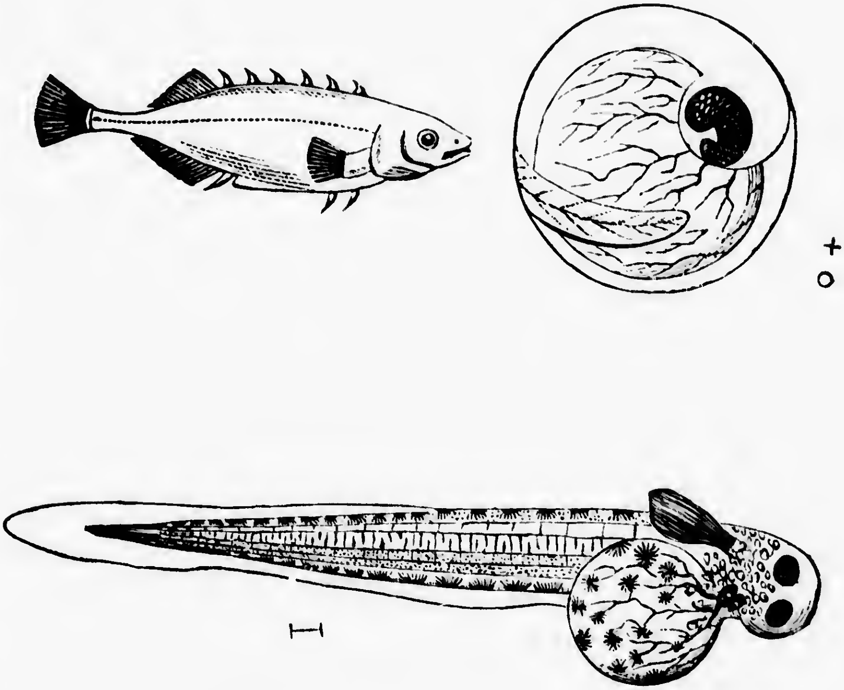
This species inhabits brooks, and constructs nests of aquatic plants to contain its ova. A full description of the species and account of its habits will be found in the paper above cited.

Fig. 1.—Adult male, natural size, drawn by R. J. Fowler.

Fig. 2.—Ovum magnified, with the embryo nearly ready to be hatched, showing position of embryo on the yolk.

Fig. 3.—Recently hatched embryo, with yolk-sac attached, showing the eyes, the two-chambered heart, the vessels distributed over the yolk-sac, the pectoral fin, and in the body the cartilaginous notochord and principal vessels. Pigment-cells are seen on the yolk-sac and sides of the body.

PLATE VI.



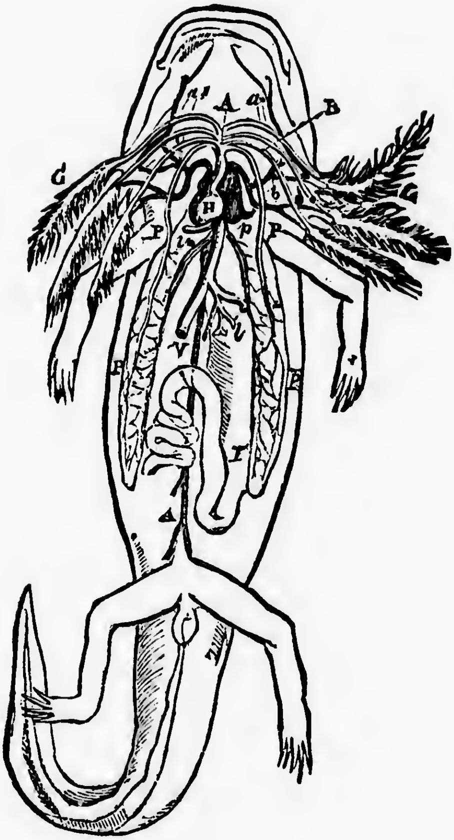
DEVELOPMENT OF A FISH.

PLATE VII.

THE AXOLOTL—SIREDON PISCIFORME (after Gervais and van Beneden.)

