LECTURER NOTES

On

INVERTBRATE TAXONOMY

For

THIRD YEARS (CHEMISTRY AND ZOOLOGY)

PREPARED BY

Prof. Dr

AHMED SAYED MOUSTAFA

Prof of Invertebate Zoology

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PRINCIPLES OF SYSTEMATIC ZOOLOGY

The number of animals inhabiting the earth today is more than one million. Since it is impossible for man to keep in mind separately all the millions of animals which exist. He must of necessity arrange them into groups. This arrangement is created the origin of classification or taxonomy or systematic. In such a system animals with several similar characters are placed together in the same group. Members of a group will show marked similarities and many features common with other members of their own group. So the branch of zoology for grouping or classification of animals on a scientific bases is called taxonomy or systematic zoology.

Taxonomy is a man-made system for orderly storage and retrieval of things or bits of information about them. As we said before the different kinds of organism run into millions. We can refer to them each has a name and place in a classification system which shows its relationship with other organisms. Naming and classification providing a terminology which essential in the exchange of knowledge and ideas in research and teaching. Terms represent information by implication. The name Echinus, for example, means to zoologists not only particular genus of sea Urichin but also a particular body structure, mode of life and so forth. When we speak of the Echinodermata we imply a range of animals with various characters in common but with a particular diversity in form, behavior and distribution. The terminology of classification is part of the languae of the science of biology. Its importance increases as the subject expands into new fields of knowledge, such as ecology, when the recognition of different kinds of organism and the interaction between them forms a significant part.

Before we going further we have to know what is the meaning by these terms systematic, classification, taxonomy and nomenclature.

A- <u>Systematic</u> : Is the scientific study of the kinds and diversity of organisms on of any and all relationships among them. The term was originally stemmed from the Greek word system.
B- <u>Zoological classification</u>: is the ordering of animals into groups (or sets) on the bases of their relationships of association by similarity.
C- <u>Taxonomy</u> : The term was derived from the Greek word taxis, meaning arrangement and nomos, meaning low. So, taxonomy is the theoretical

study of classification, including its bases, principles, procedures and rules.

D- Zoological nomenclature : Is the application of distinctive to each of the groups recognized in any given Zoological classification. Thus nomenclature is an essential or secondry outcome of classification.

History of scientific taxonomy :

The History of classification goes back to early man, who distinguished one group and another by purely personal and practical criteria. For example, he would think of plant as harmful or harmless, edible or inedible, and some what the same standards would be used in classification of animals. We still talk of weeds, flowers, of fruits, and vegetables, and of herbivores and carnivores.

One of the first persons collected and organized an animals classification system was the Greek philosopher Aristotle (384-322), who characterized animals according to their way of living, their actions. Their habitats and their body parts. He classified about 500 types of animals in 11 categories according to their structure form and their degree of development at birth. He arranged the animals world in a hierarchy a graded series in which he remarked different categories one above the other.

The first attempt to classify the known animals in a scientific man called John Ray (1627-1705) and a Sweden man called Carlos Linnaeus (1707 – 1778). Ray classified some of 18.600 species of plants according to general differences in anatomical organization. He did the same for animals, arranged them in six classes: quadraoeds, birds, amphians, fishes, insects and worms. A century later. Linnaeus personally classified 18.000 species of plants. He also, did classification for animals and diseases.

Naming Animals (nomenclature) :

Any system of classification demands a method of naming. Any method of naming things is arditray, though in biology many of the names refer to some characteristic or property of the organism. The schema which is universally adopted is the binomial system, devised by Linnaeus, and used in his book systema Naturae , which was written in latin, 1758 (10^{th} edition). Since this was the international languae for communication between scholars. Biological classification as we use it today dates from the 18^{th} century and is based on the binomial system, a standard method for naming plants and animals. Under the binomial system, each species: plant or animal has two names. The first is the generic name which indicates the genus to which it belongs and always written with a capital letter as a latin singular (whatever its derivation) thos – Arenicola. Care should be taken to see that the generic name is used correctly. When it used as a common name or nouns it should be written with a small letter. The second is the trivial name often called the specific name which designating the species to which the organism belongs. It is not capitalized and is treated as latin noun in apposition with the generic name thus marina. The name of the species therefore is the binomial, in this case Arenicola marina. Generic and specific names are normally printed in italics, except as the title of a paragraph or a list.

Where it is desired to give the author of a specific name, it should be follow the name without a comma and should be printed in Roman type e.g. *Mytilus edulis* L.; *Littorina saxatilis* olive. *Lasaea rubra* (Montagu, 1803), (Cardium rubra). It must be borne in mind that the auther thus quoted is the one who first applied the specific name to the species in question in a printed publication, and not necessarily the one who first employed the particular combination of generic and specific names that is being used. Abbreviations for authors name are frequently, but are of little value unless the reader is a specialist. The initial L.is, however, in general used for Linnaeus. Attempts have been made to establish universal name-endings for the higher categories, but except in a few instaces, no real agreement has been reached. In Zoology, names of families are formed by adding the termination idea to the stem of the name of the type genus, e. g. Ranidae from Rana, the Frog; Lasaeidae from Lasaea, Bivalve. Subfamily names in zoology are formed by adding inae to the stem e.g. fasciolinae, from Fasciola; Lasaeinae from lasaea. There is no uniformity in the size of categories; any group may contain from one to many hundreds.

Linnaeus and nomenclature:

Although lists of names in binary from appeared more than once in 15th century manuscripts and were more extensively used by Gaspand Bauhin at the end of the 16th century and then by Joachim Jug a little later, it was karl Linnaeus who established the system. Linnaeus was Swedish biologist who set himself the task of recording the animals and plants as God had created them. He produced classified lists of names, many of which were binary, gave a brief description of the plants and animals and arranged them according to a variety of characters which seemed to him to be important. The first was species planetarium published in 1753 and containing binary names for over 7000 plants. For the animals Linnaeus achieved similar uniformity in the 10th edition of his systema Naturea in 1758. These works now constitute the origins of modern botanical and zoological nomenclature and names given before these dates are considered invalid. Although the same name cannot be used for two different animals, it can be used for a plant and an animal, that is the name for plant cannot preoccupy that for an animal. For example Bougainvillea applies both to a tropical shrup and to a colonials hydrozoan. So, Linnaeussuccessfully formulated a system of classification of living organisms depending on superficial resemblances in structure, colour, habit (aquatic- terrestrial) diet (carnivores- herbivores – omnivores) rtc.

The Linnaean hierarchy:

In addition to introducing the binomial system, Linnaeus subdivided the plant and animal kingdoms into group on taxa. In the 1st edition of the Systema Naturae the natural world of plants and animals is divided into a decending sequence of categories as follows :

Empire

Kingdom

Class

Order

Genus

Species

Variety

The animals known to Linnaeus were thus arranged in a single scheme from Man to worm. The names given to the groups were all latinised, those in the categories above the genus, unlike generic and subgeneric names, being treated as plurals. Empire and variety are no longer recognized as legitimate terms in formal classification although varietal names are sometimes used informally. Later workers increased the number of categories by adding the phylum and family. The Linnaeus hierachy has thus been modified to give the following seven obligatory categories into which in modern taxonomic practice all animals must be classification.

Kingdom

Class

Order

family

Genus

Species

These are sufficient for a relatively small group of animals, but some such as the arthropods, are so numerous and diverse that five categories below phylum level results in groups that are still too large and heterogeneous for convenient systematic handling. In this case the number of categories can be increased by using the prefixes supers, sup-, and infra- while other categories, not obligatory, for example, division, cohort, trible, may also be embloyed.

Units of classification:

The basic unit of classification is the species. It adopted by Linaeus and it has been used ever since. A species has never been defined to the satisfaction of all biologists, but when applied to group of organisms. It indicates that have certain common characteristics. An attempt to define a species has been made as follow:

1. A species is a group of organisms which do not differ from one another more than the offspring of a single pair may do.
2. Gradations from one species to a closely related one, do not occure. There is no intermediate forms, but sharp and distinct differences between each species and any other.
3. Members of a species can interbreed freely with one another but not usually with members of another species; if they do, the hybrid offspring are infertile.
4. Usually, the geographical locations inhabited by a particular species, are distinct from those inhabited by most nearly related species.

It must be pointed out that there are exceptions to each of above cretitie thus, there is no clear definition which will suit all cases. Perhaps, the commonest method of distinction is the non-interbreeding characteristic.

From the species, we group organisms in upward manner as previous description. A group of species which are closely related form a genus, and genera are further grouped into a family. Families with closed relationship are placed in the same order and orders into a class. Similar classes are placed in the same phylum, and phyla into a kingdom. Each higher category includes a wider range of species. Where necessary. Subgroupings are made. The introduction of sub- and super- categories appear to be almost a personal matter, and many laxonomists have used them according to their private opinion. In some cases, this has led to considerable confusion which has been increased by the use of grade, branch division etc. it would perhaps be advisable for the students at this level to concentrate on the essential sever categories; kingdom, phylum, Class, Order, Genus, Species. The full classification as follows:

Kingdom

Subkingdom

Branch

Grade

Divisin

Subdiovision

Phylum

Subphylum

Superclass

Class

Subclass

Intraclass

Superorder

Order

Suborder

Section

Superfamily

Familv(idea)

Subfamily (inae)

Tribe (ini)

Supergenus

Genus

Subgenus

Superspecies

Species

Variety

Form or Race

Taxonomic types:

There are two types of laxonomy; artificial and natural. The artificial classification at which animals are grouped according to their place of living (Aquatic or terrestrial). Type of feeding (Rerbovorous, Carnivorous, Omnivorous) and area of living (hot, cold, icy) etc…. while the natural classification at which animals are grouped depending on the degree of relationships among the individuals of each group. These relationships can only be obtained by help of other science branches as Comparative Anatomy, physiology, Cytology, Embryology, Paleontology and ecology etc.

Natural taxonomy and taxonomic methods:

The earliest efforts at natural classification were based on three lines of investigation, comparative morphology, comparative anatomy and palaeontology. These are now supplemented by comparative, physiology, cytology and genetics, serology, ecology, embryology and geography. In both animals and plants, morphology and anatomy are the most widely used instruments of classification. By their use, major features of organisms can be assessed rabidly, and in the majority of cases, newly discovered forms can be quickly allocated to their respective categories. In Lower organisms, such as bacteria and funqi however, similar appearance my be deceptive, since there may be wide physiological differences. e.g. two sorts of bacteria which look similar, may cause quite different diseases. There is need for the newer methods in these lower groups. Palaeontology therefore has been of great value, specially where sufficient fossils have been discovered to provide a chronological record of the evolution of a particular group. There are many cases where fossil discoveries have confirmed classification based on morphology of present forms. Though the fossil record is but fragmentary, new finds will continue to fill in the present "missing links". Cytology, by microscopic examination of cells, is a modern way of supplementing results obtained by the order methods. It is of particular use in the lower groups. Genetics, by chromosome counts and interbreeding techniques, has helped to confirm and even to correct earlier opinions. Embryology in turn, help for leveling of some important characters are not available in the adult stage. e.g. prostomium, and deuterostomium; type of cleabvage (spiral or radial). Type of gastrulation (invagination, epipoly etc.) type of larvae etc.

The importance of taxonomy :

1. Taxonomy provides a useful convenient and universal system into which all observations about an organism or a group of organisms can be compiled.
2. In helps for the exchange of applied informations on a given organism or organisms and this helps in the study other branches of biology.
3. Taxonomy provides good distrimination for the organisms introduced from abroad and how to control it from wide spread.
4. Good information about an organism and its relation with other organisms provides useful tool for its biological control.

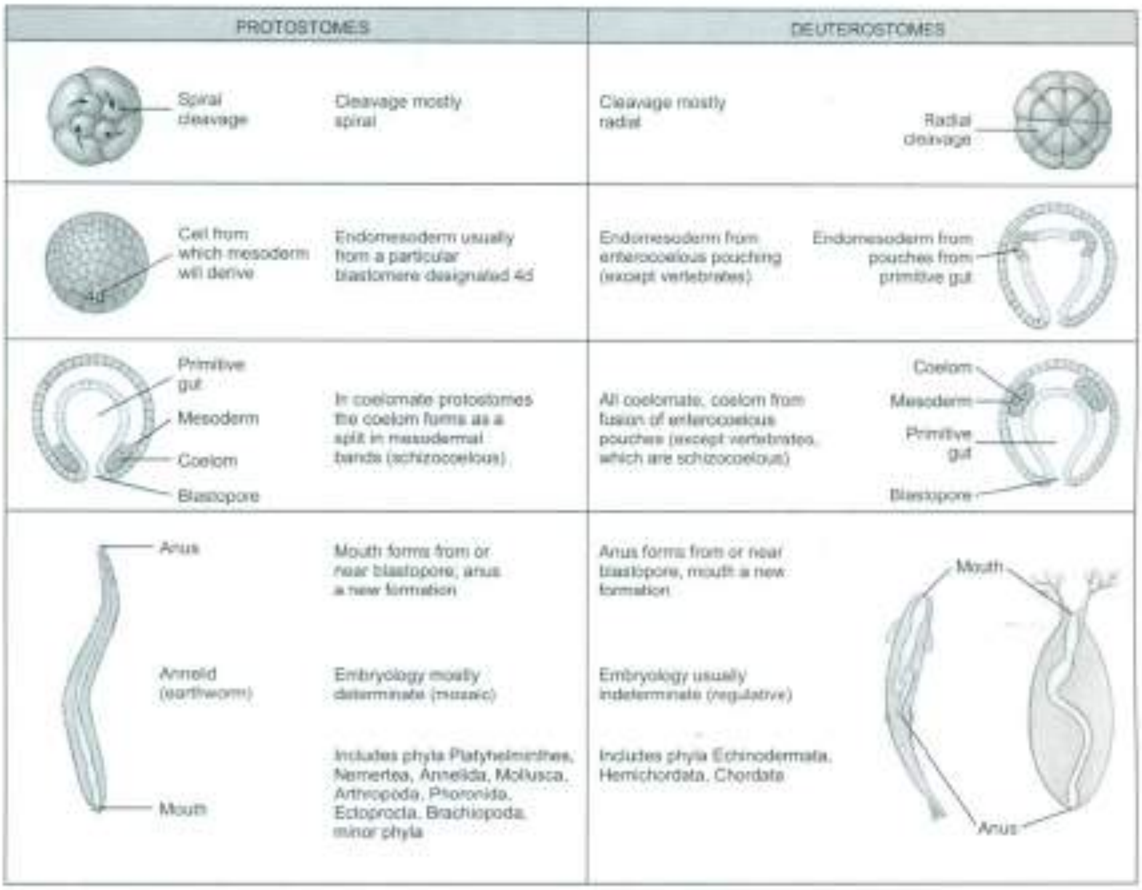
The type system :

It was Linnaeus practice to select a "typical" specimen of a plant or animal for description and to keep this specimen in his museum as the type or reference specimen. It is therefore to this type that the description refers and not to the species as a whole. In this way there can be no ambiguity arising from variation within the species.

This procedure is still followed and type specimens of the world. But ambiguities arise in other ways. Doubt may exist about who first described a species, or the procedure for combining two species, or splitting a third. Such problem call for a set of regulations, international rules for zoological nomenclature were prepared in 1931 to clarify the position with an international commission to interpret the "Rules" and to suspend them where a change in nomenclature would result in undue confusion.

<u>Discrimination bases of animal classification</u>

The animal kingdom is divided into a number of major subdivision or phyla on the basis of several morphological features which are considered to be fundamental and basic. Some of these characteristics are; homologous and analogous structure. Type of symmetry, number of germ layers type of digestive system, type of body cavity, fate of the blastopore, body segmentation, skeletal system, larval forms etc.



Homology and Phylogenetic Reconstruction

Darwin recognized the major source of evidence for common descent in the concept of **homology.** Darwin's contemporary, Richard Owen (1804 to 1892), used this term to denote "the same organ in different organisms under every variety of form and function." A classic example of homology is the limb skeleton of vertebrates. Bones of vertebrate limbs maintain characteristic structures and patterns of connection despite diverse modifications for different functions. According to Darwin's theory of common descent, the structures that we call homologies represent characteristics inherited with some modification from a corresponding feature in a common ancestor. Darwin devoted an entire book, *The Descent of Man and Selection in Relation to Sex,* largely to the idea that humans share common descent with apes and other animals. This idea was repugnant to many Victorians, who responded with predictable outrage. Darwin built his case mostly on anatomical comparisons revealing homology between humans and apes. To Darwin, the close resemblances between apes and humans could be explained only by common descent. Throughout the history of all forms of life, evolutionary processes generate new characteristics that are then inherited by subsequent generations. Every time a new feature arises on an evolving lineage, we see the origin of a new homology. That homology gets transmitted to all descendant lineages unless it is subsequently lost. The pattern formed by the sharing of homologies among species provides evidence for common descent and allows us to reconstruct the branching evolutionary history of life. We can illustrate such evidence using a phylogenetic tree for a group of large, ground-dwelling birds. A new skeletal homology arises on each of the lineages shown (descriptions of specifi c homologies are not included because they are highly technical). The different groups of species located at the tips of the branches contain different combinations of these homologies, which reflect ancestry. For example, ostriches show homologies 1 through 5 and 8, whereas kiwis show homologies 1, 2, 13, and 15. Branches of the tree combine these species into a **nested hierarchy** of groups within groups. Smaller groups (species grouped near
terminal branches) are contained within larger ones (species grouped by basal branches, including the trunk of the tree).

If we erase the tree structure but retain patterns of homology observed in the living species, we are able to reconstruct thebranching structure of the entire tree. Evolutionists test the theory of common descent by observing patterns of homology present within all groups of organisms. The pattern formed by all homologies taken together should specify a single branching tree that represents the evolutionary genealogy of all living organisms.

Ontogeny, Phylogeny, and Recapitulation

Ontogeny is the history of the development of an organism through its entire life. Early developmental and embryological features contribute greatly to our knowledge of homology and common descent. Comparative studies of ontogeny show howthe evolutionary alteration of developmental timing generatesnew characteristics, thereby producing evolutionary divergenceamong lineages.

The German zoologist Ernst Haeckel, a contemporary ofDarwin, proposed that each successive stage in the developmentof an individual represented one of the adult forms thatappeared in its evolutionary history. The human embryo withgill depressions in the neck corresponded, for example, to theadult appearance of a fishlike ancestor. On this basis Haeckelgave his generalization: *ontogeny (individual development) recapitulates(repeats) phylogeny (evolutionary descent).* This notionlater became known simply as **recapitulation** or the **biogeneticlaw.** Haeckel based his biogenetic law on the flawed premisethat evolutionary change occurs by successively adding newfeatures onto the end of an unaltered ancestral ontogeny whilecondensing the ancestral ontogeny into earlier developmentalstages. This notion was based on Lamarck’s concept of theinheritance of acquired characteristics

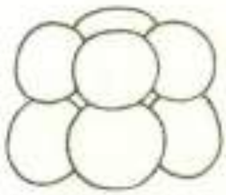
Types of cleavage and gastrulation

A comparative study of the early embryology of the various groups in the animal kingdom provides a considerable body of evidencefor the determination of the evolutionary inter-relationships between these various groups. Embryology, the study of the developmentof an animal from the zygote or fertilized egg to the' fully formed, free-living and feeding animal, can be divided into three major stages. These are firstly, cleavage, the series of cell divisions which increase the number of cells prior to the next stage, gastrulation.This second stage is a short sudden change in form of the developing embryo, not associated with a cell division, which brings about the formation and differentiation of the two primary germlayers, the ectoderm and endoderm. The third stage, which is really a complex of many separate formative processes, consists of the formation of the mesoderm and organogenesis. When considering interrelationships at the phylum level the types and forms of the first two stages only, cleavage and gastrulation, are of any significantvalue, whereas embryological evidence of similarities and differences in organogenesis between animals is of more value whenconsidering relationships at about order or family level. Embryology is a very complicated subject with many specialised terms to describe the various stages. The following descriptions are thereforea gross oversimplification, and for further information the student is referred to Hyman (1951), Barrington (1967) and Waddington (1956).

