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AND

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With regards
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HANDBOOK

OF

ZOOLOGY:

WITH EXAMPLES FROM

CANADIAN SPECIES, RECENT AND FOSSIL.

BY

J. W. DAWSON, LL.D., F.R.S., &c.

PART I.—INVERTEBRATA.

WITH 275 ILLUSTRATIONS.

MONTREAL:
DAWSON BROTHERS, ST. JAMES STREET.
1870.

JOHN LOVELL, PRINTER.

PREFACE.

IN teaching Zoology nothing is of more importance than to have the means of directing the attention of the student to the animals of the country in which he lives. For this reason I have been in the habit of preparing a synopsis of the subject for the use of my classes, with examples taken as far as possible from common native species. In preparing a new edition of this synopsis, I was advised by the publisher to give it greater extension, in the hope that it might be useful to other teachers, and also to isolated students and collectors. The present manual is the result of this attempt; and the only merit which it claims is that of giving a skeleton of the subject, with illustrations taken from species which the student can collect for himself within the limits of British North America, or can readily obtain access to in public or private collections.

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.

I have avoided the modern doctrines of a "physical basis of life" and of "derivation," because I believe them to rest on grounds very different from those of true science, and therefore to be unsuitable for the purposes of a text-book. I have also retained the Cuvierian Provinces of the Animal Kingdom as amended by modern discoveries. I am quite aware that there are Zoologists who affirm that the Province Radiata has been "effectually abolished" and that other provinces should be broken up; but as I cannot help perceiving that the four types of the great French naturalist exist in nature, I have not scrupled to adhere to them, as the expression of a grand and philosophical idea, essential to an accurate and enlarged conception of nature.

In the present chaos of synonymy in Zoology, I have often been perplexed as to the generic and specific names to be given to our most common animals; but have endeavoured to take such a middle way between the older names and the later innovations, as seemed likely to be least perplexing to the student.

For many 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'Urbain, Mr. Whiteaves and Mr. Packard in the "Canadian Naturalist." A number are from my own papers in the Naturalist and from "Acadian Geology," and many are original. I have to thank Dr. P. P. Carpenter and Mr. Whiteaves for some valuable hints toward the improvement of the chapter on Mollusca.

Should this volume be well received, it may be followed by another on the Vertebrata. In the mean time I shall be much indebted to any of my fellow workers who may use this manual, if they will give me the benefit of such hints as may occur to them, either with reference to a new edition or to a second volume.

I may add that I have kept in view the possible utility of this manual to tourists and visitors to the sea-side, who will find it to contain figures or notices of most of the common animals they are likely to meet with, as well as directions for collecting and preserving specimens.

McGill College, *Montreal*,
Dec. 1869.

ERRATA.

Page 7 line 5—*for* and *read* each.

" 7 " 20—*for* very largely present in all *read* also largely present in these.

" 16 " 2 from bottom—*for* Mollusous *read* Molluscous.

" 32 " 17—*for* anologies *read* analogies.

" 46—*for* class 2, Acalephæ, *read* class 3, Acalephæ; *and for* class 3, Anthozoa, *read* class 2, Anthozoa.

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HANDBOOK OF ZOOLOGY.

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.*

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

We shall consider these in their order, devoting one chapter to each of the two first subjects, and entering at greater length into the third, which necessarily includes the larger part of Zoology proper.

CHAPTER I.

PHYSIOLOGICAL ZOOLOGY.

1. General Nature of the Animal.

In answer to the question—"What is an animal?"—we may say, in the first place, that an animal is a being composed of certain organised tissues and possessing powers usually styled vital forces. The tissues of the animal are such as membrane, flesh, nerve-matter, bone; and these are built up, especially in the higher animals, into organs or more or less complex machines. The results of vital force acting in the animal, are such processes as digestion, nutrition, circulation, respiration, sensation, muscular action. The tissues and organs are necessary to the performance of these functions; but the tissues and organs themselves can only be produced under the influence of life. The tissues and organs may, however, continue to exist, or may be preserved for a greater or less time after their vitality has departed. These statements are sufficient to distinguish animal organisms from mineral substances, though the constituent elements of the former are the same with a part of those occurring in the latter. It is further to be observed that since structure and peculiar chemical compounds pervade the animal organism, we can, by the aid of the microscope and of chemical tests, distinguish the smallest shred of animal matter from that which is merely mineral: and this even when the former, imperfectly preserved or partially mineralised, is imbedded in a fossil condition in the rocks of the earth.

Plants are organised and living, as well as animals, and contain the same organic compounds, though in different proportion from that in which they occur in the animal.

To distinguish the animal from the plant, we may affirm, 1st, that the former is reproductive by eggs or ova and not by seeds and spores, the latter being distinct in their origin, their structure, and their chemical composition; 2nd, that in its processes of nutrition it digests organic food in an internal cavity, subsequently consuming a part of this food at the expense of the oxygen of the atmosphere; and that it builds up its tissues principally of nitrogenised matter; 3rd, that the animal possesses the power of voluntary motion, and to subserve this, muscular tissue; 4th, that it possesses sensation, and to subserve this and motion as well, a nervous system and external senses.

We thus find four general characteristics of the animal:

1. *Sensation*—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.

In every animal, even the simplest, these functions are in greater or less perfection performed; 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. For the student, I hold it to be necessary, before proceeding further, to understand well these functions and structures, as they exist in some one of the higher animals. For this purpose it will be sufficient that he should read carefully any small elementary work on animal physiology, such as any of those mentioned below.* In this outline, I shall merely indicate in the following sections, the most important points to be known.

2. 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.†

The essential material of the animal tissues is albumen, a substance with which we are familiar as

* Agassiz and Gould's Principles of Physiology. Huxley's Elements of Physiology.

† The teacher should if possible illustrate the several tissues by specimens seen under the microscope. If this cannot be done, by as good drawings or plates as can be procured. Those of Marshall, issued by the Department of Science and Art, England, are very useful.

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 of albumen and albuminoid substances in the animal tissues, the animal may be regarded, in a chemical point of view, as consisting of only four elements, carbon, oxygen, hydrogen, and nitrogen.

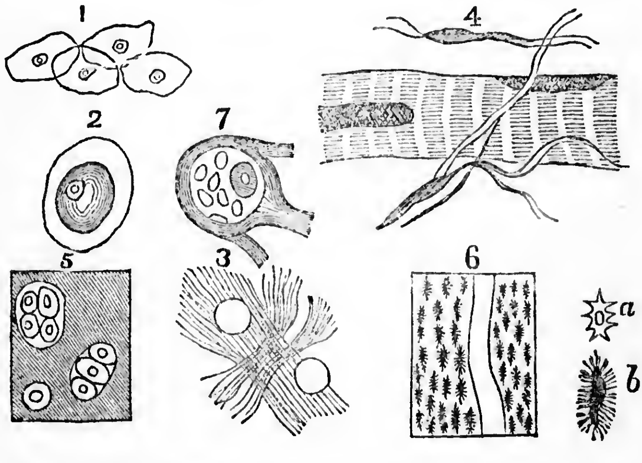

Fig. 1.—Cellular Tissue—Showing Nuclei and Nucleoli.
Fig. 2.—Young Blood-Cell, (after Beale).
Fig 3.—Fibrous Tissue and Fat-cells.
Fig. 4.—Striated Muscular Fibre with Nerve-Fibres and Nuclear matter—(after Beale.)
Fig. 5.—Cartilage, showing groups of cells with Nuclei.
Fig. 6.—Bone, showing cells and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

Cellular Tissue. — The simplest kind of animal tissue is that to which we give the name cellular. It consists of cells or sacs, with albuminous walls more or less firmly attached together, and containing a semi-fluid substance 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. Large portions of the bodies of many of the lower animals are composed entirely of simple cellular tissue; and it also exists in the higher animals, in the epidermis and other membranes, glands, cartilages, &c. It is very largely present in all animals in their earlier embryonic stages. (Figs. 1—2.)

Fibrous or Connective Tissue.—This is composed either of gelatine or of albumen, and presents the aspect of fibres either parallel or interlaced. 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. [Fig. 3.]

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. Smooth muscular fibres occur in some involuntary muscles of the higher animals, and in the lower tribes of animals. (Fig. 4.)

Osseous or Bony Tissue.—Bone consists of gelatinous animal matter in which are imbedded granules of phosphate of lime. 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 the whole with canals traversing the bone, (Haversian canals) which carry the blood-vessels that nourish the bone. These vessels open upon the surface of the bone, and unite with those of the periosteum, a strong membrane covering its surface. Bone in its young state is usually a compact elastic substance known as cartilage or gristle. Under the microscope this presents a series of nucleated cells imbedded in a firm animal substance, and the whole mass grows by division of the cells, and development of intercellular substance between their separated parts. 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 drawn out into narrow contiguous tubes. Enamel, which is the hardest kind of bony tissue, consists of solid bony prisms placed side by side. (Figs. 5–6.)

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 gray 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 consist of a central cord, surrounded by a clear substance, and this by a more opaque coating enclosed in a structureless membrane, the *Neurilemma*. The animal matter constituting Nerve, contains phosphorous as one of its essential elements, but the relation of its composition and structure with its function is not known. This function 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, marks 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 very lowest forms of animal life.

3. 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.*

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* These functions should be illustrated to the class, either by actual specimens of the organs referred to, or by models or good figures: the engravings already mentioned will be found very useful.

SENSATION.

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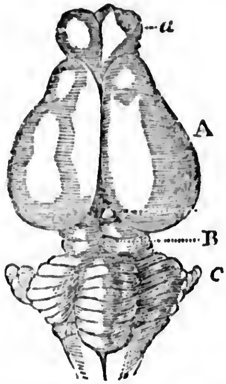


BRAIN OF OPOSSUM (after Owen) (*a*) Olfactory Lobes; (A) Cerebral Hemispheres; (B) Optic Lobes; (C) Cerebellum and origin of Spinal Cord.

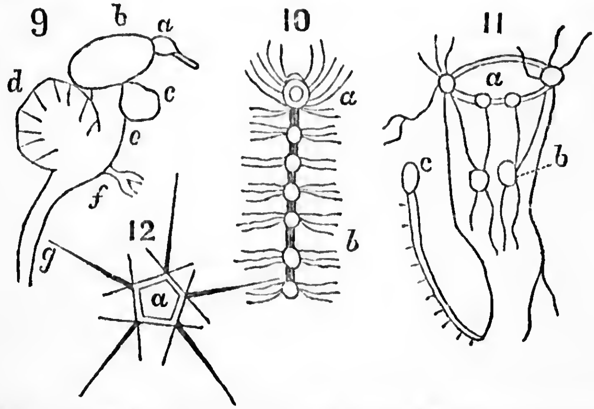


Fig. 9.—Diagram of Brain of Bird, (Myelencephalous).—(*a*) Olfactory Lobes; (*b*) Cerebral Hemispheres; (*c*) Optic Lobes; (*d*) Cerebellum; (*e*) Medulla Oblongota; (*f*) Auditory nerves; (*g*) Spinal Cord.

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.

The organs of sensation are the nervous system and special senses. The former consists of nerve-centres and nerve-fibres, and these may be arranged in four different ways.

1. **Myelencephalous.**—Consisting 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 consists of several 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 taking their origin in part from each. The mammals, birds, reptiles and fishes have their nervous system constructed on this type. (Fig. 8 & 9.)

2. **Homogangliate**—In this type the principal nerve-centre consists of a ring surrounding the gullet, with a mass above giving off nerves of sensation, and a mass below 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. **Heterogangliate.**—In this type the principal nervous masses are distributed around a large

œsophageal ring, and in the course of nerve-cords irregularly distributed to the different organs. This is the nervous system of cuttle-fishes, land and water snails, bivalve shell-fishes and their allies.—Fi g. 11.)

4. 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.)

In some of the lower animals the nervous system has not been made out; but there can be little doubt that, even in those of simplest organization, there must be at least scattered nervous cells and fibres.

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-going 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 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.

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. 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.

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 **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, in connection with small solid granules to 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 the objects without. The varied colours and lights of this picture, acting on the ramifications of 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 powers. In insects and some other creatures, there are great numbers of minute tubular eyes centering in a common point. In animals of still lower grade, the eye consists 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.

VOLUNTARY MOTION AND SUPPORT.

With reference to the apparatus for voluntary motion and support, all animals may be arranged in four great groups, corresponding to those referred to under the last head. These types of structure are:

1. **Vertebrate**, in which the body 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. This group coincides with the myelencephala, and includes mammals, birds, reptiles, and fishes. (Fig. 13.)

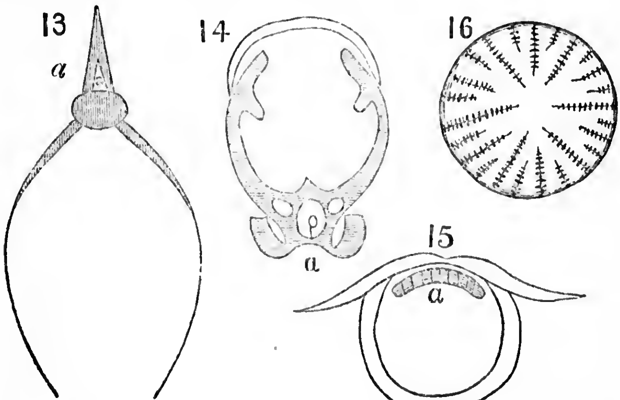


Fig. 13.—Section of Skeleton of a Fish (Vertebrate); (*a*) Spinal cord.
Fig. 14.—Section of Skeleton of a Crustacean (Articulate); (*a*) Abdominal nervous cord.
Fig. 15.—Section of mantle of a Cuttle-fish (Saccate or Molluscous); (*a*) Internal shell.
Fig. 16.—Section of Skeleton of a Coral, (Radiate.)

2. **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 homogangliata, and includes the spiders, insects, crustaceans, and worms. (Fig. 14.)

3. **Molluscous** or **Saccate**.—In this there is no skeleton, but the body is enclosed in a muscular

sac or mantle, and the locomotive organs, when present, consist of layers of muscles without hard parts, but there are often shelly organs for support and protection. This coincides with heterogangliata, and includes cuttle fishes, snails, bivalve shell-fishes, &c. (Fig. 15.)

4. **Radiate.**—In this, the skeleton, when present, is internal with reference to the muscles, and consists of pieces disposed in radiating lines, or of a solid, stony, or corneous mass; but in many there are no hard parts, or only an external case or tube. This coincides with nematoneura, and includes star-fishes, sea-urchins, coral animals, sea-jellies, &c. (Fig. 16.)

NUTRITION.

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, and completed in the small intestines by the action of the bile and pancreatic juice. (3.) Absorption by the villi or processes of the intestine, from which the fluid nutritive matters, the results of digestion, are removed from the intestinal canal and conveyed to the circulatory system. (4.) Excretion 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 very simplest animals digestive cavities appear to be temporarily excavated in the soft substance of the body.

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 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.

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 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.

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 and from the ovum of an 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 embryo 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.

CHAPTER II.

ZOOLOGICAL CLASSIFICATION.

1. General Considerations.

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.

The reasons of this, it seems to the writer, are twofold. First, zoology is so extensive, that it has become divided into a number of subordinate branches, the cultivators of which attach an exaggerated value to their own specialties, and are unable to appreciate those of others. Thus we find naturalists subdividing one group more minutely than others, or raising one group to a position of equivalency with others, to which, in the opinion of the students of these others, it is quite subordinate. So also we have some zöologists basing classification wholly on embryology or on mere anatomical structure, or even on the functions of some one class of organs. Secondly, there is a failure to perceive that if there is any order in the animal kingdom, some one principle of arrangement must pervade the whole; and that our arrangement must not be one merely of convenience, or of a desultory and uncertain character, but uniform and homogeneous.

The writer of these pages does not profess to be in a position to escape from these causes of failure; but as a teacher of some experience, and as a student of certain portions of the animal kingdom, he has endeavoured carefully to eliminate from his own views the prejudices incident to his specialties, and to take a general view of the subject; and is therefore not without hope that the results at which he has arrived may be found useful to the young naturalist. More especially we may hope to present to the student a mode of arranging animals which experience has shown to be well suited to the purposes of the learner.

Classification in any department of Natural History is the arranging of the objects which we study in such a manner as to express their natural relationship. In other words, we endeavour in classification to present to our minds such a notion of the resemblances and differences of objects as may enable us to understand them, not merely as isolated units, but as parts of the system of nature. Without such arrangement, there could be no scientific knowledge of nature, and our natural history would be merely a mass of undigested facts.

At first sight, and to a person knowing only a few objects, such arrangement may appear easy; but in reality it is encompassed with difficulties, some of which have not been appreciated by the framers of systems. The more important of these difficulties we may shortly consider.

1. There are in the animal kingdom a vast number of kinds or species. To form a perfect classification it would be necessary to know the characters or distinctive marks of all these species. To

make even a tolerable approximation to a good system, requires an amount of preparatory labour which can be estimated only by those who have carefully worked up at least a few species in these respects.

2. So soon as we have ascertained the characters of a considerable number of species, we find that in their nearest resemblances these do not constitute a linear series, but arrange themselves in groups more or less separated from each other like constellations in the heavens, and having relationships tending with more or less force in different directions. This not only introduces complexity into our systems, but renders it impossible to represent them adequately in written or spoken discourse, or even by tables or diagrams. We think and speak of things in series, but nature's objects are not so arranged, but in groups radiating from each other like the branches of a tree; and our imperfect modes of thought and expression are severely tested in the attempt to understand nature, or to convey ideas of classification to the minds of others.

3. The considerations above stated oblige us to enquire what leading characters we may take as the principal guides in our arrangement, so as to make this as natural as possible and at the same time intelligible. It is simplest to take only one obvious character, as if for example we were to arrange all animals according to their colour or to the number of their limbs; but the greater the number of characters we can use, or the more completely we can represent the aggregate of resemblances and differences, the more natural will

our arrangement be, and consequently also the more scientific and useful.

In attempting to weigh the several characters presented by any object, we find some that are of leading importance, others that are comparatively unimportant, though still not to be neglected ; and we find that some indicate grades of complexity, others are connected with adaptations to certain uses, and others indicate plan of construction. Due weight must be given to all these kinds and degrees of characters. It is perhaps in the proper estimation and value of their relative importance and different modes of application that the greatest failures have been made.

Keeping in view these difficulties of the subject, we may now proceed to the consideration of the more elementary of the groups in which we arrange animals.

2. The Species in Zoology.

We cannot consider the animals with which we are familiar, without perceiving that they constitute kinds or *Species*, which do not appear to graduate into each other, and which can be distinguished by certain *characters*. Yet simple though this at first sight appears, we shall find that many intricate questions are connected with it. Our idea of the species is based on the resemblance of the individuals composing it in all the characters which we consider essential. If, for instance, a number of sheep and goats are placed before us, we readily select the individuals of each species. In doing this we give no regard to differences of sex or age, but put the young and old, the male and female, of each species together. Nor do we pay attention to merely accidental differences: a mutilated or deformed specimen is not on that account separated from its species. Nor do we attach value to characters which experience has proved to vary according to circumstances, and in the same line of descent. Such, for example, are differences of colour, or fineness of the hair or wool. The remaining resemblances and differences are those on which we rely for our determination of the species, and which we term essential. We shall find that these essential characters of the species are points of structure, proportion of parts, ornamentation, and habits.

These characters constitute our idea of the species, which we can readily separate from the *Individuals* composing it. The individuals are temporary, but the species is permanent, being continued through the succession of individuals. If all the adult individuals are alike and indistinguishable from each other, then any one may serve as a specimen of the species. If there are differences of sex, or *Varieties* subordinate to the species, then a suite of specimens showing these will represent the species. The species is thus an assemblage of powers and properties manifested in certain portions of matter called individuals, and which are its temporary representatives. It follows that the species is the true unit of our classification, and that the indefinite multiplication of individuals leaves this unchanged.

Our idea of the species will however be imperfect if we do not distinctly place before our minds its continued existence in time. This depends on the power of reproduction, whereby the individuals now existing have descended from similar progenitors, and will give birth to successors like themselves. A moment's thought will suffice to show that, independently of this, species could have no real existence in nature. If animals were not reproductive, the species would become extinct after the lapse of a generation. If their reproduction followed no certain law, and the progeny might be different from the parents, then the characters of the species would speedily become changed, and it would practically cease to be the same. Again, it is necessary that the reproduction of species should be pure or unmixed; for an indiscriminate hybridity would soon obliterate the boundaries of species. It is impossible, therefore, to separate the idea of species from the power of continuous unchanged reproduction, without depriving it of its essential characters.

In like manner it is obvious that we must assume a separate origin for each species, and that we need not assume more than one origin. Practically, species remain unchanged, and do not originate from one another; and if all the individuals of a species were destroyed except one pair, this would, under favourable circumstances, be sufficient to restore the species in its original abundance.

The questions which have been raised as to the origin of species by descent with indefinite variation, and as to the possible creation of individuals of the same species in different places or at different times, are not of a practical character, at least in zoology proper, inasmuch as species are unchanged within the limits of time included in our observations of nature; and the whole burden of proof may be thrown on those who assert such views.

We are thus brought to the definition of species, long ago proposed by Cuvier and De Candolle; and may practically unite in one species all those individuals which so resemble each other that we may reasonably infer that they have descended from a common ancestry. All our practical tests for the determination of species resolve themselves into this general consideration. The only modification of this statement on which even an advocate of the mutability of species can insist, is, that a sufficient time and great geological changes being given, one species may possibly split into two or more; and since this is an unproved hypothesis, we may practically neglect it, except as a warning to be very sure that we do not separate as distinct species any forms which may be merely varieties of a single species, an error exceedingly prevalent, and which vitiates not a little of our reasoning on such subjects.

The origin of the first individuals of a species may be, and probably is, a problem not within the province of natural history. In the case of vital force it is the same as in the case of gravitation and other forces. We can observe its operation and ascertain the laws of its action, but of the force itself we know nothing, nor do we know to what extent it may be identical in its essence with other forces, since the interchange of forces observed in nature may be as different from the actual conversion of one force into another, as the substitution of one element for another in a chemical compound is different from the conversion of one element into another.

With regard to the properly creative force or power, if we suppose this to be distinct from mere vital force, we are still more ignorant. We do not witness its operation. We know nothing, except by inference, of its laws; and whatever we may succeed in ascertaining as to these, we may be sure that in the last resort we shall, as in the case of all other natural effects, be obliged to pause at that line where what we call force resolves itself into the will of the Supreme spiritual power. The "miracle" of enactment must necessarily precede law; the "miracle" of creation, the existence of matter or force. Those who deny this have no refuge but in a bald scepticism, discreditable to a scientific mind, or in metaphysical subtilties, into which the zoologist need not enter.

We must not suppose, however, that the species is absolutely invariable. Variability, in some species to a greater extent than in others, is a law of specific existence. It is the measure of the influence of disturbing forces from without, in their action on the specific unity. In some cases it is difficult to distinguish varieties from true species, and with many naturalists there has been a tendency to introduce new species on insufficient grounds. Such errors can be detected ordinarily by comparing large suites of specimens and ascertaining the gradations between them, which always occur in the case of varieties, but are absent in the case of species truly distinct. Such comparisons require much time and labour, and must be pursued with much greater diligence than heretofore, in order to settle finally the question whether the varietal perturbations always tend to return to a state of equilibrium, or whether in any case they are capable of indefinite divergence from the specific unity.

The species is the only group which nature furnishes to us ready made. It is the only group in which the individuals must be bound together by a reproductive connection. There might or might not be affinities which would enable us to group species in larger aggregates, as *genera* and *families;* and the tie which binds these together is merely our perception of greater or less resemblance, not a genetic connection. We say for example, that all the individuals of the common Crow constitute one species, and we know that if all these birds were destroyed except one pair, the species would really exist, and might be renewed in all its previous numbers. We can make the same assertion with reference to the Raven or to the Blue Jay, considered as species. But if, because of resemblances between these species, we group them in the genus *Corvus* or in the family *Corvidœ*, we express merely our belief in a certain structural resemblance, not in any genetic connection. Nor need we suppose that if any of the species of a genus were destroyed they would be reproduced from the others. Further, while all the individuals of any of the species may be precisely similar to each other and still be distinct individuals, all the species of the genus cannot be similar in all their characters, otherwise they would constitute but one species.

In other words, the species and the genus, considered as groups, differ, not in degree merely, but in kind. To make this very plain, let us take a familiar illustration. I have a number of maps, all uniform in size and in style of execution; but in the whole there are only two kinds,—maps of the eastern hemisphere, and maps of the western hemisphere. Now all of the maps of *one* kind constitute a species; those of *both* kinds, a genus. The individuals of one species, say of the eastern hemisphere, are all alike. They have all been struck from one plate, from which many similar maps may be produced. But the other map, though necessary to make up the set or genus, may be quite dissimilar in all its details from the first, and could not be produced from its plate. We have no difficulty here in understanding that the specific unity is of a different kind from the generic unity, and that the distinction is by no means one of mere grade of resemblance. A very little thought must convince any one that this applies to species and genera in zoology; and that those naturalists who affirm that species have no more real existence in nature than genera, have overlooked one of the essential elements of classification. Nor would this distinction be invalidated by the assumption of a descent with modification, unless it could be shown that in actual nature species shade into each other; and this is certainly not the case in those which are reckoned as good species.

I have been thus careful to insist on the nature of the species in natural history; because I believe that loose views on this subject have caused a large proportion of the errors in classification.

Though the groups higher than species do not exist in nature in the same sense in which species exist, they are not arbitrary, but depend on our conception of resemblances and differences which actually exist. We go out into the forest and perceive different species of trees; but, at the same time, we find that these species can be grouped in genera, as Oaks, Birches, Maples, &c., under each of which generic names there may be several species. It is evidently not an arbitrary arrangement of ours thus to group species: they naturally arrange themselves in such groups, under the action of our comparing powers.

3. Genera and Higher Groups.

In comparing species with each other for purposes of classification, there are four distinct grounds on which such comparison can be made. These are:—1st. intimate structural or anatomical resemblance; 2nd. Grade or rank; 3rd. Use or function; 4th. Plan or type. All of these may be, indeed must be, used in classification, though in very different ways.

1. *Intimate structural relationship* is the ground on which we frame *Genera*. Two or more species resemble each other structurally to such an extent that the same definition will in many important points apply to both. Such species we group in a genus. It is most important to observe, as Agassiz has well pointed out, that this close resemblance in structure is really our main ground for the formation of genera. But for this very reason it is not to be expected in our higher groups.

2. *Grade or rank* refers to degree of complexity of structure, or to the degree of development of those functions that are the highest in the animal nature. A coral polyp is more simple in structure than a fish, and is therefore lower in rank. A fish is less highly endowed in brain, sensation, and intelligence, than a mammal, and is therefore of lower rank. An egg or an embryo is simpler than the adult of the species to which it belongs; and when

one animal resembles the embryo of another, it ranks lower in the scale. A worm ranks lower than an insect whose larva it resembles.

We use this difference of grade or rank in grouping genera in *Orders;* but it occupies a very subordinate place in the construction of other groups. Many grave errors have arisen from its indiscriminate application ; most heterogeneous assemblages being formed when we construct groups larger than orders merely on the ground of similar grade : and when, on the other hand, we separate the lower members of natural groups on the ground of simplicity of structure, we fall into an equal mistake of another kind. Of errors of these kinds still current, I may instance the attempt of some naturalists to establish a province or sub-kingdom of *Protozoa,* to include all the simplest members of the Animal Kingdon, and the separation of the Entozoa or intestinal worms from the other worms as a distinct class.