H—Heart. A—Ascending aorta. b—Branchial veins and arches. V—Vena cava. P—Lungs and Pulmonary artery. I—Intestine. l—Liver.

PLATE VII.



STRUCTURE OF A BATRACHIAN.

PLATE VIII.

SKELETON OF TORTOISE—TESTUDO GRÆCA.

Showing the Vertebræ and Ribs expanded to form the Carapace, and with the Shoulder-bones and Pelvis placed in the interior.

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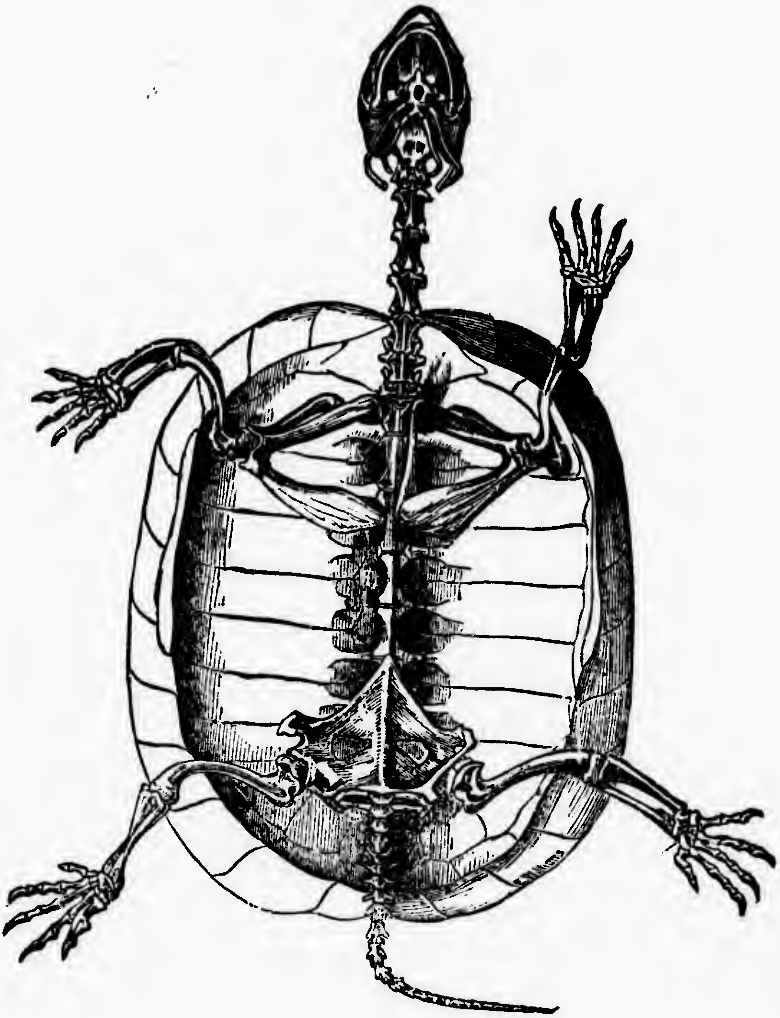
PLATE VIII.



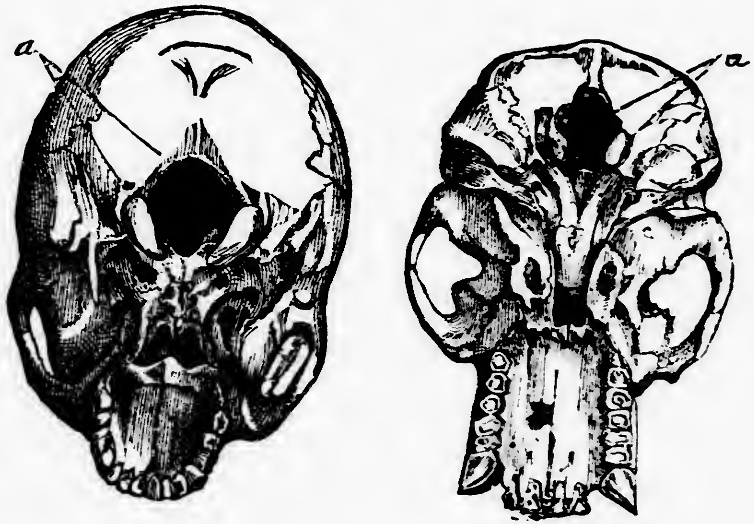
SKELETON OF A CHELONIAN (After Owen).