Cleavage is the series of cell divisions of the fertilized egg which take place before gastrulation. There are many different types of cleavage according to the characteristics of division sequences and patterns under review. One series of types of cleavage is largely dictated by the morphology of the egg and particularly by the amount of yolk present in the egg. When the egg contains little or no yolk (isolecithal), all the egg divides at each cleavage and the cleavage is therefore termed holoblastic (Fig. 1, A). If, however, the egg contains so much yolk (telolecithal) that the entire egg cannot divide at cleavage, then only a small yolk-free area at the top or animal pole divides, forming a small cap of cells, and the cleavage is termed meroblastic (Fig. 1, B). Within these two main divisions are many sub-divisions where a medium amount of yolk is present and is characteristically placed in the egg. Another way of classifying cleavage types is according to the subsequent fates of the various daughter cells or blastomeres. Ifexperimental separation of the blastomeres at various cleavage stagesis carried out, two strikingly different types of results are obtained.In some animals the separated blastomeres, even if separated as earlyas the first or second cleavage divisions, will only develop into thatpart of the animal that they would have formed if left in the entireegg. Thus their fate is determined in some way very early in developmentand the type of cleavage is called determinate cleavage. It isfound mainly in the Protostomia. The converse of this type is indeterminatecleavage in which each separated blastomere will form acomplete animal even when the separation is carried out quite late in the cleavage sequence. This type of cleavage is mainly found in the Deuterostomia. The most important distinction between different types of cleavage is based on the actual pattern of cleavage and the morphology of the blastula. The two major types of cleavage based on these criteria andwhich have considerable importance as evolutionary evidence arespiral cleavage and radial cleavage. These are both patterns of holoblasticcleavage, the difference being indicated by the shape of theline joining the centres of one series of related

daughter cells fromone pole to the other. Spiral cleavage is determinate and is largely
characteristic of the Protostomia, while radial cleavage is indeterminateand is seen mainly in the Deuterostomia. These two importanttypes of cleavage will now be considered in more detail.

B



A

Fig. 1. Diagram showing (A) holoblastic cleavage, in which the egg contains little yolk, and (B) meroblastic cleavage, in which there is a large quantity of yolk present thus restricting division to the animal pole.

Spiral cleavage

Spiral cleavage is holoblastic and is characterised by the axes ofthe cleavage spindles being oblique to the polar axis of the egg orblastula, rather than at right angles or parallel to it. Thus the blastomeres become spirally arranged, anyone cell beinglocated betweenthe two blastomeres below or above it. This type of cleavage is seenin polyclad platyhelminths, nemerteans, annelids and molluscs. In allthese groups the fate of each cell is so similar that each of the cellscan be designated numerically and a standard system of describingspiral cleavage in all these groups has been evolved. This system wasfirst proposed by Wilson in 1892.

The first two cleavage planes are vertical from pole to pole anddivide the egg into four equal blastomeres designated A, B, C and D.The third cleavage is transverse and a little above the equator,because of the presence of a moderate amount of yolk at the vegetalpole in most cases, giving rise to four smaller micromeres designatedla, 1b, lc and Id situated in the axes between the four largermacromeres, lA, IB, lC and ID. All the cleavages are oblique andalternately to the right (dextrotropic) and then to the left (levotropic).four original blastomeres and hence occupy one quadrant of theembryo (Fig. 2). The next cleavage is a transverse division of themacromeres to give the second quartet of micromeres, 2a, 2b, 2c and2d, leaving the macromeres 2A, 2B, 2C and 2D. Then the firstmicromeres divide again, exponents are added; thus the daughtercells of la' are numbered la11 and lal2

By the 32-cell stage all the germ layers are determined. The fourmacromeres 3A, 3B, 3C and 3D form the whole of the entoderm andthe true entomesoderm. At the next division, they give off at thevegetal pole another quartet of micromeres, three of which (4a, 4band 4c) are purely entodennal. The fourth cell, 4d, is the entiresource of the entomesoderm and is called the mesentoblast or M cell.This 4d or M cell is of immense importance in future developmentand plays a leading role in the next stage, gastrulation.

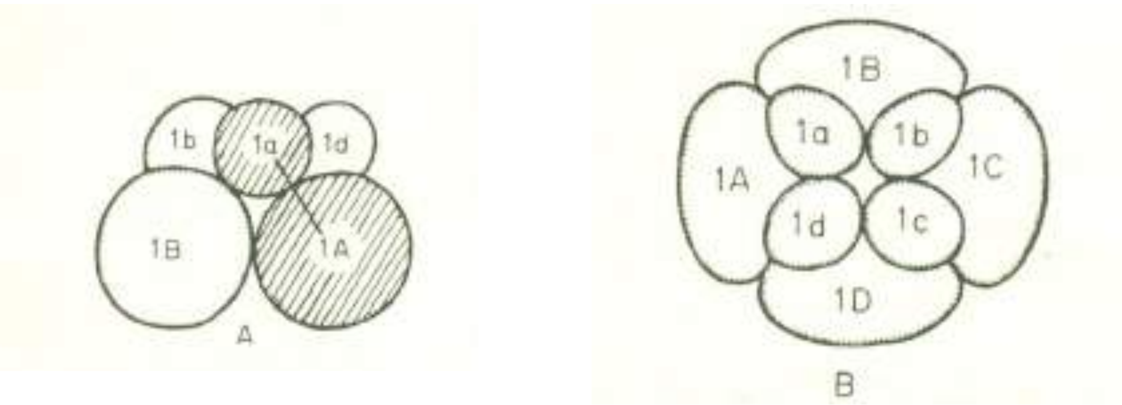


Fig. 2. Diagram showing stages in spiral cleavage; A and C, lateral views; B and D, polar views of the same stages. The shaded blastomeres are all derived from the original A blastomere. Black lines indicate the orientation of spindles at each cleavage. (After Villee and Hyman.)

Radial cleavage

In radial Cleavage, which is also holoblastic, the plane of cleavage is always either at right angles or parallel to the polar axis of the blastula. This type of cleavage is indeterminate, the fates of the various parts of the developing embryo being essentially plastic until after gastrulation has occurred. This form of cleavage is seen in the echinoderms, hemichordates and chordates. It is characterised by the radially arranged cleavage furrows in the early stages of cleavage with the blastomeres of one layer being directly above the blastomeres of the layer below (Fig. 3). However, this arrangement is less compact than the spiral cleavage arrangement and the pattern soon breaks down to give an irregular ball of cells. From this stage begins the next phase in the embryological development, gastrulation.

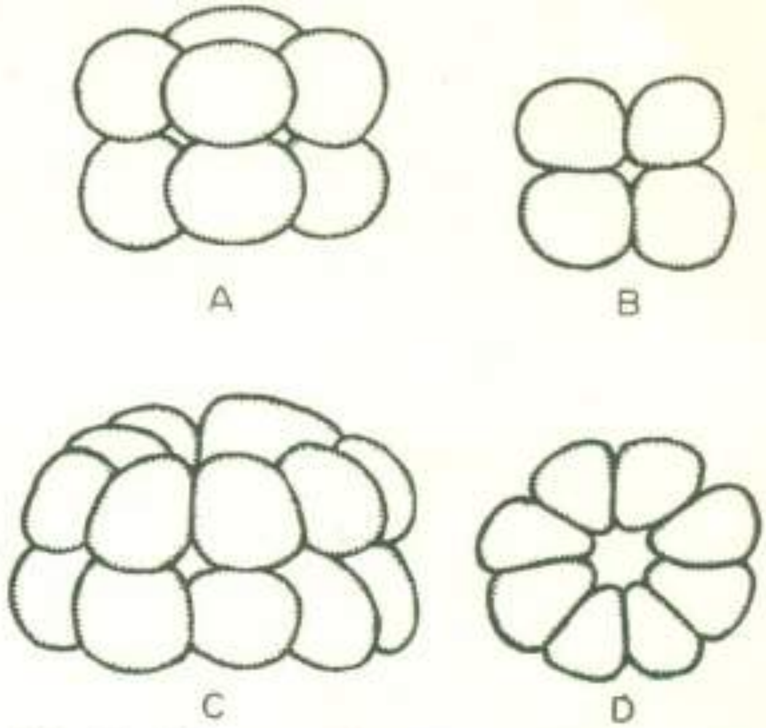


Fig. 3. Diagram showing radial cleavage at the 8 (A, B) and 16 (C, D) cell stages. A and C are lateral views; B and D are polar views.

Gastrulation

The process of gastrulation is a sudden process during which the embryonic elements move with respect to each other and there is nocell division. The process organisms the embryonic elements into a two-layered structure, the two primary germ layers. In the case ofdetermined blastulae the process is the moving into place of the preordained parts while in. the undetermined embryos it is the actuallaying down of the germ layers and the initiating of determination for later development.

As the majority of animals show holoblastic cleavage giving rise to a hollow ball of cells or blastula, the most common form of gastrulation is by invagination. This is the in-pushing of part of the ball of cells, usually at or near the vegetal pole, to form a second layer of cells inside the original layer (Fig. 4, A). The resulting structure is called a gastrula with an outside layer the ectoderm and an inside layer the endoderm. The site of initiation of the gastrulation process and the resulting hole into the inside of the gastrula, the blastopore, both have important places in the evolutionary picture.

As stated above, the Bilateria are divided into two main groups, the Protostomia consisting of the platyhelminthes, nemerteans, annelids, arthropods and molluscs, animals either showing or descended from animals showing spiral cleavage; and the Deuterostomia, consisting of the echinoderms, pogonophorans, hemichordates and chordates, all showing radial cleavage. These two group terms arose from the fates of the blastopore and its relationship with the origin of the mouth or stomodeum. In the Protostomia the mouth arises either from the blastopore itself or from a new opening very close to the original blastopore. In the Deuterostomia on the other hand the mouth is a completely new structure or 'second opening' and the blastopore, in many cases, forms the anus.

The portion of the vegetal pole of the blastula immediately next to the portion that invaginates is also very important in later development and in evolutionary studies. In the spirally cleaved blastula it is the 4d or M cell that is the site for the initiation of the act of invagination. On completion of gastrulation, the products of divisionof this cell grow into the blastocoel to lay down the third germ layer,the mesoderm. In the Deuterostomia, the initiation of invaginationand the formation of a blastopore start the determination of the fatesof the various areas. The area to be determined first is the dorsal lipof the blastopore which forms the mesoderm layer. From here thedetermination of the cells of the early gastrula spread rapidly so that the various parts of the gastrula have been completely determinedsoon after gastrulation has been finally completed.

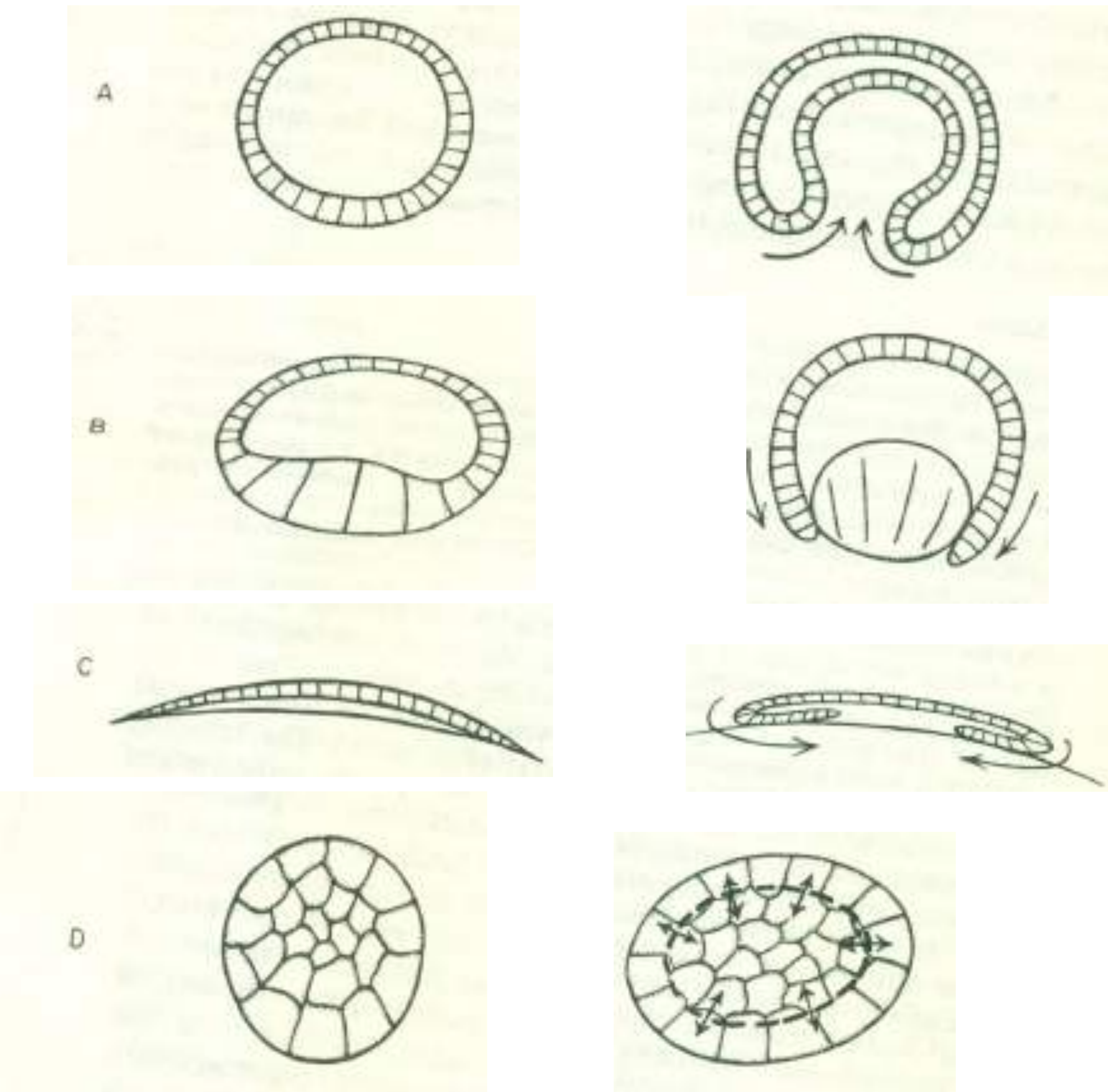
This method of gastrulation by invagination is only possible whenthe blastula is a hollow ball of cells containing very little yolk. Whenthe egg has a moderate amount of yolk concentrated at the vegetalpole and cleavage has produced large yolk-filled macromeres, theprocess of invagination is difficult or impossible. Under these circumstancesgastrulation is by epiboly, a modification of the invaginationprocess. In epiboly the smaller micromeres move down to surroundthe larger macromeres, forming a blastopore at the vegetalpole (Fig. 4, B).

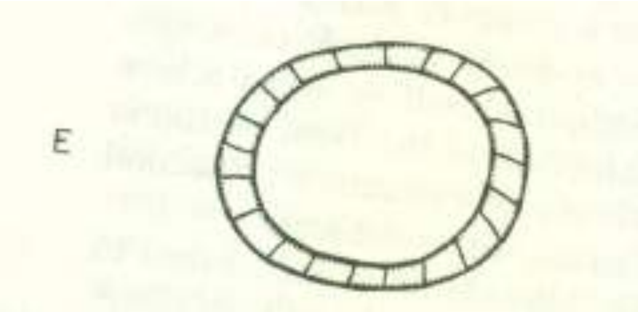
If the amount of yolk has been so great as to necessitate meroblasticcleavage forming a small cap of cells or discoblastula, thengastrulation is usually by involution (C). This is seen in such animalsas cephalopods and is a process whereby cells at the periphery of thedisc move down and back under the surface layer of cells to form a double layer.

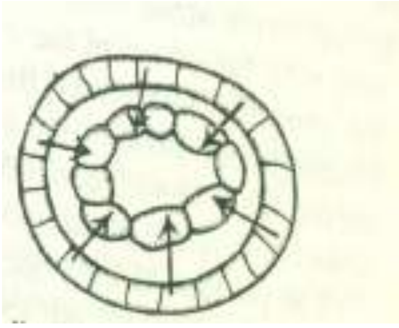
There are many other forms of gastrulation seen in a few unusualtypes of development. These are mainly in response to special developmentsequences. Two such forms are gastrulation by delaminationand ingression. Delamination occurs when, instead of a hollowblastula, the cleavage divisions produce a solid ball of cells or stereoblastula(D). Gastrulation in such a form is accomplished by theseparation of the outer layer of cells from the inner cells. Gastrulationby

ingression occurs when, instead of a regular series of cellsbeing pushed into the blastocoel to form the second layer (as ininvagination), cells simply invade the inner cavity and form a second
layer inside without forming a blastopore (E). This process is seen insome coelenterates and in sponges where it is the usual form ofgastrulation.

After gastrulation, mesoderm formation rapidly takes place andthe embryos quickly take up the forms and modes of developmentcharacteristic of the various phyla to which they belong. Two kindsof mesoderm may be distinguished, ecto- and entomesoderm (orendomesoderm). They appear to be phylogenetically distinct. Ectomesodermis derived from ectodermal cells that have wanderedinwards; it is always mesenchymal. Entomesoderm includes allmesoderm originating within or from the endoderm, and is referredto as 'true' or definitive mesoderm since it characterises all the higheranimal phyla.







Symmetry and Evolution of the Bilateria

Ever since zoologists began to try to elucidate the relationshipsbetween animals by comparative morphology, one of the main criteriaused has been the overall symmetry of animal bodies. Symmetryis the division into equal parts by lines or planes.In theorythere are four possible types of symmetrical pattern, and it is possibleto find animals which show anyone of these. The types are radialsymmetry, bilateral symmetry, spherical symmetry and finally asymmetry(Fig. 5). When considering animal body form it is readily seenthat the Protozoa can be said to show all four types of symmetry intheir diverse body forms while the Metazoa only show two, radial and bilateral symmetry.

Early workers saw these two types of metazoan body form as aconsequence of the type of life led by the animals and their needs inrelation to their contact with the environment. Radially symmetricalanimals are either sessile or free-floating animals requiring all-roundknowledge of the environment. Their sense organs are therefore set
peripherally. Bilaterally symmetrical animals on the other handmove in a particular direction and their sense organs are all crowdedat the end that first reaches the new environment. This process is called cephalisation and involves the formation of a head orspecialised anterior end and an anterio-posterior axis.Using this reasoning the earlier workers, especially Hatschek(1888-91), divided the Eumetozoa into two super-groups, theRadiata consisting of the Cnidaria and the Ctenophora, and theBilateria consisting of all the other eumetazoan phyla.

The Bilateria are defined as the ilaterally symmetrical Eumetazoa, or those with embryonic bilateral symmetry latermodified into radial symmetry (as seen in many of the echinoderms).Organ systems are present and the mesoderm is well developed.

Common to many of the groups, but not characteristic of theBilateria as a whole, is the presence of a rear opening to the digestivetract, the anus, and the presence of the coelom and of segmentation.The Bilateria can be divided into two major divisions or groups ofphyla mainly according to embryological criteria: the Protostomiaconsisting of the annelid-arthropod line of evolutionary development,and the Deuterostomia or chordate line of evolutionary development.The relationships between the phyla in these two groups, the possibleaffinities of the two main divisions and the origin of the Bilateria willnow be looked at in more detail.

Of these two major groupings perhaps the Protostomia morenearly approaches a natural grouping. In this group it is commonlyheld that the three major phyla, the annelids, arthropods andmolluscs, are closely related ancestrally and have as their precursorsanimals closely resembling certain types of present-day platyhelrninthes.

The only group in the Protostomia whose relationship with therest of the division is in doubt is the Aschelminthes, a somewhatheterogeneous array of up to seven classes. In the Protostomia, theblastopore, or an opening close to it, characteristically becomes themouth. There is a well-developed stomodaeum; embryonic developmentis of the determinate type with spiral cleavage and often atrochophore larva; the mesoderm originates by the solid ingrowth ofcells proliferated from the endoderm; and the coelom, if present, isnot an enterocoel.

The Deuterostomia, on the other hand, is a more heterogeneous assemblage, consisting not only of the Hemichordata, Protochordataand Chordata, but also of the Echinodermata and the Chaetognatha.Excluding this latter group, with its highly problematical relationships,the main evidence for a relationship between the echinoderms,hemichordates and chordates is the similarity between the larvae of
the various groups. It was postulated by Hyman (1940) and othersthat a dipleurula-type larva was the ancestral form of the chordateline of evolution. The Deuterostomia is characterised by the blastoporebecoming the anus, or the anus forms where the blastoporeclosed; the mouth is a new formation; cleavage is of the indeterminate
type with a dipleurula larva; and the mesoderm andcoelom originate by outfolding of the gut wall, the enterocoelousmethod.