There are two kinds of investigation much used in classification, which more especially develope the idea of grade or rank among animals. One is that of embryology, or the development of animals from the ovum. Another is that of cephalisation, or the development of the head and organs connected therewith. Both of these are of great importance, but, on the principles above stated, they aid us chiefly in referring animals to their *Orders.* Other limitations of the criterion of grade or rank will appear when we arrive at the consideration of *Classes.*

3. *Function or Use.*—In different animals we often find the same use served by different kinds of organs, as, for instance, the wing of a bird and

the wing of an insect, which, though both used for flying, are constructed in very different ways. It would lead us astray were we to arrange animals primarily on this ground: for instance, if we were to group together fishes and crustacea because both swim; or birds and insects, because both fly. Again, in different groups of animals, certain functions and the organs which subserve them, are greatly developed in comparison with others. For example, the enormous reproductive power of fishes, or the remarkable development of the locomotive organs in birds, as compared with other vertebrates. This consideration is not applicable in our primary division of animals, but it constitutes the principal ground on which naturalists have based the secondary divisions or *Classes;* and it serves also to indicate the *anologies* between the corresponding members of different primary groups, as, for instance, of the birds in one group to the insects in another.

4. *Plan or Type.*—Under this head we consider the similarity of construction in different animals or organs, without regard to uses. We say, for example, that the wing of the bird and the bat, the paddle of the whale, and the fore-leg of the dog, are similar in type or *homologous* to each other, because they are made up of similar sets of bones. They are modifications of one general plan of structure. Animals thus constructed on similar plans are said to have an *affinity* with each other.

It is evident that this consideration of 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.

As a simple illustration of this and the preceding heads, we may suppose that we are writing a treatise on architecture, or the art of building. We observe 1st, that there are differences of material employed, as stone, brick, or wood; 2nd, that there are various grades of buildings, from the simplest hut to the most elaborate palace or temple; 3rd, we find a great variety of uses for which buildings are constructed, and to which they are adapted; 4th, there are different orders of architecture or styles, which indicate the various plans of construction adopted. It will, in studying such a subject, be the most logical order to consider, 1st, the several orders of architecture or plans or types adopted; 2nd, under each of these to classify the various kinds of buildings according to their uses; 3rdly, under each of these secondary heads, to treat of buildings more or less elaborate or complex; and 4thly, to consider the materials of which the structures may be composed. This is precisely what the most successful formers of systems have done in natural history, in dividing the animal kingdom into provinces or branches, classes, orders, and genera. On the other hand, classifications produced by mere anatomists who content themselves with a close adherence to similarity of structure and rigid definitions based on these, may be compared to a system of architecture produced by a mere bricklayer, who regards only the materials used and the manner of putting them together.

4. Primary Division of Animals into Provinces, Branches, or Sub-kingdoms.

This, on the principles already stated, must be made solely on the ground of type or plan, taken in its most general aspects.

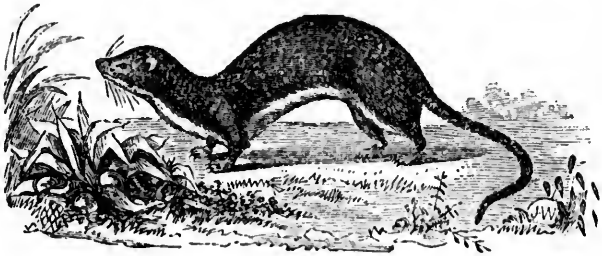
If we bring before us mentally the several members of the animal kingdom, we shall probably be struck in the first instance with the general prevalence of bilateral symmetry, or the arrangement of parts equally on the right and left sides. We may observe, however, that there is a large group of animals to which this general style of construction does not apply, and which have, in the words of Agassiz, a " vertical axis around which the primary elements of their structure are symmetrically arranged," conforming in this respect, and also often in other points, to the symmetry of the plant, rather than to that of the more perfect animals. We would thus obtain what is perhaps the most obvious of all primary divisions of animals,—that into those with bilateral symmetry and those that are radiated, or the *Artiozoaria* and the *Actinozoaria* of Blainville. We shall soon find, however, on more detailed examination, that this division is very unequal, since the first group includes by far the greater part of the animal kingdom, and its members are nearly as dissimilar among themselves as any of them are from the radiates.

Penetrating a little deeper into structural character, we find that one large group of the bilateral animals possesses an internal skeleton, arranged in such a way as to divide the body into an upper chamber holding the brain and nervous system, and an under chamber for holding the ordinary viscera; whereas in the greater number of the bilateral animals and all the radiates, there is but one chamber for containing the whole of the organs. The first of these groups, from the vertebræ or joints of the back bone, peculiar to its members, we name *Vertebrata*, and all the other animals *Inverte brata*, as proposed by Lamarck: this division corresponds to the *Enaima* and *Anaima* of Aristotle. Here also, however, we have a very unequal division,—the Invertebrata being a vast and heterogeneous assemblage.

If, however, after separating the Vertebrata on the one hand, and the Radiata on the other, we study the remainder of the animal kingdom, we find that it readily resolves itself into two groups, known as the *Articulata* and the *Mollusca*. We thus reach the fourfold division of Cuvier; which is by much the most natural and philosophical yet proposed. This system may be summarised as follows:

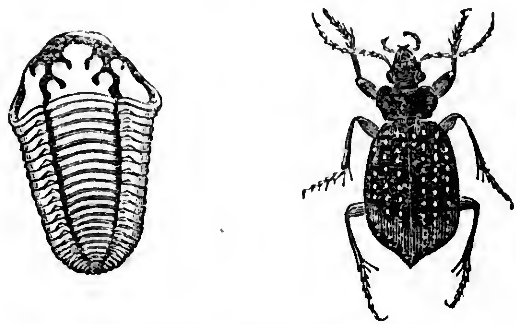
1. **Vertebrata,** including Mammals, Birds, Reptiles, and Fishes. All these animals are bilateral and symmetrical, have an internal vertebrated skeleton, a brain and a dorsal nerve-cord lodged in a special cavity of the skeleton. With reference to their general form, they may be termed doubly symmetrical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

Fig. 19.



VERTEBRATE Type.

Fig. 20.

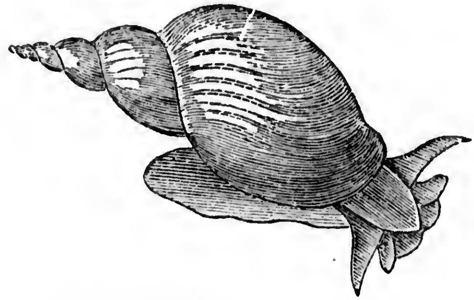


ARTICULATE or ANNULOSE Type.

2. **Articulata,*** including Arachnida, or spiders and scorpions; Insects; Crustaceans, and Worms. These animals are bilateral and symmetrical. 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. They are otherwise named *Annulosa*, longitudinal animals, or *Homogangliata*.

* I prefer this term to "Annulosa," as being Cuvier's original name—a fact which should overrule merely verbal objections.

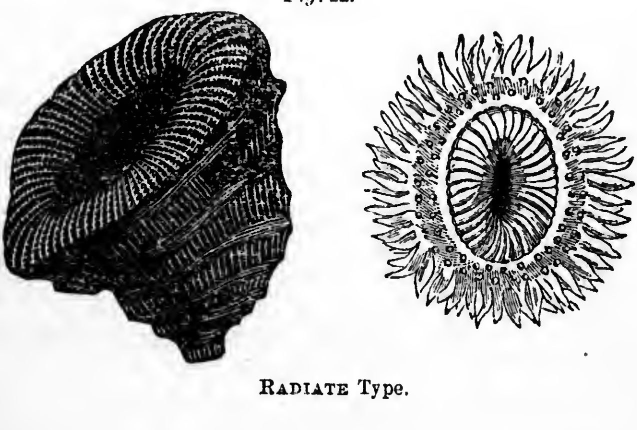
Fig. 21.



MOLLUSCOUS OR SACCATE Type.

3. **Mollusca,** including Cuttle-fish and their allies; Gasteropods or univalve shell-fishes and their allies; Lamellibranchiates 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 enclosed in mantles, massive animals, or *Heterogangliata*.

Fig. 22.



RADIATE Type.

4. **Radiata,** including Sea-urchins and Starfishes; Sea-nettles and Hydras; Polyps and Coral-animals; and Sponges and their allies. These have the parts arranged radially around a central axis, and have the nerve-system when discernible consisting of a central ring with radiating fibres. They may be otherwise named *Actinozoaria*, peripheric animals, or *Nematoneura*.

This fourfold division includes the whole animal kingdom, and is the only rational one which can be based on type or plan of structure. Since the time of Cuvier, though modifications in detail have become necessary, it has been strengthened by the progress of discovery; and more especially Von Baer has proved that the study of embryology establishes Cuvier's branches, by showing that in their development, animals pass through a series of forms belonging to their own branch and to that only.

The attempts which have been made to introduce additional branches or provinces, I regard as retrograde steps. Such for example is the province *Cœlenterata* of Leuckart, including the Polyps and the Acalephs, both of them good classes, but not together constituting a group equivalent to a province; the province *Protozoa* of Siebold, which, to resume our architectural figure, includes merely the huts and cabins which it is difficult to refer to any style of architecture, but which do not, on that account, themselves constitute a new style; and the Provinces *Molluscoida* and *Annuloida* of Huxley, which, as their names indeed import, are in the main merely simple forms of Mollusca and Articulata.

5. Division of Provinces into Classes.

Having formed our Primary divisions or Provinces on the ground of type or plan, we must, in dividing these into classes, have regard either to subordinate details of plan, or to some other ground. In point of fact, naturalists seem to have tacitly agreed to form classes, on what Agassiz terms the "manner in which the plan of their respective great types is executed, and the means employed in their execution." In other words, they have, in forming classes, adopted, perhaps unconsciously, a *functional* system, similar to that employed by Oken in forming his primary groups. They have taken the relative development of the four great functional systems of the animal,—the sensitive, the locomotive, the digestive, and the reproductive. This is very manifest in the ordinary and certainly very natural sub-division of the vertebrates into the four classes of Mammals, Birds, Reptiles, * and Fishes. The Mammals are the nerve or sensuous animals, representing the highest development of sensation and intelligence. The Birds are eminently the locomotive class. The Reptiles represent merely the alimentary or vegetative life. The Fishes are the eminently reproductive or embryonic class.

If this is a natural division of vertebrates into classes, and if the other three Provinces are of

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* The *Amphibia*, as Dana well argues on the principle of cephalisation, are clearly Reptiles, because we arrange animals in their mature and not in their embryonic condition, and because the points of reproduction in which Amphibia differ from ordinary reptiles, have relation to an aquatic habitat, and are ordinal or rank characters merely.

equivalent value, then there should be but four classes in each, one corresponding to each of the great functional systems. We may name the first of these the nervous class; the second, the motive class; the third, the nutritive class; the fourth, the reproductive or embryonic class. Let us then endeavour, as a test of the truth of this system, to make such an arrangement of the classes of the animal kingdom.

TABLE OF CLASSES OF ANIMALS.

Provinces or Branches.	Vertebrata	Articulata.	Mollusca.	Radiata.
1. Nervous class	*Mammalia.*	*Arachnida**	*Cephalopoda...*	*Echinodermata.*
2. Motive class..	*Aves.......*	*Insecta.. ..*	*Gasteropoda* (including *Pteropoda*)........	*Acalephæ.*
3. Nutritive class	*Reptilia....*	*Crustacea..*	*Lamellibranchiata.*	*Anthozoa.*
4. Embryonic or Reproductive class.	*Pisces .....*	*Annulata..* (including *Rotifera*).	*Heterobranchiata* including *Tunicata. Brachiopoda, Bryozoa*	*Protozoa.*

* The rank given to t[illegible] [illegible]*hnida* will be disputed by some naturalists; but a co[illegible] [illegible]ion of the structures of these animals will show [illegible] [illegible] relations to the insects and the crustacea are sim[illegible] [illegible]ose of the mammals to the birds and the reptiles; and [illegible] it is no more reasonable to say that the arachnidans are nearer to the crustaceans than to the insects, on the ground of general structure, than it would be to do the same in the case of the mammals and the reptiles as compared with the birds.

All of the above groups are recognized by common consent as classes, except a few which have been already incidentally adverted to, and to which it is not necessary again to refer here.*

It will be observed that the order in descending the columns is that of *affinity;* that in reading across the columns is the order of *analogy.* With reference to the analogies, it will be seen that the first class in each province includes animals remarkable for condensation of the head and body, where the former exists; for high nervous energy, sensation, and intelligence; for prehensile apparatus, and for absence or simplicity of metamorphosis. The classes in the second line are characterized by the greatest locomotive powers in their respective provinces; those in the third line by the development of the nutritive apparatus and of vegetative growth; those in the fourth line by embryonic characters when mature, and by abundant reproductive energy.

It will be observed also as a necessary consequence of the system we have pursued, that each of our classes includes animals of very various rank or grade. Indeed, most of them have, at their bases, forms so simple or imperfect that it is almost impossible to include them in the class-characters. This is no objection to our arrangement, but a proof of its correctness; for we have now arrived at the point where we must form *Orders* based solely on this consideration of rank. Of these humbler mem-

* Before reading the paragraphs following this table, the student should turn to the pages in the descriptive zoology referring to the several classes, beginning with Protozoa, and familiarize themself with the forms of the creatures included in them.

bers of our classes we may mention the *Marsupials* and the *Monotremes* among the mammals, the *Amphibia* among the reptiles, the *Mites* among the arachnidans, the *Myriapods* among the insects, the *Entozoa* among the worms. Indeed it is quite possible on this ground to divide each of our classes into two or more *Sub-classes.* This is sometimes convenient for the sake of mo accurate definition; but it is not necessary, since the division into orders sufficiently expresses these grades of complexity or elevation.

6. Division of Classes into Orders and Families.

Orders, as already stated, are based principally on rank or grade, to be determined by relative complexity, or by the development of the higher nature of the animal. The last section, however, obliges us to take this with some limitation; for since we have four descriptions or sorts of classes, each of these must have the grade within it ascertained on special grounds. For example, the orders of birds, insects, gasteropods, and acalephæ, should be ascertained chiefly by reference to the locomotive organs, as being the system of organs most eminently represented in the class. If we glance for a moment at the systems which have been proposed, we shall see that this view has unconsciously commended itself to naturalists. The orders of insects, for example, are very plainly based on such characters, being founded mainly on the wings. This is nearly equally manifest in the ordinarily received orders of birds. It appears in the division into Pteropods, Heteropods, and Gasteropods proper among the Gasteropoda. It is also seen in the orders *Ctenophora*, *Discophora*, *Siphonophora*, among Acalephæ. It would be easy to show by a detailed review of the orders in the animal kingdom, that, in so far as they have been distinctly defined, they have in most cases been framed with a reference to the prevailing characteristics of the class; and also with the idea of grade or rank as a leading ground of arrangement. As previously observed, also, it is in the construction of orders, and in ascertaining rank in other divisions, that embryology and the doctrine of cephalisation are chiefly useful. For the present, however, we must leave this subject until we shall have an opportunity to enter into descriptive zoology.

In Botany, orders and families are identical. In Zoology we use the term *Family* for a group inferior to an order, and equivalent to the sub-order or tribe in botany. The family consists of an assemblage of genera resembling each other in general aspect. Most large orders are readily divisible into such assemblages, which, though in themselves somewhat vague, have the advantage of being formed on grounds which, being conspicuous and obvious at first sight, much aid the naturalist in the preliminary part of his work. For example, among the carnivorous mammalia such groups as the *Mustelidæ* or weasels, the *Canidae* or dogs, the *Felidæ* or cats, are so obvious that any member of one of these groups can be referred to that to which it belongs almost at first sight. Still I do not regard families as necessary divisions of the order. Some small orders may not admit of division into families; and even where such division is admissible, the genera may be studied as members of the order, without being grouped in families, though this grouping is often very useful and convenient.

It is important to observe, before leaving this part of the subject, that, in consequence of the great multiplication of species in some groups, and the close scrutiny of their structures, it is the tendency of specialists to form many small genera. This leads to the construction of numerous families, many of which would more properly remain as genera. A still worse consequence is, that, instead of forming sub-orders and sub-classes, such specialists often call sub-orders or even families orders, and raise sub-classes or orders to the rank of nominal classes, thus introducing a confusion which leads the student to suppose that these terms have no definite meaning. I would further observe here, that I do not so much insist on the use of one name for a group rather than another, as on the constant use of each term for groups truly equivalent in the system.

It may be necessary here to state that the formation of orders on the ground of rank, and of families on the ground of general aspect, does not exclude the ideas of rank and general aspect from the province or class. On the contrary, as a secondary ground, general aspect is a good character in the province and class, and a gradation of rank can be perceived in provinces and classes. In the provinces, the *Vertebrata* stand highest, and the *Radiata* lowest, the *Articulata* and the *Mollusca* being nearly equal, and their lower members not so high as the highest *Radiata;* so that they would stand in a diagram thus:

Vertebrates
Articulates *Mollusks*
Radiates.

So among classes, the nerve class in each province is the highest and the embryonic class the lowest, and the other two intermediate; but the idea of rank is not here the primary one, as it is in forming the orders. It is also true that from the province downward the idea of type or plan is constantly before us.

We have now, in descending from provinces, reached the genera and species, with the consideration of which we commenced; and if the preceding views have been understood, we shall be prepared to commence the study of Descriptive Zoology, or to enter upon the details which fill up the outline which has been sketched. In doing this we must take specimens of known species and study them in their structural and physiological peculiarities, and in their relation to the other species congeneric and co-ordinate with them.

CHAPTER III.

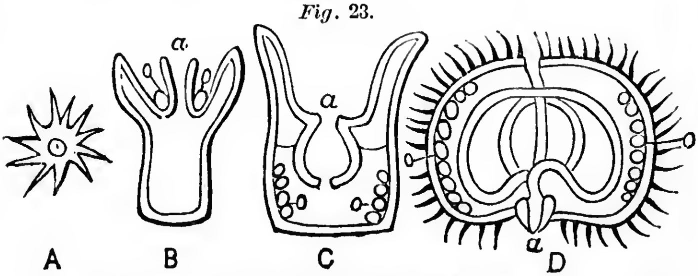
DESCRIPTIVE ZOOLOGY.

PROVINCE RADIATA.

Parts arranged around a central axis—No distinction between neural and hæmal sides—Nervous system nematoneurous, or not discernible.

Class 1. *Protozoa*—Animalculæ, Sponges.
" 2. *Acalephæ*—Jelly-fishes, and Hydroid Polyps.
" 3. *Anthozoa*—Sea-anemones, Coral Animals.
" 4. *Echinodermata*—Sea-urchins, Star-fishes.

Fig. 23.



DIAGRAMS OF RADIATES.
(A) Protozoan; (B) Hydroid; (C) Anthozoon; (D) Echinoderm; (*a*) Mouth; (*o*) Ovary.

Many naturalists have abandoned the Cuvierian province of Radiata, and have proposed to constitute the Protozoa a distinct province, to include the *Acalephæ* and *Anthozoa* in another sub-kingdom to be named that of the *Cœlenterata*, and to associate the *Echinoderms* with the *Annelids*. That this proposed improvement is founded on a misconception of the true plan of nature, I have no doubt; but as it has been adopted in many recent works, the student should be acquainted with it. It does not make any material change in the limits of the four groups above noted as classes.

Class I.—Protozoa.

Body composed principally of gelatinous sarcode—destitute of distinct internal cavities and nervous system—Motions principally by cilia or pseudopodia.

The Protozoa are the simplest in structure of all animals. Their bodies are composed of a thin apparently structureless substance, which has been named "Sarcode," and the only proper tissues associated with these 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*. 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 & 41. 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 orders on the basis of relative rank, or degree of complexity. Those naturalists, however, who regard the Protozoa as constituting a distinct province, elevate these orders to the position of classes. The orders of Protozoa are the following:—

Order 1. Rhizopoda, including those Protozoa which are destitute of a mouth, and move and obtain their food by extensions of the sarcode of the body, or Pseudopodia. These are the Foraminifera and their allies.

Order 2. Porifera, including those which have the sarcode mass 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 order is that of the Sponges, at one time supposed to be plants, but now known to be truly animals.

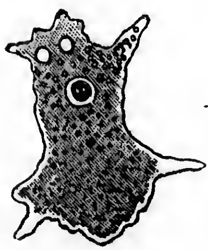
Order 3. Infusoria, including those which have an oral aperture, and an integument of cellular tissue enclosing the sarcode mass, and provided with external cilia.

To these are usually added the *Thalassicolidæ*, creatures of uncertain affinities and apparently allied to Rhizopods, and the *Gregarinidæ*, a group of parasites, probably rudimentary Entozoa.

1. Rhizopoda.

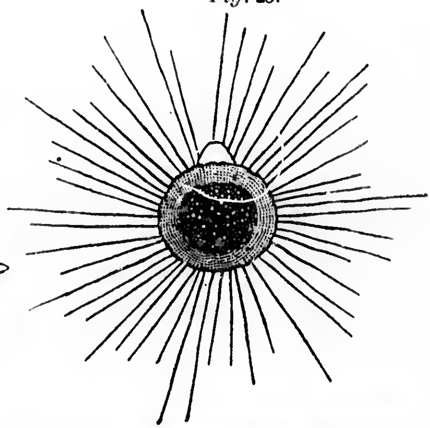
We may take as a type of this group the *Amoeba*, a microscopic creature frequently found in ponds containing vegetable matter. It occurs in Canada, and may readily be procured by the microscopist. Different species have been described, but they are very similar to each other. When placed under the microscope, 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 pseudopodial prolongations; the hinder part appearing to be drawn after it, and presenting fewer irregularities. In its interior are seen 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 appears to be more transparent and dense than the central portion. 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 act-

Fig. 24.



Amoeba, (Montreal,) Magnified.

Fig. 25.



Actinophrys, (Montreal,) Magnified.

ing from within, and probably of the nature of muscular contraction. Nor are there wanting indications that these motions are voluntary and prompted by the appetites and sensations of the animal. Fig. 24 represents one of the states of a specimen from a pond on the Montreal Mountain.

Another generic form found in the same situation is *Actinophrys*, the Sun-animalcule. In this the outer coat is more distinctly marked, and the body retains a globular form, while the pseudopodia are very slender and thread-like. Fig. 25 represents a specimen found with the preceding.

Amoeba and Actinophrys belong to a family of Rhizopods, (the Amoebina), which either have no hard covering or a thin crust or lorica covering part or the whole of the body. The remainder of the Rhizopods are protected by calcareous shells, often of several chambers and perforated by pores for the emission of pseudopodia, (*Foraminifera*), or they are covered by a silicous shell or framework of one piece (*Polycistina*). The whole of the Rhizopods may thus be included in the following groups, which may be regarded as sub-orders or families:

1. *Amoebina*, without hard skeletons, and mostly fresh-water.

2. *Foraminifera*, with calcareous skeletons; marine.

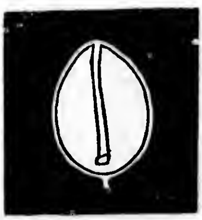
3. *Polycistina*, with silicous skeletons; marine.*

The Foraminifera are the most important of these groups, since they occur in immense abundance in the waters of the ocean, and in its deeper parts

* Some naturalists form for these a separate class or order (*Radiolaria*).

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. 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 gigantic dimensions as compared with living species. A Foraminiferal organism of dimensions unequalled in the modern seas (Eozoon Canadense, Fig 36) occurs in the Lower Laurentian, and is the oldest form of animal life known to us. The forms figured (Figs. 26 to 35), as seen under the microscope, are some of the most numerous in the Gulf of St. Lawrence; in the deeper parts of which great numbers of these creatures occur.

Fig. 26.

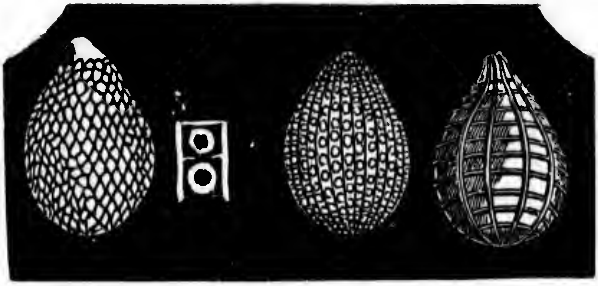


ENTOSOLENIA GLOBOSA,
(Gulf St. Lawrence.)

Fig. 27.

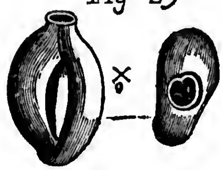
ENTOSOLENIA COSTATA,
(Gulf St. Lawrence.)

Fig. 28.



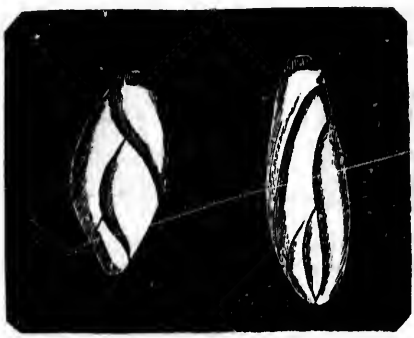
ENTOSOLENIA SQUAMOSA, three varieties, (Gulf St. Lawrence.

Fig 29



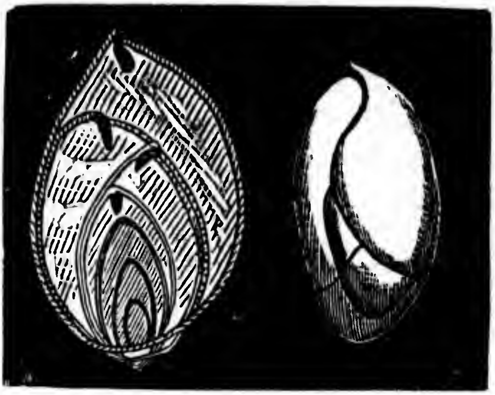
QUINQUELOCULINA SEMINULUM, (Gulf St. Lawrence.)

Fig. 30.



POLYMORPHINA LACTEA, (Gulf St. Lawrence.)

Fig. 31.

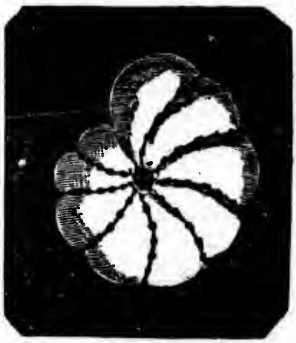


BULIMINA PRESLI, (Gulf St. Lawrence.)

Fig. 32.

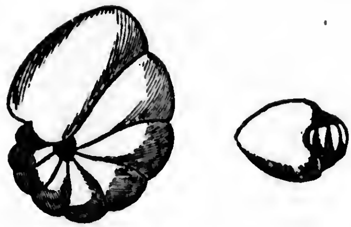
BILOCULINA RINGENS—SECTION, (Gulf St. Lawrence.)

Fig. 33.



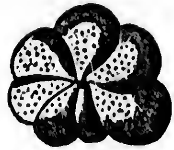
POLYSTOMELLA CRISPA, (Gulf St. Lawrence.)