PLATE IX.

SKULLS OF MAN AND GORILLA,

Showing the great difference in the proportions of the brain-case and facial bones, and the different positions of the Foramen magnum, (a)

PLATE IX.



Skulls of Man and Gorilla (After Martin).

DIRECTIONS FOR COLLECTING AND PRESERVING ANIMALS.

An excellent Manual for Collectors is "*The Practical Naturalist's Guide,*" by J. B. Davies, (Maclachan & Stewart, Edinburgh). The "Directions" published by the Smithsonian Institution, Washington, are also very valuable. The following hints have been compiled chiefly from these works, to which the reader is referred for further information on the subject.

The beginner in the study of Zoology, should collect and study such animals as may be within his reach, forming, at first, a miscellaneous collection. He may subsequently direct his attention specially to some one group of animals; and, after making this decision, he should provide himself with the special works necessary to the prosecution of the particular branch selected. General knowledge is necessary as a foundation, but the animal kingdom is too extensive to permit any one to attain to thoroughness in more than one limited department.

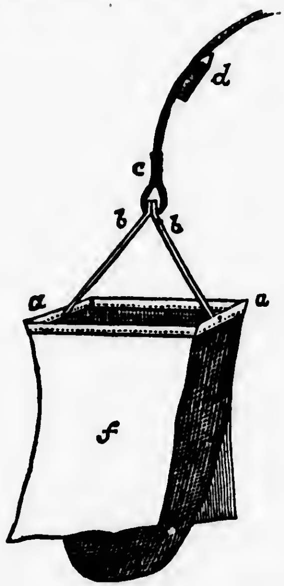
GENERAL DIRECTIONS FOR COLLECTING MARINE ANIMALS.

"Where the retreat of the tide is sufficient, the sea-shore always affords the best field for the collector, and the specimens generally increase in number and interest in proportion as we approximate to low-water-mark. Nevertheless the whole area should be searched, as each species has its peculiar range, and many forms can live only where they are exposed to the air for the greater part of the time each day. The ground may be either muddy, sandy, weedy, gravelly, stony or rocky, and the animals inhabiting each kind of ground will be found more or less peculiar to it, and rarely to occur on the others. *Sand* and *mud* are, however, so similar in character that their denizens are nearly the same, though some prefer the clearer waters which flow over sand, to the turbid tide which deposits mud. But few specimens will be found on the surface of such ground, although the little pools lying on it should be scooped with the dip net for shrimps, etc., but it is only by the spade that its true riches can be developed. By digging in spots indicated by small holes, a great number of worms, boring crustaceans, and bivalves may always be found. *Weedy ground* is so called from the abundance of eel-grass and sea-weed which covers it. These weeds should be examined carefully for small shells and crustaceans; perhaps the best method of doing this being to wash quantities of the weed in a bucket of water and examine the sediment. *Gravelly ground* is not generally very rich in animal life, but will repay an examination, as small crabs are fond of lurking among the pebbles. *Stony ground* is by far the richest of all. Wherever there are stones, particularly flat ones, about large enough to afford a moderate degree of exercise to a common sized man in turning them over, there the zoologist can never fail to fill his basket and bottles; for beneath these stones myriads of rare and beautiful species retire for moisture and protection during the retreat of the tide. *Rocky ground* should be searched chiefly in the pools and crevices.

"Littoral or sea-shore investigations should be carried on not only in the bays, harbours, and creeks, but on the ocean beach, in each locality, to get at a true idea of its fauna, as the respective animals will be found different,"—*Smithsonian Directions.*

DREDGING.