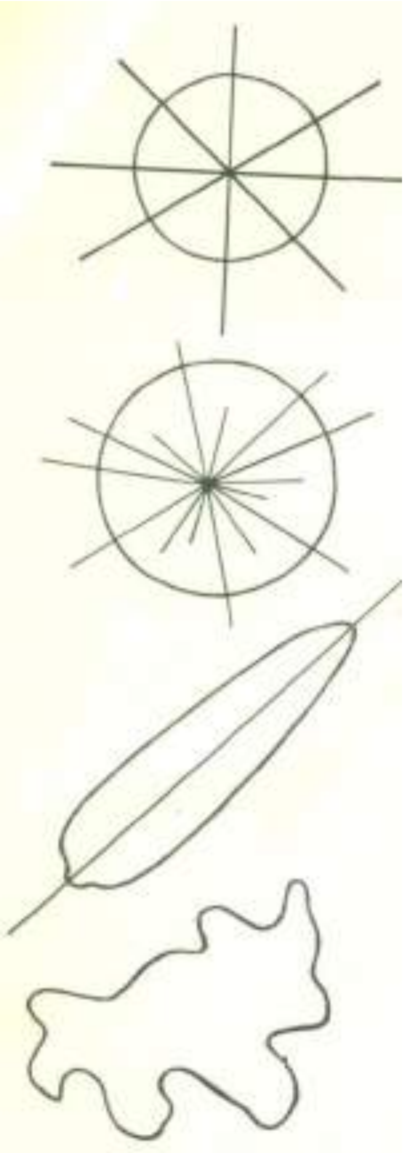


Fig. 5. Types of symmetry. A, radial symmetry, many lines of symmetry possible in one plane only; B, spherical symmetry, many lines possible in every plane; C, bilateral symmetry, only one line or plane of symmetry possible; D, asymmetry, no symmetry in the structure.

Evolution and Significance of the Coelom

The evolution of a secondary body cavity appears to have been ofmajor and undamental importance in metazoan evolution in that itseems an essential prerequisite to the development of greater size andcomplexity. However, the study of the evolution of the secondarybody cavity must, by the nature of the structure, relysolely onindirect evidence since direct evidence from palaeontology is notavailable. This indirect evidence is chiefly from the study of theembryology of present-day metazoans and it is in the interpretationof this evidence that widely conflicting ideas and theories have arisen.Another area of disagreement between zoologists has been over thevery nature of the various body cavities found in the various animalgroups. The evolution of the coelom has recently been extensivelydiscussed (Clark, 1964).

The coelom is defined as a liquid-filled cavity in the mesoderm; itdevelops in, and is surrounded by, the embryonic mesoderm. In somegroups, by contrast, the body cavity is formed by a persisting of theblastocoel. This cavity is a false coelom or pseudo-coelom and issimply a space between the digestive tract and that part of the bodywall not bounded by mesoderm. It is obvious that the only reliableway to characterize the exact nature of the body cavity of a particularanimal is to study its embryology. Although our knowledge of invertebrateembryology is still incomplete, enough information is availableto 'facilitate arrangement of the various groups of the Bilateriaaccording to the nature of their body cavities.

There are three major groups:

(1) Acoelomate: The region between the digestive tract and the epidermisis completely filled with mesenchyme and muscle fibres, withno body space present (Fig. 6, A). phyla Platyhelminthes andNemertini.

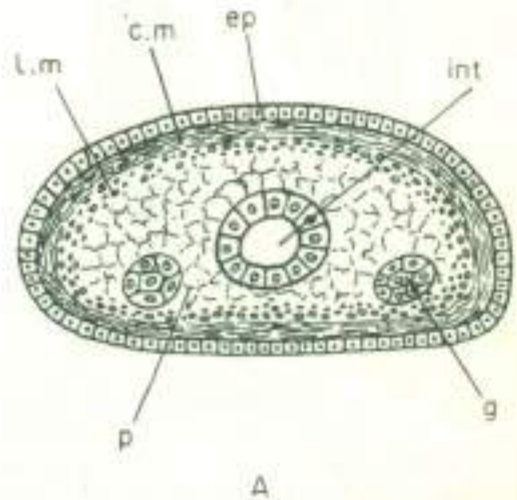


Fig. 6. Cross-sections indicating main types of body arrangement. A, acoelomate, with no body cavity.

(2) - Pseudocoelomate: The body space is a pseudocoelom (Fig. 6, B).Phyla Acanthocephala, Aschelminthes (Rotifera, Gastrotricha,Kinorhyncha, Nematoda, Nematomorpha) and Entoprocta.

(3) Coelomate: The body space is a true coelom (Fig. 6, C). Theremaining phyla of the Bilateria, Phyla Annelida, Arthropoda,Mollusca, Priapuloidea, Bryozoa, Phoronida, Brachiopoda,Chaetognatha, Echinodermata, Hemichordata, Chordata. The coelomate group can be again divided according to the type ofcoelom present, each type determined by the manner of origin of theentomesoderm and coelomic cavity.

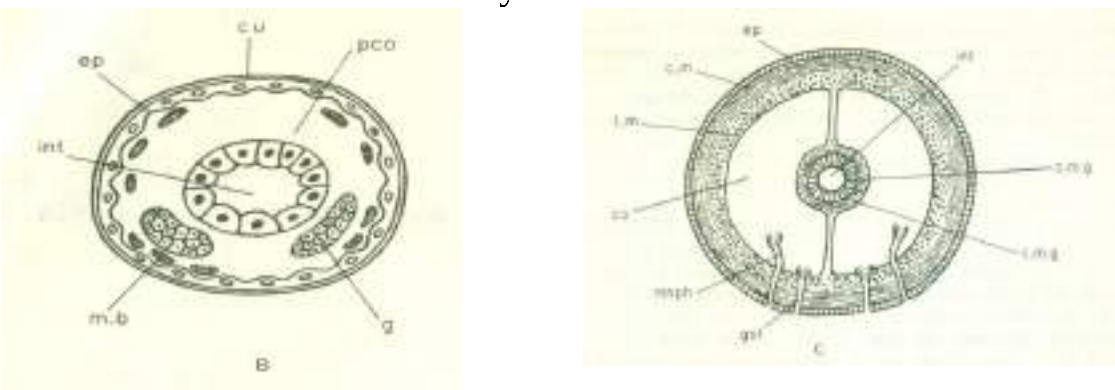


Fig. 6 (*continued*). B, pseudocoelomate, the body cavity is not a cavity in the mesoderm; C, coelomate, with the body cavity as a cavity in the mesoderm. *c.m*, circular muscle layer; *c.m.g*, circular muscle layer of gut; *co*, coelom; *cu*, cuticle; *ep*, epidermis; *g*, gonad; *gst*, gonostome; *int*, intestine; *l.m*, longitudinal muscle layer; *l.m.g*, longitudinal muscle layer of gut; *m.b*, muscle band; *mnph*, metanephridium; *p*, parenchyma; *pco*, pseudocoelom.

According to embryological studies, there are three basic ways in which the entomesoderm andthe coelom can arise (Hyman, 1951):

(a) Schizocoel:

The coelom arises from a split in the mesodermic bands, plates ormasses. It occurs in teloblastic mesoderm formation in spiralcleavage, in the derived mesoderm formation from cells around theblastopore as in most arthropods, or in lamellar mesoderm formationwhere the mesoderm originates from a mesenchymal origin. The
groupsin which the coelom is believed to have arisen as a schizocoelinclude most of the Protostomia.

(b) Enterocoel:

The coelom is thought to arise from the cavines in mesodermalsacs which evaginate from the archenteron and which expand untilthey touch the gut and

body walls. This method of coelom productionis seen in the Deuterostomia or chordate line and in the
Brachiopoda.

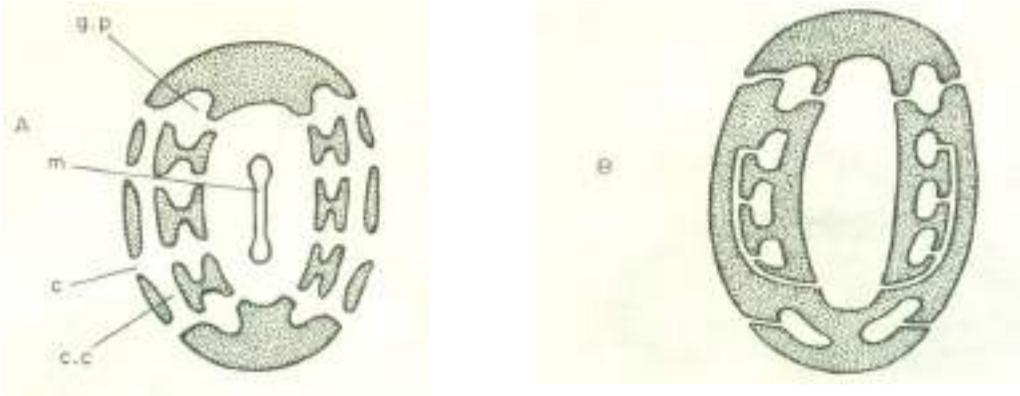


Fig. 7. Diagram illustrating the enterocoel theory of coelom formation by the transformation of the gastric pockets of an anthozoan (A) into coelomic pouches (B). *c*, cinclis; *c.c*, circular canal; *g.p*, gastric pocket; *m*, mouth. (From Clark, after Sedgwick.)

(c) Mesenchymal

This is an unusual method of coelom production seen only in thePhoronida; it can be regarded as an aberrant form of schizocoel. Inthis method the mesenchyme rearranges itself to enclose a space, thusforming a coelom.

That the evolution of the coelom was a major advance in metazoanevolution is not questioned; the great increase in size and diversity inway of life in the coelomate groups of animals compared with theacoelomate and pseudocoelomate groups must make this obvious.However the mechanism of that evolution and the question as towhether it occurred only once or many times by different routes hasbeen the subject of many theories. There are four basic theories ofthe evolution of the coelom, the other theories being simple variantsof these basic ideas. A lengthy discussion of these is given by Clark(1964) and the following description is only a brief summary of each theory.

(a) **Enterocoel Theory**

This theory accepts the origin of the coelom from gastric pouchesas primitive and suggests that it indicates the phylogenetic origin ofthe coelom. Sedgwick (1884) suggests that the gastric pouches ofcertain coelenterates, principally Anthozoa, became separated fromthe main gastric cavity to form coelomic pouches (Fig. 7). The
theory is widely followed and detailed discussions of it are putforward by Hartman (1963) and Remane (1963). The chief argumentsagainst this theory are

that gastric pouches only occur in moreadvanced coelenterates not very suitable for ancestral types; that thesealing-off of the gastric pouches defeats the object for which they
were formed; and that most supporters of this theory tend toassociate the evolution of the coelom with that of metameric segmentation,an association imposing severe restrictions on the theory.

(b) **Gonocoel Theory**

This is perhaps the most widely held of the theories of the origin ofthe coelom and is based on the common association between thegonads and the coelomic epithelium; it regards the coelom as thecavity of an expanded gonad. The theory was first enunciated byBergh in 1885 *(cit.* Clark, 1964) who compared the segmentedcoelom of annelids with the linear series of gonads of flatworms andnemerteans (Fig. 8). One of the main arguments against the theory,like that of the enterocoel theory, is that it closely links the origin ofthe "coelom with that of metameric segmentation. The main difficultyis to account for unsegmented coelomates. Another argument against
the theory is that it regards as separate processes the formation ofendomesoderm from the inward. migration of gonadial cells and theformation of the coelom by cavitation of the gonads after the releaseof gametes. This is contrary to the facts displayed by embryologicalstudies. ,

(c) **Nephrocoel Theory**

The theory proposes that the coelom originated as an expandednephridium. It is not a theory held seriously by many, the chiefopposing arguments being that - protonephridia have been describedin coelomates, and that some coelomate groups, such as the echinoderms,do not have excretory organs.

(d) **Schizocoel Theory**

This theory has very little mention in the literature. The coelom isregarded as a new formation from the mesoderm, which, by thistheory, has a mesenchymal origin, and is not related to gonads orentodermal pouches and has no antecedents in the lower forms.

None of the above theories is entirely satisfactory for three mainreasons. Firstly, they largely ignore the intermediate stages passedthrough in the course of evolution and the advantages which theseconferred on their developers. That such intermediate stages wereadvantageous is mandatory for their evolution and their adaptivesignificance should be considered. Secondly, the relationship between
the evolution of the coelom and the evolution of metameric segmentationshould have been elucidated and if their connection isnecessary then an explanation of unsegmented coelomates shouldbe included. Thirdly, there is no clear statement concerningthe exact nature of a coelom and explaining which cavities shouldbe regarded as coelomic and which not, in specific cases. A discussionof evolution of the coelom including these topics and anaccount of the significance and

functions of the coelom is presentedby Clark (1964); the following discussion is based largelyon this work.

In studying the evolution of the coelom and its significance in metazoan evolution, the key evidence is the likely function of thecoelom that made it of such evolutionary advantage. Of all thevarious functions prescribed for the 'coelom the one which best fitsthis requirement is a purely mechanical one: the coelom provided the animal with a hydrostatic skeleton. Strong evidence for this is foundin the fact that in the groups of animals where it does not serve thisfunction the coelom is severely reduced.

In the early stages of evolution of the Bilateria the body wall musculature probably consisted of only a few contractile elementspermitting only feeble movements. As the body size and musculatureincreased and animals abandoned a free swimming existence to liveon the substratum, locomotion by ciliary activity became less efficient.Even with a more advanced body muscular system made up of longitudinal and circular layers permitting reversible changes inbody shape, the limitations imposed on movement by a solid bodyare severe, as is illustrated by the platyhelminthes. These limitationsare certainly too severe to permit strong burrowing.The limitationsimposed on the circular and longitudinal muscle systems would be lifted if, instead of a solid body, a true fluid skeleton were evolved topermit strong, antagonistic contractions of the circular and longitudinal muscles and a controlled local change of body size. For thisthe morphological nature of the fluid filled cavity is of no importanceso long as it can serve this mechanical function. Indeed, the embryologicaland morphological evidence gained from modern animals, tosay nothing of the number of totally irreconcilable theories concerningthe evolution of the coelom, suggest that a fluid skeleton wasevolved independently several times. Moreover, there is no evidenceto suppose that the secondary body cavity is homologous throughoutthe animal kingdom. In fact the contrary is indicated, that is, that thecoelom is polyphyletic in origin.

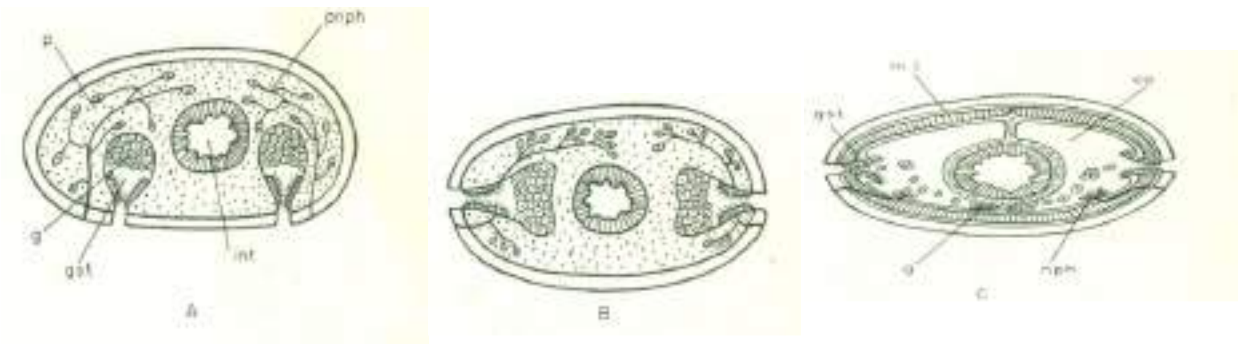


Fig. 8. Diagram illustrating the gonocoel theory of coelom formation by enlargement and cavitation of gonads to form coelomic pouches. A, platyhelminth condition; B, nemertean condition; C, annelid condition. *co*, coelom; *g*, gonad; *gst*, gonostome; *int*, intestine; *m.l*, muscle layers; *nph*, nephridium; *p*, parenchyma; *pnph*, protonephridium. (From Clark, after Goodrich.)

Evolution and Significance of Metamerism

Segmentation in animals involves the longitudinal division of the body into serial sections, each typically having one pair of some orall of the various organ units. The terms metamerism or metamericsegmentation are used only when organs of mesodermal origin are soarranged. Pseudometamerism refers to superficial segmentation andcould be termed body annulation. This definition of metamerism applies to tapeworms, but this is a view many zoologists do notaccept. A modern one now gaining favour is that cestodes are indeedmetamerically segmented, although their metamerism is of a differenttype.

Metameric segmentation appears to have arisen independentlythree times: in the annelid-arthropod and chordate lines, and in the cestodes. The main theories concerning the origin of metamerismrevolve around the questions as to whether it is the repetition oforgans or mesodermal segmentation that is of primary importance, and whether there is a connection between the evolution of metamerismand of the coelom.

1 - Pseudometamerism Theory

This theory proposes that the serial repetition of o~gans, orpseudo-segmentation, in some elongated turbellarians and nernerteans'crystallised' into metamericsegmentation, and was linked withcoelom evolution. Metamerism was an accidental consequence of theserial arrangement in acoelomate animals of those structures associatedwith the coelomic pouches. Sub-division of the musculaturewas mandatory because in serpentine swimming the body could bendonly in the spaces between coelomic compartments. However, allribbon-like animals swim in this way whether segmented or not.

2 - Cyclomerism Theory

This theory is the corollary of the enterocoelous theory of mesodermand coelom formation and implies the development of metamericsegmentation from the fundamentally radial organisation ofthe actinians (Fig. 9). However, the theory depends on the acceptanceof an ancestral coelenterate group with gastric

pouches arranged in alinear and not a circular fashion, and also assumes that the original
Bilateria were segmented and coelomate and that many groups nowwithout these characters secondarily lost them.

3 - Corm Theory

This theory postulates that metameric segmentation resulted fromincomplete separation following asexual reproduction during which achain of zooids was formed. Such an event occurs in rhabdocoels andtriclads (Fig. 10), in cestode proglottid formation, and in scyphozoanstrobilae. The chief objection is that in platyhelminthes and scyphozoansthe sequence of zooid formation is never serial with terminal fission; fission occurs always somewhere in the middle of the chain.In cestodes the proglottids are serially arranged but in a reverseorder to the metameres of annelids and chordates; moreover, ifcestodes are considered metamerically segmented, they are noteligible as ancestors to this condition. Another objection is that such reproduction is usually confined to sessile animals, unlikely ancestors to take advantage of the potentials of metamerism.

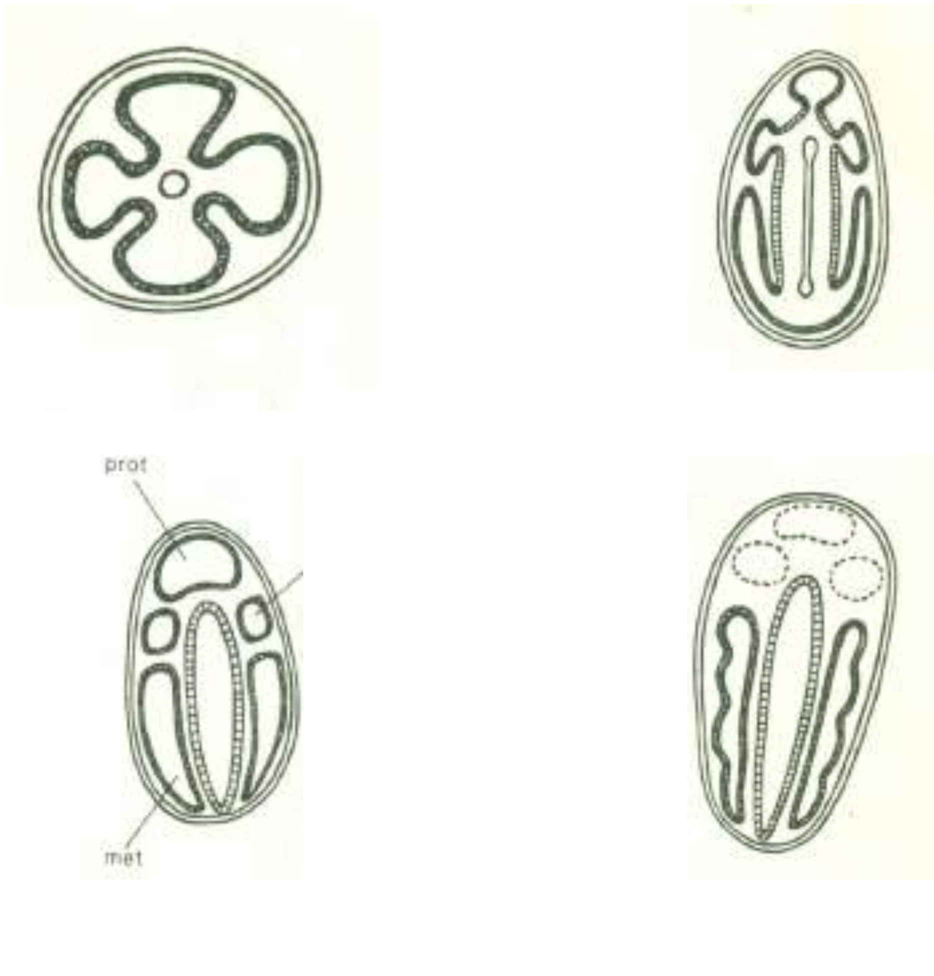


Fig. 9. Diagrams illustrating the cyclomerism theory of metamerism formation by the transformation of the gastric pockets of a medusoid into the coelomic pouches of a protocoelomate which then produced primary segments by subdivision of the metacoel accompanied by reduction of the proto- and mesocoels. *mes*, mesocoel; *met*, metacoel; *prot*, protocoel. (After Remane.)