Fig. 34.



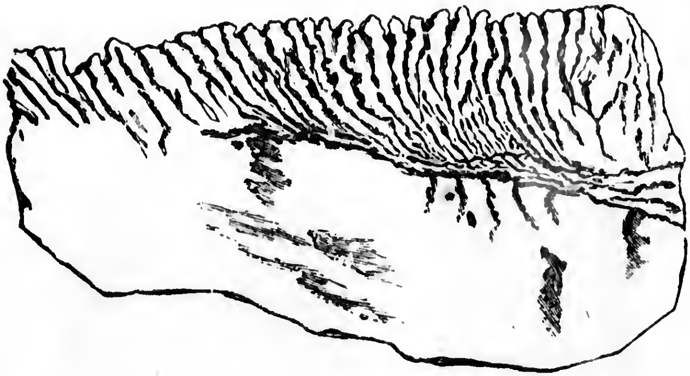
NONIONINA SCAPHA—VAR. LABRADORICA, Gulf St. Lawrence.

Fig. 35.



TRUNCATULINA LOBULATA, Gulf St. Lawrence.

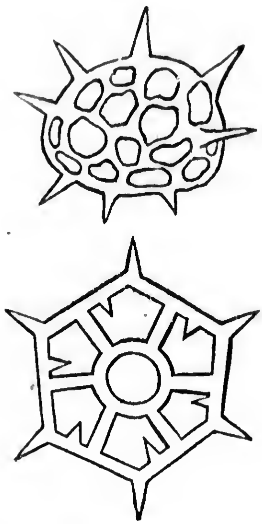
Fig. 36.



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

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. 37 represents two species obtained from a depth of 313 fathoms in the Gulf of St. Lawrence, by Capt. Orlebar, R. N.

Fig. 37.



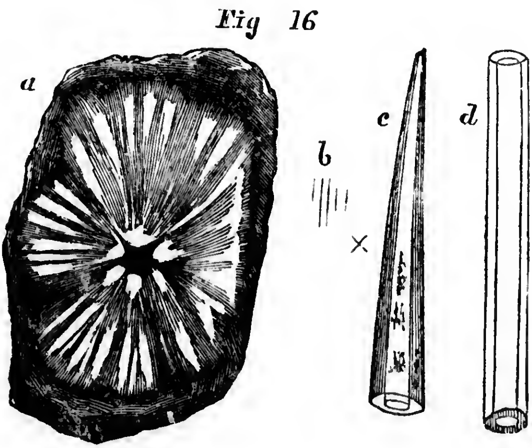
CERATOSPYRIS and DICTYOCHA ACULEATA? Gulf St. Lawrence, 313 Fathoms.

2. **Porifera**.

Of this order 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 the *Spongilla*, or fresh-water sponge, as well as in the species often washed on shore on the sea coast, the skeleton consists of a network of corneous fibres, in which are inserted very numerous tubular spicules of silica, only visible under the microscope. In the living condition this skeleton supports a soft glairy 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 the sides of the canals. The currents thus produced, entering by the smaller pores on the surface, and passing out by larger pores, 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 this country few have been described. A species of Tethia, dredged in deep water at Portland, has been named by Dr. Bowerbank, *T. 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 honour of the distinguished head of the Geological Survey, (Fig. 38.) One of the fresh-water sponges found in

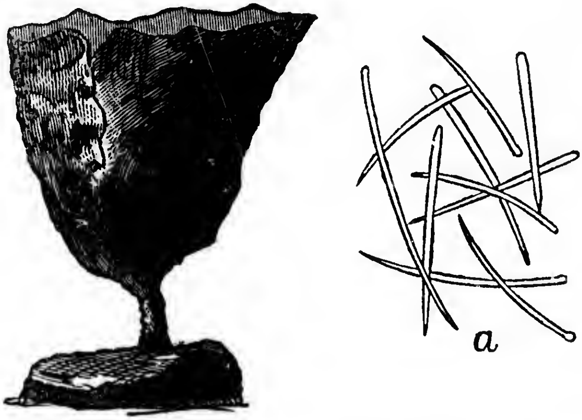
Fig. 38.



TETHEA LOGANI, Post pliocene; (a) Specimen in clay; (b) (c) (d) Spicules.

the St. Lawrence, has been described by Dr. Bowerbank as *Spongilla Dawsoni*, and is very closely allied to the British *S. lacustris*. Two of the most common species on our shores are the beautiful funnel-shaped or cup sponge of the lower St. Lawrence, (*Isodictya*) Fig. 39, and the pal-

Fig. 39.



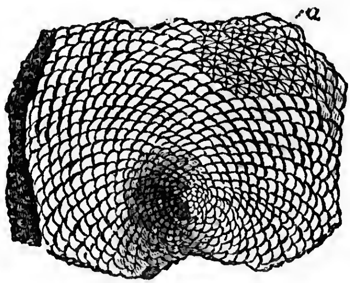
ISODICTYA, Murray Bay; (a) general form—reduced; (b) Spicules highly magnified.

mate sponge of the Atlantic coast. Another very common species found attached to sea-weeds, is the close-grained and shapeless "crumb-of-bread sponge." Many other species have been collected, but they have not been named or described. It is difficult, in the present state of our knowledge, to form any natural classification of the sponges. A very convenient subdivision, proposed by Dr. Bowerbank, is based on the composition of the skeleton, and may serve for the present the purposes of classification. He divides the order into:

(1) **Calcarea**, or those supported by calcareous spicules; (2) **Silicea**, or those supported by silicous spicules; and (3) **Keratosa**, or those having only horny fibres. All our common native sponges belong to the second of these groups.

Several kinds of Protozoa of affinities not quite certain, occur in the older Silurian rocks of Canada. Of these may be mentioned *Receptaculites*; (Fig. 40.) supposed by Salter to be a Foraminifer; and the species of *Archæocyathus*, *Calathium*, *Trichospongia* and *Rhabdalia* described by Mr. Billings and supposed by him to be allied to Porifera.* A species of *Dentalina* occurs in the Lower Carboniferous of Nova Scotia.†

Fig. 40.



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

3. Infusoria.

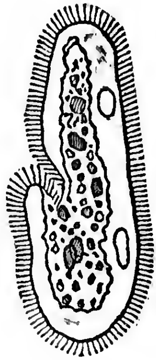
Examples of these creatures may be found in stagnant water, or in any vegetable infusion which

* Palæozoic Fossils of Canada, Vol. I.

† Acadian Geology, 2nd Edition.

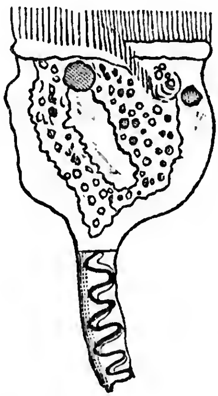
has been exposed to the air. They are all microscopic in size, though more complex in structure than the previous orders. Some are locomotive, others fixed. As a type of the first, the genus *Paramœcium* may be taken (Fig. 40.) The species

Fig. 41.



PARAMŒCIUM—Magnified.

Fig. 42.



VORTICELLA—Magnified.

of this genus are very 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. 42.)

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.

Green's Manual of Protozoa; Carpenter on Foraminifera (Royal Soci. Trans.); Bowerbank on Sponges; and Pritchard's Infusoria, may be consulted with advantage on these creatures.

TABULAR VIEW OF PROTOZOA.

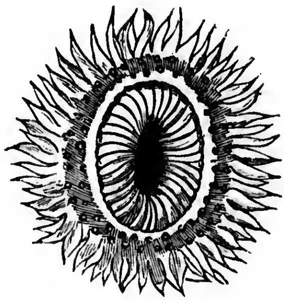
PROTOZOA.	*Rhizopoda.*	Amœbina. Foraminifera. Polycistina.
	Porifera.	Calcarea. Silicea. Keratosa.
	Infusoria.	

CLASS II.—ANTHOZOA, OR ACTINOZA.

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. (Fig. 23c.)

The Anthozoa present a considerable advance in complexity beyond the Protozoa. 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. 43.



ACTINIA (Urticaria) CRASSICORNIS.

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.

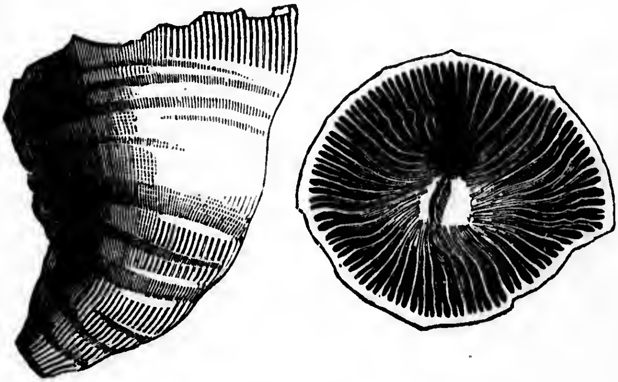
1. **Zoantharia or Actinoids.** These are either naked or provided with a sclerodermatous (rarely sclerobasic) corallum, and have the tentacles simple, usually numerous and in multiples of six or of five. When the corallum is developed, it has radiating septa corresponding to the soft mesenteries. In this group are the Sea-anemones and their allies, and the Madrepores or reef-building corals. (See Figs 43, and 47 to 50.)

2. **Alcyonaria 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 calcareous 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. 51.)

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 next. I believe with Agassiz that some of these corals are closely allied to modern corals of the next 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:

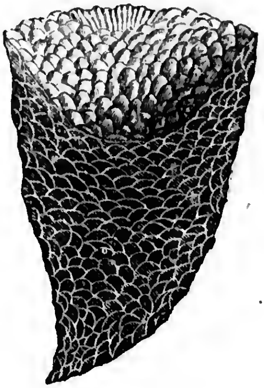
1. Rugosa. In these the corallum is sclerodermic, with septa arranged in four and multiples of four, and often with horizontal floors or tabulae and a well developed external wall or theca. In some the septa and tabulae coalesce into a vesicular substance very unlike that of modern corals. (Fig. 44, 45.)

Fig. 44.



ZAPHRENTIS PROLIFICA—Billings—*Devonian.*

Fig. 45.

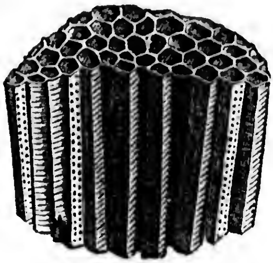


CYSTIPHYLLUM SULCATUM—Billings, Devonian—Section.

Count Pourtales has recently 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 ocurrence 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 next class. (Fig. 46.)

Fig. 46.



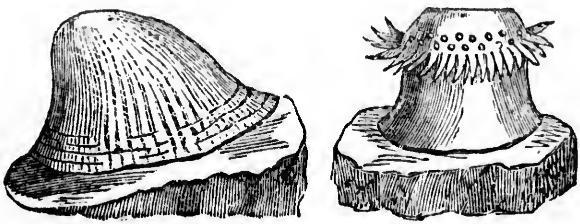
FAVOSITES GOTHLANDICA—Goldf.—Upper Silurian.

The orders Rugosa and Tabulata include nearly all the numerous fossil corals found in the limestones of Canada. (See Figs. 58 to 61.)

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 tuberculated 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. 43 and 47,) were dredged in Gaspé, and referred to a new species, *R. nitida*, but may possibly be a variety of the above. Another variety found in the River St. Lawrence, is permanently tuberculated and cannot be distinguished from *A.* (*Urticina*) *crassicornis*, as ordinarily seen in Great Britain.

Fig. 47.

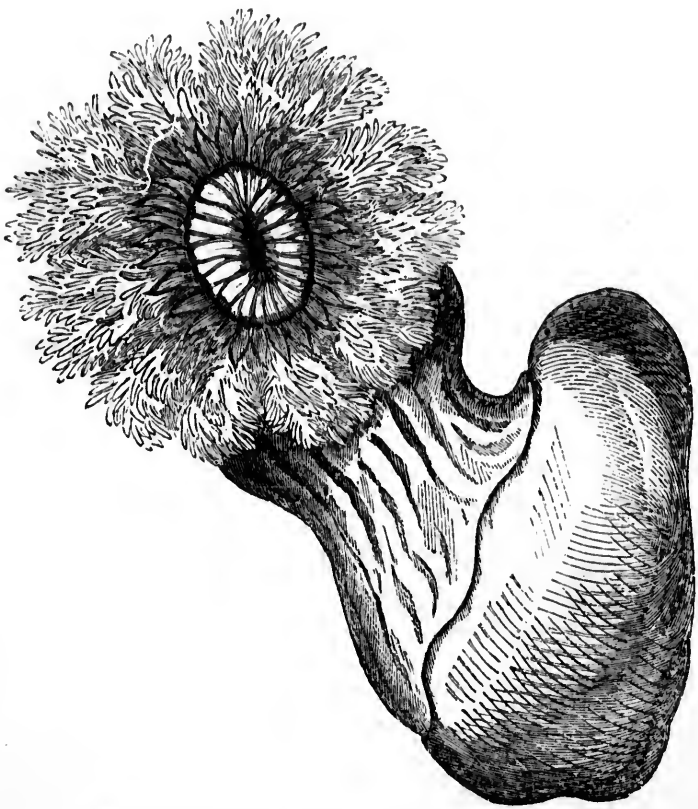


ACTINIA (Urticina) CRASSICORNIS, contracted, and smaller individual expanded.

A larger and often more beautiful representative of the Actinoids is the *Metridium marginatum*, a species closely allied to the *Actinia dianthus* of

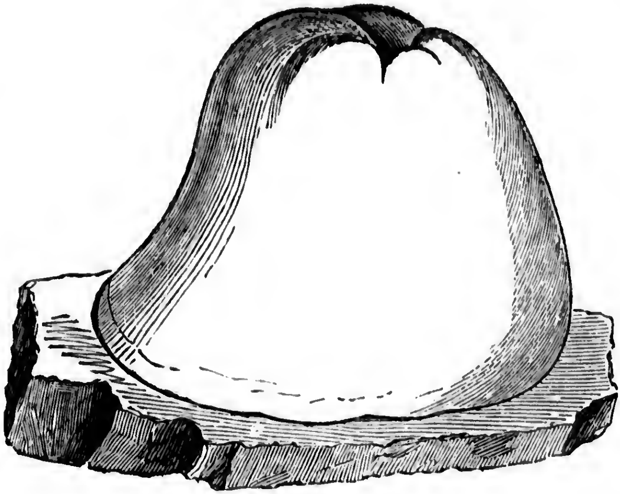
Great Britain. It is found in great perfection at the mouth of Gaspé Basin, where the specimens represented in the following figures (Figs. 48, 49) were obtained. In this species the tentacles are in two series, the outer series being very numerous and arranged on lobes of the edge of the disc.

Fig. 48.



METRIDIUM MARGINATUM, Edw. & Haime, (Gaspé.)

Fig. 49.



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. **Ilyanthidae.** No Corallum. Polyps independent, with rounded or tapering base. Examples, Ilyanthes, Cerianthes.

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

4. **Antipathidae**. Corallum sclerobasic, having Polyps with six tentacles. Example, Antipathes.

5. **Fungidae**, Corallum calcareous, septiform. Individuals mostly distinct and large, with numerous tentacles.

6. **Astreadae**, Septa numerous, cells attached, without cœnenchyma.

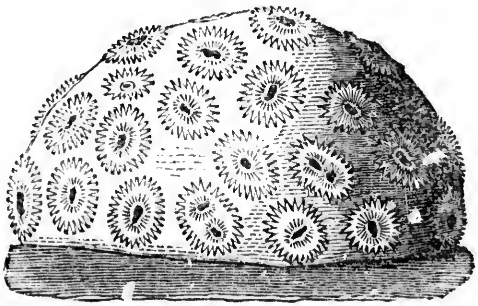
7. **Poritidae**, Corallum reticulate, cell-walls not distinct from surrounding cœnenchyma.

8. **Oculinidae**. Cœnenenchyma abundant, compact, calcareous.

9. **Madreporidae**. 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. 50, taken from Dana, shews the appearance of one of the tropical species.

Fig. 50.

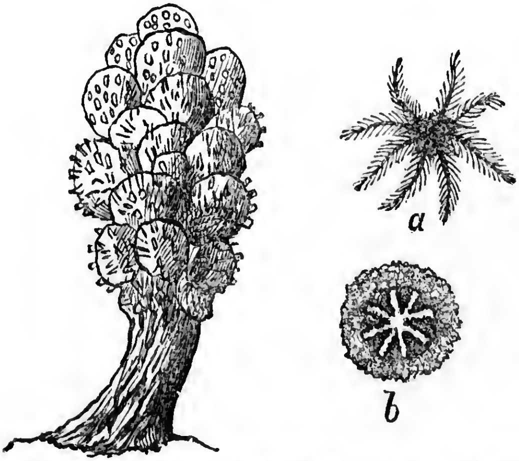


ASTREA PURPUREA, with polyps expanded—after Dana.

2. Alcyonaria or Alcyonoids.

As a native example of this group, we may take the *Alcyonium rubiforme* Fig. 51, which is sometimes cast 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.

Fig. 51.



ALCYONIUM RUBIFORME, Dana (Gaspé), (a) P[illegible] expanded, (b Polyp contracted.

The families of Alcyonaria are the following:

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

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

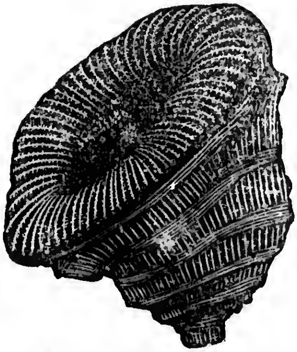
3. **Pennatulidae**. The Sea-pens. In these the corallum is free or with its base immersed in mud at the bottom of the sea. The cells are placed on pinnate branches.

4. **Gorgonidae**. 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.

3. Rugosa and Tabulata.

Figs. 52 to 57 represent Canadian species of corals of the order Rugosa, and Figs. 58 to 61 represent corals of the order Tabulata. All of these are fossil.

Fig. 52.

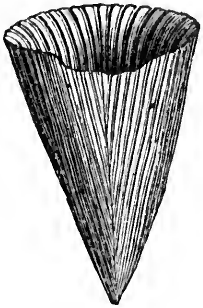


HELIOPHYLLUM HALLI,
Devonian.

Fig. 53.

PETRAIA CORNICULUS,
L. Silurian.

Fig. 54.



PETRAIA profunda, Hall, L. Silurian.

Fig. 55.

STROMBODES SIMPLEX, Hall, Devonian.

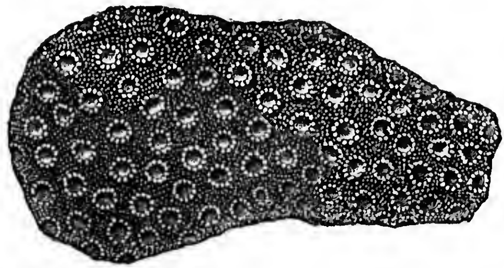
Fig. 56.

CYSTIPHYLLUM AMERICANUM, E. & H., Devonian.

Fig. 57.

CYATHOPHYLLUM RECTUM, Hall, Devonian.

Fig. 58.

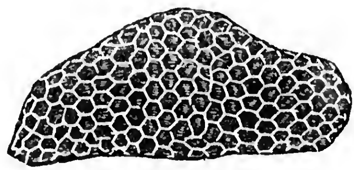


HELIOLITES SPECIOSUS, Billings—Upper Silurian.

Fig. 59.

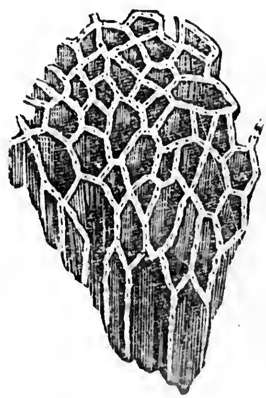
SYRINGOPORA MACLUREI, Billings—Devonian.

Fig. 60.



COLUMNARIA ALVEOLATA, Goldf.—L. Silurian.

Fig. 61.



HALYSITES CATENULATUS, Upper Silurian.

TABULAR VIEW OF ANTHOZOA.

ANTHOZOA.	*Zoantharia*	Actiniadæ.
		Ilyanthidæ.
		Zoanthidæ.
		Antipathidæ.
		Fungidæ.
		Astraeadæ.
		Poritidæ.
		Oculinidæ.
		Madreporidæ.
	Alcyonaria	Alcyonidæ.
		Tubiporidæ.
		Pennatulidæ.
		Gorgoniadæ.
FOSSIL ANTHOZOA OR HYDROZOA.	*Rugosa.*	Cyathophyllidæ.
		Cystiphyllidæ.
		Cyathaxonidæ.
		Stauridae.
	Tabulata.	Favositidæ.
		Ceriatoporidæ.
		Thecidæ.

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 class. American fossil species will be found in the reports of the Palæontology of New York and Canada, by Prof. Hall and Mr. Billings.

Class III.—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. (Fig. 23b.)

The Acalephæ are by many naturalists regarded as of lower grade than the last class, in consequence of the apparently more complex internal structure of the latter. But to counterbalance this, we have in the present group a much higher development of locomotive and sensorial powers. In other words the Anthozoa excel in the complexity of the organs of *vegetative* life: the 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 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.

The Acalephæ resemble the animals of the last class in having a polyp-like form; but they have the digestive sac turned outward instead of being folded inward; and instead of the perivisceral chambers, there is 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 destitute of radiating septa and wholly sclerodermic. 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, the Physalias, &c. (Fig. 62.)

2. **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 jelly-fishes and their allies. (Fig. 66.)

3. **Ctenophora**.—Disc closed at both poles, giving to the body a double appearance like that of the Anthozoa, though the parts are much more complex. Tentacles absent or reduced to two ; when present, pinnate. External surface with eight bands of paddles (Ctenophores) which are the locomotive apparatus. (Fig. 67.)

1.—Hydroida.

The fresh-water Hydra of Europe, 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.

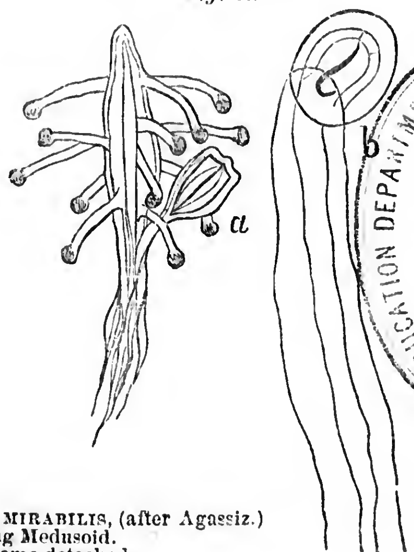
Fig. 62.

HYDROIDA, Gulf St. Lawrence, Nat. size and magnified.
(*a*) Sertularia (Dynamena) pumila. Lamx.
(*b*) Tubularia (Parypha) crocea Ag.
(*c*) Campanularia (Laomedea) amphora Ag.

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.

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

Fig. 63.



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

1. **Hydridæ.**—Polyps independent, locomotive, naked. Example, Hydra viridis.

2. **Corynidæ.**—Polyps independent or in communities. Animals enclosed in tubular corneous cells. Example, Coryne mirabilis (Fig. 63).

3. **Tubulariadæ.**—Polyps solitary, in elongated corneous tubes, and with two rows of tentacles. Example, Tubularia crocea. (Fig. 62).

4. **Eucopidæ.**—Polyps in corneous conical cells at the extremities of the branches. Example, Laomedea amphora. (Fig. 62).

5. **Sertulariadæ.**—Polyps arranged in corneous cells on the sides of branching tubular stems. Example, Sertularia pumila. (Fig. 62).

6. **Plumulariadæ.**—Polyps in single rows on one side of corneous branches. Example, Plumul ria 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 in a stony coral. The cells divided by transverse tabulæ. Example, Millepora.

In or near this group may probably be placed the fossil tabulate corals referred to under the Anthozoa. The recent Milleporas are tropical animals.

9. **Calycophoridæ.** — Polyps of different kinds attached to a common stem moved by swimming bells, and supported near the surface by a float at its extremity. Example, Nanomia cara.

10. **Physophoridae.**—Polyps of different kinds supported on the lower surface of a floating vesicle or pneumatophore. Example, Physalia arethusa.

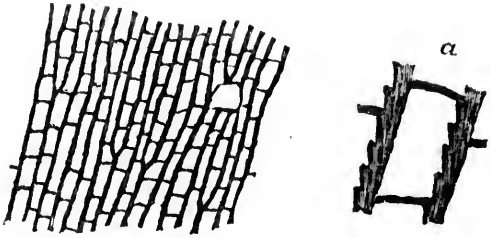
The Physalias and their allies are tropical; but one species, *P. arethusa*, is occasionally found on the coast of Nova Scotia.

11. To these may be added the fossil family of *Graptolitidae*, characteristic of some portions of the Lower Silurian rocks. They are regarded by Professor Hall as allied to Sertulariadæ. (Figs. 64 and 65.)

Fig. 64.

GRAPTOLITHUS BICORNIS, Hall—L. Silurian.

Fig. 65.



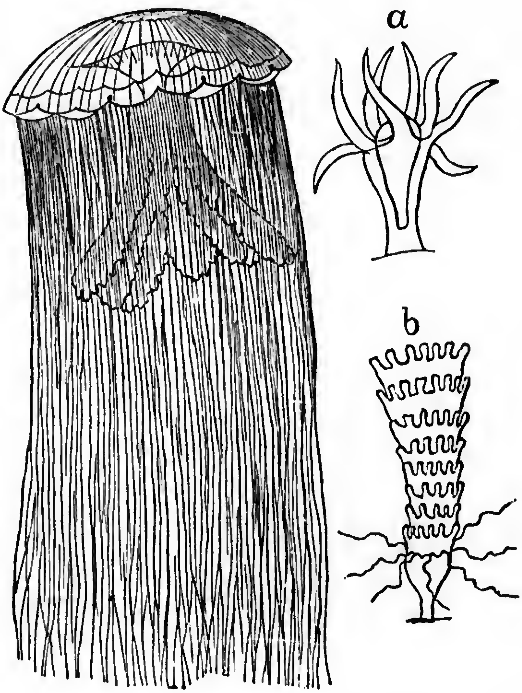
DICTYONEMA WEBSTERI, Dawson—Upper Silurian; (a Portion magnified showing the cells.

2.—Discophora.

One of the best representatives of this order on our coast is the great blue Jelly-fish, *Cyanea Arctica*, (Fig. 66), which is often found in the Gulf of St.

IMAGE EVALUATION TEST TARGET (MT-3)

Fig. 66.



CYANEA ARCTICA, Per. and Les. reduced.
(*a*) Hydroid progeny.
(*b*) Strobila.

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 network of vessels ramifying through the disc. Though these animals are as 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. 66 a), and which have the power of increasing by gemmation. From this stage the young animal passes by a transverse fission into a sort of jointed form (the Strobila. Fig. 66 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 colourless 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. Semæostomeæ,—in which the proboscis is divided into labial processes or oral tentacles. This group includes our commoner species above mentioned.