"A large proportion of the marine invertebrates never approach the shore closely enough to be left by the tide, and these can only be obtained with certainty and facility by means of the *dredge.* This consists of a rectangular frame of iron, the longer sides of which are sharpened in front and beveled outward a little. Along the back of the frame holes are perforated for the attachment of a fine meshed net, and to the short sides handles are hinged, which may be folded down in packing. There should be a ring at the end of each handle, and through these rings the rope may be passed when the handles are raised, which will be found a simple and sufficiently safe method of fastening the dredge for use. A weight should be attached to the rope two or three feet in front of the dredge, which is useful in sinking and keeping it in proper position when operating in deep water. On each of the longer sides of the frame there should be a leather flap attached for the protection of the net. The following are convenient dimensions for the apparatus: Frame, *a*, *a*, 20 inches long by 10 inches broad, of bar-iron 1½ inches wide and one-fifth of an inch thick. Handles, *b*, *b*, each 17 inches long, of half-inch rod-iron. Bag, *e*, three feet long, of mesh as fine as can be got, and strong twine; size of aperture rather larger than that of the frame. Rope, *c*, 20 to 200 fathoms to suit the depth of water. Weight, *d*, 5 lbs.;



an iron window-weight answers the purpose, and is much cheaper than lead.

"The dredge should be carefully cast mouth downward, that the tail of the net may not foul the handles or scythes. No precise directions can be given as to the amount of scope of warp to be let out; about twice the depth of water is generally sufficient, but this should be diminished or increased in proportion as the dredge nips too hard or slides too easily over the ground, which may be readily determined by feeling the rope. The dredge is liable to be caught on rocky bottoms. When the check is felt, it is usually only necessary to heave in a portion of the warp, but sometimes the boat must be put about and run in an opposite direction.

"All bottoms should be searched with the dredge, but gravelly and shelly ground will be found most productive. The boat may be propelled by sails if sufficient care be taken to graduate the amount of canvas to the strength of the wind, in order that the dredge may move slowly over the bottom. Oars are safer, if the force is at command; and in a tide-way, the tide alone may move the boat with sufficient power, the rope being made fast amidships, or towards the bows, according to the strength of the current."—*Smithsonian Directions.*

FORAMINIFERA.

These occur in almost every specimen of mud or sand, obtained by dredging or sounding in deep water, and also in sponges and among hydroids, &c. The specimens of such materials should be wrapped in parcels and labelled. When quite dry the earthly matter may be thrown into a vessel of water and thoroughly stirred. The lighter Foraminifera will float to the surface, and may be skimmed off or collected in a filter of fine muslin. Larger species may be shaken up to the surface of the sediment, and collected with a camel hair pencil. They should be mounted for the microscope either as opaque objects, or immersed in balsam as transparent objects.

Living Foraminifera can be obtained from recent marine mud and attached to shells, sponges and Hydroids.

SPONGES.

These are easily preserved, by simple drying; but if it is desired to keep them in their natural state, they should be immersed in spirits immediately after being taken from the sea. The spicules may be obtained for microscopic examination by boiling a fragment of the sponge in nitric acid until all the animal matter is decomposed.

INFUSORIA.

These may be readily collected from stagnant pools, &c. by means of a wide-mouthed bottle attached to a stick. They occur in all waters in which living or dead vegetable matters are present. Different species may be found at the top and bottom of the water, or attached to different kinds of aquatic plants. Rhizopods, Rotifers, minute Crustaceans and worms, and one-celled plants (Desmids and Diatoms) will generally be found in the same places with Infusoria.

CŒLENTERATA.