4 - Embryological Theory

This theory suggests that the formation of metameric segmentsoriginated mainly as an embryological accident. Originally, it suggested thatmechanical stresses in the mesoderm during elongation ofthe embryo or larva resulted in mesoderm fragmentation, manifested in the adult as a meristic repetition of all mesodermal derivatives. Anobstacle is the lack of segmentation in elongated nemerteans and
turbellarians.

The theory has been partly revised by Berrill (1955) to accountfor chordate metamerism. He suggested that metamerism occurred in the tail muscles of an ascidian tadpole larva as an adaptational swimming. But this still leaves unanswered the question of the originof non-chordate segmentation.

Locomotory Theory

This theory postulates that undulatory, serpentine swimmingmovements completed the process of segmentation begun by thepiecemeal repetition of organ systems; it is really an amalgamation ofernbryological and pseudometamerism theories. The major objectionagain is the lack of correlation between the ability to perform undulatoryswimming motions and the possession of a segmented musculature.

If most current ideas concerning metazoan evolution are accepted,

then it is also necessary to accept the fact that metameric segmentationevolved at least three times. Each time it had a majoradvantage for the group in question: it evolved as an adaptation toburrowing in annelids, to swimming in chordates and to reproduction
in cestodes.

Although many have supposed that metameric segmentationevolved in annelids to facilitate undulatory, serpentine swimming,Clark (1964) has shown that segmented musculature is not necessaryfor this. It arose, it seems, to facilitate burrowing and was used inconjunction with the coelom and particularly with a fluid-filled cavitydivided by septa. The crucial step, therefore, was the evolution ofsepta impeding transmission through the body of locally generatedfluid pressures. The coelom gave the animal a hydrostatic skeleton allowing the circular and longitudinal muscles to act against each
other, but it was the septa and metameric segmentation togetherwhich allowed only part of the body to contract while other parts inthe longitudinal axis relaxed, and enabled a strong peristaltic wave tobe propagated down the body.

Chordates are thought to have evolved from a free-swimming,ascidian, larva-like animal, and their metamerism is thought to havebeen associated with the evolution of the notochord as a continuedresponse to the advantages of strong swimming. Berrill (1955)postulated that originally the tail and notochord arose*de novo* as asudden change caused by a developmental change in back cells.These grew out as a row of vacuolated cells, the notochord, forminga tail, and the mesodermal elements associated with them becamearranged in metameric pattern. Metameric segmentation is *certainly*important in swimming in chordates as it *allows* powerful torsionalforces to be applied to the relatively inflexible axial skeleton in order
to produce powerful swimming movements.

Cephalization and polarity :

Bilatreral animals and few others are polar. They have anterior end called oral end and posterior one called aboral end. at the oral end concentrates the nervous tissue within a head. Such a morphological state is known as cephalization. Cephalization and polarity are adaptations for the most efficient means against the environments. The complexity of organism structure and concentration of major sense organs and neural materials at the anterior end the organism are obvious in most advanced animals.

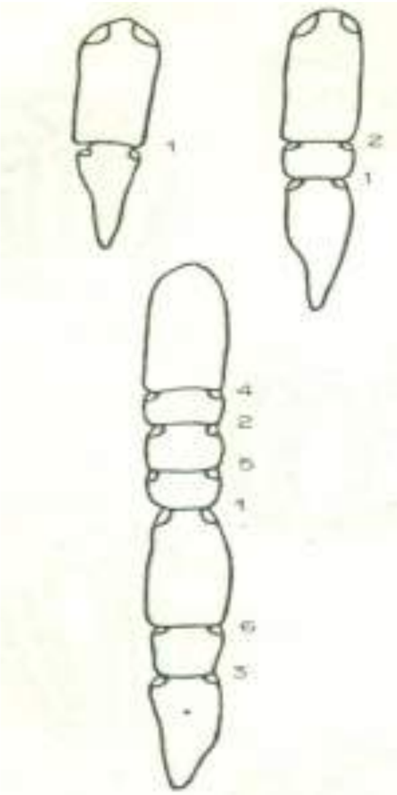


Fig. 10. Diagram showing the stages in the development of a chain of zooids in the rhabdocoel flatworm *Stenostomum*. Numbers indicate the sequence of appearance of the fission planes. (After Child.)

1. <u>The number of germ layers:</u>

   Diploblastica are those have two germ layers; ectoderm and endoderm; e.g. coelenterates. While triploblastica are those have three germ layers; ecto-endo and mesoderm. e.g. flate worm and up.

2. <u>Appendages</u>:

Are body protrusions serve different functions as locomotion, feeding sensory functions etc e.g. tentacles, antennae, lager, fins, wings and arms. The number and physiology of appandages of organisms are good means of taxonomy especially among arthropods e.g. arachnida (spider) have eight Legs while insect have six.

3. <u>Skeletal system:</u>

Skeletal is a supporting frame work of organisms. There is two type of which; endoskeleton and exoskeleton. Endo are found in sponges echinoderms, chordata while exo is found in mollusca, arthropoda.

4. Sexual characteristics :
   A. Dioecious organisms are unisexual, where both sexes are separated.
   B. Monocious or hermaphroditic forms are contain both sexual characteristics in the same individuals. They develop male and female organs in the same gonad. Sporulation is is important in taxonomic sporozoa and very small invertebrates.
5. Larval forms:

Type of larvae is important in classification. There are several forms of larvae and each of while characterizing a special group of animals e.g., Vileger characterizing Mollusca, Noplius larva for arthropods, Planula for Coelentrates and Brachularia for Echinodermata et .

KINGDOMS OF THE LIVING WORLD

Our conception of the kingdoms in the living world have been revised several times over the years. The living world firstly, is divided into two major kingdoms; Animalia and Plantia. This classification was accepted for sometimes, but refinement become necessary as more formation was obtained. As early as 1860, a suggestion to increase the living world another kingdom which Protista.Kingdoms Protista including all unicellular organisms. As 195 with accumulation of detailed data another scheme of classification is speared. The new beme suggested the living world should be divided into 5 kingdoms as follows :

KINGDOM : MONERA (The Procaryotes : Bacteria & blue green algae)

KINGDOM : PROTISTA (Unicellular algae & Protozoans)

KINGDOM : PLANTAE (Multicellular plants)

KINGDOM : FUNGI (Nonphoto- synthetic plant like organisms)

KINGDOM : ANIMALIA (Multicellular animals)

KINGDOM PROTISTA

Protistan phyla are differentiated by means of locomotion, methods of nutoition, reproduction, number of nuclei and possession of some organelles. The body is non-cellular and if sexual reproduction occurs the entire body is fragmented to form gametes or the body itself acls as a gameles.

Class : Sarcodina: Are Protozoans in which (1) Flagella are rarly or absent in the adult (2) Pseudopodia of some types are developed (3) Most membersare free living forms but there are some parasitic forms. (4) They live in moist soil and aquatic hapitates. (5) Some forms have shell consists of one or many chambers acts as exoskeleton.

Class : Mastigophora : They are Protozoans in which (1) the body possesses one or more flagella (2) Amoeboid action is rare (3) Syngamy occurs in only a few groups and is then not followed by abundant spore formation (4) most members are free-living but some are parasitic (5) Some members have chloroblasts (Phytomastigophora) while others have not (zoomastigophora).

Class : Ciliata : They are Protozoans in which (1) cilia are present in the adult forms (2) Amoeboid action is rare (3) exchange of genetic materials takes place by conjugation (4) free living and parasitic forms (5) some forms have more than one uncleus.

Class : Sporozoa : They are Protozoans in which (1) there are no flagella or cilia (2) the body my be amoeboid (3) Multiplication is typically by the formation of large number of spores following synogamy (4) They are exclusively parasitic.

PHYLUM : ROTOZOA

REPRESENT KINGDOM PROTISTA

As per two-kingdom classification, Protozoa was treated as a phylum under animal kingdom

• Under the three-kingdom classification, proposed by Haeckel, it was separated from animal kingdom and was included under the kingdom Protista.

• There are about 215000 described species of protists of which about 92000 species are protozoans.

The first protozoan observed was Vorticella convellaria by Anton Van Leeuwenhoek. Anton Van Leeuwenhoek called Protozoans as animalcules.

• The term Protozoa was coined by Goldfuss, for a group of organisms which included protozoans, sponges, coelenterates, rotifers and bryozoans. Von Siebold restricted the name Protozoa to apply to all unicellular forms of animal life.

• Hyman preferred the term acellular.

General Characters

• The body is unicellular, however they are preferably be referred to as acellular because the single cell performs all the life activities and is functionally equivalent to the whole metazoan animal. • Division of labour occurs among various organelles of the cell.

• These may be solitary (Euglena or colonial (Proterospongia) Freeliving-Amoeba

• Symmetry - Spherical - heliozoans, (Actinopodeans), radiolarians (Collozoum) Radial - (Sessile forms) Bilateral - Giardia

• Lobose protozoans and foraminifers are asymmetrical

• Body is naked or covered by pellicle or shell made of silica or calcium carbonate • Division of body is at subcellular level

• Locomotion is brought about by the locomotory organelles like flagella and cilia, cellular extensions like pseudopodia and in some, pellicular contractile structures like myonemes.

• Nutrition is holozoic or holophytic or osmotrophic. Euglena shows mixotrophic nutrition.

• Digestion is intracellular.

• Contractile vacuoles, which are common ir freshwater forms mainly, serve for osmoregulation,

• Asexual reproduction by binary ormultiple fissions or plasmotomy or budding. • Sexual reproduction by syngamy or conjugation.

• The phenomenon to tide over unfavourable conditions is encystment.

• They are immortal - somatoplasm and germplasm are not differentiated.

Classification

• B.M. Honigberg and others classified Phylum Protozoa into four subphyla: <u>Sarcomastigophora, Sporozoa, Cnidospora and Ciliophora.</u>

Subphylum-1 Sarcomastigophora

• it Is characterized by the presence of pseudopodia or flagella for locomotion,

It includes three superclasses – Mastigophora, Opalinata and Sarcodina.

<u>Superclass Mastigophora:</u>

• Body is covered by pellicle; locomotoiy organelles are flagella;

• Asexual reproduction by longitudinal binaiy fission.

• It includes two classes – Phytoinastigophon and Zoomastigophora

Class Phytomastigophora:

• Some are with chlorophyll bearing chloroplasts

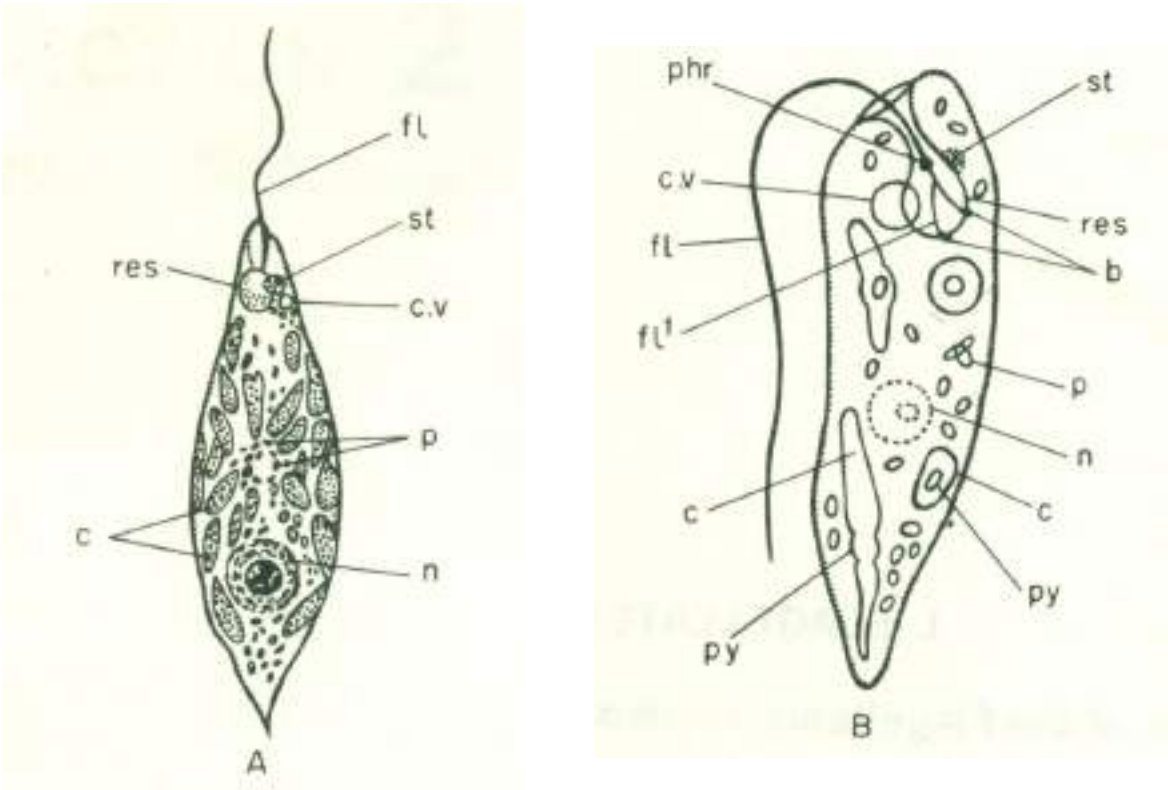
• Nutrition is holophytic • Reserve food is paramylum

o Includes euglenoids and dinoflagllates • Examples: Ceratium (dinoflagellate with chloroplasts) Noctiluca (dinoflagellate withoui chloroplasts), Euglena

Class Zoomastigophora:

• Mostly parasitic; Chloroplasts are absent; nutrition is holozoic

• saprobic or parasitic, Reserve food is glycogen or volutin, Examples: Trichomonas, Trichonympht (Mutualistic), Leishmania.



Two species of *Euglena*. A, *Euglena viridis*; B, *Euglena gracilis* (diagrammatic). *b*, basal body; *c*, chloroplast: *c.v*, contractile vacuole; *fl*, flagellum; *fl*,[1] short accessory flagellum; *n*, nucleus; *p*, paramylum; *phr*, photoreceptor; *py*, pyrenoid; *res*, reservoir; *st*, stigma. (A, from Doflein; B, from MacKinnon, D. S. and Hawes, R. J. S., *An Introduction to the Study of Protozoa*, 1961. Clarendon Press, Oxford.)

Superclass Opalinata:

• Commensals or parasites in the gut of anurans

• Body is covered by oblique rows of cilia but without infraciliary system.

• Some are binucleate, others are multinucleate but homokaryotic i.e. the nuclei are identical.

• Asexual reproduction by longitudinal binary fission and plasmotomy.

• Sexual reproduction is syngamy with flagellated gametes Examples Opalina, Zelleriella

Superclass Sarcodina:

• Locomotion is brought about by pseudopodia.

• It includes three classes - Rhizopodea, Piroplasmea and Actinopodea. Class

Class : Rhizopodea:

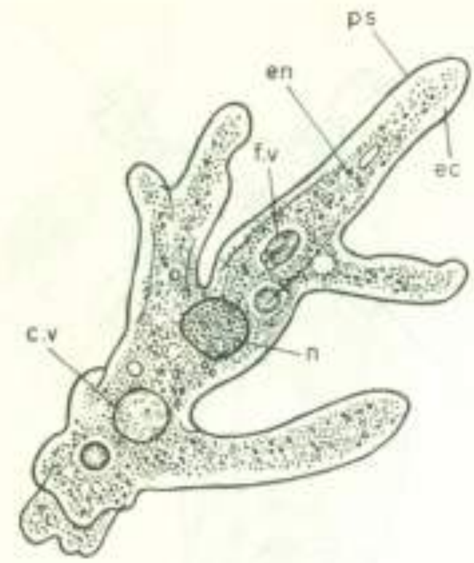
• It includes amoebas, foraminiferans and mycetozoans.

• Amoebas have lobopodia or filopodia; foraminiferans have reticulopodia.

• In amoebas, body is naked (Amoeba, Entamoeba) or covered by a test (Arcella).

• Foraminiferans have a calcareous porous shell.

• Calcareous shells of dead individuals form foraminiferan ooze, Examples: Elphidium (foraminiferan), * Physarum (acellular slime mould with a Plasmodium stage in the life history), Dictyostelium (cellular slime mould with pseudoplasmodium stage in the life history).



Amoeba proteus, living. *c.v*, contractile vacuole; *ec*, ectoplasm; *en*, endoplasm; *f.v*, food vacuole; *n*, nucleus; *ps*, pseudopodium. (After MacKinnon and Hawes, op. cit.)

Class Piroplasmea:

Parasitic; locomotory structures absent; spores are absent. Example: Babesia (causes red water fever in cattle)

Class Actinopodea:

• These are the ray footed protozoans

• Locomotory structures are axopodia

• Skeleton consists of siliceous shell (Radiolaria) or strontium sulphate spines (Acantharea) or siliceous shell or radiating needles (Heliozoa).

• Silicious shells of radiolarians form ooze Examples: Collozoum (radiolarian) Actinophrys (heliozoan) Acanthometra (acantharean), Actinosphaerium

Subphylum-II : Sporozoa or Apicomplexa:

• Parasitic; no special locomotory structures;

• pseudopodia, if present, useful only in ingestion, o Sporozoites and merozoites bear anterior apical complex that helps penetrate host cells, o No polar filaments

• It includes three classes - Telosporea, Toxoplasmea and Haplosporea.

Class Telosporea: • Sporozoites are long, o Garrtonts are large, extracellular - gregarinids • Gamonts are small, intracellular - coccidians • Syngamy is isogamy - Gregarinids Anisogamy - Coccidians • Examples: Monocystis (parasite in the seminal vesicles of earthworms), Eimeria, Plasmodium, Gregarina

Class Toxoplasmea: • Body covered by two layered pellicle • Only asexual reproduction, by endodyogeny. • It is internal budding wherein two daughter cells are produced within a mother cell and the mother cell is destroyed in the process, Example: Toxoplasma

Class Haplosporea: • Spores are present and are amoeboid, o Reproduction is only asexual, by multiple fission. • Each spore contains singl e sporozoite o Example: Haplosporidium

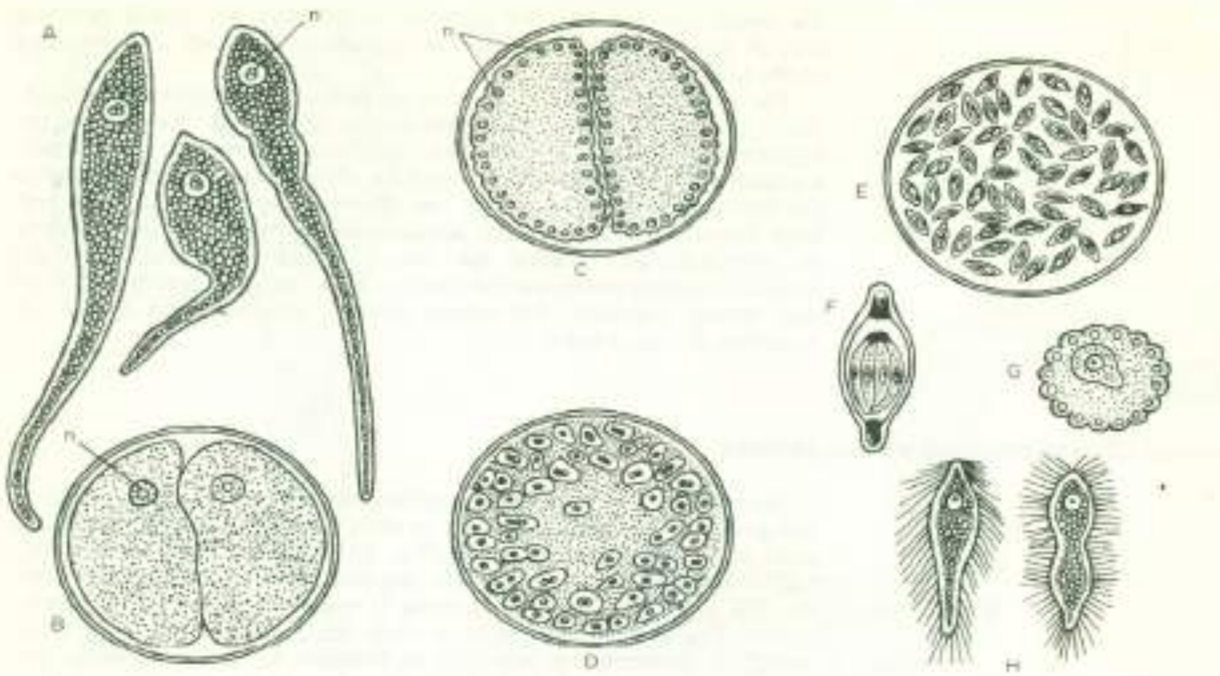
Subphylum-III Cnidospora:

• Parasitic. • No special locomotory structures, • Spores with 1 or more protoplasmic masses called - sporoplasms • Spores are provided with one or more polar filaments, which are useful for attachment to the host.