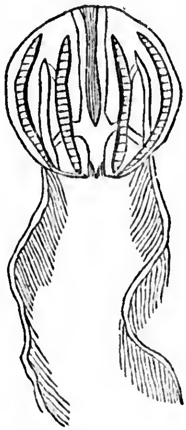
3. Haplostomeæ.— Are simple-mouthed Medusæ, including the curious animals known as *Lucernaria*, a species of which is found in the Gulf of St. Lawrence, adhering to sea-weeds or floating freely. It forms a curious link between the Polyp and Medusa forms, having a stalk for attachment developed in the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

3. Ctenophora.

Pleurobrachia rhododactyla of Agassiz (Fig. 67) may be taken as a type of this group. As it occurs on the 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

Fig. 67.



PLEUROBRACHIA RHODODACTYLA, (after Agassiz.)

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 shewing 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.

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

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* Agassiz, Seaside Studies, p. 27.

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

Some European naturalists have proposed to separate the Ctenophora from the Acalephæ, and place them with the Anthozoa; but this does not seem to be a natural arrangement.

In the Acalephæ generally, the radiated arrangement of parts is very regular; but in the highest group, the Ctenophora, there is an obvious tendency to bilateral symmetry.

TABULAR VIEW OF ACALEPHÆ.

ACALEPHÆ OR HYDROZOA.	*Hydroida.*	Hydridæ.
		Corynidæ.
		Tubulariadæ.
		Eucopidæ.
		Sertulariadæ.
		Plumulariadæ.
		Hydractiniadæ.
		Milleporidæ.*
		Calycophoridæ.
		Physophoridæ.
		Graptolitidæ.
	Discophora.	Rhizostomeæ.
		Semaeostomeæ.
		Haplostomeæ.
	Ctenophora.	Eurystomeæ.
		Saccatæ.
		Taeniatæ.
		Lobatæ.

* Near these should perhaps be placed the *Favositidæ* and other Tabulata.

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 previous class well stated in Greene's Manual of Coelenterata, London.

Class IV.—Echinodermata.

Animals usually free and repent; nervous system nematoneurous; alimentary canal in a distinct internal cavity; circulation by a vascular system; respiratory organs in some. Integument hardened by calcareous plates or spines, and with erectile tube feet. (Fig. 23 d.)

These creatures are the highest in rank of the Radiata, and in their adult state and in their more typical forms, present very admirable examples of radial arrangement, though in some of the more aberrant forms we cannot fail to perceive an 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 œsophageal 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. 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). There are also in many species minute stalked pincers for cleaning the surface of the body (pedicellariæ).

The orders of Echinodermata are:

1. **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. These are the Feather-stars. Encrinites, Cystideans. (Fig. 68.)

2. **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 protected externally by plates or by plates and spines. Serpent-stars, Brittle-stars. (Fig. 72.)

3. **Asteroidea.**—These have the disc and rays confluent, and the latter thick and traversed by ramifications of the digestive apparatus, and furnished with rows of tube-feet along their lower sides. Ordinary Star-fishes. (Fig. 74.)

4. **Echinoidea.**—In these the rays are obsolete, and the skeleton becomes a case or box enclosing the viscera, with spines articulated upon it, and tube-feet projected through rows of ambulacral pores. Sea-urchins or Sea-eggs. (Fig. 76.)

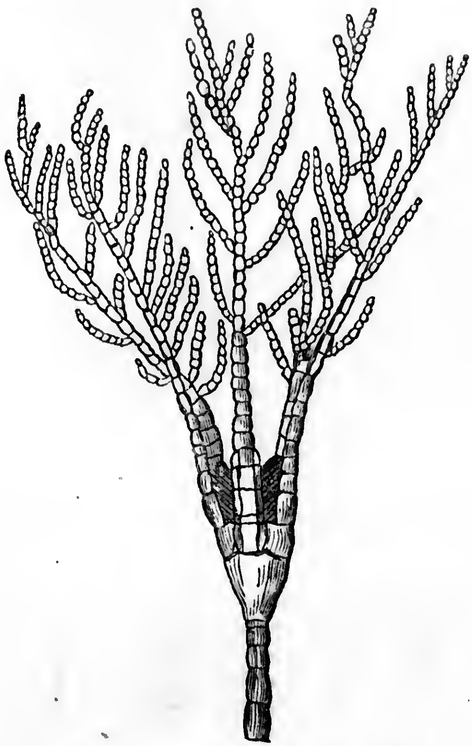
5. **Holothuridea.**—In these the body becomes elongated and horizontal, and is covered above with spines or irregular plates. Though aberrant in form, some of these creatures are very complex in organization, and are the only radiates furnished with special respiratory tubes. Some of the species simulate worms in their external form. (Fig. 77.)

1. Crinoidea.

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 pinnate arms, on which are borne the reproductive organs in the form of small brownish spots; and which are also locomotive and prehensile organs.

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. 68). These are the only living representatives of vast numbers of species of stalked crinoids, found abundantly as fossils in the rocks of the earth's crust, and sometimes constituting a great part of the substance of crinoidal limestones. Fig. 69, is a species of Glyptocrinus, from the Lower Silurian. Fig. 69 a, shows parts of the same enlarged.

Fig. 68.



RHIZOCRINUS LOFOTENSIS, (after Sars).

Fig. 69.

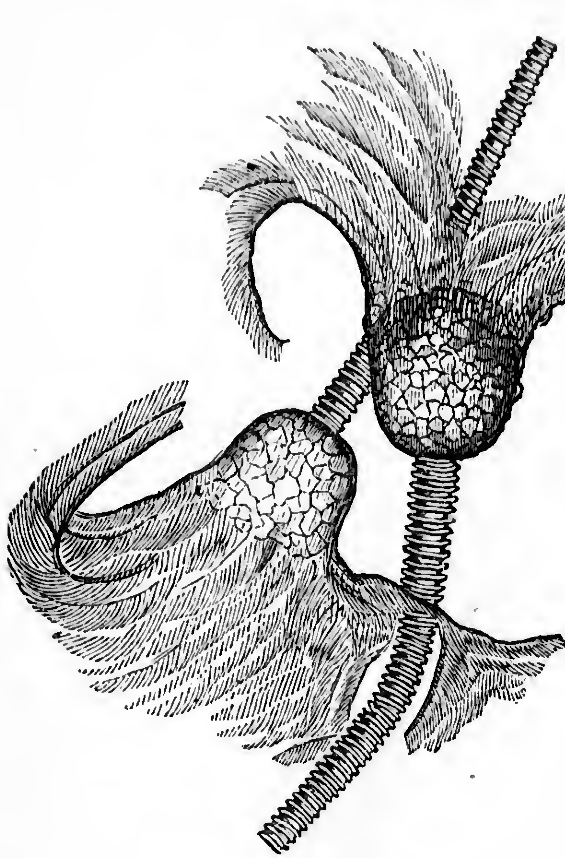
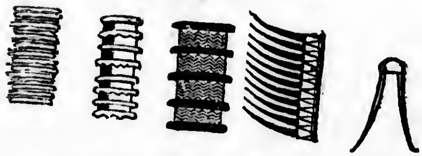


Fig. 69*a*.



GLYPTOCRINUS RAMULOSUS, Billings.—L. Silurian.
(*a*) Parts of the same.

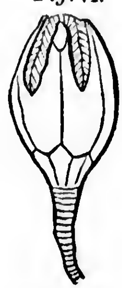
Beside the typical crinoids, there occur as fossils two other groups, known to us only by their skeletons, but included in this order. They are :

1. *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. 70), but a living species from Torres Strait has recently been described by Prof. Loven, under the name of Hyponome Sarsii.

2. *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. 71.)

Fig. 70.

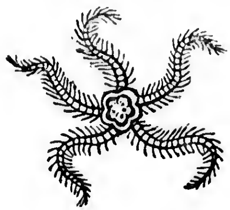
Fig. 71.



68. **Pleurocystites elegans**, L. Silurian, (after Billings.)
69. **Pentremites pyriformis, carboniferous**, U. States, (after Dana.)

2. Ophiuridea.

Fig. 72.



OPHIOPHOLIS ACULEATA, Lutken, Gaspé—reduced.

This order is represented on our coasts by several beautiful species. *Ophiopholis aculeata*, the Daisy Brittle-star, (Fig. 72), *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 thousands of filaments, each consisting of a series of curiously formed joints. This creature is known as the Sea-basket. *A. Agassizii* is our most common species.

Fig. 73 represents two of the calcareous joints of *Ophioglypha Sarsii*, a species found living at Gaspé and fossil in the Post-pliocene clays.

Fig. 73.

OINTS OF RAY of OPHIOGLYPHA SARSII, Post-pliocene.

3. Asteroidea.

As the type of this order may be taken *Astera-canthion* (*Uraster*) *Vulgaris*. Fig. 74. It is the

Fig. 74.

ARTERACANTHION VULGARIS, Stimpson, Atlantic Coast, reduced, and section of a ray showing tube feet.

representative on 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 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 sacks 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 developed 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 *Asteracanthion 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 oculata*, *C. sanguinolenta* of Muller.

A few species of fossil star-fishes occur in the

Silurian rocks of Canada. Fig. 75 represents one of these.

Fig. 75.

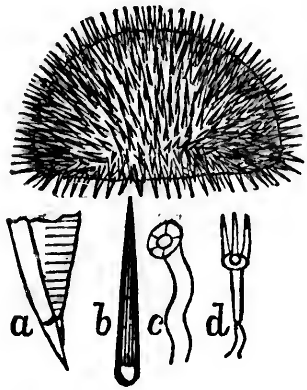
PALÆASTER NIAGARENSIS, Hall—
Upper Silurian.

4. Echinoidea.

The most common Sea-urchin of our coast is *Echinus* (*Toxopneustes**) *Drobachiensis*, so called from the port of Drobach in Norway, where it was first observed. (Fig. 76.) 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

* *Eurechinus* of some authors.

Fig. 76.



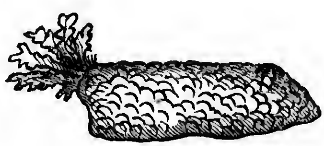
ECHINUS DROBACHIENSIS,—Tadousac—reduced.
(*a*) Portion of Jaw.
(*b*) Spine.
(*c*) Tube-foot, enlarged.
(*d*) Pedicellaria, enlarged.

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*.

5. Holothuridea.

One of the best known representatives of this order on our coasts is the *Psolus* (*Cuvieria*) *Fabricii*. (Fig. 75.) It is of a bright red colour and

Fig. 77.



PSOLUS FABRICII,—Gaspé,—reduced.

oval form, and covered above 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.

TABULAR VIEW OF ECHINODERMATA.

ECHINODERMATA.	*Crinoidea.*	Cystideæ.
		Blastoideæ.
		Crinoideæ.
	Ophiuridea.	Ophiuridæ.
	Asteroidea.	Asteriadæ.
	Echinoidea.	Echinidæ.
		Clypeasteridæ.
		Spatangidæ.
	Holothuridea	Holothuridæ.
		Synaptidæ.

CHAPTER IV.

DESCRIPTIVE ZOOLOGY—*Continued.*

PROVINCE II.—MOLLUSCA, OR SACCATA.

Parts bilaterally arranged,—often unsymmetrical; no Skeleton; Nerve system heterogangliate, consisting of an œsophageal ring and ganglia, with nerves unsymmetrically disposed. Heart compact; blood colourless or not red; respiratory organs opening laterally or posteriorly.

CLASS 1.—*Heterobranchiata**—Polyzoans, Brachiopods, Tunicates.
" 2.—*Lamellibranchiata*—Ordinary bivalve shell-fish.
" 3.—*Gasteropoda*—Univalve shell-fish and Sea Snails.
" 4.—*Cephalopoda*—Cuttle-fish, Nautili.

It is usual with Zoologists to regard the three groups constituting the first class above mentioned, as distinct classes. Without, however, denying their great importance and distinctness, I believe that, if we understand the class in the sense explained in chapter second, however extensive and important the groups of Polyzoa, Brachiopods and Tunicates, the differences between them are those of orders rather than of classes; and that

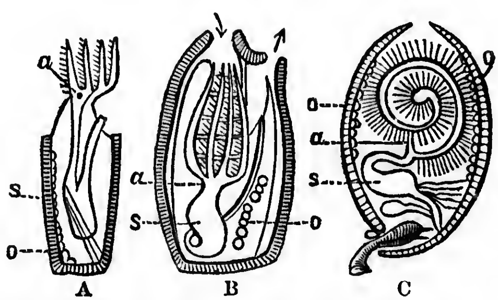
* This term was applied by Blainville to the Tunicates; and is, I think, a very appropriate name for the whole class.

they form a series parallel with the three orders of Protozoa among the Radiates. The names and subdivisions, however, remain the same under either view. The Pteropods are also regarded by some as a distinct class from Gasteropods, but they seem more properly to constitute the lowest order of that class, which without them would not be complete.

CLASS 1.—HETEROBRANCHIATA.

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.

Fig. 78.



DIAGRAMS OF HETEROBRANCHIATES.
(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 as far removed in grade of complexity from the more typical Mollusks as the Rhizopods are from typical Radiates. Yet naturalists have long been convinced that they must be reckoned as humble Mollusks. 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 Heterobranchiata 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. 78 A.)

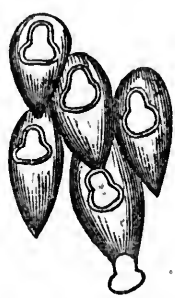
Order 2. Tunicata.—Body unsymmetrical ; integument an uncalcified tunic having two openings and lined by the mantle ; Cilia for producing currents of water disposed on an inner tunic or band representing the tentacles. These are the Ascidians and their allies, sac-shaped or bottle shaped Mollusks. The Tunicates are all marine. (Fig. 78 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. 78 C.)

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. 79.



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 either ciliated or covered with a crust. In the Membranipora they are hatched in a sort of hood or ovicapsule 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.

Fig. 80.

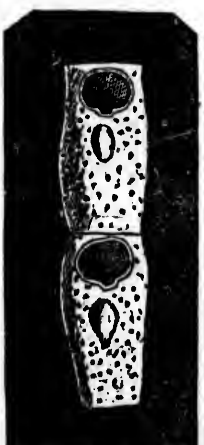
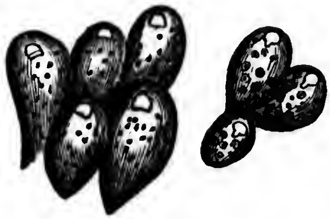


Fig. 81.

79. LEPRALIA PERTUSA Johnston—Gulf St. Lawrence.
80. L HYALINA Lin—Gulf St. Lawrence.

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. 80 to 85) may be

Fig. 82.



L. PRODUCTA, Packard—Gulf St. Lawrence.

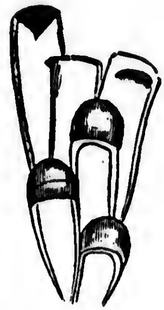
Fig. 83. *Fig.* 84. *Fig.* 85.

83. HIPPOTHOA CATENULATA, Fleming.
84. H. DIVARICATA, Lm.
85, TUBULIPORA FLABELLARIS, Fabricius. (All magnified.)

found; other species build up their cells in slender branches or broad leaves, either soft and flexible (Figs. 86 and 87) or hard and stony; (Fig. 88.) Some of the latter have the aspect of small corals. Other species (*Halodactylus*) are imbedded in a dense mucilaginous substance arranged in thick branches, in which the coloured stomachs of

Fig. 86.

Fig. 87.

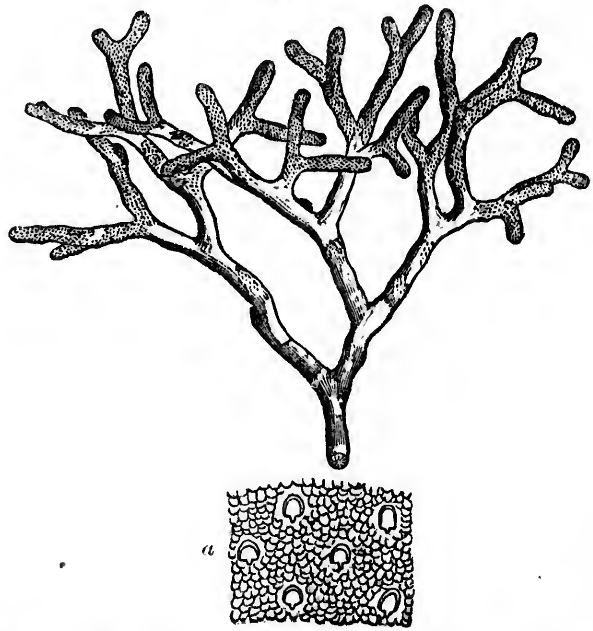


86. MENIPEA FRUTICOSA, Packard, Gulf St. Lawrence.
87. HALOPHILA BOREALIS, Packard, Gulf St. Lawrence. (Both magnified.)

the animals are seen as little specks. In the fresh water there are other species, several of which have been described by Leidy and Hyatt. In the limestones of the Silurian, Devonian and Carboniferous periods, many species are found fossil, of the genera Ptilodictya, Fenestella, &c, &c. (Figs. 89

and 90.) Several species are also fossil in the Post-pliocene clays (Fig. 91.)

Fig. 88.

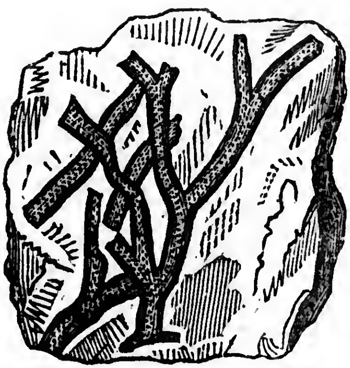


MYRIOZOUM SUBGRACILE, D'Orbigny, Gulf St. Lawrence, Natural size. (*a*) Cells of the same magnified.

The animals of 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. 89.



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.

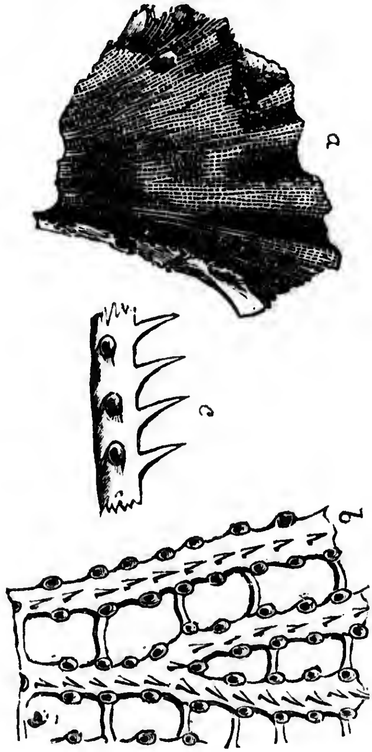
Sub-order 2. **Cyclostomata**, or those with circular mouths, includes the marine genera Tubulipora, Crisia, Idmonea, &c.

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

Sub-order 4—**Pedicellinea**. In these the cells are supported on a stalk or pedicel. Example, Pedicellina.

Sub-order 5. **Lophophea**.—These are fresh-water species having the disc or Lophophore divided

Fig. 90.

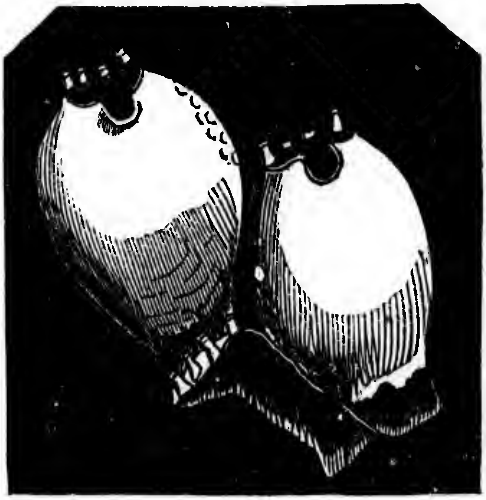


90. FENESTELLA LYELLI, Dawson,--Carboniferous. (b, c,) Parts enlarged to shew the cells.

into two branches like a horse-shoe, and the investing substance gelatinous. Example, Fredericella, Pectinatella, Cristatella.

Sub-order 6. **Paludicellea**.— These are freshwater species like the above, but with the disc circular. Example, Paludicella.

Fig. 91.



91. LEPRALIA QUADRICORNUTA, Dawson, Post-pliocene, Montreal.

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 Schuylkil River.

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

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. 92.)

Fig. 92.

BOLTENIA BOLTENI, Lin., Gulf St. Lawrence—reduced.

The sac has two apertures, 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 rhythmical 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.

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. Eackard 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.

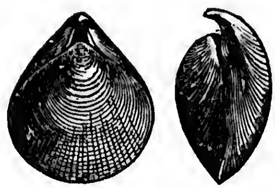
All the species found on our coast belong to the first sub-order of Tunicates, that of the *Ascidiae*, which also includes the remarkable *Pyrosomidae* of the warmer seas, freely moving forms in which the animals are grouped in radiating series in the walls of a hollow cylinder closed at one end, and 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.

3. Brachiopoda.

Of these curious and rare bivalve shell-fish, only a few species are found on our coasts. The most common is *Rhynconella psittacea*, the parrot's-bill Rhynconella. (Fig. 93.) It is a little horny

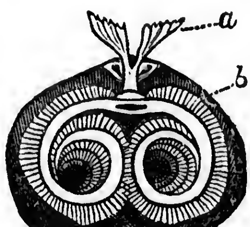
Fig. 93.



RHYNCONELLA PSITTACEA, Lin. Gulf St. Lawrence.

bivalve shell, with one 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.94.)

Fig. 94.



RHYNCONELLA PSITTACEA. Interior of dorsal valve, showing (*a*) adductor muscles, and (*b*) spiral arms; drawn from a specimen dredged at Gaspe—Natural size.

At the base of these is the mouth leading to a small stomach 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 Rhynconella is found attached to stones and dead shells in moderately deep water.

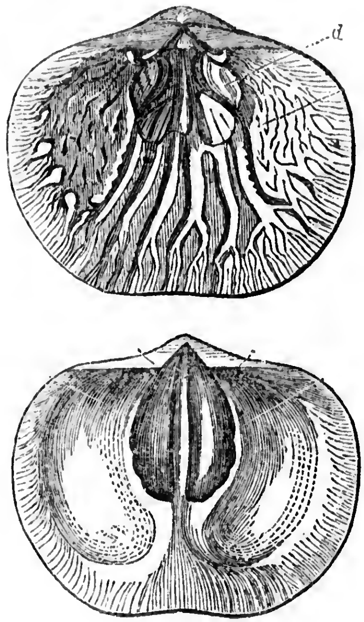
In addition to this species we have on our coasts *Terebratulina septentrionalis*, of more elongated form than the above-named species, ribbed longitudinally, with a round perforation at the beak, instead of a notch, and with an internal shelly loop. Other species found on our coasts are *Waldheimia 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's 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.

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.

95 represents the interior of the dorsal and ventral valves of an Orthis, showing the muscular and mantle impressions, teeth and foramen.

Fig. 95.



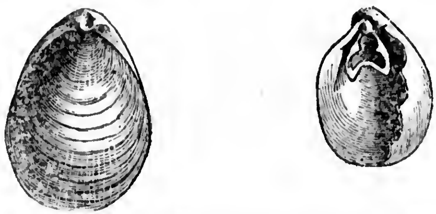
ORTHIS STRIATULA, after Woodward,
(A) Dorsal value, showing the muscular impressions at (d); also the vascular impressions of the mantle, and the notch, tooth and brachial processes in the hinge.
(B) Ventral valve, showing the impressions of the hinge and pedicel muscles.

The families of Brachiopoda 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, Waldheimia, Terebratella, Rensellaria. (Figs. 96, 97.)

Fig. 96.



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

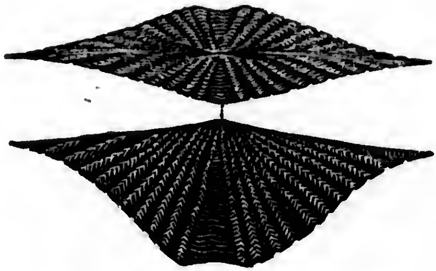
Fig. 97.

RENSELLARIA OVALIS, Hall,—Devonian.

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. 98, 101.)

Fig. 98.

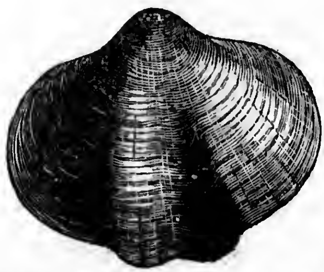


SPIRIFER MUCRONATUS, Hall,—Devonian.

Fig 99.

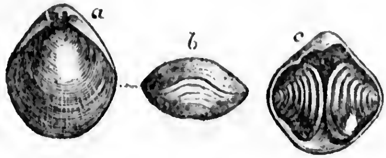
SPIRIFER VARICOSA, Hall,—Devonian.

Fig. 100.



SPIRIFER GLABER, Martin,—Carboniferous.

Fig. 101.



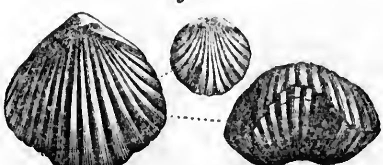
ATHYRIS SUBTILITA, Hall,—Carboniferous, with interior (c) showing spiral supports for the arms.

3. **Rhynconellidæ.**— Shell not punctate, hinge line curved, Foramen under beak. Supports short or rarely spiral. Recent and fossil. Examples.—Rhynconella, Atrypa, Pentamerus. (Figs. 102, to 106, also Figs. 93, 94.)

Fig. 102.

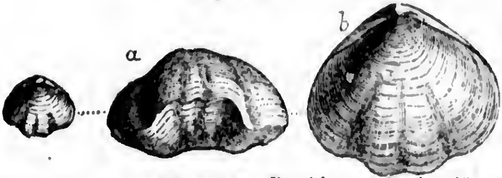
RHYNCONELLA INCREBRESCENS, Hall,—L. Silurian.

Fig. 103.



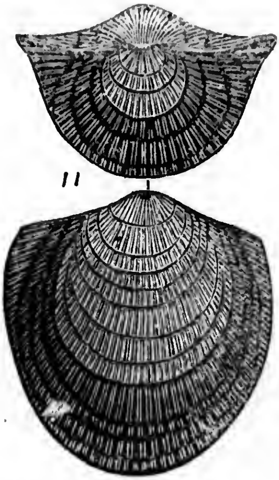
RHYNCONELLA ACADIENSIS, Davidson,—Carboniferous.

Fig. 104.



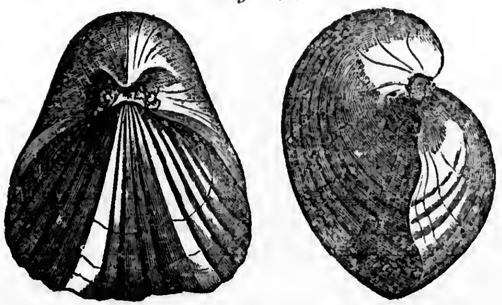
RHYNCONELLA DAWSONIANA, Davidson,—Carboniferous.

Fig. 105.



ATRYPA RETICULARIS, Lin,—U. Silurian.

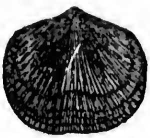
Fig. 106.

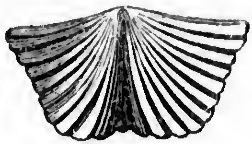


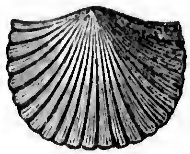
PENTAMERUS GALEATUS, Dalman,—U. Silurian.