"Sea-pens, Alcyoniums, and other allied animals, must be put up as wet preparations. This remark also applies to Actiniæ, though the means usually adopted, —*i. e.*, spirit or saline solutions —so destroy the colour and appearance of the specimens, that it is hardly possible to distinguish one species from another when preserved. The writer, as the result of his own experiments, proposes the following method of preserving something of the natural form and colour of these animals:—The Actinia is allowed to remain in sea-water until nearly dead. While the tentacles are completely distended with sea-water, the animal is gently lifted into a smaller vessel, and the end of a glass tube of suitable size, and previously filled with glycerine, is pushed in at the mouth, and the contents forced into the body by blowing. The tube is again and again filled and applied, until the fluid which exudes at the points of the tentacles has lost its saline taste: the surrounding fluid is then removed, and replaced with glycerine. Large specimens will require to have the glycerine again changed before fastening up the preparation, which may be done in a month.

"The Hydroid Polyps may all, with the exception of the softer species, be easily dried. They are preserved in exactly the same manner as Polyzoa, with which they are often confounded, by drying them in blotting paper, under slight pressure; when it is desired to preserve the animals as well as the cells, they must be placed in spirit.

"Jelly-fishes (*Acalephae*) are variable in form; but the most conspicuous kinds in this country resemble a flattened hemisphere. and are familiarly known as sea-blubbers or sea-nettles, the latter name being conferred on them from the stinging properties which some of them possess. The term Medusæ is also applied to them. The more minute species occur plentifully in sheltered places, and have either the form of the larger kinds or are spherical or cylindrical.

"The larger species are frequently cast on shore, or may be caught with a sieve held over the edge of a small boat. The smaller kinds are caught in a towing net. Being extremely fragile, they all require to be handled with the greatest care.

"Medusæ are preserved with difficulty. Spirit, diluted vinegar, and other preparations have been tried, but with very little success; until Mr. Goadby proposed a modification of his solution. (Reduce a saturated solution of Bay Salt to the strength indicated by a bead marked 1148. Dilute to half strength and add 2 oz. alum to the quart. Soak the specimens in this for 24 hours or more, according to size, changing the solution daily. Then immerse in a solution of Bay Salt of strength 1148.) This certainly surpasses anything previously in use, although it is open to the same objections as all other saline solutions. Where these objections are not deemed important, the collector cannot do better than use his method."—*Davies*.

ECHINODERMATA.

"Echini and star-fishes may be preserved dry. With the former it is necessary to cut a slit in the membrane which surrounds the dental apparatus (where such exists), on the lower part of the sphere, and thence remove the viscera. In drying it is well to suspend in a place where there is a thorough draught of air. Some collectors, with a view to keeping the spines erect, fasten a hook in the soft skin at the mouth, and without removing tbe viscera, hang the Echinus to dry, either exposed to the heat of the sun or to artificial heat.

"The larger star-fishes (*Solaster*, *Uraster*, &c.), may be either plunged in hot water, and laid out to dry, or may be first cleaned in the following manner:—A hooked wire is passed in at the mouth, or on the under surface, and into each limb, from which so much as possible of the soft matter is removed; the mouth is then held close to a water-pipe, and the force of water carries out what cannot be extracted with the wire. A little of the corrosive sublimate solution in alcohol may be poured in at the mouth with advantage.

Slender-armed star-fishes (*Ophiocoma*, *Ophiura*, &c.). merely require to be steeped for a short time, say twenty-four hours, in spirit, and laid in a situation where they will dry rapidly. The same treatment will answer equally well for the Medusa-head star-fish. These forms are all extremely brittle, but with tolerable care need not be injured either in capturing or preparing.

"Sea-cucumbers (*Holothuroida*) being destitute of the dense bony plates which cover the other orders of Echinoderms, cannot be successfully dried. The chief thing to be attended to in putting up as wet preparations is to let them die in sea-water, so as to preserve their branched tentacles is an extended condition."—*Davies.*

MOLLUSCA.

"Like the true Polypi, many of the Polyzoa may be preserved dry by washing in fresh-water, and pressing between sheets of absorbent paper; but in this state they are far less valuable than as wet preparations." The tunicates should be preserved in spirits, but some of the kinds may be stuffed with cotton and dried.