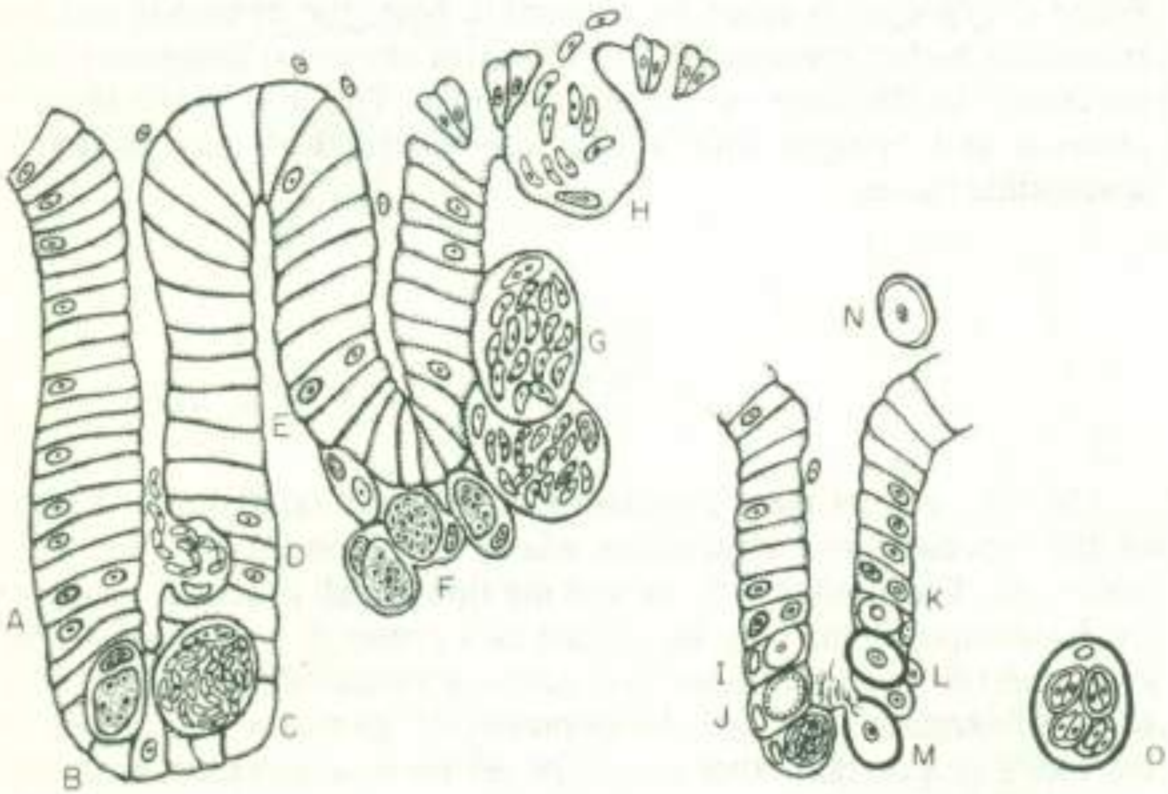
• It includes two classes - Myxosporidea and Microsporidea.

Class Myxosporidea: • Extracellular parasites of cold blooded vertebrates • Spores with typically two capsules each with single polar filament. Example: Myxobolus

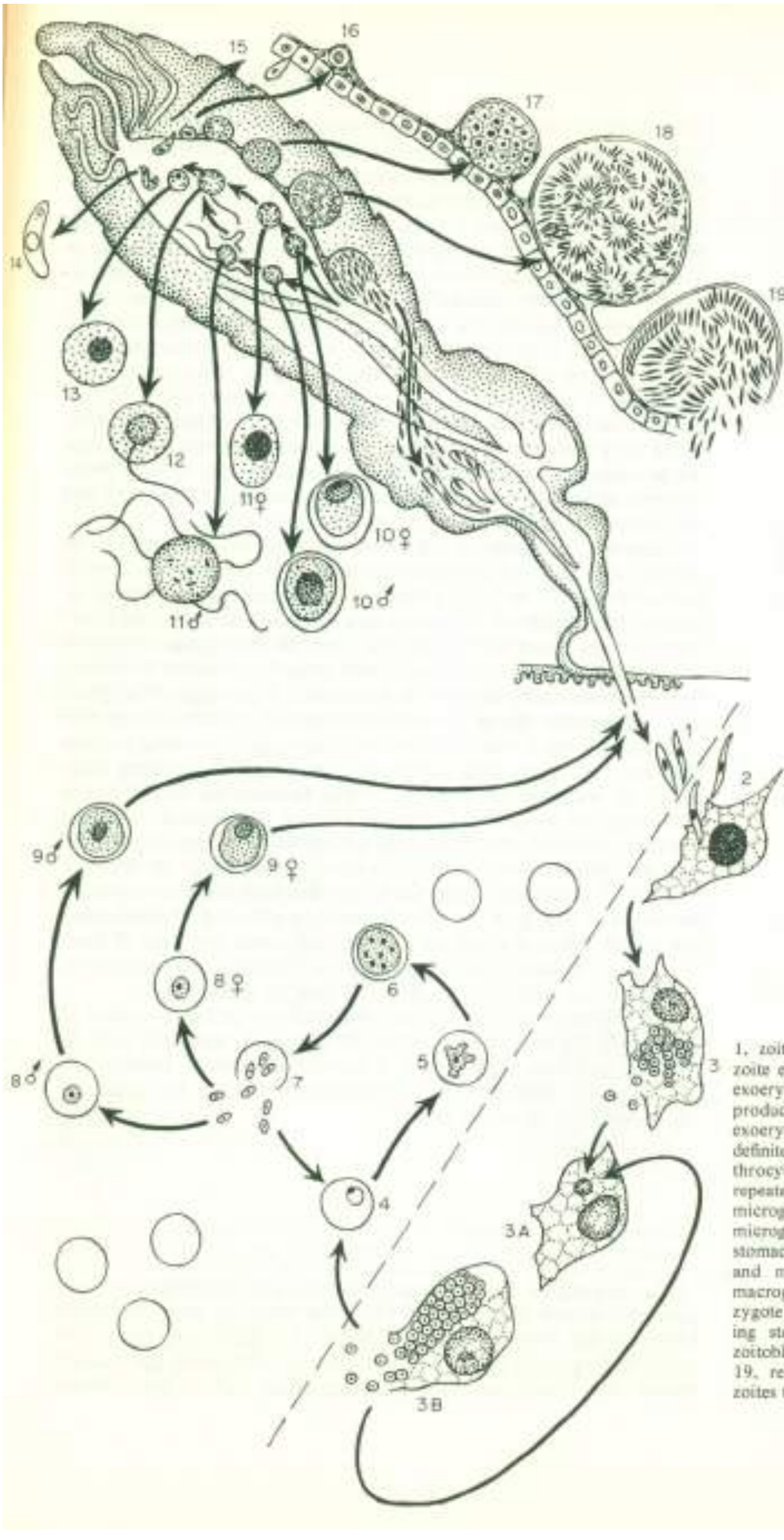
Class Microsporidea: • Intracellular parasites. • Spore with one intrasporal or 1 - 2 intracapsular filaments. • Spores with single sporoplasm Example: Nosema bombycis (causes pebrine disease in silkworms). Subphylum IV Ciliophora: •Complex protozoans. • Cilia are useful in locomotion and food capture, • Suctorian ciliates are sessile and are with cilia only in young stages. In adult suctorians the cilia are replaced by sucking tentacles that help in food capture, • Dimorphic nuclei - macronucleus (vegetative and polyploid) and micronucleus (reproductive and diploid), o Infraciliary system is present, o Sexual reproduction by conj ugation, which brings about nuclear reorganization. • Only class under this subphylum is Class Ciliata. o Example: Paramecium, Balantidium, (parasitic ciliate in man) Acineta (Suctorian)



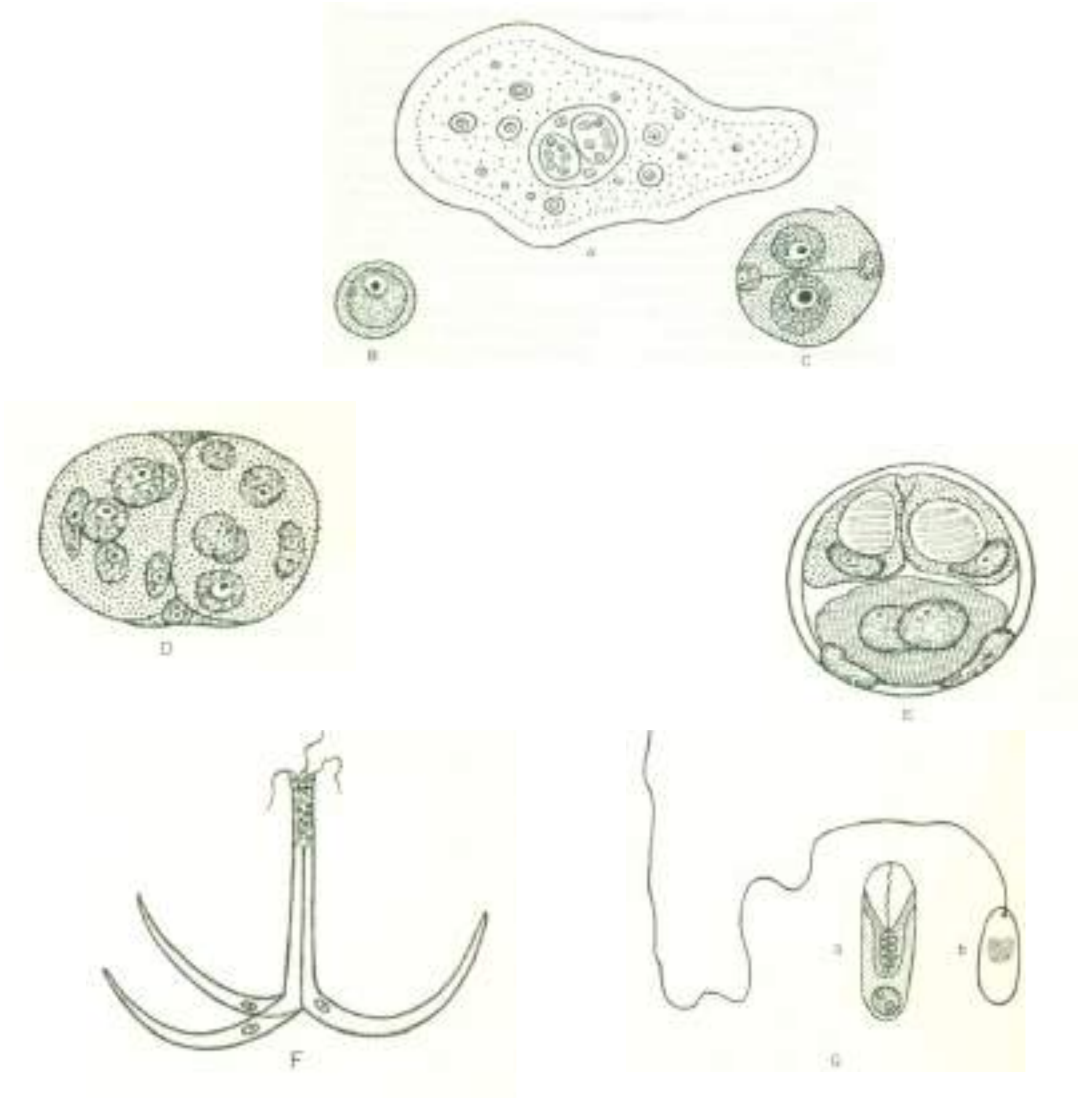
Monocystis. Life cycle. A, mature gregarines (gamonts); B, two gamonts encysted; C, early stage in production of gametes; D, pairing of gametes; E, zygocysts derived from zygotes; F, a zygocyst containing 8 zoites; G, young gregarine within a mass of developing sperm; H, half-grown gamonts with adherent sperm tails. *n*, nucleus. (From Parker, *Practical Zoology*.)



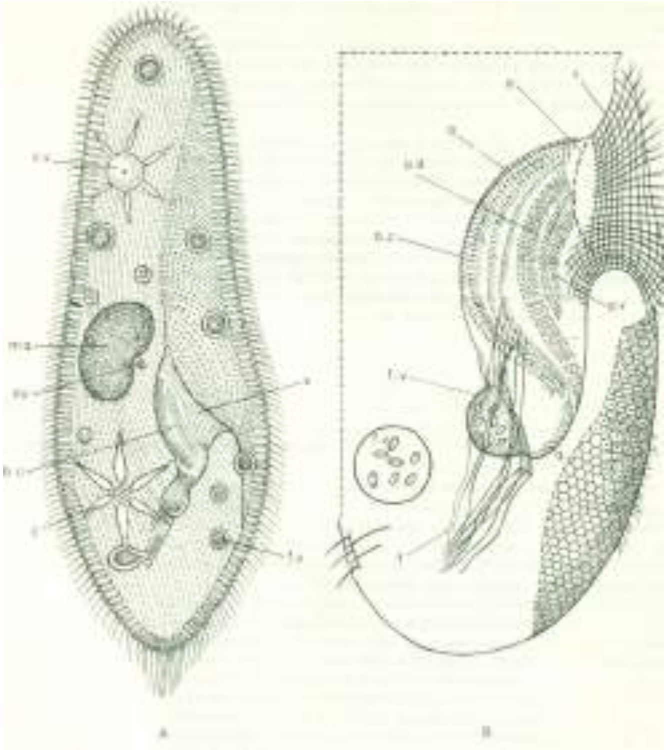
Life cycle of *Eimeria tenella* in intestine of chick. A, prospective schizont, derived from zoite, in epithelial cell; B, nuclear proliferation in young schizont; C, first generation of merozoites produced by schizogony; D, release of merozoites by rupture of parasitised cell; E, prospective schizont derived from merozoite; F–H, schizogony leading to production of second generation of merozoites (schizogony may be repeated); I, prospective microgamont, derived from merozoite; J, development of microgametes; K, prospective macrogamont; L, macrogamete; M, fertilisation of macrogamete; N, young zygocyst; O, mature zygocyst, containing eight zoites arranged in pairs within zoitocysts. (From Tyzzer.)



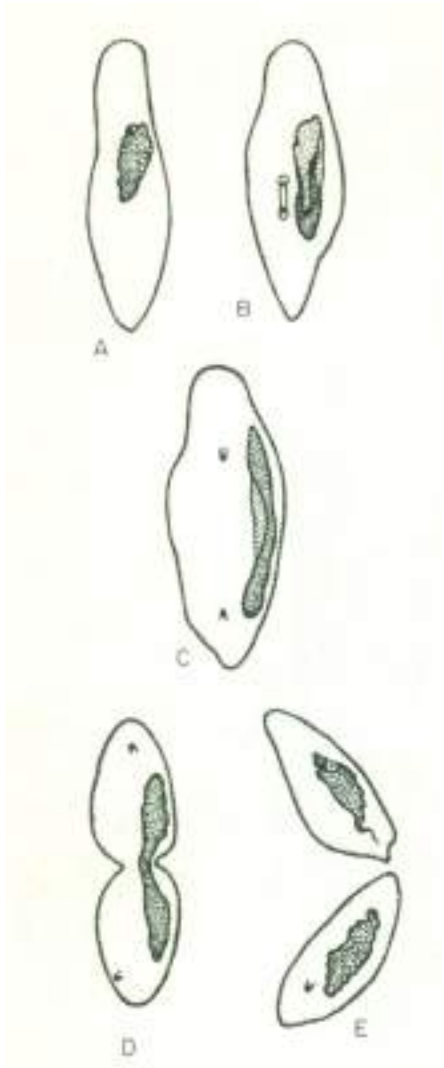
Life cycle of *Plasmodium vivax*. 1, zoites injected into blood stream; 2, zoite entering reticuloendothelial cell; 3, exoerythrocytic schizogony, leading to production of merozoites; 3A, 3B, exoerythrocytic schizogony repeated indefinitely; 4, young schizont in erythrocyte; 5–7, erythrocytic schizogony, repeated indefinitely; 8, 9, development of microgamont and macrogamont; 10, microgamont and macrogamont in stomach of mosquito; 11, microgametes and macrogamete; 12, fertilisation of macrogamete; 13, zygote; 14, motile zygote ('ookinete'); 15, ookinete penetrating stomach wall; 16, development of zoitoblasts; 17, production of zoites; 18, 19, release of zoites and migration of zoites to salivary glands.



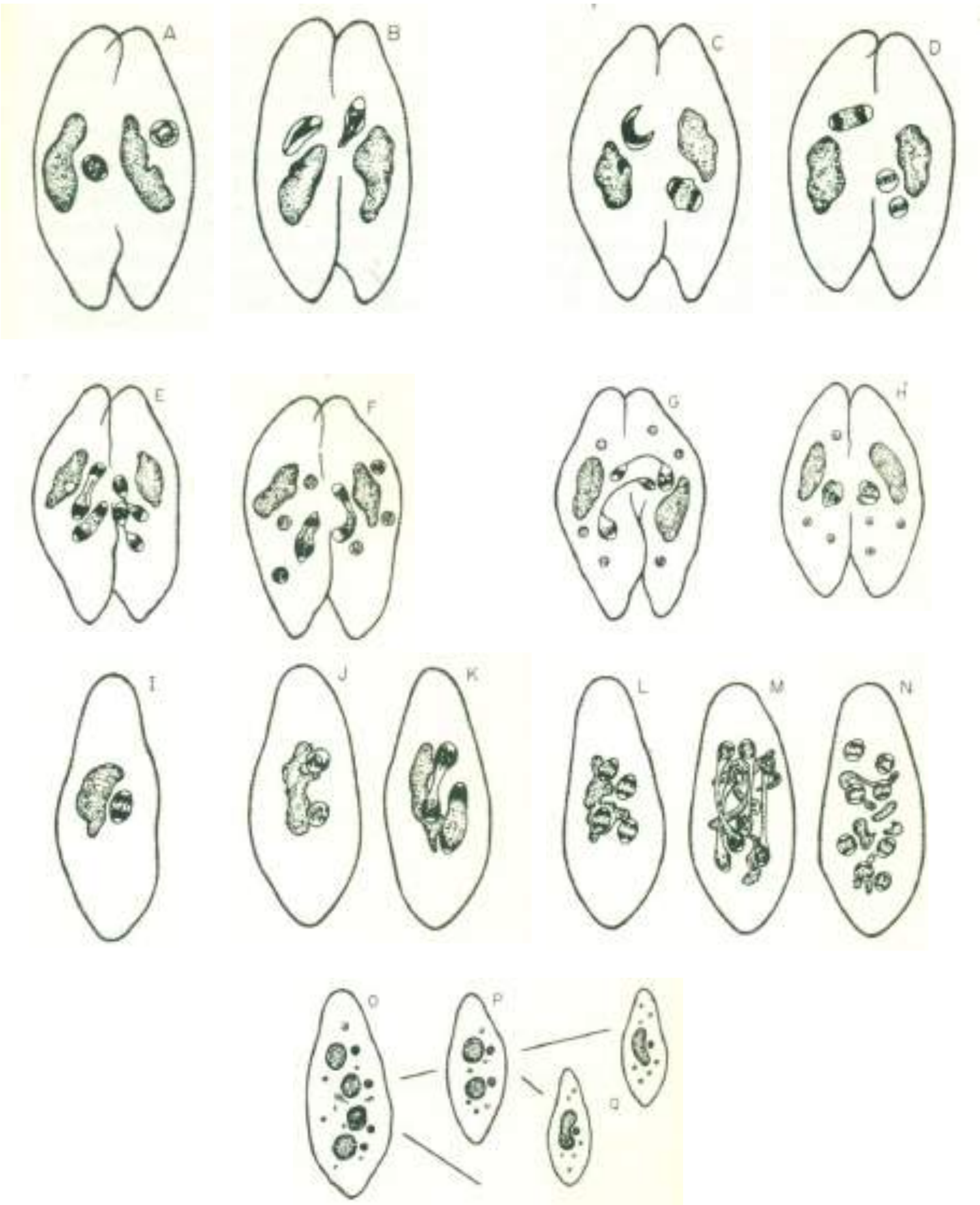
Myxosporidians, Actinomyxidians, Microsporidians. A–E, life cycle of *Myxobolus*, a myxosporidian. A, plasmodium with vegetative cells, reproductive cells, and a centre of spore formation derived from a reproductive cell; B, reproductive cell; C, products of first two divisions of reproductive cell; D, six nuclei derived from each of the two larger cells shown in C; E, mature 'spore', showing derivatives of the six nuclei and cytoplasm associated with them; F, 'spore' of *Triactinomyxon*, an actinomyxidian; G, 'spore' of *Nosema*, a microsporidian. *a*, polar filament inverted; *b*, polar filament everted. A–E, from MacKinnon and Hawes, op. cit.; F, from Kudo, op. cit.; G, from Grassé, op. cit.)