4. **Orthidæ.**—Shell usually punctate. Hinge line wide and straight, with an area. Internal supports small or wanting. Fossil. Examples.—Orthis, Strophomena, Leptaena. (Figs. 107 to 112.)

Fig. 107. *Fig.* 108. *Fig.* 109.

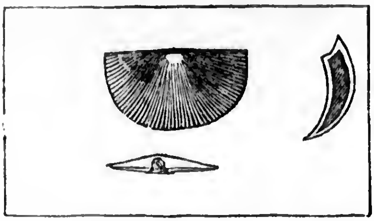






100. ORTHIS TESTUDINARIA, Dalman,—L. Silurian.
101. O. LNYX, Eich,—L. Silurian.
102. O, PECTINELLA, Conrad,—L. Silurian.

Fig. 110.

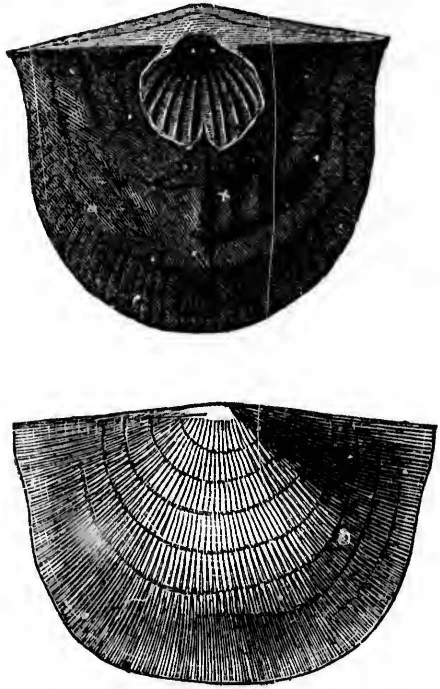


LEPTAENA SERICEA, Sow,—L. Silurian.

Fig. 111.

ORTHIS BILLINGSI, Hartt—Primordial.

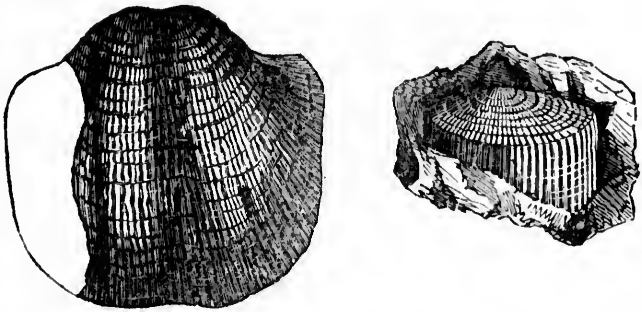
Fig. 112.



STROPHOMENA FILITEXTA, Hall, L. Silurian, interior and exterior.

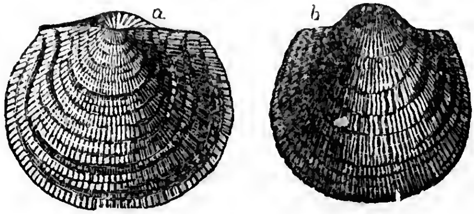
5. **Productidæ.** — Shell concavo-convex. Hinge line straight. Tubular spines on the surface. Fossil. Examples.—Productus, Chonetes. (Figs. 113, 116.)

Fig. 113.



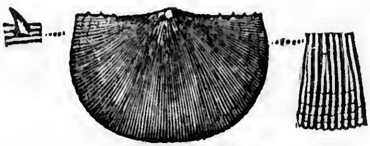
PRODUCTUS SEMIRETICULATUS, Martin,—Carboniferous.

Fig. 114.



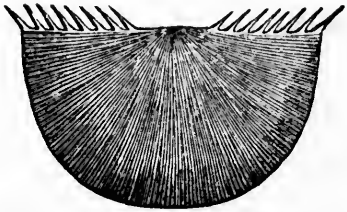
PRODUCTUS CORA, D'Orbigny,—Carboniferous.

Fig. 115.



CHONETES NOVASCOTICA, Hall,—Up. Silurian.

Fig. 116.



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. (Fig. 117.)

Fig 117.

CRANIA ACADIENSIS, Hall,—U. Silurian. Ventral valve, nat. size and mag.

7. **Discinidæ.**—Resembling Crania, but attached by a peduncle passing through a foramen in the ventral valve. Recent and fossil. Examples. —Discina, Trematis. (Figs. 118, 119.)

Fig. 118. *Fig.* 119.

DISCINA CIRCE, Billings,—L. Silurian.
D. ACADIAE, Hartt,—Primordial.

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. 120, 121.)

Fig. 120.

Fig. 121

120. LINGULA QUADRATA, Eich.—L. Silurian.
121. L. MATHEWI, Hartt,—Primordial.

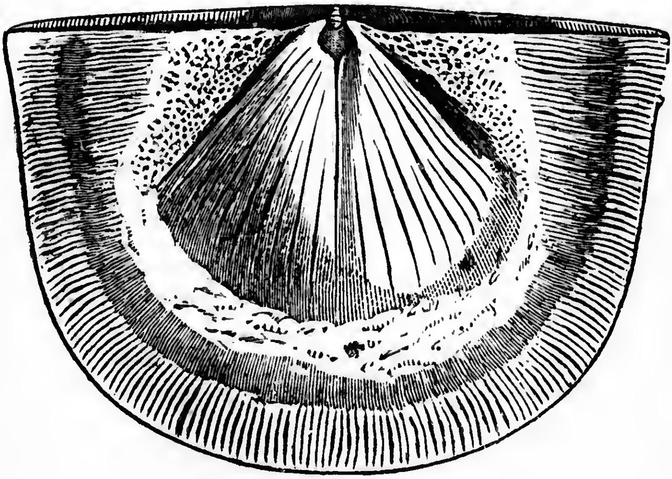
TABULAR VIEW OF HETEROBRANCHIATA.

HETEROBRANCHIATA.	*Polyzoa or Bryozoa.*	Cheilostomata.
		Cyclostomata.
		Ctenostmata.
		Pedicellinea.
		Lophophea.
		Paludicellea.
	Tunicata.	Ascidiæ.
		Biphora,
	Brachiopoda.	Terebratulidæ.
		Spiriferidæ.
		Rhynconellidæ.
		Orthidæ.
		Productidæ.
		Craniadæ.
		Discinidæ.
		Lingulidæ.

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.

The following figures represent additional species of Fossil Brachiopoda from the Palæozoic rocks of Canada: (Figs. 122 to 128.)

Fig. 122.



STROPHOMENA MAGNIFICA, Hall,—Devonian, Interior.

Fig. 125.

LEPTOCOELIA INTERMEDIA, Hall,—Up. Silurian.

Fig. 124.

Fig. 125.

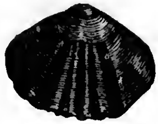
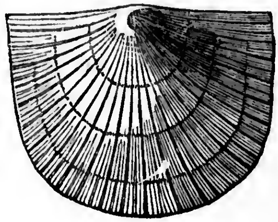
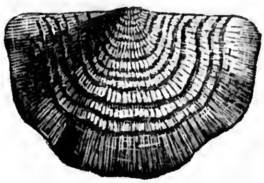


Fig. 126.



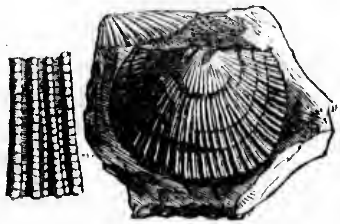
124. Rhynconella plena, Hall,—L. Silurian.
125. Camarella, hemiplicata, Hall, L.—Silurian.
126. Strophomena alternata Con.—L. Silurian.

Fig. 127.



Strophomena Analoga, Phil,—Carboniferous.

Fig. 128.



Streptorhyncus crenistria, Phillips,—Carboniferous.

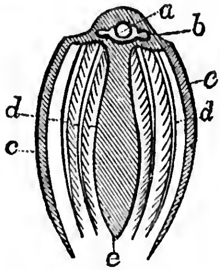
Class II.—Lamellibranchiata.

Body with a dextro-sinistral bivalve shell; mantle more or less closed; tentacles four; gills lamelliform, in two pairs.

The Lamellibranchiates are the ordinary Bivalve Shell-fish, 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, another at the base of the foot and a third at the posterior adductor muscle. These are connected by nervous fibres. The foot, above mentioned, is a fleshy or muscular organ capable of being used for locomotion or for burrowing. In some genera 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. 129.)

Fig. 129.

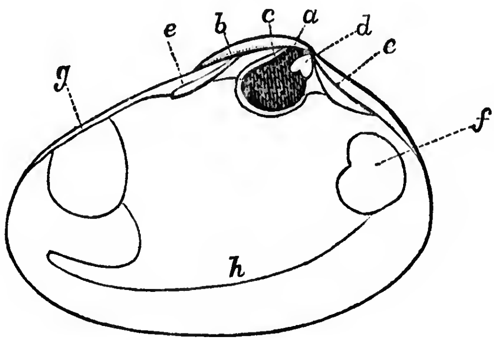


SECTION OF A LAMELLIBRANCHIATE.
(*a*) ALIMENTARY CANAL. (*b*) Heart. (*c*) Mantle. (*d*) Gills, (*e*) Foot

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 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. 130.)

Fig. 130.



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.

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. 131, 132 show the appearance of a siphonide and asiphonide species.

Fig. 131.

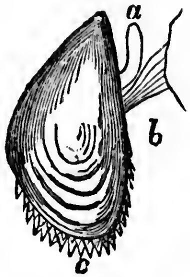


Fig. 132.

131. MYTILUS EDULIS, Lin. (*a*) Foot. (*b*) Byssus. (*c*) Margin of mantle.

132. TELLINA GROENLANDICA, Beck. (*a*) Siphons. (*d*) Foot.

The Lamellibranchiates may be arranged in the following families:

(*Siphonida, sinu-pallialia.*)

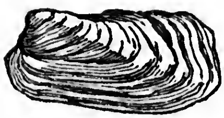
Pholadidæ—ex. Pholas, Teredo.—The shells of the genus Pholas are remarkable as burrowers in stone and hard clay. Our species is *P. crispata*. The species of *Teredo* burrow in sunken timber and are very destructive to piles and shipping. The animal is worm-like and the valves appear to be constructed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

Gastrochaenidæ—ex. Gastrochaena.—Burrowers, with the valves sometimes united into a shelly tube. No Canadian species.

Anatinidæ—ex. 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.

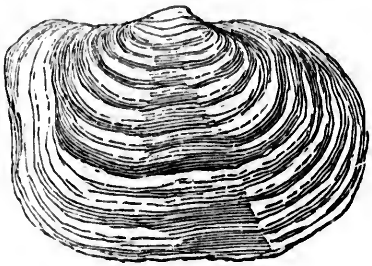
Myacidæ—ex. Mya, Saxicava, Glycimeris.—Shell coarse and wrinkled, gaping posteriorly. Animal with closed mantle, small foot and united siphons. *Mya arenaria* is the common sand clam, *Mya truncata* is more rare and in deeper water, *Saxicava rugosa* abounds on rocky coasts, and burrows in limestone. Fig. 133 to 135.

Fig. 133.



SAXICAVA RUGOSA, Lin.

Fig. 134.



MYA TRUNCATA, Lin.

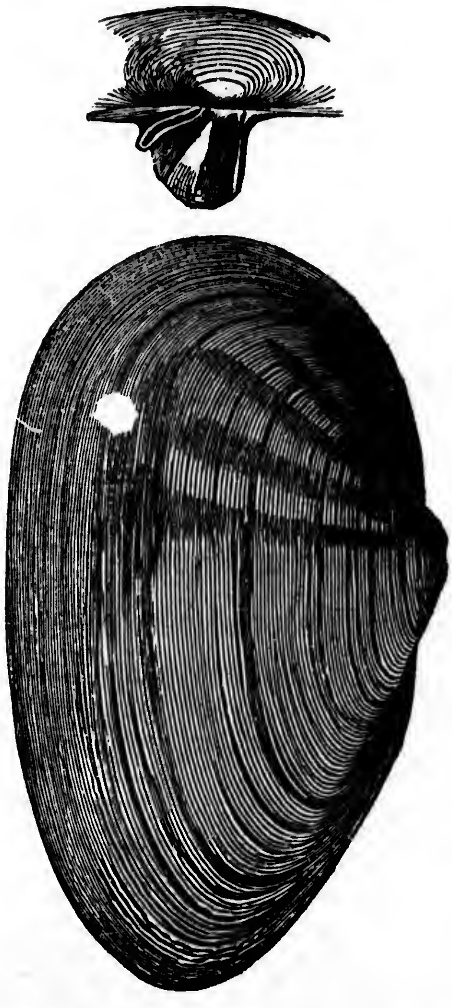
Solenidæ—ex. Solen, Machaera.—Shells elongated, gaping at both ends. The common "razor-fish." *Solen ensis*, is a typical example.

Tellinidae—ex. Tellina, Sanguinolaria, Donax.—Shell compressed, usually closed and equivalve. Animal with mantle widely open in front, foot tongue-shaped, siphons long and separate. (Fig. 132.) *T. Groenlandica* and *T. proxima* are common species. Fig. 136, 137.

Mactridae—ex. Mactra, Gnathodon.—Shell equivalve, triangular. Internal ligament in a deep triangular pit. Two diverging cardinal teeth, and two lateral. (Fig. 130). *Mactra solidissima*, the great clam, is the largest bivalve found on our coasts.

Fig. 135.

a



MYA ARENARIA, Lin. (*a*) process for internal ligament.

Fig. 136.

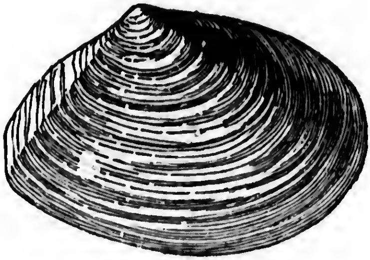
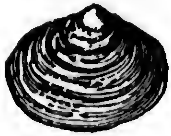


Fig. 137.



TELLINA PROXIMA (sabulosa, Spongl.) T. GROENLANDICA, Beck.

Veneridae — ex. 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*] *violacea*, the Quahaug or Wampum shell. *Venus gemma* abounds at Gaspé.

(*Siphonida, integro-pallialia.*)

Cyprinidae—ex. Cyprina, Astarte, Cardita.—Shell regular ıvalve, oval, solid; epidermis thick and ardinal teeth one to three, and usually a ..rior lateral tooth, *Cyprina Islandica* is our largest species; and we have several species of *Astarte*, and *Cardita borealis*. [Figs. 138, 139.]

Fig. 138.

ASTARTE STRIATA, Leach.

Fig. 139.

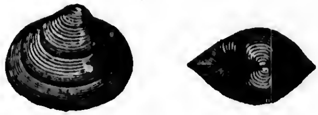
A. LAURENTIANA—Post-pliocene.

Cycladidae—ex. Cyclas, Cyrena, Pisidium.—Fresh and brackish-water shells, sub-orbicular, closed, with thick horny epidermis and cardinal and lateral teeth. Several small shells of the genera *Sphœrium* and *Pisidium* are found in our streams and ponds. Fig. 140 to 146.

Fig. 140.

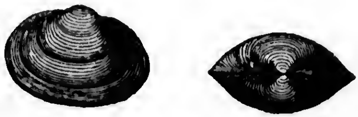
SPHAERIUM RHOMBOIDEUM, Say.

Fig. 141.



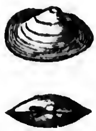
S. SOLIDULUM, Prime.

Fig. 142.



S. SULCATUM, LAM, (*Cyclas similis*) Say.

Fig. 143.



S. TRANSVERSUM, Say.

Fig. 144.

SPHAERIUM SECURIS, Prime.

Fig. 145.

PISIDIUM VIRGINICUM, Brongt.

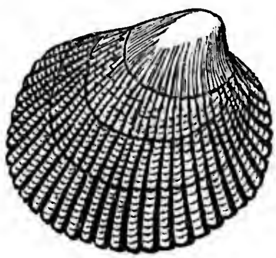
Fig. 146.

P. ALTILE, Anthony.

Lucinidae—ex. 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—ex 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. 147.

Fig. 147.



CARDIUM ISLANDICUM, Lin.

Tridacnidae— ex. Tridacna, Hippopus.—Shell regular, equivalve, truncated in front. *Tridacna gigas* is the largest of bivalves. No species occur in Canada.

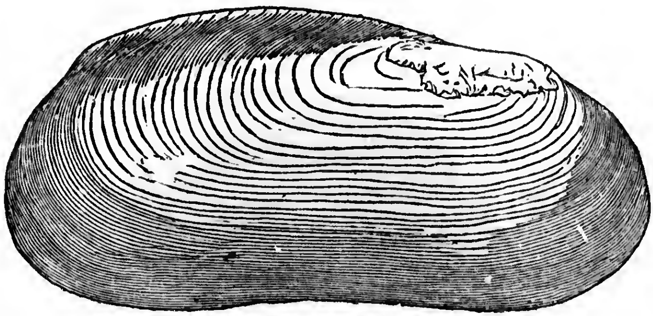
Hippuritidae—ex. Hippurites, Radiolites.—Fossil in the Cretaceous rocks; remarkable for the great and abnormal thickness of the right valve.

Chamidae—ex. Chama, Diceras.—Shell inequivalve, attached, with spiral beaks. We have one species.

(Asiphonida.)

Unionidae—ex. Unio, Anodon, Alasmodon.—Fresh-water shells, regular, equivalve, closed. Epidermis thick, shell nacreous within, ligament large, external. These are the fresh-water 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. 148.

Fig. 148.



ALASMODON, (Margaritana) MARGARITIFERA.

Trigonidae—ex. 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 — ex. 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. 149, 150.)

Fig. 149.

LIDA MINUTA, Mull.

Fig. 150.

LEDA (YOLDIA) TRUNCATA, Post-pliocene.

Mytilidae—ex. 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. 151.) The horse mussel is *M. modiolus*.

Fig. 151.

MYTILUS EDULIS, Lin.

Aviculidae—ex. 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. (Figs. 152, 153.)

Ostreadae—ex. Ostrea, Anomia, 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*

Fig 152.

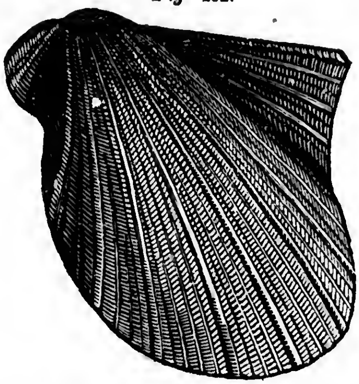
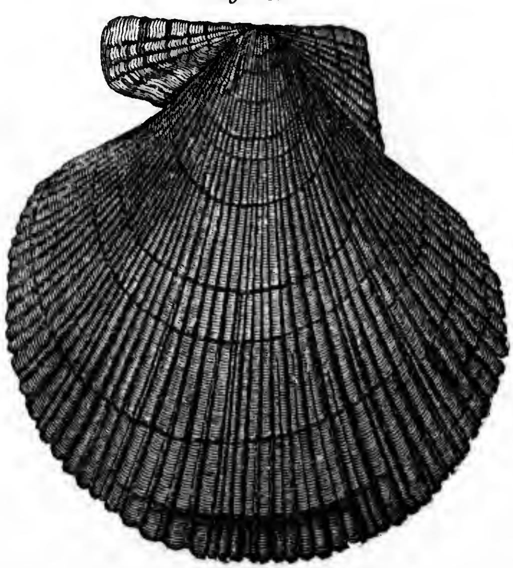


Fig. 153.

152. AVICULA FLABELLA, Vanuxem, Devonian.
153. A. HONEYMANI, Hall, Up. Silurian.

Virginica, and the Pectens or Scallops are well-known examples. (Fig. 154.)

Fig. 154.



PECTEN ISLANDICUS, Chemnitz.

The following figures represent fossil Lamellibranchiates found in Canadian rocks, but which, for the most part, can be only doubtfully referred to any of the above families. (Figs. 155 to 166.)

Fig. 155.

AMBONYCHIA SUPERBA, Hall—M. Silurian.

Fig. 156.

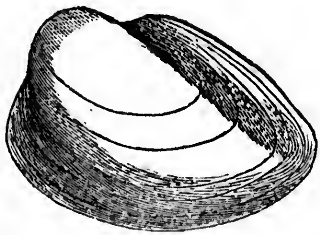
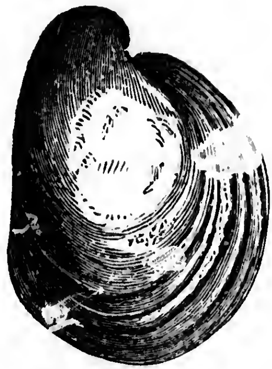
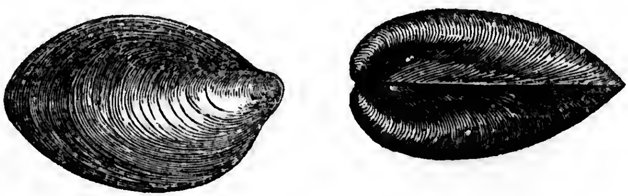


Fig. 157.



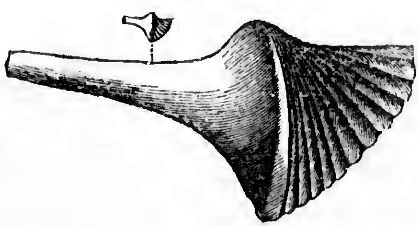
151. Cyrtodonta sigmoides, Billings,—M. Silurian.
152. Cyrtodonta ungulata, Billings,—M. Silurian.

Fig. 158.



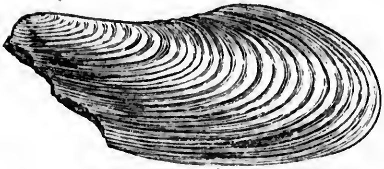
Megambonia nitida, Billings,—M. Silurian.

Fig. 159.



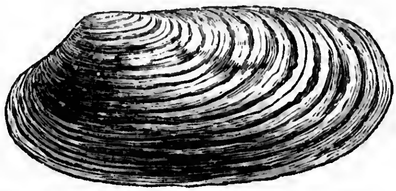
Conocardium Acadianum, Hartt.—Carboniferous.

Fig. 160.



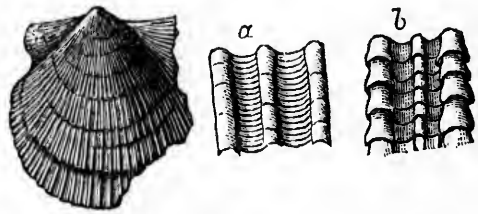
CYPRICARDIA INSECTA, Dawson.—Carboniferous.

Fig. 161.



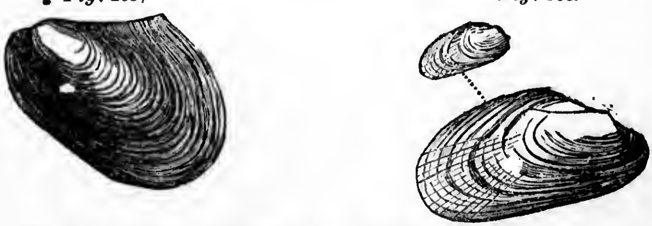
EDMONDIA HARTTI, Dn.—Carboniferous.

Fig. 162.



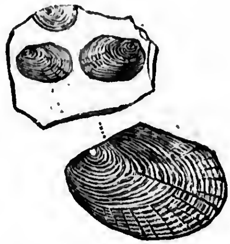
AVICULOPECTEN LYELLI, Dn.— (*a*, *b*) 8 sculpture—Carboniferous.

Fig. 163. *Fig.* 164.



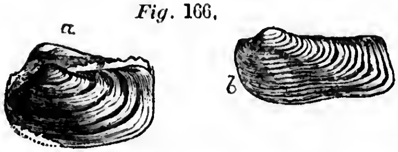
163. NAIADITES CARBONARIUS, Dn.—Carboniferous.
164. N. ELONGATUS, Dn.—Carb.

Fig. 165.



N. LAEVIS, Dn,—Carb.

Fig. 166.



MACRODON HARDINGI, Dn.—Carboniferous. (*a*) cast. (*b*) exterior.

TABULAR VIEW OF LAMELLIBRANCHIATA.

	Siphonida, *Sinu-* *pallialia.*	Veneridæ. Mactridæ. Tellindæ. &c.
LAMELLIBRANCHIATA.	*Siphonida,* *Integro-* *pallialia.*	Cardiadæ. Lucinidæ. Cyprinidæ. &c.
	Asiphonida.	Ostreadæ. Mytilidæ. Unionidæ. &c.

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 Papers by Packard, Whiteaves, Bell, and others, published in the *Canadian Naturalist.* Fossil species will be found in Memoirs by Billings in Reports of Canadian Survey, and in Dawson's Acadian Geology.

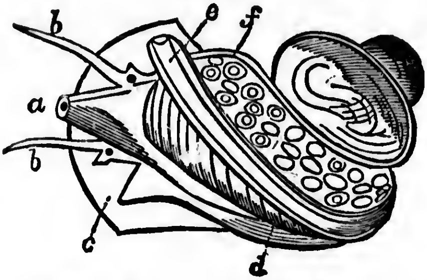
Class III.—Gasteropoda.

Encephalous; body symmetrical or spiral; foot along the ventral aspect of the body.

A typical Gasteropod, 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. 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 following figure shows the arrangement of the principal organs in a fresh-water snail of the genus Paludina. (Fig. 167.)

The shell of the Gasteropods is constructed of the same materials with that of the last class, and is deposited by the mantle. It is never bivalve,

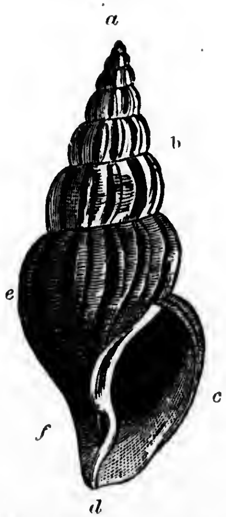
Fig. 167.



ANIMAL OF PALUDINA, after Woodward.
(*a*) Mouth. (*b*) Tentacles and Eyes. (*c*) Foot, (*d*) Gills. (*e*) Intestine. (*f*) Ovary.

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 Figure 168.

Fig. 168.



UNIVALVE SHELL, (BUCCINOFUSUS) to show its parts.
(*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 Gasteropods 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 5th 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 ground 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 Gasteropods. 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 all are 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.

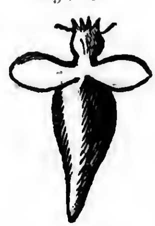
Order 4. Pulmonifera. — These are land and fresh-water snails and slugs, and are distinguished by the possession of an internal pulmonary chamber or air-sac by which they breathe air. The greater part have spiral shells, and all are creepers.

Order 5. Prosobranchiata. — These are sea-snails proper, though a few occur in fresh water. 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 Gasteropods, and are nearly all creepers, by means of a muscular foot.

Order 1.—Pteropoda.