"*Fresh-water Mollusca* may be gathered with a hand net, or, still better, by using the *shell-spoon.* This consists of a hemispherical cup of white-iron, about four inches in diameter, with a half-lid soldered on the top, and an oblique socket for the insertion of the point of a walking-stick. The whole cup is perforated with holes. When, say, a Limnæus is obtained from the pool, the cup is raised until the stick is nearly horizontal, and slightly turned over on the side on which the covering is, so that the creature lodges securely between the side of the cup and the partial lid. Bivalves seldom float; therefore they must be sought for either by lifting some of the mud in the spoon, and washing, or by pulling up the reeds and other plants, and examining the roots. Fresh-water mussels stick in the mud at the bottom of ponds and rivers; an iron rake is very useful in capturing them.

"*Land Mollusca* must be hand-picked among leaves, roots, or the decaying stones of old walls. For collecting land shells, a few wide-mouthed bottles or pill-boxes should be carried.

"By far the greater number of collectors content themselves with the cleaned and dried shells of Mollusca, without attempting to preserve their softer parts. Indeed a moderately-sized private cabinet will not admit of anything more. It is extremely desirable, however, that not only should the soft parts inhabiting shells be preserved, but more especially the mollusks, which either are destitute of a shell altogether, or have only a small rudimentary one inside the mantle. This, though applicable to the well-known species of our own country, applies with far greater force to those of little-known regions.

"Cephalopods or cuttle-fishes should always be preserved in fluid. Two genera—Spirula and Nautilus, inhabiting the southern seas—are much wanted in a perfect condition in all public museums. In the case of the latter, it will be well to make a small perforation in the first chamber of the shell to allow the preservative fluid to enter.

"Naked Mollusca should be allowed to die in sea-water before being placed in the spirit or other fluid. The same remark applies to shell-bearing Mullusca, especially the univalved. Shells may be cleaned out either by pouring hot water over the living creatures, or allowing them to die in the water. A bent pin will be found useful in extracting the animal from the smaller shells. The chief thing to be attended to is to have the shells well cleaned and dried before being packed.

"The operculum, which covers the opening in many spiral shells, must be preserved, and if of a hard, calcareous substance, simply placed within the mouth of the shell: but if thin and horny, a little cotton should be put into the shell, and the operculum fastened to this with gum.

"In cleaning bivalve shells care must be taken not to break the hinge, as otherwise the valves are apt to be separated and lost. They should be tied together while yet the hinge is soft.

"No attempt should be made to remove the adherent shells of Worms, Crustacea, &c. It ought especially to be kept in mind that the application of acids will injure the specimen far more than than the presence of scores of surpulæ and barnacles.

"The epidermis which covers the shell is, so far as colour is concerned, the most characteristic feature in all species; therefore it follows that this must be carefully preserved. An application of oil has been often recommended; and, more recently, Gen. Totten has proposed the use of *cloride of calcium* for the purpose of keeping the epidermis moist and clear. In the majority of instances no such application will be necessary, provided the shells are carefully dried and preserved."—*Davies.*

WORMS AND CRUSTACEA.

"In the case of *Worms*, the first thing to be attended to is killing. This is an easy matter with moderately-sized worms, but with the more elongated genera, as Nemertis and Phyllodoce, it requires some nicety. The plan which the writer pursues is as follows:—The worm is allowed to remain in a jar with sea-water, until, by the vitiation of the latter, the creature begins to lose its irritability. This can be easily put to the test by touching it, and watching the effect. The water is then to be nearly all poured off, and weak spirit slowly added. The Nemertis will endeavour to throw itself in pieces by producing sudden bends in its body. When these are observed, the finger is gently pressed against the outside of the curve to reduce it until the worm dies. By adopting this plan, any worm may be preserved without a single break. There is another advantage gained by allowing the worm to become enfeebled in the sea-water, *i. e.*, that it generally throws out its proboscis, an organ of much value in distinguishing genera. Serpulæ and other shell-inhabiting worms should be preserved with the shell attached, and, if possible, another specimen removed from the shell should be placed in the same jar. Flat marine worms (Planaridæ) can scarcely with safety be allowed to linger in the water, owing to their extreme liability to decay, but should at once be plunged into the preserving fluid.