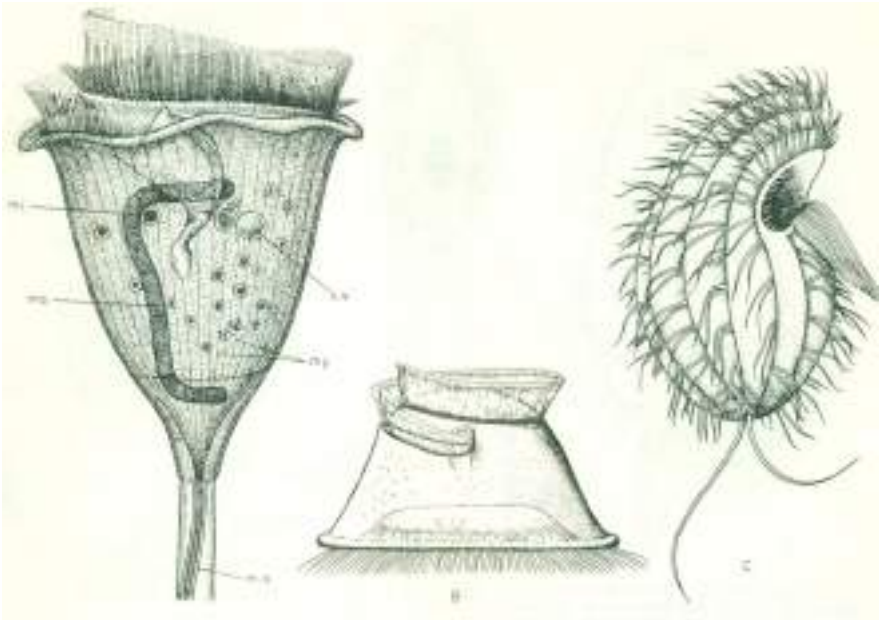
Paramecium caudatum. A, entire specimen; B, vestibule, buccal cavity and cytostome. *b.c*, buccal cavity; *c*, canal; *c.v*, contractile vacuole; *e*, base of endoral membrane; *f*, fibrils of cytostomal region; *f.v*, food vacuoles; *ma*, macronucleus; *mi*, micronucleus; *p.d*, dorsal peniculus; *p.v*, ventral peniculus; *q*, quadrulus; *v*, vestibule. (A, from Grell, op. cit.; B, after MacKinnon and Hawes, op. cit.)



Paramecium caudatum. Binary fission. A, interphase; B, anaphase of mitosis of micronucleus and elongation of macronucleus; C, separation of micronuclei complete; D, cytoplasmic and macronuclear division in progress; E, daughter ciliates recently separated. (From Kudo, op. cit.)



Paramecium caudatum. Conjugation. A, union of two conjugants by oral surfaces; B–E, two successive divisions of micronuclei forming four micronuclei in each conjugant, of which three degenerate; F–G, division of persisting micronucleus, and migration of one product of each division into other conjugant; H, formation of synkaryon; I–N, three successive divisions of synkaryon of one exconjugant, forming a total of eight micronuclei, degeneration of old macronucleus; O, metamorphosis of four micronuclei into new macronuclei; P–Q, segregation of macronuclei and micronuclei by binary fission of exconjugant. (From Kudo, op. cit.)



Peritrichs, Trichostomes. A, *Vorticella*; B, *Trichodina*; C, *Colpoda*. *c.v*, contractile vacuole; *ma*, macronucleus; *mi*, micronucleus; *m.s*, 'muscle' of stalk; *my*, myonemes. (A, from Grell, op. cit.; B, C, from Corliss, op. cit.)

Phylum Porifera

Characteristics, classification, examples

Porifera Definition

The Porifera may be defined as an asymmetrical or radially symmetrical multicellular organism with a cellular grade of an organization without well-definite tissues and organs; exclusively aquatic; mostly marine, sedentary, solitary or conical animals with body perforated by pores, canals, and cambers through which water flows; with one or more internal cavities lined with choanocytes; and with a characteristic skeleton made of calcareous spicules, siliceous spicules or horny fibers of spongin

Phylum Porifera Characteristics

1. Porifera are all aquatic, mostly marine except one family Spongillidae which lives in freshwater.
2. They are sessile and sedentary and grow like plants.
3. The body shape is vase or cylinder-like, asymmetrical, or radially symmetrical.
4. The body surface is perforated by numerous pores, the Ostia through which water enters the body and one or more large openings, the oscula by which the water exists.
5. The multicellular organism with the cellular level of body organization. No distinct tissues or organs.
6. They consist of outer ectoderm and inner endoderm with an intermediate layer of mesenchyme, therefore, diploblastic
7. The interior space of the body is either hollow or permeated by numerous canals lined with choanocytes. The interior space of the sponge body is called spongocoel.

8. Characteristic skeleton consisting of either fine flexible spongin fibers, siliceous spicules, or calcareous spicules.
9. Mouth absent, digestion intracellular.
10. Excretory and respiratory organs are absent.
11. Contractile vacuoles are present in some freshwater forms.
12. The nervous and sensory cells are probably not differentiated.
13. The primitive nervous system of neurons arranged in a definite network of bipolar or multipolar cells in some, but is of doubtful status.
14. The sponges are monoecious.
15. Reproduction occurs by both sexual and asexual methods.
16. Asexual reproduction occurs by buds and gemmules.
17. The sponge possesses a high power of regeneration.
18. Sexual reproduction occurs via ova and sperms.
19. All sponges are hermaphrodite.
20. Fertilization is internal but cross-fertilization can occur.
21. Cleavage holoblastic.
22. Development is indirect through a free-swimming ciliated larva called amphiblastula or parenchymula.
23. The organization of sponges are grouped into three types which are ascon type, sycon type, and leuconoid type, due to simple and complex forms.
24. **Examples:** *Clathrina, Sycon, Grantia, Euplectella, Hyalonema, Oscarella, Plakina, Thenea, Cliona, Halichondria, Cladorhiza, Spongilla, Euspondia*, etc.

Phylum Porifera Classification

The phylum includes about 5,000 species of sponges, grouped into 3 classes depending mainly upon the types of skeleton found in them. The classification here is based on **Storer** and **Usinger** (1971) which appears to be a modification from **Hyman's** classification**.**

Class 1. Calcarea (L., calx=lime) or Calcispongiae (L., *calcis*= lime+ *spongia*= sponge)

- Small-sized **calcareous sponges**, below 10 cm in height.
- Solitary or conical; body shape vase-like or cylindrical.
- They may show asconoid, Syconoid, or leuconoid structures.
- A skeleton of separate one or three or four-rayed calcareous spicules.
- Exclusively marine.

Order 1. Homocoela (=Asconosa)

- Asconoid sponges with cylindrical and radially symmetrical bodies.
- Body wall thin, not folded. Choanocytes line the Spongocoel.

- Often conical.
- Examples: *Leucosolenia*, *Clathrina*.

Order 2. Heterocoela (=Syconosa)

- Syconoid and leuconoid sponges having a vase-like body.
- The body wall is thick, folded. Choanocytes line the flagellated chambers (radial canals) only.
- Spongocoel is a line by flattened endoderm cells.
- Solitary or conical
- Examples: *Sycon* or *Scypha*, *Grantia*.

Class 2. Hexactinellida (Gr., *hex*=six + *actin*=ray) or Hyalospongiae (Gr., *hyalos*=glass+ *spongos*= sponge)

- Moderate -sized. Some reach 1 meter in length.
- Called glass sponges.
- Body shape cup, urn, or vase-like.
- Skeleton is of siliceous spicules which are triaxon with 6 rays. In some, the spicules are fused to form a lattice-like skeleton.
- No epidermal epithelium.
- Choanocytes line finger-shaped chambers.
- Cylindrical or funnel-shaped
- Found in deep tropical seas.

Order 1. Hexasterophora

- Spicules are hexasters i.e. star-like in shape with axes branching into rays at their ends.
- Flagellated chambers regularly and radially arranged.
- Usually attached to substratum directly.
- Examples: *Euplectella* (Venus' flower basket), *Farnera.*

Order 2. Amphidiscophora

- Spicules are amphidiscs i.e. with a convex disc, bearing backwardly directed marginal teeth at both ends.
- Flagellated chambers are slightly different from the typical type.
- Attached to the substratum by root tufts.
- Examples: *Hyalonema*, *Pheronema*.

Class 3. Demospongiae (Gr., *dermos*= frame+ *spongos*= sponge)

- Contains the largest number of sponge species.
- Small to large-sized.
- Conical or solitary.

- The body shape is a vase, cup, or cushion.
- Skeleton of siliceous spicules or spongin fibers, or both, or absent.
- Spicules are never 6-rayed, they are monaxon or tetraxon and are differentiated into large megascleres and small microscleres.
- The body canal system is leucon type.
- Choanocytes restricted to small rounded chambers.
- Generally marine, few freshwater forms.

Subclass I. Tetractinellida

- Sponges are mostly solid and simple rounded cushion-like flattened in shape usually without branches. Dull to brightly colored.
- Skeleton comprised mainly of tetraxon siliceous spicules but absent in order Myxospongida.
- The Canal system is a leuconoid type.
- Mostly in shallow water.

Order 1. Myxospongida

- Simple structure.
- Spicules absent.
- Examples: *Oscarella*, *Halisarca*.

Order 2. Carnosa

- Structure simple.
- Spicules are not differentiated into megascleres and microscleres.
- Asters may be present.
- Examples: *Plakina*, *Chondrilla*.

Order 3. Choristida

- Both large and small spicules present.
- Examples: *Geodia*, *Thenea*.

Subclass II. Monaxonida

- Occurs in a variety of shapes from rounded mass to branching types or elongated or stalked with funnel or fan-shaped.
- Spicules monaxon. Spongin present or absent.
- Spicules are distinguished into megascleres and microscleres.
- Found abundant throughout the world.
- Mostly in shallow waters, some in the deep sea, some in freshwater.

Order 1. Hadromerina

- Monaxon megascleres in the form of tylostyles.
- Microscleres when present in the form of asters.
- Spongia absent.

- Examples: *Cliona*, *Tethya*.

Order 2. Halichondrina

- Monaxon megascleres are often of 2 types i.e. monactines and diactines.
- Microscleres are absent.
- Spongia present and scanty.
- Example: Halichondria (crumb-of-bread sponge).

Order 3. Poecilosclerina

- Monaxon megascleres are of 2 types, one type in the ectoderm and another type in the choanocyte layer.
- Microscleres are typically chelas, sigmas, and toxas.
- Example: Cladorhiza.

Order 4. Haplosclerida

- Monaxon megascleres are of only one type i.e. diactinal.
- No microscleres.
- Spongia fibers are generally present.
- Examples: *Chalina*, *Pachychalina, Spongilla*.

Subclass III. Keratosa

- The body is rounded and massive with a number of conspicuous oscula.
- Horny sponges with the skeleton of spongin fibers.
- No spicules.
- Found in shallow and warm waters of tropical and subtropical regions.
- Examples: *Euspongia*, *Hippospongia*.

References

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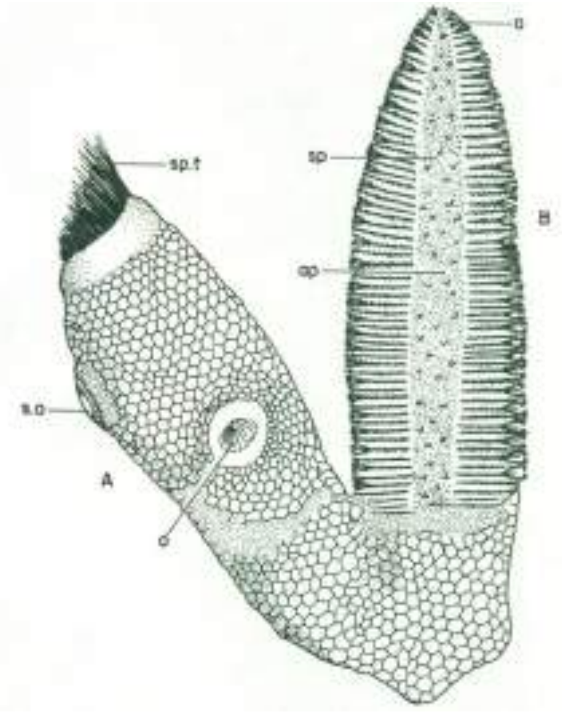
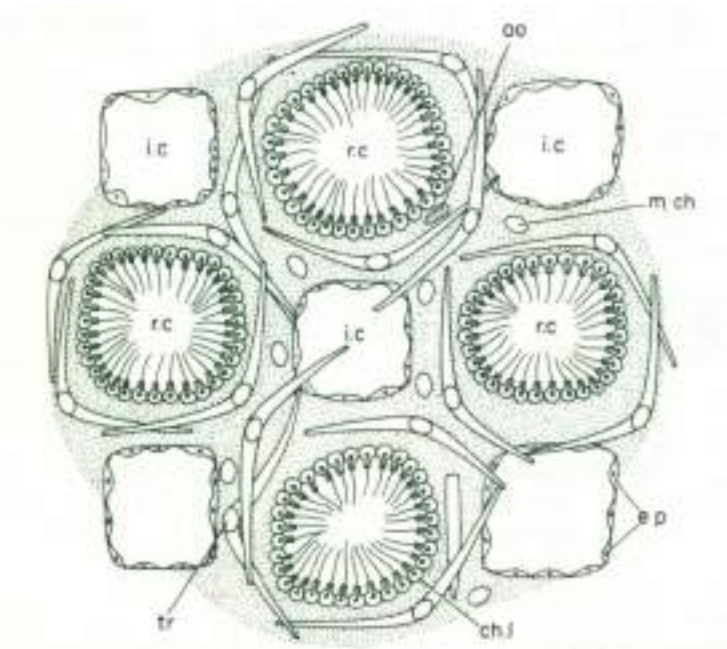
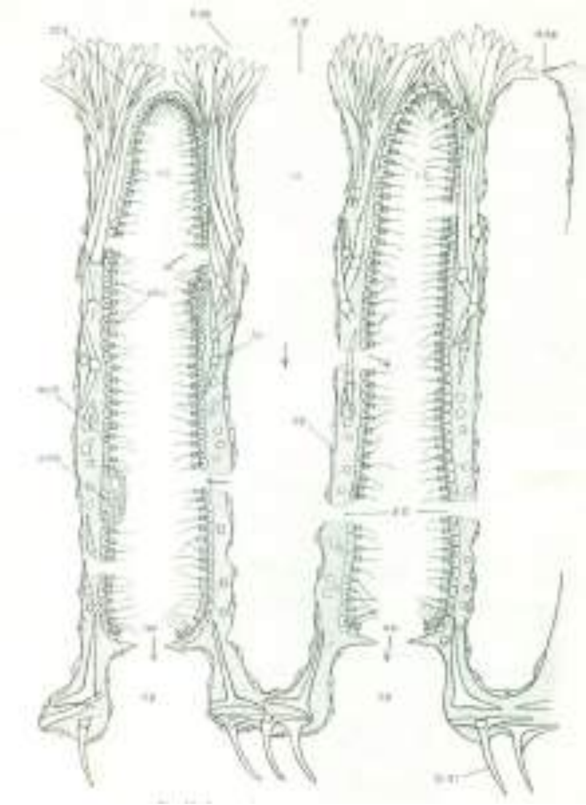
2. Jordan EL and Verma PS. 2018. Invertebrate Zoology. 14th Edition. S Chand Publishing.



Sycon gelatinosum dissected and slightly magnified to show: (A) the polygonal pattern of surface conules with dermal pore grooves between; (B) arrangement of the radial and incurrent canals around the central spongocoel. *ap*, apopyle; *o*, osculum; *s.o*, secondary osculum; *sp*, spongocoel; *sp.t*, oscular spicule tuft (oxeas).

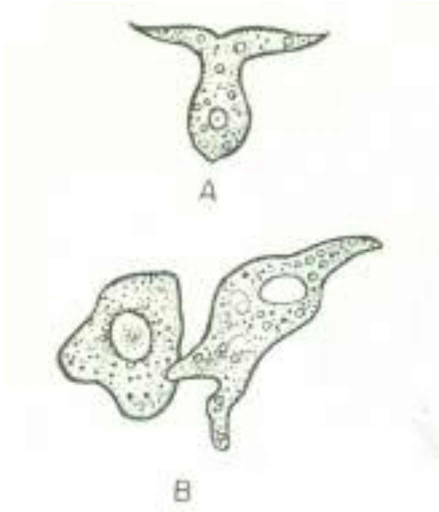


Sycon gelatinosum, tangential longitudinal section through the body wall. *ch.l*, choanocyte layer; *ep*, endopinacocytes; *i.c*, incurrent canal; *mch*, mesenchyme; *oo*, egg cell or oocyte; *r.c*, radial canal; *tr*, triradiate spicule layer. (After Dendy.)

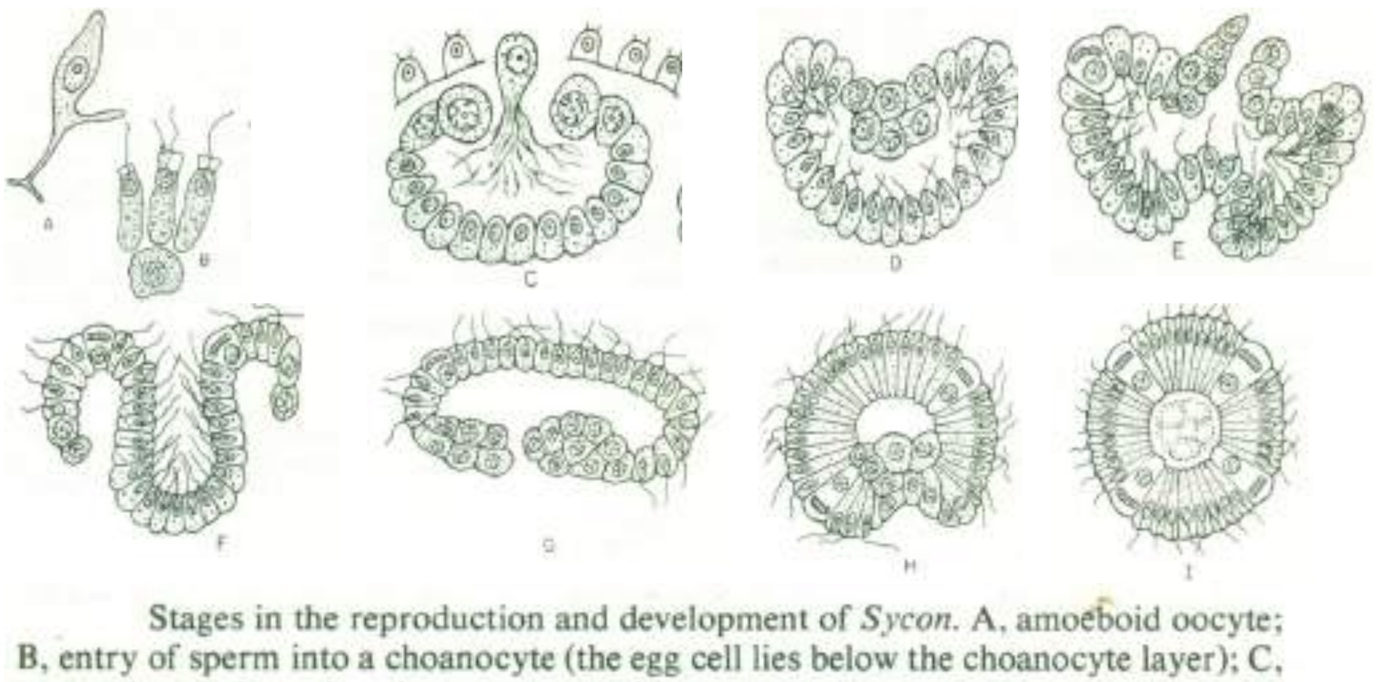


Sycon gelatinosum, transverse section through the wall. *ap*, apopyle; *ch.l*, choanocyte layer; *c.ox*, cortical oxeas; *ctx*, cortex; *d.ep*, dermal epithelium; *d.p*, dermal pore; *emb*, embryo; *ep*, endopinacocytes; *g.qr*, gastral quadriradiates; *i.c*, incurrent canal; *mch*, mesenchyme; *pp*, prosopyles; *r.c*, radial canal; *sp*, spongocoel; *tr*, triradiate spicule layer. (After Dendy.)