On the coast of Labrador the tow-net sometimes secures great numbers of the little creature represented in Fig. 169, [*Clione limacina*, Phipps, *C.*

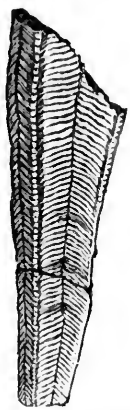
Fig. 169.



CLIONE LIMACINA.

borealis of Brugière.] 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 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, are supposed to belong to this order. Fig. 170.

Fig. 170.



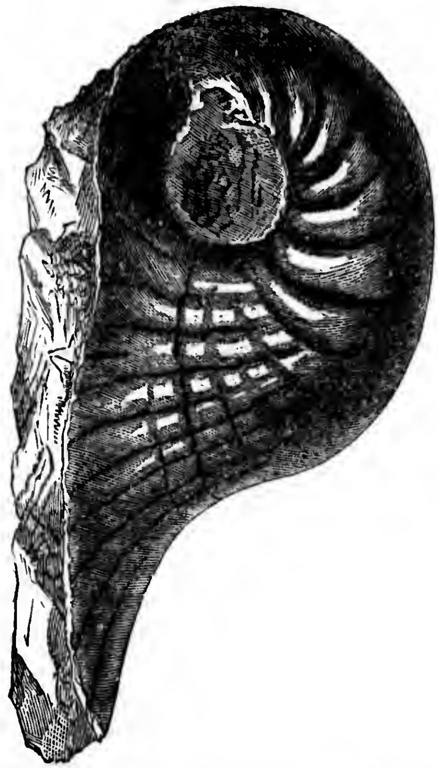
CONULARIA PLANICOSTATA, Dawson—Carboniferous.

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 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. Figs. 171, 172. The curious and somewhat anomalous shells of the genera *Maclurea* and *Ecculiomphalus*, are also supposed by some palaeontologists to belong to this order.

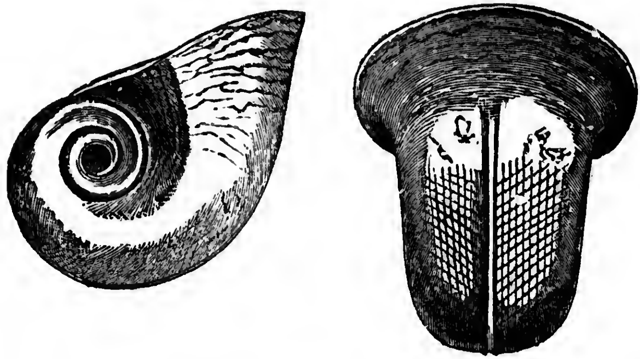
Fig. 171.



BELLEROPHON CANADENSIS, Billings,—M. Silurian.

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. 172.

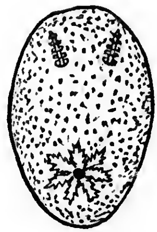


BELLEROPHON SULCATINUS,—Billings, L. Silurian.

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. 173).

Fig. 173.



DORIS PLANULATA, Stimpson.

The most interesting of the Tectibranchiates are the *Bullae* 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 coasts. (Fig. 174.)

Fig. 174.

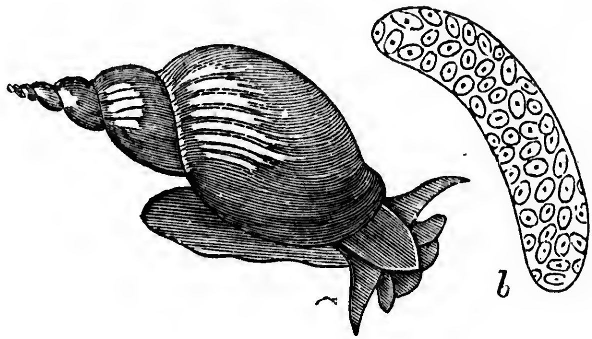
CYLICHNA ALBA, Brown.

Order 4.—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 :

1. **Auriculidae.**—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.

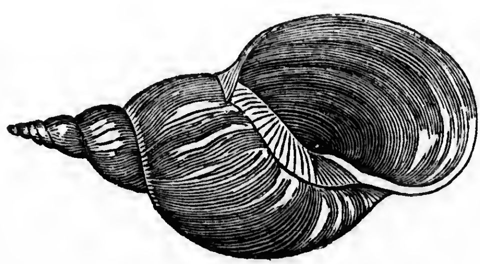
Fig. 175.



LIMNEA STAGNALIS, Lin, Shell and Animal,—(b) Mass of Eggs magnified.

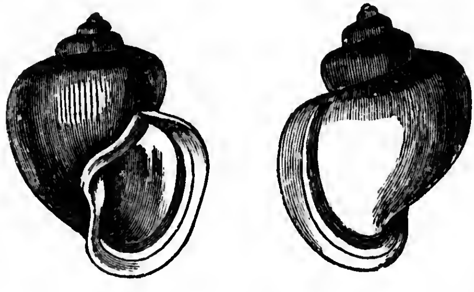
2. **Limnacadae**.—Here we have the Limneas and Physas or spiral fresh-water snails, and the discoid snails belonging to the genus *Planorbis*. Allied to the former is the curious genus *Ancylus*. with a conical shell, like that of a limpet. Figs. 175 to 187 show some common species. All these crea-

Fig. 176.



LIMNEA STAGNALIS, Lin.

Fig. 177.



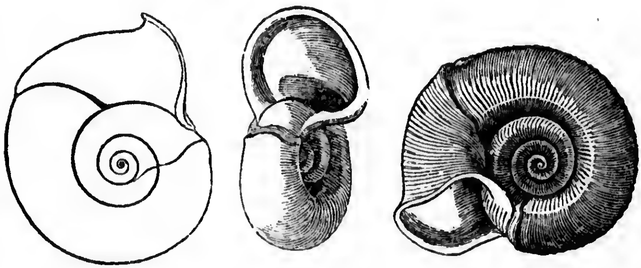
LIMNEA AMPLA, Mighels.

Fig. 178.

LIMNEA ELODES, Say.

tures, though living in water, breathe air; and they are especially interesting to students residing in inland regions remote from the sea. Specimens

Fig. 179.



PLANORBIS MACROSTOMUS, Whiteaves.

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

Fig. 180.

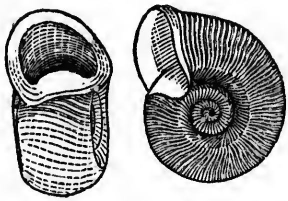
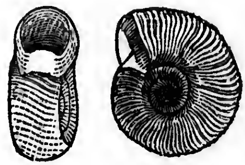
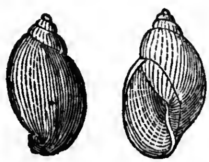


Fig. 181.



180. PLANORBIS TRIVOLVIS, Say.
181. P. LENTUS, Say.

Fig. 182.



Fig, 183.

Fig. 184.

182. PHYSA HETEROSTROPHA, Say.
183. ANCYLUS RIVULARIS, Say.
184. A. FUSCUS, Adams.

Fig. 185.

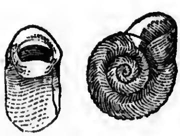


Fig. 186.

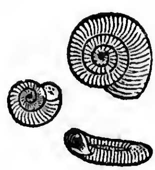
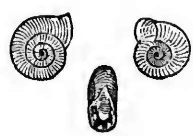


Fig. 187.



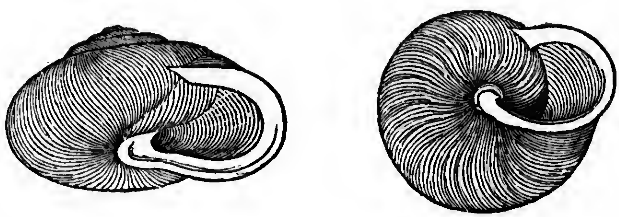
185. PLANORBIS CAMPANULATUS, Say.
186. P. DEFLECTUS, Say.
187. P. ARMIGERUS, Say.

3. **Limacidae.**—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. These creatures are remarkable for the large quantity of tenacious mucus secreted from glands in the mantle, and which greatly contributes to their protection.

4. **Helicidae.**—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. Figs. 188 to 190.

Fig. 188.



HELIX ALBOLABRIS, *Say*.

Fig. 189.

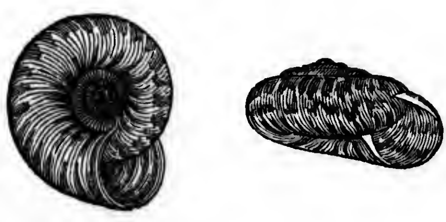
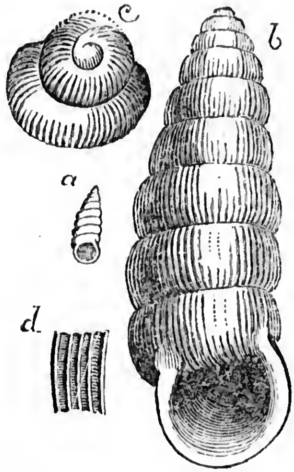


Fig. 190

189. HELIX ALTERNATA, Say.
190. HELIX MONODON, Rackett.

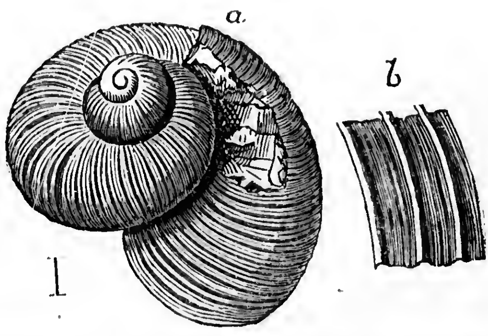
The oldest known Pulmonates are *Pupa vetusta* and *Conulus priscus* from the Coal-formation of Nova Scotia. Figs. 191, 192.

Fig. 191.



PUPA VETUSTA, Dawson.—Carboniferous. (a) nat size. (b) magnified. (c) apex. (d) sculpture.

Fig. 192.



CONULUS PRISCUS, Carpenter.—Carboniferous. (a) magnified. (b) sculpture.

5. **Siphonariæ.** — These are marine snails, breathing air and with limpet-like shells.

Order 5.--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:

Chitonidae.—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. 193.

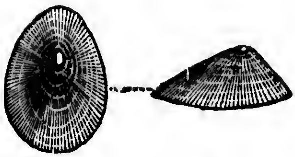
Fig. 193.

CHITON EMERSONII, two of the valves.

Dentaliadae.—Long tubular shells, living in deep water in muddy bottoms. *Dentalium* (*Entalis*) *striatum* is found on our coasts.

Patellidae.—Shells conical, animals clinging to or creeping on stones. *Tectura testudinalis*, the common limpet of our coasts, is an example. *Lepeta cæca.* (Fig. 194) is less common.

Fig. 194.



LEPETA CÆCA, Mull,

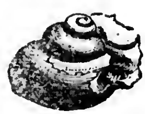
Fissurellidæ. — The "Key-hole" or perforated limpets. One little species, *Cemoria Noachina*, is found on our coasts.

Haliotidæ.—The Sea-ears are beautiful pearly shells not represented in this country.

Turbinidae.—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 *Platyschisma* of the carboniferous limestone perhaps belongs to this family. Fig. 195.

Fig. 195.



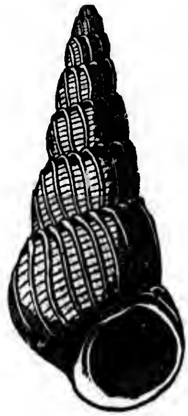
PLATYSCHISMA DUBIA, Dn.—Carboniferous.

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

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

Turritellidae.—These, as their name imports, are long turreted shells with rounded aperture, and often of very graceful form. They are marine.—*Turritella erosa* is not uncommon, and *Scalaria Groenlandica*, (Fig. 196), though rare, is one of our most beautiful shells.

Fig. 196.



Scalaria Groenlandica, Parry.

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 larger rivers, as also are certain curious little shells of the genus Valvata. (Figs. 198, 199.)

Fig. 197.

Fig. 198.

Fig. 199.

197. AMNICOLA PORATA, Say.
198. VALVATA TRICARINATA, Say.
199. 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.197.)

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 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. 200 to 202.)

Fig. 200.

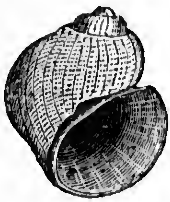


Fig. 201.

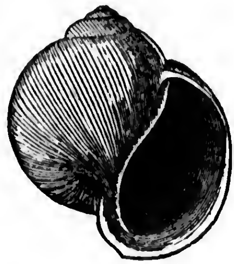


Fig. 202.

200. NATICA HELICOIDES, Johnston.
201. N. CLAUSA, Brod and Sow.
202. 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.

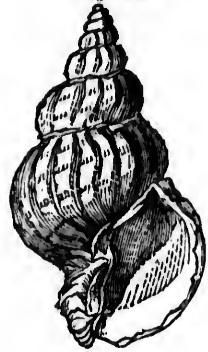
Volutidæ.—The Volutes are also tropical and sub-tropical shells, often of great beauty.

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. 203.)

Muricidæ.—These have a straight inferior canal, often of considerable length. They are

Fig. 203.



203. Buccinum undatum, Lin, Variety.

represented on our coast by species of *Fusus*, *Trophon*, and *Trichotropis*, mostly deep water shells. (Figs. 205, 206

Fig 205.

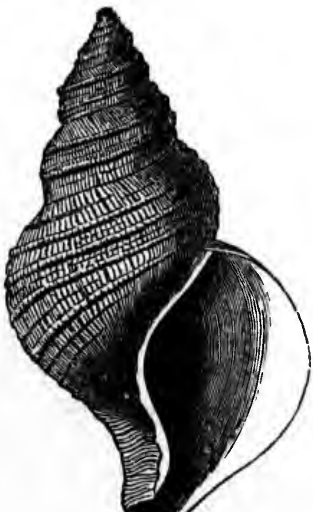
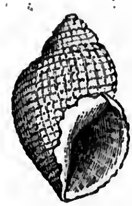


Fig. 206.



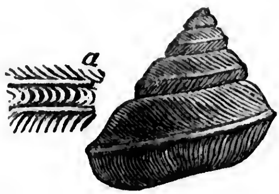
205. Fusus tornatus, Gould.
206. Admete viridula, O. Fabricius.

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*, (Figs. 207) 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. 207



184. PLEUROTOMARIA SYBILLINA, Billings,—M. Silurian.
(*a*) Sculpture and notch.

The genera *Loxonema* and *Euomphalus* also include fossils of uncertain affinities. Figs. 208, 209.

Fig. 208.

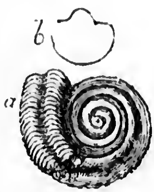
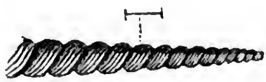


Fig. 209.



208. EUOMPHALUS EXORTIVUS, Dn.,—Carboniferous.
209. LOXONEMA ACUTULA, Dn., Do.—Magnified.

TABULAR VIEW OF GASTEROPODS.

GASTEROPODA	*Order Pteropoda.*	Hyaleidæ.
		Limacinidæ.
		Cliidæ.
	Order Heteropoda	Firolidæ.
		Atlantidæ.
		Ianthinidæ.
	Order Opistho-branchiata.	Elysiadæ.
		Phillyrhoidæ.
		Acolidæ.
		Tritoniadæ.
		Doridæ.
		Phyllidiadæ.
		Pleurobranchidæ.
		Aplysiadæ.
		Bullidæ.
		Tornatellidæ.
	Order Pulmoni-fera.	Aciculidæ.
		Auriculidæ.
		Limnaeidæ.
		Oncidiadæ.
		Limacidæ.
		Helicidæ.
	Order Prosobran-chiata.	Chitonidæ.
		Dentaliadæ.
		Patellidæ
		Fissurellidæ.
		Haliotidæ.
		Turbinidæ.
		Neritidæ.

TABULAR VIEW OF GASTEROPODS.—*Continued.*

Class	Order	Families
GASTEROPODA	*Order Prosobranchiata.*	Calyptraeadæ.
		Turritellidæ.
		Littorinidæ.
		Paludinidæ.
		Melaniadæ.
		Cerithiadæ.
		Pyramidellidæ.
		Naticidæ.
		Cypræadæ.
		Volutidæ.
		Conidæ.
		Buccinidæ.
		Muricidæ.
		Strombidæ.

For the Gasteropods the student may be referred to the works mentioned under the last class.

CLASS IV.—CEPHALOPODA.

Encephalous; body symmetrical; locomotive and prehensile organs attached to the head; 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, or by the re-action 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 are divided into two orders.

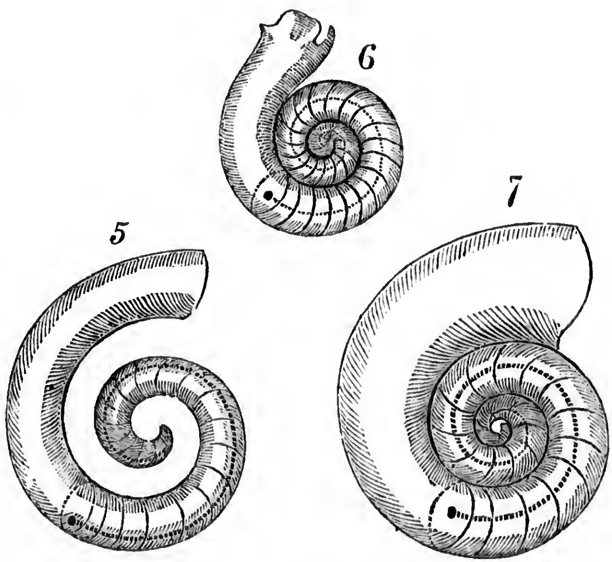
1. Tetrabranchiata.—In which there are four gills, numerous arms, and an external chambered shell, the inner chambers of which are empty, and serve as a float to render the animal independent of gravity, by accommodating its weight to the specific gravity of the sea-water. These are the Nautili and their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

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 1.—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 siphon or tube, communicating with the body of the animal. But though we 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 development 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. 210.

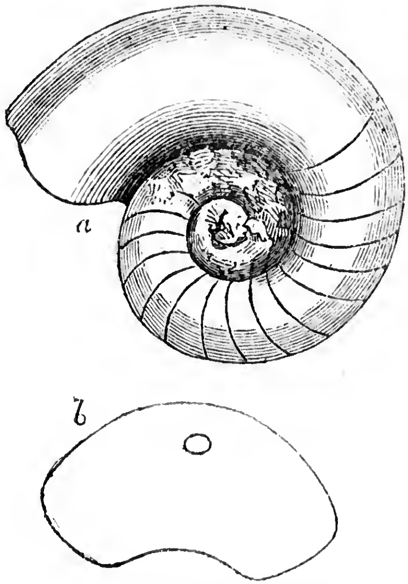


LITUITES, (6), GYROCERAS (5), NAUTILUS, (7.)

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. 211.)

Fig. 211.



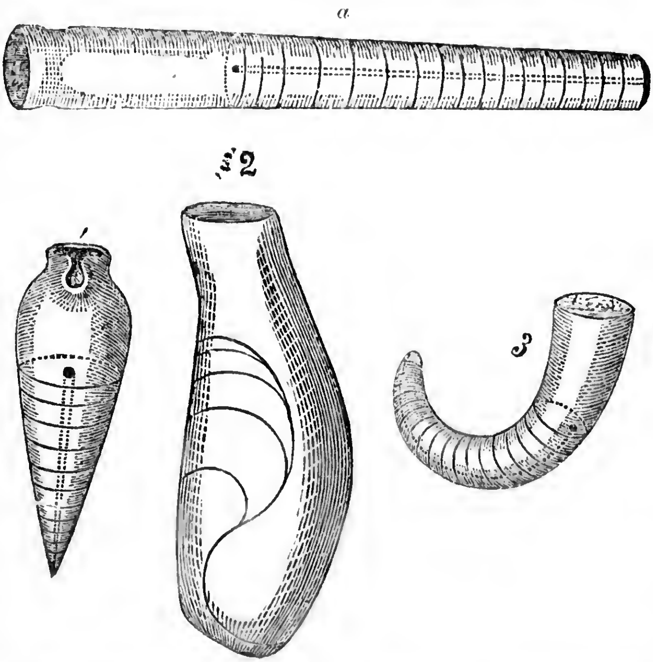
NAUTILUS AVONENSIS, Dawson,—Carboniferous. (b) Section showing position of Siphuncle.

Fig. 212.

GYROCERAS HARTII, Dn.—Carboniferous.

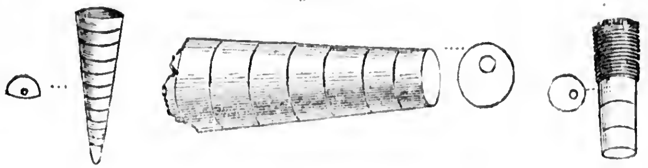
Orthoceratidæ.—These are all extinct. They differ from the Nautili in having the shell often straight, or merely curved ; in the smallness of the last chamber for containing the body of the animal, and in the aperture being contracted. Many of them have the siphuncle or tube leading through the chambers singularly complicated. Some of the species were of very great size, the shells being several feet in length. Several genera of this family are represented on the Palaeozoic rocks of Canada. (Fig. 213.)

Fig. 213.



ORTHOCERAS (*a*). GOMPHOCERAS (1). ASCOCERAS (2). CYRTOCERAS (3)
—after Billings.

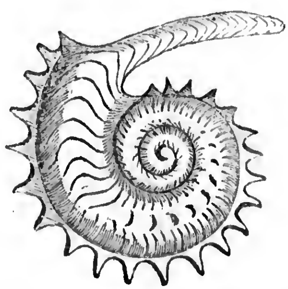
Fig. 214.



ORTHOCERAS DOLATUM Dn.—Carboniferous.
O. VINDOBONENSE, do. do.
O. PERSTRICTUM, do. do.

3. Ammonitidæ.—In these the body-chamber is elongated and guarded by processes and closed with an operculum or lid. The 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 most of them belong to formations less ancient than those of Canada. (Fig. 215.) The genus *Goniatites* is, however, represented in the Devonian and Carboniferous.

Fig. 215.



AMMONITES JASON, Reinecke,—Oxford Clay, England.

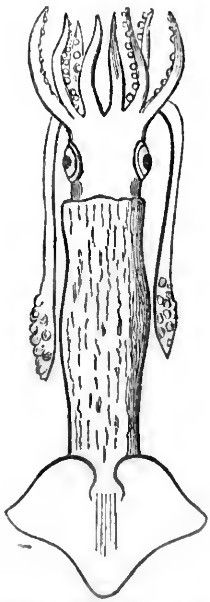
Order 2.—Dibranchiata.

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.

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

Fig. 216.

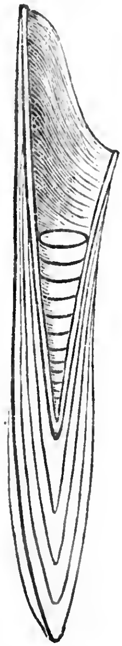


OMMASTREPHES BARTRAMII, LeSueur.

Bay of Fundy. *Ommastrephes* includes those which have an elongated narrow pen, with a conical hollow extremity. *O Bartramii?* occurs in the Gulf of St. Lawrence and is known as the Squid. (Fig. 216.) 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.

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. 217. No Canadian species are known.

Fig. 217.



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. We have no known Canadian species, though there are Northern species which might occur on our coasts.

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 Mr. Billings in the Reports of the Geological Survey.

Tabular View of Cephalopods.

Cephalopoda.	Order *Tetrabranchiata*	Nautilidæ.
		Orthoceratidæ.
		Ammonitidæ.
	Order *Dibranchiata.*	Teuthidæ.
		Belemnitidæ.
		Sepiadæ.
		Spirulidæ.
		Octopodidæ.
		Argonautidæ.

CHAPTER V.

DESCRIPTIVE ZOOLOGY—*Continued.*

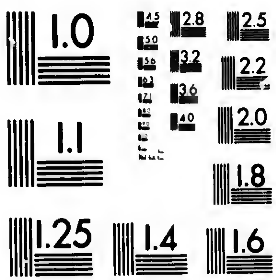
PROVINCE ARTICULATA.

Bilateral, symmetrical ; skeleton annulose, external ; nervous system homogangliate, consisting of an œsophageal ring, and double abdominal nerve-cord and ganglia. Heart dorsal, usually vasiform ; blood not red except in some Annulata ; respiratory organs lateral ; jaws move horizontally.

Class 1. *Annulata*—Worms.
" 2. *Crustacea*—Soft Shell-fish.
" 3. *Insecta*—Insects, and Myriapods.
" 4. *Arachnida*—Mites, Spiders, Scorpions.

The plan embodied in the skeleton of the Articulata 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 the worms this structure is simple and nearly uniform, from front to rear of the animal. In the higher forms it becomes more complex and varied. 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, and there is sometimes also an indication of antero-posterior symmetry. The respiration is performed in the aerial species by air tubes (tracheæ) opening by

IMAGE EVALUATION
TEST TARGET (MT-3)



pores or stigmata at the sides, or by air-sacs. In the aquatic species it is effected by gills, usually placed at the sides of the body. In the smaller species the skeleton is composed of a tough elastic substance named chitine. In the larger species it is often hardened by calcareous matter. The number of species of Articulates far exceeds that in any other province.

Class I.—Annulata.

Body soft, vermiform, annulated; with suckers, setæ or setigerous feet. In most an alimentary canal with proper parietes, a vascular system, respiratory organs and a double ganglionic nervous cord.

In the typical Annelids, like the sea-worms, earth-worms, &c., we have a series of nearly equal rings, in each of which an upper and under area and two side areas are distinguishable, and to the latter, in the higher types, *Setæ* or setigerous feet are attached. The intestinal canal, the circulating system and the nerve-cord, are arranged, as above stated, with regard to articulates in general; but in all the members of this class 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, the *Rotifera* or wheel animalcules, 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, and their movement by means of cilia at once recal some of the lower forms above mentioned. It must, however, be admitted that the group of Entozoa, as at present held by naturalists, is rather one of convenience, depending on 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 two sub-classes, in the manner suggested by Prof. Huxley,—the one, including the Entozoa, Rotifera and Ciliated Worms, to be named *Scoecida*; the other, the Worms properly so called, or *Annelida.*

(1. *Scolecida.*)

Under the first of these sub-classes, the orders are:

1. Sterelmintha, comprehending those worms called by Cuvier parenchymatous, and by others sterelminthous, that is, worms having cellular bodies without distinct viscera. This will include the cestoid worms or Tape-worms, the Flukes, Planariæ and other Turbellarians, and the Acanthocephala or spiny-headed Entozoa.

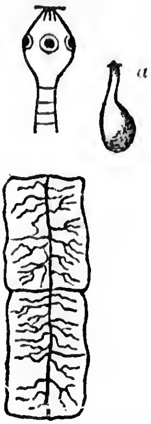
2. Coelelmintha, including those parasitic worms having distinct viscera and parietes of the body, and approaching in structure to the ordinary worms. This order includes the Round Intestinal Worms and the Hair-worms.

3. Rotifera, including certain microscopic worms, with ciliated organs at the head, and imperfectly annulated bodies; and which, while in some points resembling embryonic worms, also in some respects approach to the lower crustacea. These are the Wheel-animalcules and their allies.