"Fresh water worms, as well as tape-worms, may be placed in spirits immediately after being caught."

"Crustaceans should be allowed to die in cold fresh water. On no account whatever should hot water be employed, as it immediately changes the colour. In the case of a crab the carapace or large shell should first be removed, leaving the limbs attached to the under portion. So much as possible of the flesh of the body and claws is then to be taken out, in the latter case employing a hooked wire. Except in large crabs it is not advisable to disarticulate the claws in order to clean them ; but, when necessary, it may be done without materially injuring the specimen. Sometimes a piece is removed from the shell of the claw to facilitate the extraction of the muscle, and afterwards replaced and fastened in with cement. The whole of the inside is washed with corrosive sublimate, by means of a camel's hair brush, the limbs put in the desired position, and the shell is laid aside to dry, after which the parts are united with cement. Should the specimen be a female, the false limbs on which the eggs are borne require to be preserved. Lobsters should have the carapace removed, and the limbs treated in the same way as crabs ; the abdomen is then removed, and the contents of it extracted by means of a hooked wire. Chemical preservative may then be applied, and a little cotton pushed into the abdomen. In drying, care must be taken to give a proper set to the small limbs on the abdomen, and the tail ; this will best be accomplished by laying it upside down on a board, and propping such of the limbs as require it with pieces of cork.

"Hermit crabs should have the soft abdomen slit open, the contents extracted, and the space filled with cotton. A little gum on the cotton will secure the edges of the slit. When dry they may be replaced in the shells in which they were found.

"All Crustaceans, but especially the smaller species, are better preserved in fluid than in any other way. Nevertheless, it may be thought desirable to dry the smaller crabs, shrimps, and sand-hoppers, and wood-lice. When the carapace is not too hard, a pin is passed through it into a flat piece of cork, and the Crustacean is set in the same way as an insect, with this exception, that slips of paper are not required, the limbs and feelers being kept in their places by pins bent obliquely over them. The chief thing to be attended to in setting is symmetry of parts. Nothing looks worse than a shrimp or crab with its limbs twisted about in every direction but the right one. Cirripeds or barnacles may be either dried or put up as wet preparations. They should be kept attached to a piece of stone or wood on which they are found."—*Davies*.

INSECTS.

"The harder kinds may be put in liquor, as above, but the vessel or bottle should not be very large. Butter-flies, wasps, flies, &c., should be pinned in boxes, or packed in layers with soft paper or cotton. Minute species should be carefully sought under stones, bark, dung, or flowers, or swept with a small net from grass or leaves, They may be put in quills, small cones of paper, or in glass vials. They can be readily killed by immersing the bottles, &c., in which they are collected, in hot water, or exposing them to the vapour of ether. Large beetles, however, can generally only be killed by piercing with some poisonous solution, as strychnine.

"It will frequently be found convenient to preserve or transport insects pinned down in boxes. The bottoms of these are best lined with cork or soft wood. Attention shonld be paid to the particular part of different kinds of insects through which the pin is to be thrust ; beetles being pinned through the right wing-cover or elytron ; all others through the middle of the thorax.

"The traveller will find it very convenient to carry about him a vial having a broad mouth, closed by a tight cork. In this should be contained a piece of camphor, or, still better, of sponge soaked in ether, to kill the insects collected. From this the specimens should be transferred to other bottles. They may, if not hairy, be killed by immersing directly in alcohol.

"A lump of camphor may be placed in a piece of cotton cloth and pinned firmly in the corner of the box containing dried insects, for the purpose of preventing the ravages of larvæ. A few drops of creosote occasionally introduced will also answer the same purpose." —*Smithsonian Directions*.

In the preservation and mounting of skins and skeletons of vertebrate animals, the collector is referred to Davies' Guide; or to Kingsley's Naturalist's Assistant, or Maynard's Naturalist's Guide, published by Cassino, Boston. For directions as to dissecting and studying typical animals, the student is referred to Packard's Zoology, Holt, New York; or Brooks's Handbook of Invertebrate Zoology, Cassino, Boston.