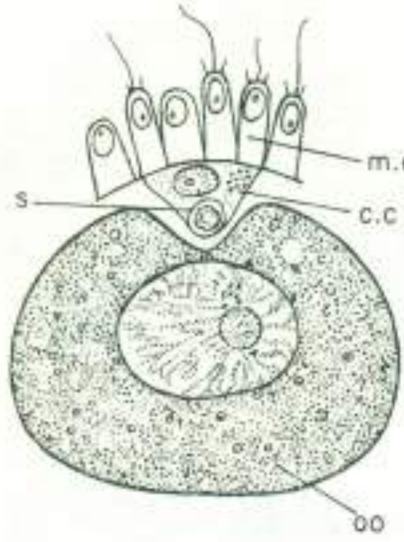
Mesenchymal scleroblasts (calcoblasts) secreting a triradiate spicule. *f.c*, founder cells; *t.c*, thickener cells.



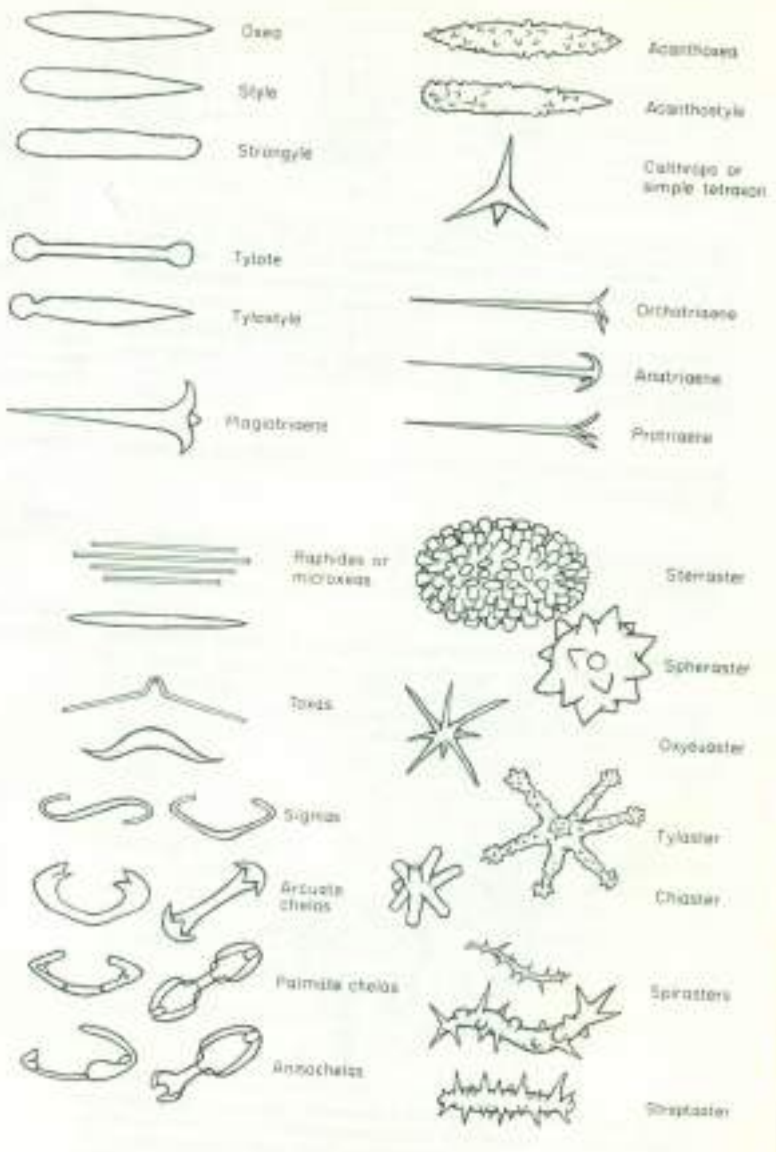
A, epidermal pinacocyte; B, amoebocytes. (After Villee, C. A. *Biology*, Ed. 5, 1967. Courtesy of W. B. Saunders Company, Philadelphia.)



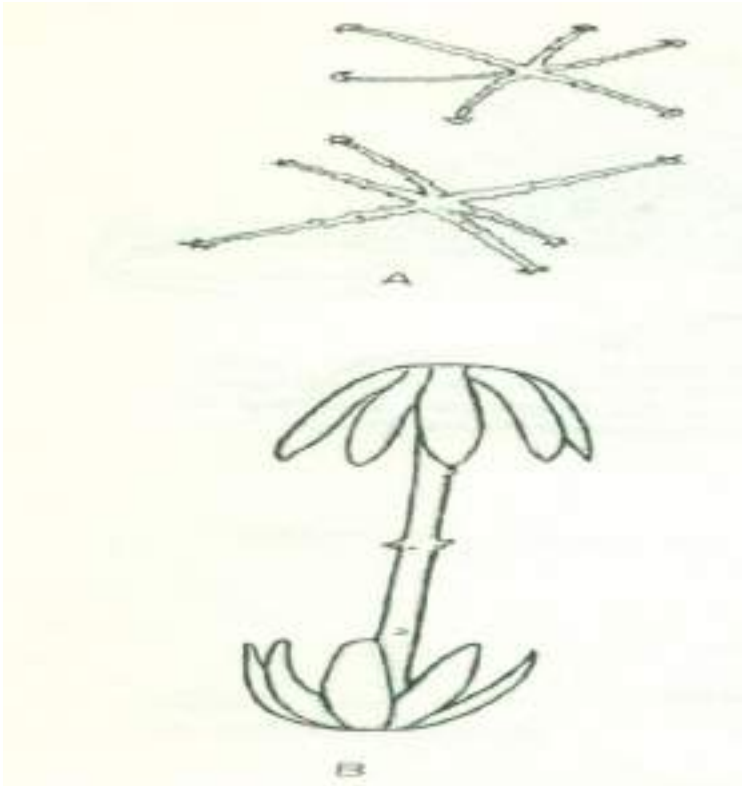
Stages in the reproduction and development of *Sycon*. A, amoeboid oocyte; B, entry of sperm into a choanocyte (the egg cell lies below the choanocyte layer); C, stomoblastula ingesting choanocytes; D, blastula with internally directed flagella; E, onset of the process of inversion of the blastula surfaces; F, G, stages in inversion; H, amphiblastula with externally directed flagella; I, section of amphiblastula showing the four 'cellules en croix'. (After Tuzet, *The Lower Metazoa*, 1963. Courtesy of the University of California Press, Berkeley.)



Carrier cell transmitting sperm to the egg. *c.c*, carrier cell; *m.ch.l*, maternal choanocyte layer; *oo*, egg cell or oocyte; *s*, sperm. (After Dubosq and Tuzet.)



Common spicule types in sponges. (After de Laubenfels, *A Guide to the Sponges of East North America*, 1953. Courtesy of the University of Miami Press.)



Parenchymal microscleres of *Hexactinellida*. A, hexasters; B, amphidisc. (After Levi, 1964. *Galathea Report* **7**.)

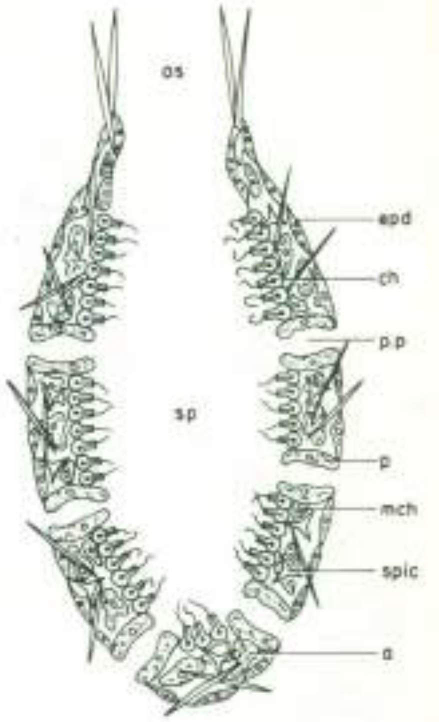


Diagram of the simplest type of sponge, the asconoid type. *a*, amoebocyte; *ch*, choanocyte; *epd*, epidermis; *mch*, mesenchyme; *os*, osculum; *p*, porocyte; *p.p*, pore through porocyte; *sp*, spongocoel; *spic*, spicules. (After Villee, op. cit.)

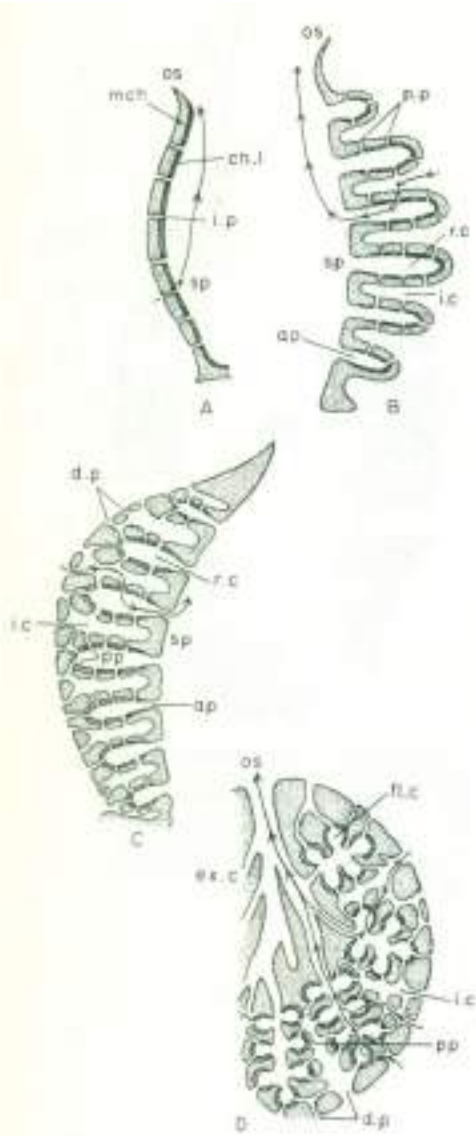
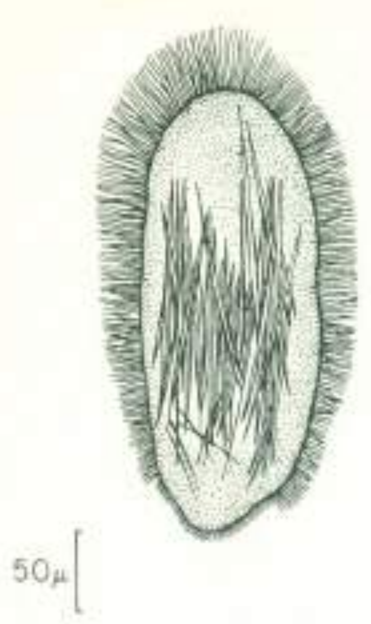


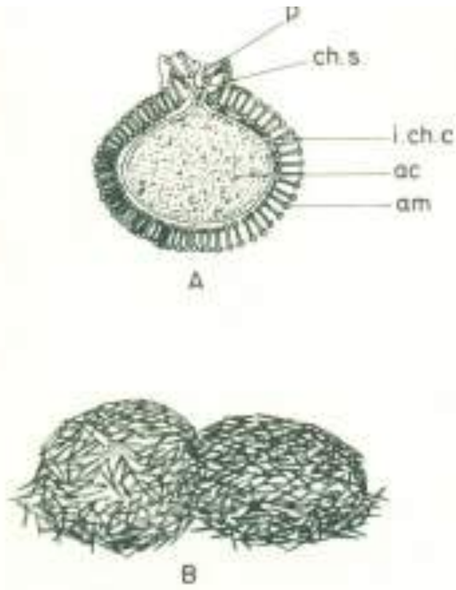
Fig. 69. Diagrams of various grades of sponge structure. A, asconoid; B, early syconoid, with no formation of a cortex; C, syconoid with cortex; D, leuconoid with mouthed (eurypylous) flagellated chambers. Choanocyte layer black, mesenchyme stipple. *ap*, apopyle; *ch.l*, choanocyte layer; *d.p*, dermal pore (ostium); *ex.c*, excurrent canal; *fl.c*, flagellated chamber; *i.c*, incurrent canal; *i.p*, incurrent pore; *mch*, mesenchyme; *os*, osculum; *pp*, prosopyles; *r.c*, radial canal; *sp*, spongocoel. (After Hyman, op. cit.)

Table Different types of sponge structure

	Asconoid	Syconoid	Leuconoid
Sponge Wall	Simple	Outfolded with alternating radial and incurrent canals	Irregular
Choanocytes	Lining central spongocoel	Lining radial canals	Restricted to flagellate chambers
Mesenchyme	Limited amount; simple layer completely traversed by porocytes	Increased in thickness. No longer completely traversed by porocytes	Highly developed
Direction of Water Current	Incurrent pores → spongocoel → osculum	Dermal pores → incurrent canals → prosopyles → radial canals → apopyles spongocoel → osculum	Dermal pores → subdermal spaces → incurrent channels → prosopyles → flagellate chambers → apopyles → excurrent canals → larger channels → oscules



Parenchymella larva of *Hali-chondria* (Ceractinomorpha). (After Hartman, 1958, *Peabody Museum of Natural History, Bulletin*, 12.)



Gemmules. A, freshwater sponge, sectional view; B, marine siliceous sponge, surface view. *ac*, archeocytes; *am*, amphidisc; *ch.s*, chitinous septum; *i.ch.c*, inner chitinous coat; *p*, pore. (From Hartman, in *McGraw-Hill Encyclopaedia of Science and Technology*, Vol. 10, Ed. 2, 1966. Courtesy of McGraw-Hill Inc., New York.)

Phylum Coelenterata (Cnidaria)
Characteristics, classification, examples

Coelenterata (Cnidaria) Definition

The Coelenterata may be defined as diploblastic metazoa with tissue grade of construction having nematocyst and a single gastrovascular cavity or the coelenteron.

Phylum Coelenterata (Cnidaria) Characteristics

1. They are aquatic, mostly marine except few freshwater forms like the *hydra*.
2. They are multicellular with tissue grade of organization.
3. They are solitary or conical. Sedentary or free-swimming.
4. Individuals are radially or biradially symmetrical about a longitudinal oral-aboral axis.
5. Body organization of cell-tissue grade. Cells mostly scattered and specialized for different functions. Some cells form tissues like nerve nets or nervous tissues.
6. Exoskeleton chitinous (perisarc) or calcareous(corals).
7. They are diploblastic animals with 2 cellular layers-outer an epidermis and an inner gastrodermis- with a gelatinous acellular mesoglea in between.
8. Acoelomate animals because they do not pose a second body cavity, the coelom.
9. Short and slender tentacles encircle the mouth in one or two whorls.
10. The tentacles are provided with nematocysts; tentacles serve for food capture, its ingestion, serve for adhesion, and for defense.
11. Two types of individuals occur, attached sessile and asexual zooid (polyps) and free swimming and sexual zooid (medusae). Some species are notable for polymorphism or variety of forms.
12. They are usually carnivorous; digestion is extracellular as well as intracellular.

13. No anus.
14. Coelom and respiratory, circulatory, and excretory system wanting.
15. Nervous system primitive, consisting of a diffuse nerve net. Central nervous system absent.
16. The muscular system includes longitudinal and circular fibers formed by epithelia-muscle and endothelial-muscle cells.
17. A single cavity, lined with gastrodermis, called gastrovascular cavity or coelenteron, into which mouth opens.
18. Sensory organs form ocelli and statocysts.
19. Reproduction is both by asexual and sexual methods.
20. Asexual reproduction occurs by budding and sexual reproduction by the formation of gametes.
21. The development includes a free-swimming ciliated planula larva.
22. Life history exhibits the phenomena of alternation of generation or metagenesis in which the asexual polypoid, sessile generation alternates with sexual medusoid, free-swimming generation.

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Phylum Coelenterata (Cnidaria) Classification

Phylum Coelenterata includes nearly 11,000 known species half of which are extinct. The classification followed here is given by **Hyman**, **L.H.,** (1940). According to Hyman phylum, Coelenterata has been classified into 3 classes.

Class 1. Hydrozoa (Gr., *hydra*=water +*zoios*=animal)

- Freshwater or marine. Solitary or conical. Sessile or free-swimming.
- Exhibit tetramerous and polymerous radial symmetry.
- The body wall consists of outer ectoderm and inner endoderm separated by non-cellular mesoglea.
- Gastrovascular cavity without stomodaeum, septa, or nematocysts bearing gastric filament.
- Skeleton or horny structure is horny perisarc in some forms, while coenosarc secretes a skeleton of calcium carbonate forming a massive stony structure or coral in other forms.
- They exhibit polymorphism. These are two main types of zooids, the asexual polyp, and sexual medusa.
- Polyp without stomodaeum and septa (mesentery).
- Medusa with true velum (Craspedote).
- Mesoglea non-cellular.
- Many of them exhibit alternation of generations.
- Gonads are epidermal. Sex cells shed directly on the outside.
- Cleavage is holoblastic, embryo ciliated in planula.

Order 1. Hydroida

- Solitary or conical.
- Polypoid stage predominant.
- Medusae are short-lived or absent.
- Sense organ of medusae are ocelli ad statocysts and exclusively ectodermal in origin.

Suborder 1. Anthomedusae or Athecata

- Solitary or conical.
- Polyps and blastostyles athecate**,** i.e. perisarc not forming hydrothecae and gonothecae.
- Medusae are tall, bell-like bearing gonads on the manubrium having a strongly arched umbrella.
- Medusae bear eyespot or ocelli at the bases of tentacles.
- Statocysts absent.
- Examples: *Hydra*, *Ceratella*, *Tubularia*, *Clava*, *Eudendrium*.

Suborder 2. Leptomedusae or Thecata

- Conical Hydrozoa.
- Polyps are enclosed in hydrothecae and medusae are covered with gonothecae.
- Free medusae are flattened, bowl or saucer-shaped, bearing gonads on the radial canal.
- Medusa with gonads on radial canals.
- Medusae usually bear statocysts.
- Eyespots or ocelli are absent.
- Examples: *Obelia*, *Sertularia*, *Plumularia*, *Aglaophenia*.

Order 2. Milleporina

- Conical coral-like Hydrozoa without perisarc.
- The massive calcareous skeleton is secreted by ectoderm provided with pores through which polyps protrude out.
- Colony have 2 types of zooids, the gastrozooid and dactylozooid.
- Gastrozooids (nutritive zooids) are short provided with mouth and tentacles.
- Dactylozooids are elongated, hollow, slender with tentacles but without a mouth.
- Medusae develop in small chambers, becoming free, devoid of mouth, radial canals, and tentacles.
- Example: *Millepora*.

Order 3. Stylasterina

- Colonial coral-like Hydrozoa colony have 2 kinds of zooids, the dactylozooids, and gastrozooids.
- Dactylozooids are small, solid without tentacles.
- Gastrozooids have a cup with a pointed spine.
- Gonophores reduced to sporosacs. Medusae not free.
- Larva is liberated as planula.
- Example: *Stylaster*.

Order 4. Trachylina

- Polypoid stage reduced or absent.
- Medusae are large, dominant, free-swimming, and may develop directly from the fertilized egg.
- Marginal sense organs or statocysts with endodermal statoliths.

Suborder 1. Trachymedusae

- Tentacles inserted above bell margin.
- The margin of the umbrella is smooth.
- The manubrium is long.
- Gonads develop in radial canals.
- Example: *Geryonia*.

Suborder 2. Narcomedusae

- Tentacles arise between the bell margin and vertex of the exumbrella.
- The manubrium is short.
- Gonads present on the manubrium or on the stomach floor.
- Examples: *Cunina*, *Solmaris*.

Order 5. Siphonophora

- They are polymorphic, free-swimming, or floating colonial Hydrozoa.
- The colony consists of several types of polypod and medusoid individuals attached to stem or disc.
- Polyps without oral tentacles.
- Medusae incomplete and rarely freed.

Suborder 1. Calycophora

- The upper end of the colony is provided with one or more swimming bells (nectophores).
- Apical float or Pneumatophore absent.
- Examples: *Diphyes*, *Praya*, *Abyla*.