1. Sterelmintha.

The internal worms belonging to this order may be represented by the common tape worm, *Tœnia solium*, of the human intestines. (Fig 2u8). This creature 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 tape-worm, 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. 218*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

Fig. 218.



TÆNIA SOLIUM—head or Scolex and two joints, with Larva or Cysticercus (*a*).

completed when the Cysticercus is transferred in the living state 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 order is 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.

A third group of these parasites, the *Acanthocephala*, may be represented by the *Echinorhyncus gigas* of the intestines of the hog. Their general structures do not seem very dissimilar from those of the last mentioned group, but they are of elongated form, and the anterior extremity is armed with a formidable proboscis furnished with hooked spines at the sides.

The last group of these worms may be represented by 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 be grouped in the following families:

1. **Taeniadæ.**—Head with suckers and spines; body jointed. These are the Tape-worms and their allies.

2. **Trematoda.**—Body depressed, but jointed, with suckers but no spines. These are the Distomas and their allies.

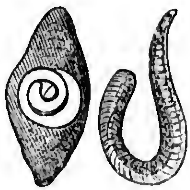
3. **Acanthocephala.**—Body saccular or cylindrical; anterior end with an uncinated proboscis. Echinorhyncus and its allies.

4. **Turbellaria.**—Body flattened and provided with external cilia. These are the Planariæ and their allies.

2. 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. 219), which inhabits the muscles of the

Fig. 219.



TRICHINA SPIRALIS, in its cyst, magnified; and specimen removed from its cyst, farther magnified.

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.

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 Cælelminths may be divided into the following sub-orders or families:

1. Gordiacea.—Body slender. Alimentary canal without vent. Example, Gordius, Trichina.

2. Nematoidea.—Body elongated. Alimentary canal with both mouth and vent. Example, Ascaris.

3. Onchophora.—Body depressed, sub-articulate, mouth with hooks, anus distinct. Example, Linguatula.

3. 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 interior 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 any other members of this sub-class; 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:—

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

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

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

4. 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 Pritchard's Infusoria.

(2. *Annelida.*)

The second 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]. For our present purpsoe we may conform sufficiently to this arrangement by adopting the older subdivision into four orders as follows:

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.

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.

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

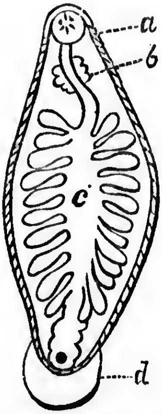
4. **Errantia.**—Body with numerous setigerous feet; external gills in most. These are the Vagrant Sea-worms or Sea-centipedes and their allies.

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 nutriment in

Fig. 220.



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

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 leeche. Fig. 220 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.

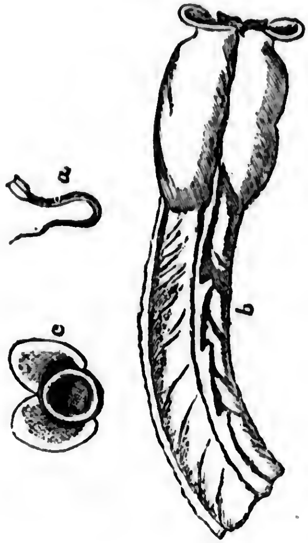
2. Terricola.

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.

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. 221

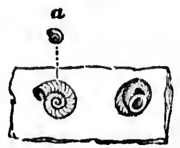
Fig. 221.



VERMILIA SERRULA, Stimpson. (*a*) Natural size. (*b*) Magnified. (*c*) Aperture magnified.

represents the tube of *Vermilia serrula*, 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. spirillum* is common on sea-weeds, and has a round tube. *S. sinistrorsa* is smaller and coiled in the opposite direction or reversed. *S. vitrea*, Fig. 224, is also a reversed species, of a semi-transparent

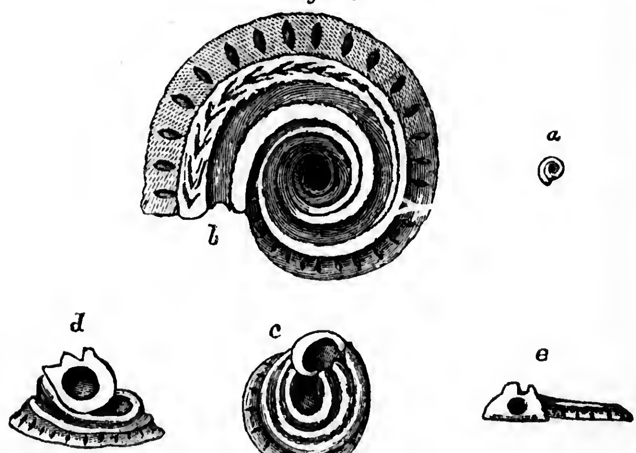
Fig. 222.



SPIRORBIS VITREA, natural size and magnified.

texture. *S. granulata* has three sharp ridges on the upper side, and *S. cancellata* (Fig. 223) is our

Fig. 223.



SPIRORBIS CANCELLATA, Fabr,—(*a*) natural size,(*b*, *c*, *d*, *e*,) magnified.

most ornate species. 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 our largest species, *S. glomerata*, also becomes somewhat irregular in its coils at the end. *

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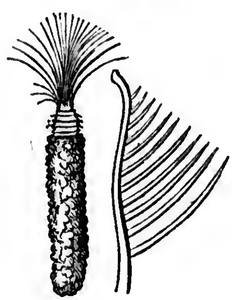
* See a paper on these shells by the author, Canadian Naturalist, Vol. V.

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 Groenlandica*, Grube. 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. 224 as it appeared when alive. 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.

Fig. 224.



SABELLA ZONALIS, Stimpson,—Upper part, natural size; and branchial process magnified.

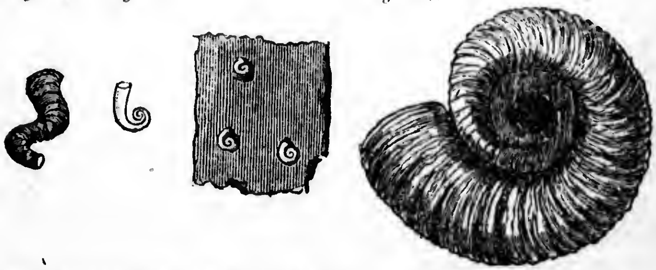
4. Errantia.

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 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.

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 fishermen. 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. 225 to 227 represent species of tubicolous worms from the Carboniferous of Nova Scotia.

Fig. 225. *Fig.* 226. *Fig.* 227.



225. SERPULITES ANNULATUS, Dn.—Carboniferous.
226. S. HORTONENSIS, Dn.—Carboniferous.
227. SPIRORBIS CARBONARIUS.—Carboniferous. Natural size, and magnified.

TABULAR VIEW OF ANNULATA.

- ANNULATA.
  - Scolecida.
    - Sterelmintha.
      - Tœnioidea.
      - Trematoda.
      - Acanthocephala
      - Turbellaria.
    - Cœlelmintha.
      - Gordiacea.
      - Nematoidea.
      - Onchophora.
    - Rotifera.
      - Monotrocha.
      - Schizotrocha.
      - Polytrocha.
      - Zygotrocha.
  - Annelida.
    - Suctoria.
      - Hirudinidæ.
      - Clepsinidæ.
      - &c.
    - Terricola.
      - Lumbricidæ.
      - Naiidæ.
    - Tubicola.
      - Serpulidæ.
      - Terebellidæ.
      - Pectinariadæ.
      - &c.
    - Errantia.
      - Syllidæ.
      - Nereidæ.
      - Nephthydæ.
      - Aphroditidæ.
      - &c.

CLASS II.—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 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 228.). To the cephalo-thorax are also attached

Fig. 228.

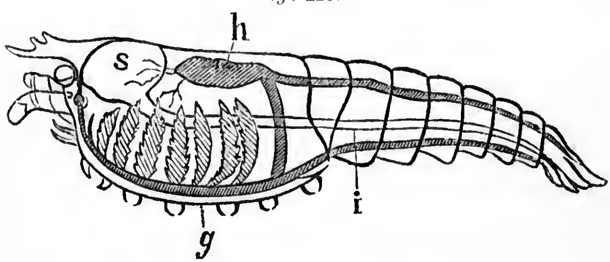


DIAGRAM OF A DECAPOD CRUSTACEAN. (*s*) Stomach. (*h*) Heart (*g*) Gills. (*i*) Intestine.

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 three 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 King-crabs, Cyprids, Trilobites, &c.

2. Tetradecapoda, or those with the feet in seven pairs, and appendages on the abdomen. These are the Opossum-shrimps, Sand-fleas, Sow-bugs, &c.

3. Decapoda, with five pairs of feet. These are the Lobsters, Crabs, &c.

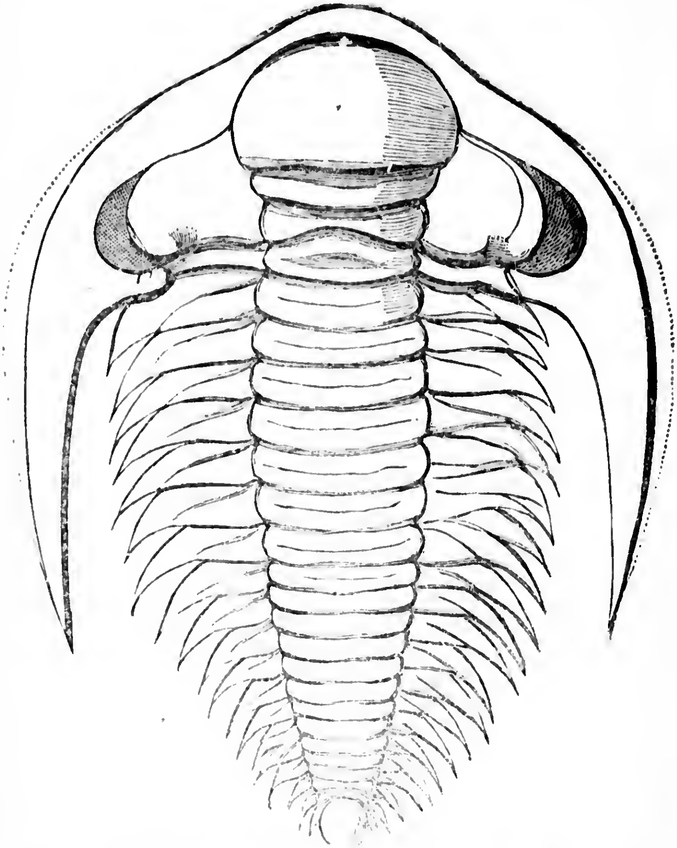
Sub-Class, 1.—Entomostraca.

The orders in this group are the following:—

1. Xiphosura.—The King-crabs or Horse-shoe Crabs. *Limulus polyphemus*, the American King-crab, is found as far north as the coast of Maine, but does not extend into British America. These creatures have the cephalo-thorax of semi-lunar form, and the abdomen reduced to two pieces, one of them being a sharp defensive appendage.

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

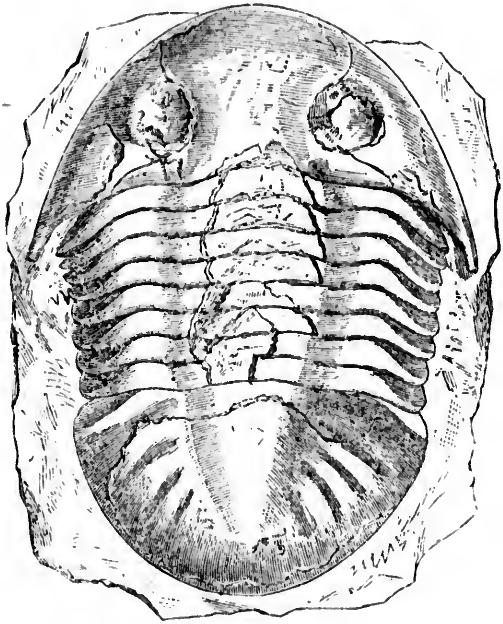
F 229.



Paradoxides Micmac, Hartt, Primordial.

divided into three lobes. The last segment which is usually similarly lobed, is named the *pygidium*. The feet of Trilobites appear to have been lamellar and adapted for swimming, but they are not certainly known. The markings on rocks known as *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. 229 to 233.]

Fig. 230.

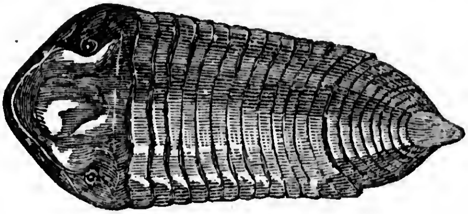


ASAPHUS NOTANS, Billings,—Middle Silurian.

Fig. 231.

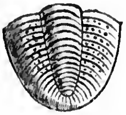
DALMANIA LOGANI, Hall—(Head & Pygidium,)—Upper urian,

Fig. 232.



HOMALONOTUS DELPHINOCEPHALUS, Green, Upper Silurian.

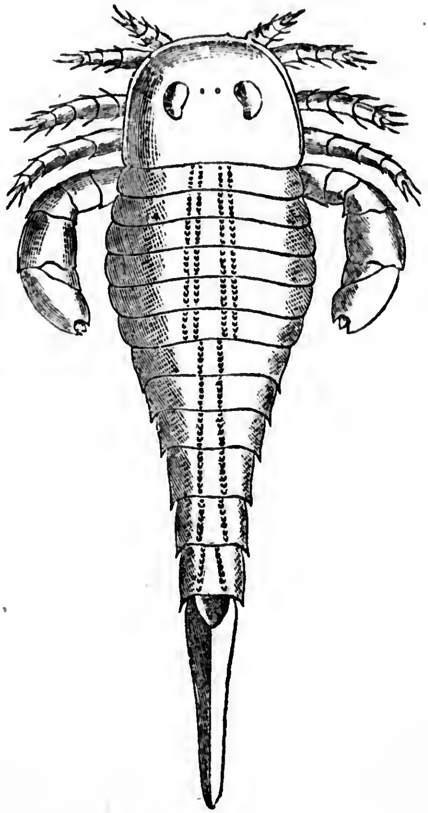
Fig. 233.



PHILLIPSIA HOWI, Billings,—(Pygidium),—Carboniferous.

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 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. 234 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*.

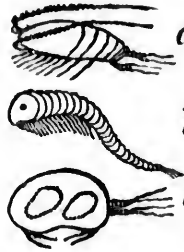
Fig. 234.



EURYPTERUS REMIPES, Dekay, (Restored),—Upper Silurian.

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 summer. (Fig. 235 b) represents a common species of *Bran-*

Fig. 235.



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

chipus, 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. 236, 237.)

Fig. 236.

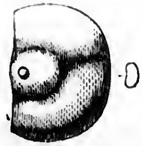


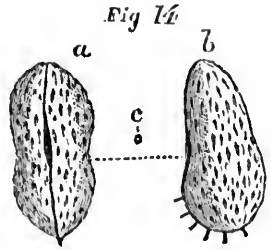
Fig. 237.

236. BEYRICHIA JONESII, Dn.—Carboniferous.
237. B. PUSTULOSA, Hall,—Upper Silurian.

5. 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.

6. 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. 235 c. represents a species of *Cypris* common in fresh-water pools and ditches, and resembling, if not identical with, *C. Agilis*, Haldeman. Fig. 238 represents *Cytheridea Mul-*

Fig. 238.

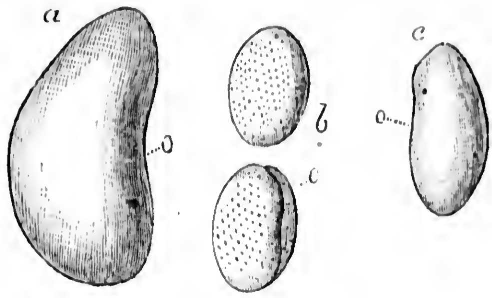


CYTHERIDEA MULLERI, Munst, (*a*) Front. (*b*) Side. (*c*) Nat. size

leri, 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. 239.)

7. Copepoda.—In these the body is shrimp-like though minute, and distinctly articulated, with

Fig. 239.



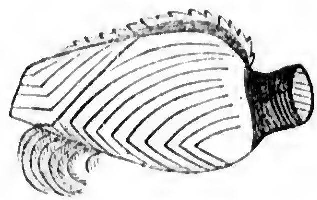
ENTOMOSTRACA,—Carboniferous.
(*a*) BAIRDIA,
(*b*) CYTHERELLA INFLATA.
(*c*) CYTHERE.

many pairs of swimming limbs. The females are remarkable for their large pendent 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. 235 a. is remarkable for its luminosity at night, often causing great breadths of the Gulf of St. Lawrence to be phosphorescent.

8. 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. 240 represents *L. dentata*, a species

Fig. 240.

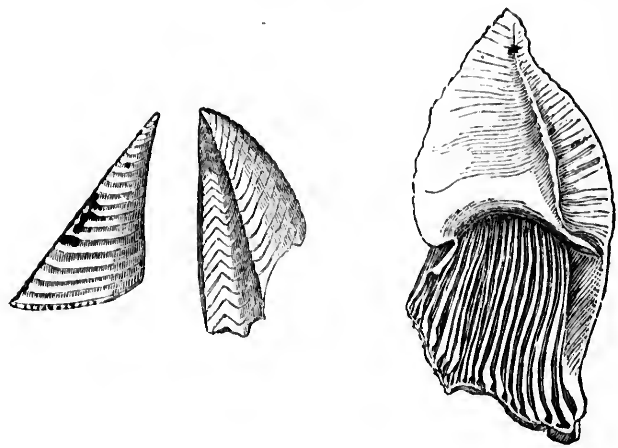


LEPAS DENTATA, Gould.

common on the Atlantic coast, and which may be a variety of *L. anatifera*. The valves which cover these creatures are five in number; 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. 241 represents portions of our largest acorn-shell.

9. 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 pendent ovisacs, and the males are animals of much smaller size and of different form. The Epizoa are curious objects for examination

Fig. 211.



BALANUS HAMERI, Opercular valves and Body valve.

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.—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 antennæ with great agility, grappling with its fore limbs anything that may come within its reach.

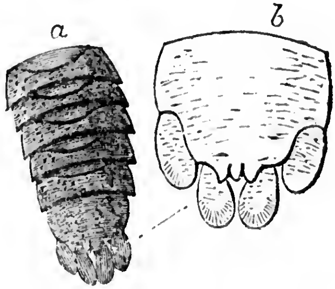
2. Isopoda.—The Isopods have the abdomen somewhat similar to the cephalothorax, and the body usually flattened, the thoracic limbs subequal, the abdominal branchial, and in the female plates for sheltering the spawn on the abdomen. The genus *Asellus* (*A. Communis*, Say, Fig. 242) is

Fig. 242.

ASELLUS COMMUNIS, Say

found in our fresh-water streams, 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 in Gaspé 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.

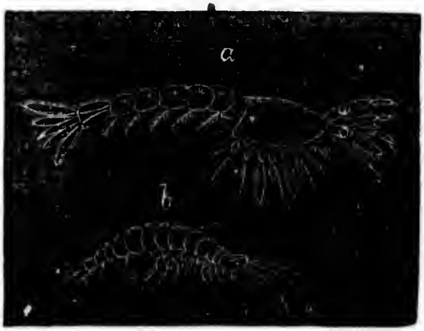
3. **Amphipoda.**—These have the thoracic limbs unequal, and with vesicular branchial organs at their bases. The abdomen is terminated by appendages for swimming or leaping. The body is usually compressed laterally and curved. The Amphipods are the "beach-fleas," "sand-hoppers," &c., and are very numerous on the 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. 243 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. 244.)



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. 293a) is abundant along the

Fig. 243.



MYSIS SPINULOSUS. (*b*) GAMMARUS MINOR.

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 sub-class.

Sub-Class 3.—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. 228 p. 192, 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

* Acadian Geology, second edition.

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 these is that represented in Fig. 245,

Fig. 245.

CRANGON VULGARIS, Fabr.

Crangon vulgaris, 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 characterised 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.

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' "Crustacés" 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 Stimpson and others in the proceedings of American societies.

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 III.—Insecta.

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

In the typical 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.

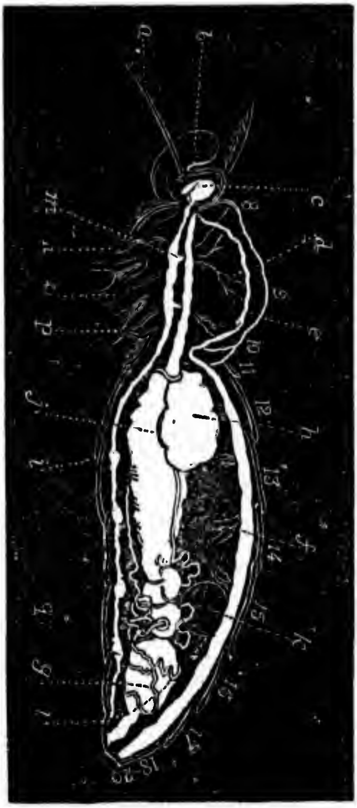
The head in the typical insects is regarded by most entomologists as composed of several rings or segments consolidated together. Its appendages may be divided into sensory and oral. The first are the eyes, ears and tactile organs. The eyes in adult insects are in two masses, or compound eyes, consisting of numerous simple eyes, each having a hexagonal or quadrangular cornea, a crystalline lens and a division of the optic nerve imbedded in pigment. Beside these there are separate ocelli, usually three in number, on the top of the head. Some uncertainty exists as to the hearing in insects, but this sense is generally believed to reside in the antennæ or jointed organs attached to the front of the head, which are at least very delicate organs of touch, much employed by insects in directing their movements.

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 rders, 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 sub-divisions, 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

Fig. 246.



ANATOMY OF SPHINX LIGUSTRI—after Newport.

(*a*) Maxillae 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.

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. 246.)

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*.

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.

The above statements apply to the typical or six-footed insects; and only partially to an aberrant group usually included in the class—the Myriapods, or centipedes and their allies.

If we include the myriapoda with the insects, it becomes necessary to divide the class into two sub-classes, *Myriapoda* and *Hexapoda*, the orders in which are as follows:—

Sub-class—Myriapoda.

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 class. In their general form of body, and in their development 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. 247.) It lives

Fig. 247.

IULUS VENUSTUS, Wood.

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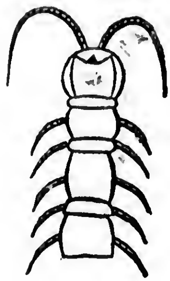
* Diplopoda, Blainville.
† Chilopoda, Latreille.

among decaying vegetable matter, on which it feeds, and when disturbed curls itself up. Of the other division one of our common representatives is *Lithobius Americanus*. (Fig. 248). The centi-

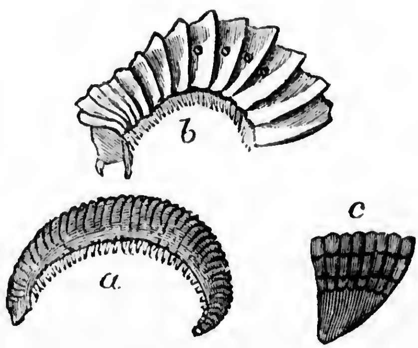
Fig. 248.



LITHOBIUS AMERICANUS, Newport,—Anterior segments enlarged.

pedes, of which this creature is an example, are carnivorous and active in their habits, and furnished

Fig. 249.



CARBONIFEROUS MYRIAPODS. (*a*) XYLOBIUS SIGILLARIAE, Dn. (*c*) Posterior Segments enlarged. (*b*) ARCHIULUS XYLOBIOIDES, Scudder.

with poisoned fangs. Some of the tropical species attain to a great size and inflict formidable bites.

The Carboniferous period seems to have been more favorable to the herbaceous myriapods than the modern time. In the coal-formation of Nova Scotia, six species have been found. One of these *Xylobius sigillariae*, is represented in Fig. 249. a and c, and another *Archiulus xylobioides* in Fig. 249 b.

Sub-class Hexapoda.

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

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. These 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. These 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 hemi-metabolian, the larvæ having six feet and the thorax and abdomen distinct. These are the Bugs, Water-boatmen, Plant-lice, &c.

Order 7. Neuroptera.—These have four membranous 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. These 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.

1. Aptera.

We figure as an illustration of this order the too well-known *Pediculus humanus*(Fig. 250) an exter-

Fig. 250.

PEDICULUS HUMANUS CAPITIS, De Geer.—magnified.

nal parasite 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.

2. Aphaniptera.

The Fleas, of the genus *Pulex*, are remarkable for their leaping powers, and the highly irritating nature of the poison which they appear to inject into the 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.

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

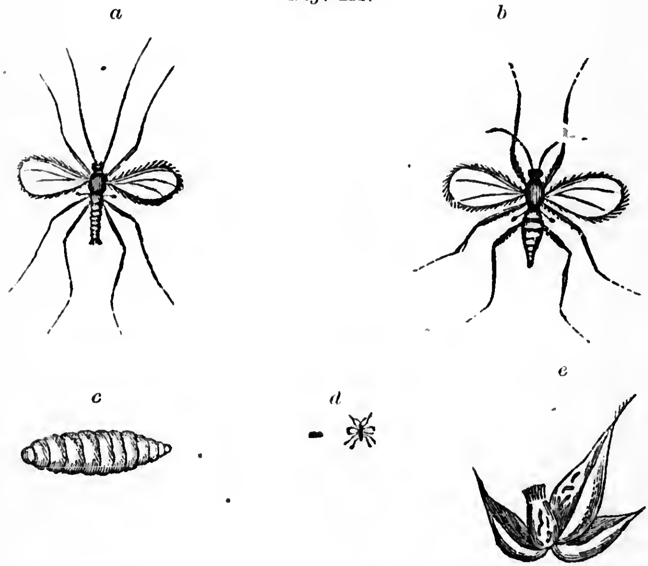
The *Tabanidæ* or biting Horse-flies, *Tabanus*, &c.

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

The *Culicidæ* 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 to the wheat crop in America. The imago and larvæ are shewn in (Fig. 251.) The

Fig. 251.



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

animal deposits its eggs in the ears of the 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 winter,

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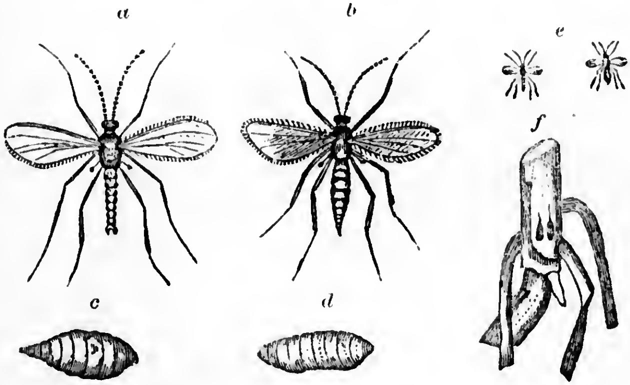
* The latter name is incorrect, the true weevils being Coleoptera.

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 "Hessin 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. 252. A proper rotation of crops is the surest remedy for the ravages of the Hessian fly.

Fig. 252.

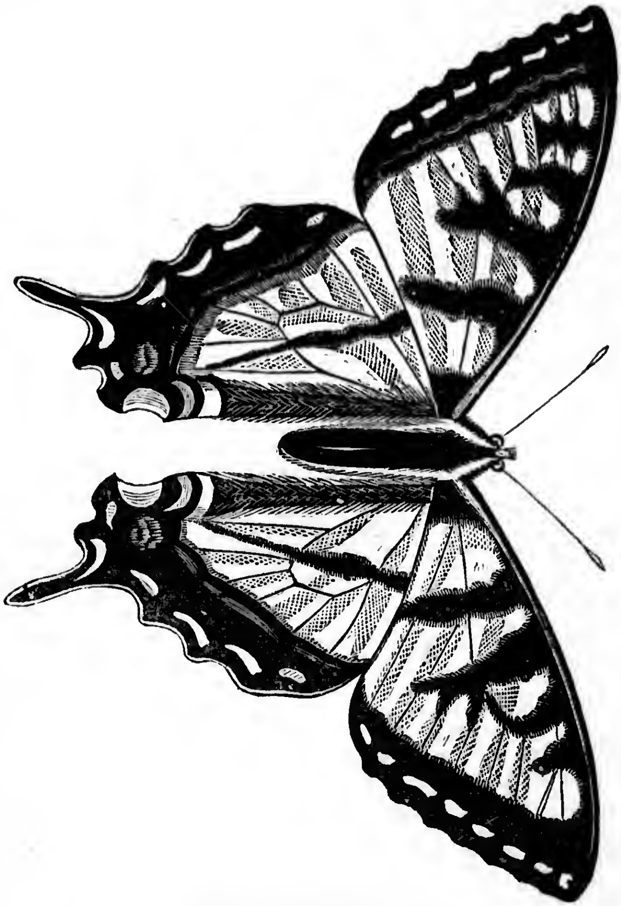


CECIDOMYIA DESTRUCTOR, Say. (*a*) Male, magnified. (*b*) Female, magnified, (*c*) Larva, magnified, (*d*) Pupa, magnified, (*e*) Imago natural size. (*f*) Joint of wheat with larvæ.

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

Fig. 253.

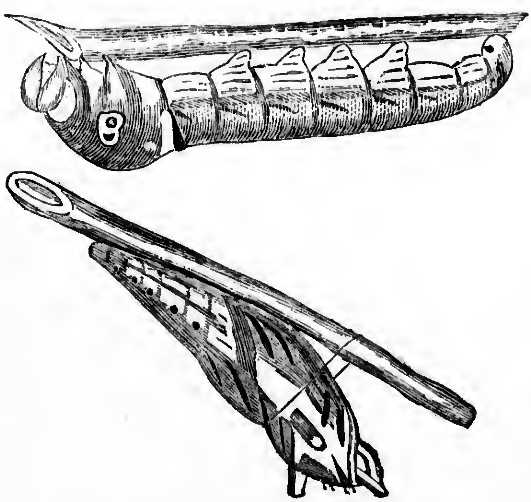


Papilio Turnus, Lin.

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 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. 253) 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,

Fig. 254.



PAPILIO TURNUS, Larva and Pupa.

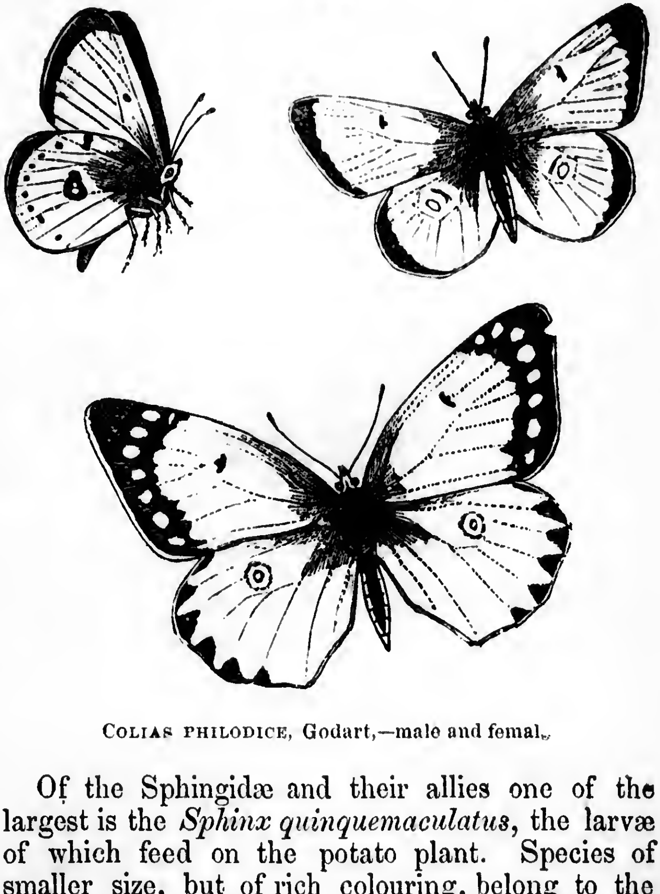
and remains by day on a silken platform spun by itself and stretched between the edges of a leaf. It feeds at night. When ready to become a chrysalis, it suspends itself by a button of silk at the tail, and a loop supporting the back. (Fig. 254.) Another common and beautiful species is the "Camberwell Beauty" (*Vanessa Antiopa*) whose spiny caterpillars feed on elm and other trees. (Fig. 255.)

Fig. 255.

VANESSA ANTIOPA, Lin.

The "Clouded 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. 256.) 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. 256.



COLIAS PHILODICE, Godart,—male and female.

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. 257 represents a pretty little *Alypia*, described by

Fig. 257.

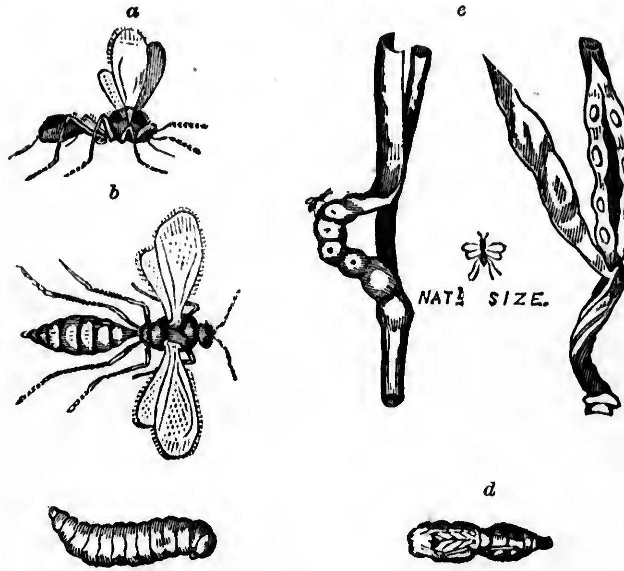
ALYPIA LANGTONII, Cooper.

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

5. 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 makes 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. 258). More typical examples are furnished by

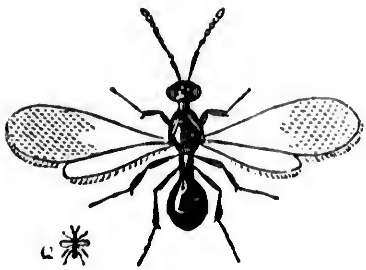
Fig. 258.



EURYTOMA HORDEI, Harris. (*a*) Male, magnified. (*b*) Female, magnified. (*c*) Larva, magnified. (*d*) Pupa, magnified. (*e*) Injured stalk of grain.

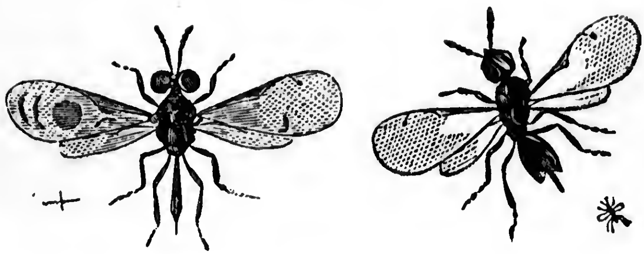
the minute insects of the genera *Platygaster* and *Macroglenes*, whose larvæ prey upon those of the wheat midges and similar insects. Figs. 259 and 260.

Fig. 259.



PLATYGASTER TIPULAE, Kirby. (*a*) natural size.

Fig. 260.



MACROGLENES PENETRANS, Kirby,—male and female magnified.

Sub-order (3) *Aculeata.* or those possessing stings, of which the Bees (*Apiariæ*) and Wasps (*Vespiariae*) are the typical examples. The Ants (*Formicariae*) are an aberrant group. Fig. 261 represents one of the smaller species of Sand-wasps, (*Pompilidæ*) which make burrows in the ground, in which they deposit the bodies of spiders and caterpillars, as food for their young.

Fig. 261.

SAND-WASP, Pompila?

C. 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 (*Cereus tristis,*) De Geer, (Fig. 162) may be taken as an example of a large group of these insects living on plants and sucking their juices. *Notonecta undulata*, Say, (Fig. 263) is an

Fig. 262.

Fig. 263.

262. CEREUS TRISTIS, De Geer.
263. NOTONECTA UNDULATA, Say.

example of the 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. 264) is very destructive

Fig. 264.

ERYTHRONEURA VITIS, Harris,—magnified.

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 groups the females are wingless.

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. 265.

Fig. 265.

EPHEMERID (Baetis.)

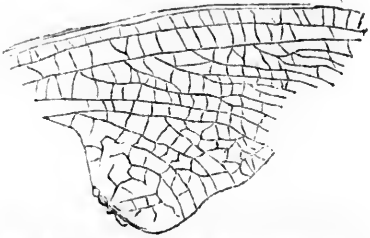
represents one of our species. The larvæ of these creatures feed on vegetable matters in the bottom of the water, and themselves furnish much food to fresh-water fishes. To the same order belong the Dragon-flies, (*Libellula*, &c.) which are highly carnivorous and predaceous, catching other insects on 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. 266 to 268.)

Fig. 266.

XENONEURA ANTIQUORUM, Scudder,—Devonian.

Fig. 267.



PLATEPHEMERA ANTIQUA, Scudder,—Devonian.

Fig. 268.

HAPLOPHLEBIUM BARNESI, Scudder,—Carboniferous, Wing in ale, with a fern leaf.

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. 269), but there are

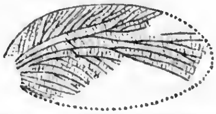
Fig. 269.

268. CALOPTENUS FEMUR-RUBRUM

numerous 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. 270.)

Fig. 270.



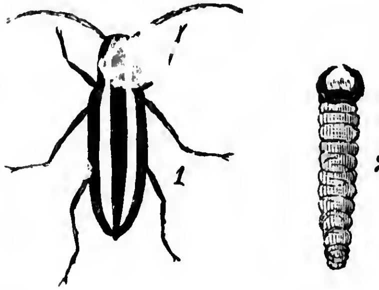
269. ARCHIMULACRIS ACADICUS, Scudder,—Carboniferous.

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. 271) 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 *Scarabaeidæ* 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. 272) is, in its larval state, the "Apple-

Fig. 271.

Fig. 272.



270. CALASOMA CALIDUM.
271. SAPERDA CANDIDA, Fab. (1) Imago. (2) Larva.

tree-borer," and another *Stenocorus villosus*, is the "Oak-pruner," whose name indicates its work in breaking off the twigs of trees by the boring action of its larvæ. *Monohammus confusor** (Fig. 273), 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 cucumber-beetle is a well-known example, and a similar species is often injurious to potatoes. 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.

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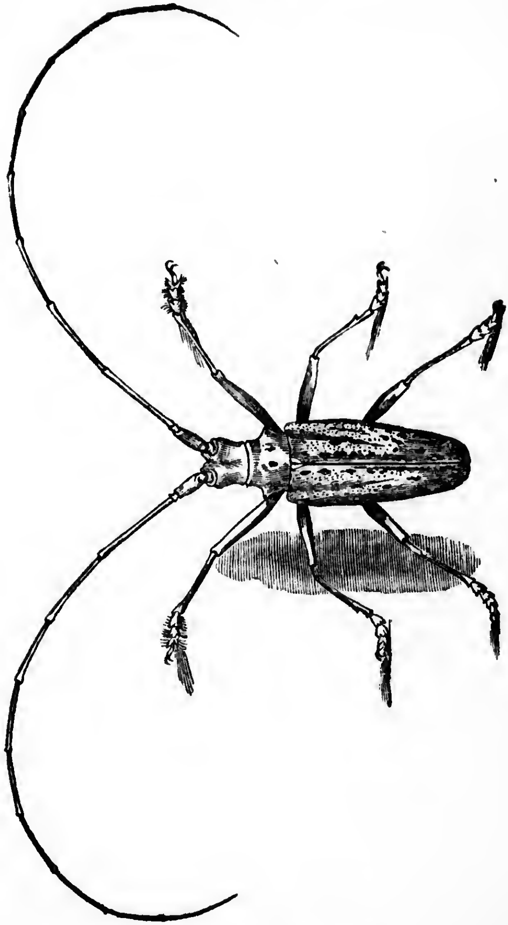
* See a paper by Billings, *Canadian Naturalist*, vol. vii.

Fig. 273.



MONOHAMMUS CONFUSOR.

Important catalogues of several orders of American insects have been published by the Smithsonian Institution; Packard's Guide to the Study of Insects, just published, is a valuable introduction to the subject of Entomology, and contains notices of nearly all the common American species. Harris' "Insects Injurious to Vegetation," and Fitch's "Reports on the Insects of New York," are also very valuable.

TABULAR VIEW OF INSECTA.

Insecta.	Myriapoda.	Chilognatha
		Syngnatha.
	Hexapoda.	Aptera.
		Aphaniptera.
		Diptera.
		Lepidoptera.
		Hymenoptera.
		Homoptera.
		Neuroptera.
		Orthoptera.
		Coleoptera.

For the families of insects the student must refer to special works on Entomology.

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 tentacles 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. Trachearia.—These have the cephalo-thorax in one or two joints, and respire by tracheæ. They are the Mites and Ticks.

Order 3. Pulmo-trachearia.—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. Pulmonaria.—These have the abdomen and cephalo-thorax separate, and the former articulated. They respire by pulmonary sacs furnised with lamellæ. They are the Scorpions and their allies.

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 mumber 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.

2. Trachearia.

The animals of this order are very diverse in form and habits, but the greater part of them belong to the group of Acarina or 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. 274). It abounds

Fig. 274.

ACARI—after Packard. (1) IXODES BOVIS, Riley. (2) ACARUS (Tyroglyphus) SACCHARI.—Magnified.

in the more impure 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. 274 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.

2. Pulmo-trachearia.

The true spiders differ from the mites in the distinct separation of the thorax and abdomen, and also in the possession 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. 275). The spiders of this coun-

Fig. 275.

EPEIRA VULGARIS, Hentz—after Emerton. (1) Eyes and Mandibles, magnified—*c* First Joint of Mandible, *a* Point of do.
(2) Underside.—*a* Legs, *b* Palpi, *c* Mandibles, *e* Spinnerets and above these the Stigmata.

try 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 number 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.

3. Pulmonaria.

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.

TABULAR VIEW OF ARACHNIDA.

ARACHNIDA.	*Dermophysa.*	Tardigrada. Nulligrada. Levigrada.
	Trachearia.	Acarina. Phalangina. Pseudo Scorpii.
	Pulmo-trachearia	Mygalidæ. Lycosidæ. Salticidæ. Drassidæ. Epeiridæ. Agelenidæ. Dysderidæ, &c,
	Pulmonaria.	Phrynidæ. Scorpionidæ.

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."

PAPILIO ASTERIAS—male and larva.

APPENDIX A.

As the Vertebrata cannot be included in this volume, the following summary is given to represent this sub-kingdom until the work can be completed.

Province IV—VERTEBRATA.

Bilateral, symmetrical; skeleton internal, vertebrate; nerve system myelencephalous, and based on a brain and dorsal nervous chord lodged in a special vertebral cavity. Heart compact, muscular, with 2 or 4 chambers; blood red; respiratory organs connected with pharynx. Extremities normally four in number; jaws moving vertically.

Class 1. *Pisces*—Fishes.
" 2. *Reptilia*—Reptiles and Batrachians.
" 3. *Aves*—Birds.
" 4. *Mammalia*—Mammals.

Class I.—Pisces.—Heart in 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. (Reference, Owen's Lectures on the Vertebrata.)

Order 1. *Dermopteri*—ex. Amphioxus, Petromyzon.
" 2. *Malacopteri, or Physostomata.*
(*a*) *Apodes.*
Muraenidæ—ex. Muraena.
Gymnotidæ—ex. Gymnotus.
(*b*) *Abdominales.*
Clupeiadæ—ex. Clupea.
Salmonidæ—ex. Salmo.
Cyprinidæ—ex. Cyprinus, Leuciscus, Catastomus.
Esocidæ—ex. Esox.
Siluridæ—ex. Pimelodus.

Order 3. *Pharyngognathi.*
Scomber-escocidæ—ex. Scomber-esox, Exocetus.
Cteno-Labridæ—ex. Ctenolabrus, Tautoga.
Cyclo-Labridæ—ex. *Labrus.*

Order 4. *Anacanthini.*

Ophididæ—ex. Ophidium, Ammodytes.
Gadidæ—ex Morrhua, Merlangus.
Pleuronectidæ—ex. Hypoglossus, Platessa.

Order 5. *Acanthopteri.*

Percidæ—ex. Perca, Lucio-Perca, Centrarchus, Pomotis.
Sclerogenidæ — ex. Trigla, Cottus, Gasterosteus.
Scomberidæ—ex. Scomber, Thynnus.
Labyrinthobranchidæ—ex. Anabas.
Blenniidæ—ex. Anarrhicas.
Lophiidæ– ex. Lophius, Malthea.

Order 6. *Plectognathi.*

Balistidæ—ex. Balistes.
Ostracionidæ—ex. Ostracion.

Order 7. *Lophobranchii.*

Syngnathidæ—ex. Syngnathus, Hippocampus.

Order 8. *Ganoidei.*

Lepidosteidæ—ex. Lepidesteus.
Polypteridæ—ex. Polypterus.
Amiidæ—ex. Amia.
Sturionidæ—ex. Accipenser.

Order 9. *Protopteri.*

Sirenoidei—ex. Lepidosiren.

Order 10. *Holocephali.*

Chimaeroidæ—ex. Chimaera.

Order 11. *Plagiostomi.*

Cestracionidæ—ex. Cestracion.
Carcharidæ—ex. Carcharias.
Lamnidæ—ex. Lamna. Selache.
Galeidæ—ex. Mustelus.
Spinacidæ—ex. Spinax.
Scymnidæ—ex. Scymnus.
Zygaenidæ—ex. Zygaena
Pristidæ—ex. Pristis.
Raiidæ—ex Raia, Pastinaca, Cephaloptera.

The fishes may also be arranged in the following manner, which is very useful for geological purposes: (1.) *Dermopteri*, cartilaginous fishes without scales, (Lampreys, &c.) (2.) *Teliosts*, or ordinary Bony Fishes, having for the most part horny scales. (3.) *Ganoids*, Fishes with bony plates or scales, often shining or enamelled. The numerous fossil fishes of the Palaeozoic rocks belong principally to this group, and may be divided into Placo-ganoids or those covered with plates, and Lepido-ganoids, or those covered with imbricated scales. (4.) *Selachians*, or sharks, rays and their allies. These have a cartilaginous skeleton, and usually have Placoid scales, or rough bony points as a protection to the skin.

Class II.—Reptilia. Heart ordinarily in three cavities (two auricles and one ventricle); respiration by lungs, or by gills and lungs; limbs, when present, usually adapted for motion on land. Skin protected by scales or plates, or naked. Reproduction oviparous or ovo-viviparous.

Sub-Class 1. *Batrachia* or Amphibia.

Order 1. *Apoda*—ex. Caecilia.

" 2. *Amphipneusta*—ex. Siren, Proteus, Menobranchus, Menopoma.

" 3. *Urodela*—ex. Salamandra, Triton.

" 4. *Anura*—ex. Rana, Bufo, Hyla.

Extinct Batrachians furnish two additional groups, probably of ordinal value:—*Ganocephala*, *Labyrinthodontia*.

Sub-Class 2. *Reptilia*, proper.

Order 1. *Chelonia*.

Chelonidæ—ex. Chelonia.

Trionycidæ—ex. Aspidonectes.

Chelydridæ—ex. Chelydra.

Emydæ—ex. Chrysemys, Emys, Cistudo, Glyptemys.

Testudinidæ—ex. Testudo.

Order 2. *Ophidia*.

Crotalidæ—ex. Crotalus, Pelias.

Coluberidæ—ex. Coluber, Tropidonotus, Calamaria, Heterodon.

Boiidæ—ex. Boa, Wenona.

Typhlopidæ—ex. Rena.

Order 3. *Sauria.*
Scincidæ—ex. Scincus, Anguis.
Lacertinidæ—ex. Lacerta, Zootoca.
Monitoridæ—ex. Monitor.
Geckotidæ—ex. Platydactylus.
Chameleonidæ—ex. Chameleon.
Iguanidæ—ex. Iguana, Phrynosoma, Amblyrhyncus.
Agamidæ—ex. Draco.
Order 4. (*Loricata*)—ex. Gavialis, Crocodilus, Alligator.
Extinct genera.—Teleosaurus, Stenosaurus.

Additional orders have been proposed to include extinct reptiles. These are,

Ord. *Ichthyopterygia*—ex. Ichthyosaurus.
Ord. *Sauropteryiga*—ex. Plesiosaurus.
Ord. *Anomodontia*—ex. Dicynodon.
Ord. *Pterosauria*—ex. Pterodactylus.
Ord. *Dinosauria*—ex. Megalosaurus.

The animals of the last group were probably the highest of Reptiles in point of rank.

Class III.—Aves.—Heart in four cavities; respiration by lungs; anterior limbs modified for flight; clothing, feathers; reproduction, oviparous.

Order 1. (*Natatores.*)
Fam. *Anatidæ*—ex. Mergus, Fuligula, Anas, Anser.
" *Laridæ*—ex. Sterna, Larus.
" *Procellaridæ*—ex. Thalassidroma
" *Pelecanidæ*—ex. Phalacracorax.
" *Colymbidæ*—ex. Colymbus.
" *Alcidæ*—ex. Uria.
" *Podocepidæ*—ex. Podiceps, Fulica.

Order 2. (*Grallatores.*)
Fam. *Phalaropidæ*—ex. Phalaropus.
" *Recurvirostridæ*—ex. Himantopus.
" *Charadriadæ*—ex. Charadrius.
" *Rallidæ*—ex. Rallus, Gallinula.
" *Scolopacidæ*—ex. Numenius, Tringa Scolopax.
" *Ardeidæ*—ex. Ardea.

Order 3. (*Cursores.*)
Fam. *Struthionidæ*—ex. Struthio.
" *Apterygidæ*—ex. Apteryx.
Extinct genera—Epiornis, Dinornis.

Order 4. (*Rasores.*)
Fam. *Tetraonidæ*—ex. Tetrao, Ortyx.
" *Cracidæ*—ex. Crax, Penelope.
" *Phasianidæ*—ex. Meleagris.
" *Columbidæ*—ex. Ectopistes, Columba.

Order 5. (*Insessores.*)
(*a*) *Conirostres.*
Corvidæ—ex. Corvus.
Fringillidæ—ex. Fringilla, Emberiza.
Ampelidæ—ex. Bombycilla.

(*b*) *Dentirostres.*
Laniidæ—ex. Lanius.
Muscicapidæ—ex. Muscicapa.
Merulidæ—ex. Turdus.
Sylviadæ—ex. Sylvia, Syalia, Regulus.
Vireonidæ—ex. Vireo.
Certhiadæ—ex. Certhia.

(*c*) *Fissirostres.*
Hirundinidæ—ex. Hirundo, Cotyle.
Caprimulgidæ—ex. Caprimulgus.
Halcyonidæ—ex. Alcedo.

(*d*) *Scansores.*
Picidæ—ex. Picus.
Cuculidæ—ex. Coccyzus.
Psittacidæ—ex. Conurus.

(*e*) *Tenuirostres.*
Trochilidæ—ex. Trochilus.

Order 6. (*Raptores.*)
Vulturidæ—ex. Cathartes, Gypaetos.
Strigidæ—ex. Bubo, Surnia.
Falconidæ—ex. Aquila, Buteo, Falco.

Class IV.—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.

(Sub-Class *Lyencephala.*)

Order 1. *Monotremata*—ex. Ornithorhyncus, Echidna.

" 2. *Marsupialia.*

(*a*) (*Phytophagous*)—ex. Phascolomys, Macropus, Phascolarctos, Petaurus.

(*b*) (*Sarcophagous*)—ex. Didelphys, Chironectes, Myrmecobius, Peracyon.

(Sub-Class *Lissencephala.*)

Order 3. *Rodentia*—ex. Mus, Arctomys, Arvicola, Sciurus, Tamias, Jaculus, Lepus, Hystryx, Castor.

" 4. *Insectivora*—ex. Sorex, Condylura.

" 5. *Cheiroptera*—ex. Vespertilio.

" 6. *Bruta*—ex. Myrmecophaga, Dasypus, Manis, Bradypus.

Extinct Genera—Megatherium, Mylodon.

(Sub-Class *Gyrencephala.*)

Mutilata.	Order 7. *Cetacea*—ex. Balæna, Balænoptera, Physeter, Monodon, Beluga, Phocæna. " 8. *Sirenia*—ex. Manatus.
Ungulata.	" 9. *Pachydermata.* (*a*) Proboscideæ—ex. Elephas. (*b*) Perissodactyla — ex. Rhinoceros, Tapirus, Equus. (*c*) Artiodactyla—ex. Sus, Hippopotamus, Extinct Pachyderms. Palæotherium, &c. " 10. *Ruminantia*—ex. Bos, Ovis, Capra, Camelus.
Unguiculata.	" 11. *Carnivora*—ex. Felis, Ursus, Mustela. " 12. *Quadrumana*—ex. Lemur, Pithecia, Hylobates, Simia, Troglodytes.

(Sub-Class *Archencephala.*)

Order 13. *Bimana*—ex. Homo.

APPENDIX B.

DIRECTIONS FOR COLLECTING AND PRESERVING INVERTEBRATE 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 Institute, 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.

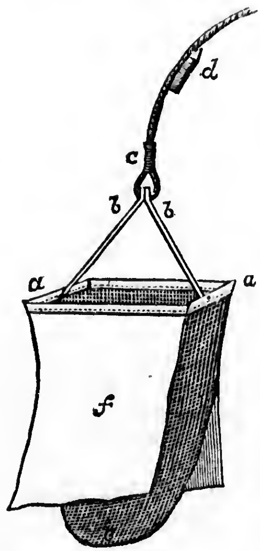
1. *General directions for collecting Marine Animals.*

"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.*

2. *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 perfo rated 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 abo' 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 slo 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."—*Smithson an Directions.*

3. *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 earthy 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.

4. *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.

5. *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.

6. *Hydrozoa and Anthozoa.*

"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 (*Acalephæ*) 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.*

7. *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 the 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, 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 in an extended condition."—*Davies.*

8. *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 Mollusca, 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 the presence of scores of serpulæ 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*.

9. *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, 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 the piece of stone or wood on which they are found."—*Davies*.

10. *Insects*.

"The harder kinds may be put in liquor, as above, but the vessel or bottle should not be very large. Butterflies, 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 should 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 kreosote occasionally introduced will also answer the same purpose." —*Smithsonian Directions.*

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