Suborder 2. Physophorida

- Upper ed of colony forms a large gas-filled float (pneumatophore).
- Examples: *Physalia*, *Halistemma*, *Stephalia*.

Class 2. Scyphozoa (Gr., skyphos=cup +zoios=animal)

- It includes large jelly-fishes or true medusae that are exclusively marine.
- Medusae are large, bell or umbrella-shaped, without true velum, free-swimming, or attached by an aboral stalk.
- Polyp stage reduced or absent.
- Marginal sense organs are tentaculocysts having endodermal statoliths.
- Gastrovascular cavity with gastric pouches and endodermal gastric filaments. No stomodaeum.
- Mesoglea extensive, gelatinous, with fibers and cells.
- Gonads are gastrodermal. Sex cells released in the digestive cavity.

Order 1. Stauromedusae or Lucernaridae

- Body goblet or trumpet-shaped.
- Sessile, attached by an aboral stalk.
- Mouth cruciform (four-cornered) with small oral lobes and a short quadrangular manubrium.
- The gastrovascular system is divided into the central stomach and four per-radial pouches by the four inter-radial septa.
- Gonads are elongated band-like borne on the faces of septa.
- No marginal sense organs or tentaculocysts.
- Fertilization external.
- The larva is planula without cilia.
- Examples: *Lucernaria*, *Haliclystus*.

Order 2. Cubomedusae or Carybdeida

- Body cubical with 4 flattened sides.
- Free-swimming Scyphozoa found in warm and shallow waters of tropical and subtropical regions.
- 4 hollow inter-radial tentacles borne on the margin of the sub-umbrella.
- 4 per- radial tentaculocysts or rhopalia are present.
- Each tentaculocyst is provided with a lithocyst and one or more ocelli.
- The mouth is cruciform and gastric pouches are present.
- Leaf-like gonads.
- Examples: *Charybdaea*, *Tamoya*.

Order 3. Coronate

- Body conical, divided by a deep circular coronary groove.
- Free-swimming scyphomedusae found inhabiting the deepwater of the ocean.
- The umbrella is divided by a coronal groove (horizontal furrow) into an upper cone and a lower crown.

- The crown consists of pedal lobes, pedalia.
- The pedalia bear solid tentacles.
- The bell margin is scalloped into lappets alternate with pedalia.
- Cruciform mouth.
- 4 to 16 tentaculocysts present.
- Examples: *Pericolpa*, *Periphylla*.

Order 4. Semaeostomeae

- Most common free-swimming medusae found inhabiting the coastal waters of all oceans.
- The umbrella is a flat, saucer, or bowl-shaped.
- Square shaped mouth extending into 4 long oral arms.
- The margin of the umbrella is fringed with hollow tentacles.
- 8 tentaculocysts present.
- Gastric pouches and filaments are absent.
- Examples: *Aurelia*, *Cynaea*.

Order 5. Rhizostomae

- Body usually hemisphere without marginal tentacles.
- Free-swimming Scyphozoa found in shallow waters of tropical and subtropical oceans.
- The umbrella is saucer or bowl-shaped or flattened or even concave on the top.
- The mouth is surrounded by 8 oral arms-bearing numerous funnel-shaped mouths on their edge.
- Typically, 8 or more tentaculocysts.
- Four subgenital pits are generally present.
- Examples: *Rhizostoma* or *Pilema*, *Cassiopeia*.

Class 3. Anthozoa (Gr., *anthos*= flower+ *zoios*= animal)

- Exclusively marine. Solitary or conical.
- Exclusively polypoid.
- No medusoid stage.
- The body is usually cylindrical with hexamerous, octamerous, or polymerous biradial or radobilateral symmetry.
- The oral end of the body is expanded radially into an oral disc bearing hollow tentacles surrounding the mouth in the center.
- The stomodaeum is present, often provided with 1or more ciliated grooves the siphonoglyphs.
- The gastrovascular cavity subdivided by 8 or more septa or mesenteries.
- Mesenteries bear nematocysts at their inner free edges.
- Mesoglea stout and contains fibrous connective tissue and amoeboid cell.

- Skeleton either external or internal.
- The exoskeleton is formed from calcium carbonate which often forms a massive coral.
- The nervous system is in the form of a typical nerve net without a concentrated central nervous system.
- Endodermal gonads, develop in the mesenteries.
- The ripe sexual products are discharged into coelenteron.
- External fertilization.
- The fertilized egg develops into a planula larva, which after a short free life settles down and develops into an adult.

Subclass 1. Alcyonaria or Octocorallia

- Exclusively colonial.
- Polyp are long or short cylinder terminating orally into a flat circular oral disc having an oval or elongated mouth in the center.
- Polyp with 8 pinnate tentacles and 8 septa.
- 8 complete mesenteries are present.
- Single ventral siphonoglyphs present.
- Endoskeleton is the product of mesogleal cells comprised of calcareous spicules either calcareous is horny in nature.
- Polyps are dimorphic in some form.

Order 1. Stolonifera

- Inhabitants of shallow water in the tropical and temperate region.
- Polyps arising independently from a creeping mat or stolon.
- Skeleton of calcareous tubes or separate calcareous spicules or absent.
- Examples: *Tubipora*, *Clavularia*.

Order 2. Telestacea

- The colony consists of simple or branched stems arising from a creeping base.
- Each stem is a very elongated polyp bearing lateral polyps.
- Skeleton consists of calcareous spicules.
- Example: *Telesto*.

Order 3. Alcyonacea

- Colony mushroom-shaped or branched into stout blunt processes.
- Lower parts of the polyp fused into a fleshy mass or coenenchyma with one oral end protruding.
- Polyp are dimorphic in some form bearing autozooids and siphonozooids.
- Skeleton consists of separate clacerous spicules, not axial.
- Examples: soft corals. *Alcyonium*, *Xenia*.

Order 4. Coenothecalia

- Skeleton is massively composed of crystalline calcareous fibers of calcium carbonate, not of fused spicules.
- Polyp embedded and connected by solenial tubes.
- Commonly called blue corals found on the coral reefs in the Indo-pacific.
- Example: *Heliopora* (blue coral).

Order 5. Gorgonacae

- The colony usually plant-like, consists of the main stem arising from the basal plate or tuft of stolon and a number of branches bearing polyp.
- Axial skeleton composed of horn-like gorgonin, separate or fused clacerous spicules, or both.
- Commonly called sea fans, sea feathers, and sea whips.
- Found in tropical and subtropical shores.
- Examples: Gorgonia, Corallium.

Order 6. Pennatulacea

- Colony elongated and divided into a proximal stalk or peduncle and distal rachis.
- Their lower part(peduncle) embedded in mud and sand.
- The upper part (rachis)consists of a very long axial polyp with lateral branches bearing a dimorphic polyp.
- The main stem is supported by a calcareous or horny skeleton.
- Examples: *Pennatula*, *Renilla*, *Cavernularia*, *Pteroides*.

Subclass 2. Zoantharia or Hexacorallia

- Solitary or colonial.
- Marine form.
- Tentacles simple usually unbranched, numerous arranged in multiples of five and six but never 8.
- Mesenteries are numerous arranged in multiple of 5 or 6, maybe complete or incomplete.
- Gullet commonly with 2 siphonoglyphs.
- Endoskeleton when present calcareous, derived from ectoderm.
- Usually monomorphic polyp.

Order 1. Actiniaria

- Solitary or colonial.
- Simple often large-sized.
- No skeleton.
- Body muscular, often with an aboral pedal disc.
- Tentacles and mesenteries are numerous.

- One or more siphonoglyphs.
- Examples: *Actinia*, *Metridium*, *Adamsia*, *Edwardsia*.

Order 2. Madreporaria

- Rarely Solitary or mostly colonial.
- The exoskeleton is hard, compact, often massive calcareous.
- Polyp small, living in cup-like cavities on the exoskeleton.
- No siphonoglyph and muscles feeble.
- Examples: true or stony corals. *Astraea* (star coral), *Fungia*, Favia*, Madrepora* (staghorn coral), *Meandrina* (brain coral).

Order 3. Zoanthidea

- Mostly colonial sometimes solitary forms.
- No skeleton and pedal disc but, the body wall contains calcareous bodies.
- Mostly epizoic.
- Small polyp and usually united by basal stolons.
- Paired mesenteries. A pair composed of one complete and one incomplete mesentery.
- Only one ventral siphonoglyph present.
- Example: *Zoanthus*.

Order 4. Antipatharia

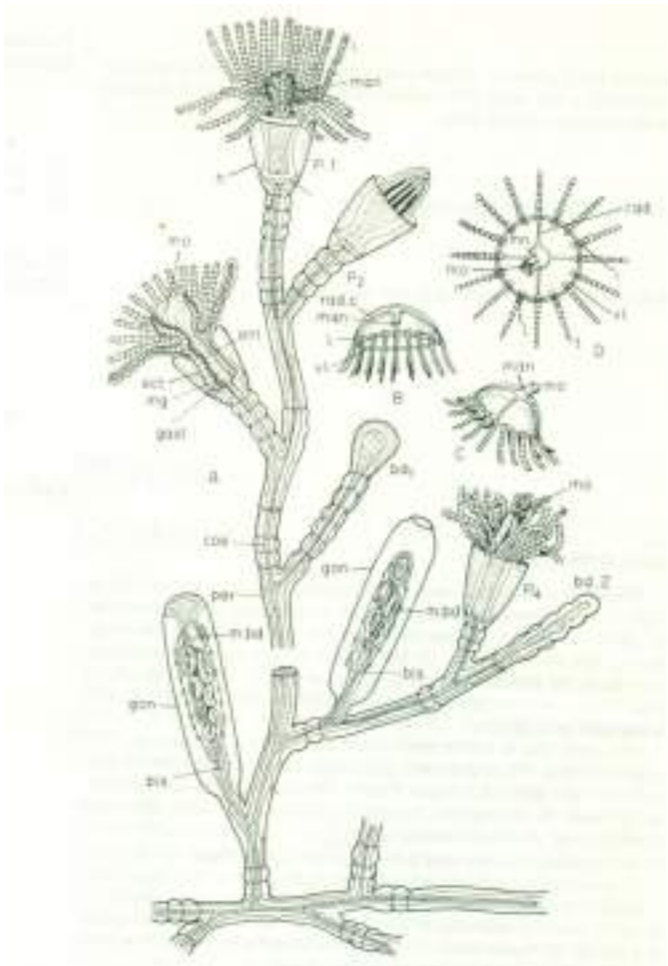
- Colonial and tree-like.
- Found in the deep waters in the oceans.
- The lower end of the colony usually consists of a basal plate for the attachment of some objects.
- Tentacles and mesenteries comparatively few (6-24) in numbers.
- Skeleton as branched, chitinoid axis derived from ectoderm.
- The axial skeleton bears the polyps which are dioecious but the colony may be hermaphrodite.
- 2 siphonoglyphs present.
- Examples: Black corals. *Antipathes*.

Order 5. Ceriantharia

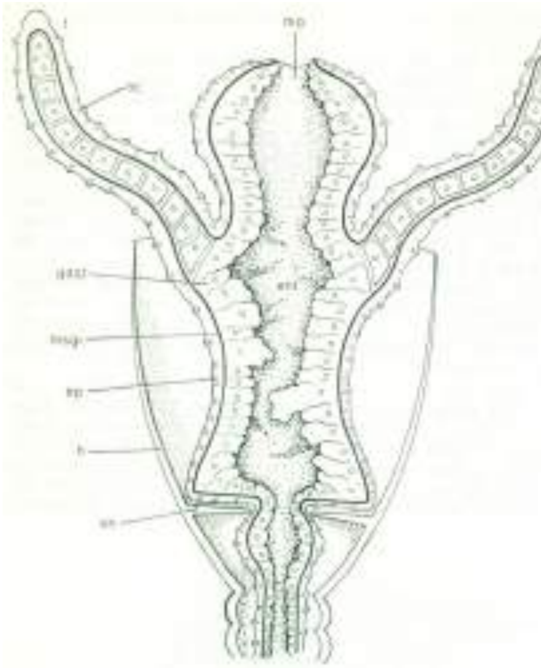
- Long, solitary, anemone-like forms living in the vertical cylindrical cavities in the sea bottom.
- No pedal disc and skeleton.
- Body smooth cylindrical and elongated with an oral disc.
- Tentacles simple, numerous, arranged in 2 whorls- oral and marginal.
- Single and dorsal siphonoglyphs.
- Mesenteries are numerous, single, and complete.
- Examples: *Cerianthus*.

References

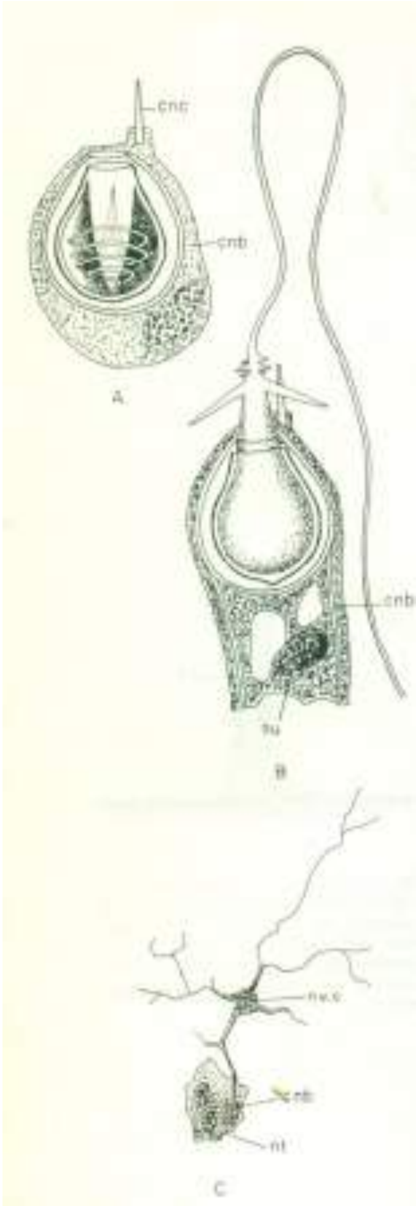
1. Kotpal RL. 2017. Modern Text Book of Zoology- Invertebrates. 11th Edition. Rastogi Publications.
2. Jordan EL and Verma PS. 2018. Invertebrate Zoology. 14th Edition. S Chand Publishing.



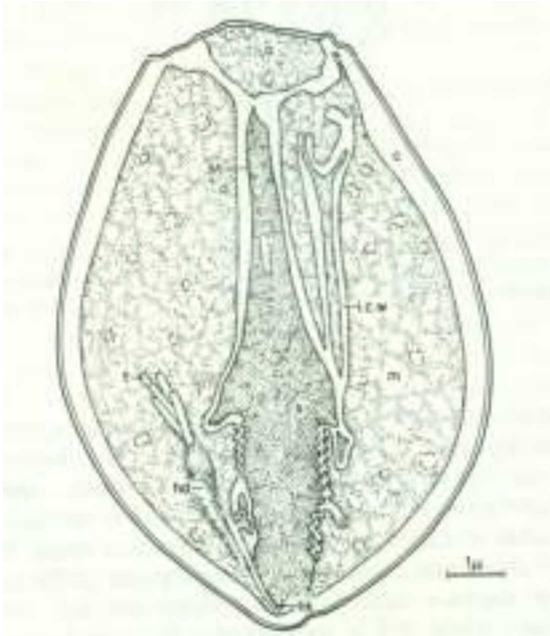
Obelia sp. A, portion of a colony with certain parts shown in longitudinal section; B, medusa; C, the same with reversed umbrella; D, the same, oral aspect. *bd. 1, 2*, buds; *bls*, blastostyle; *coe*, coenosarc; *ect*, epidermis; *ent*, enteric cavity (coelenteron); *gast*, gastrodermis; *gon*, gonotheca; *h*, hydrotheca; *l*, lithocyst; *m.bd*, medusa bud; *mg*, mesogloea; *man*, manubrium; *mo*, mouth; *per*, perisarc; *P. 1, 2, 4*, polyps; *rad.c*, radial canal; *sh*, shelf-like prolongation of hydrotheca; *t*, tentacle; *vl*, velum.



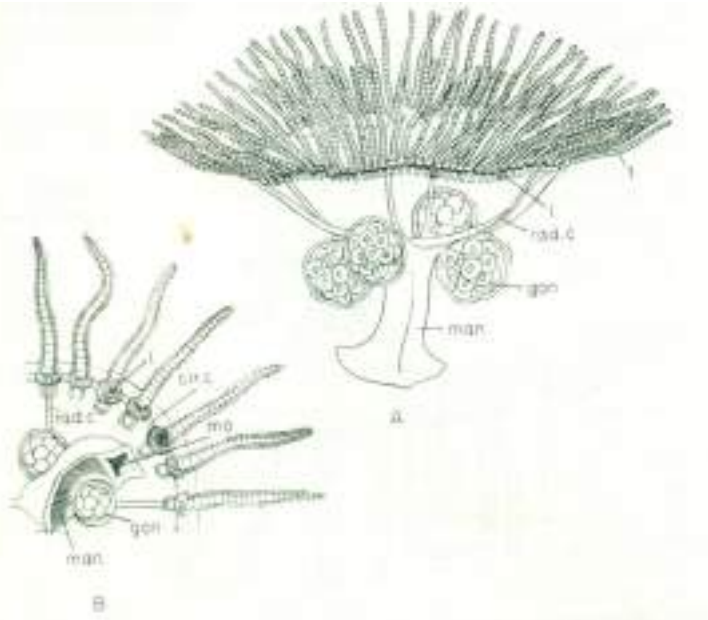
Obelia sp. Vertical section of a polyp, highly magnified. *ep*, epidermis; *ent*, enteric cavity (coelenteron); *gast*, gastrodermis; *h*, hydrotheca; *msgl*, mesogloea; *mo*, mouth; *nc*, nematocysts; *sh*, shelf-like prolongation of hydrotheca; *t*, tentacle.



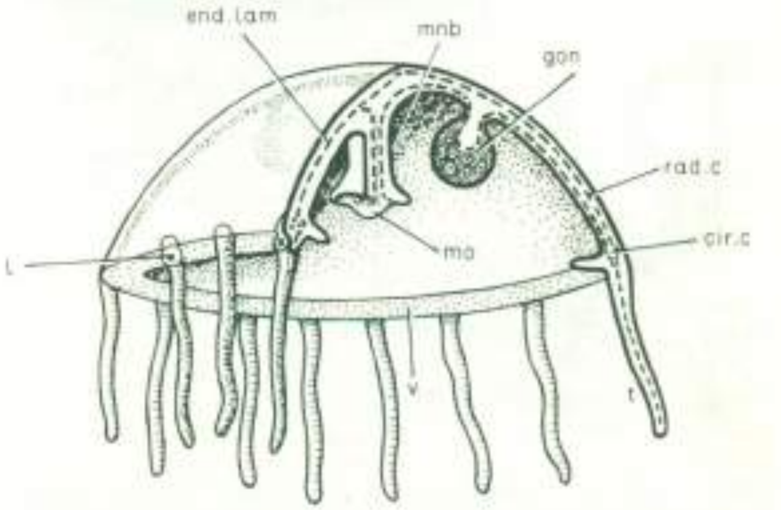
Nematocysts of *Hydra*. A, undischarged; B, discharged; C, nerve-supply. *cnb*, cnidoblast; *cnc*, cnidocil; *nt*, nematocyst; *nu*, nucleus; *nv.c*, nerve cell. (From Parker, *Biology*, after Schneider.)



Hydra, Sagittal section of a very nearly mature stenotele. *c*, capsule; *hd*, head of tubule; *hk*, hook of tubule; *i*, interstitial cell; *i.c.w*, invaginated capsular wall; *m*, matrix; *o*, operculum; *s*, spine; *st*, stylet; *t*, tubule. The magnification mark equals one micron. (After Chapman in Lenhoff, H. M., and Loomis, W. F., *The Biology of Hydra and of Some Other Coelenterates*, 1961. Courtesy of the University of Miami Press.)



Obelia sp. A, mature medusa swimming with everted umbrella; B, one-quarter of the same, oral aspect. *circ.c*, circular canal; *gon*, gonad; *l*, lithocyst; *man*, manubrium; *mo*, mouth; *rad.c*, radial canal; *t*, tentacle. (After Haeckel.)



Dissection of a medusa with rather more than one-quarter of the umbrella and manubrium cut away (diagrammatic.) *cir.c*, circular canal; *end.lam*, endoderm lamella; *gon*, gonad; *l*, lithocyst; *mnb*, manubrium; *mo*, mouth; *rad.c*, radial canal; *t*, tentacle; *v*, velum.

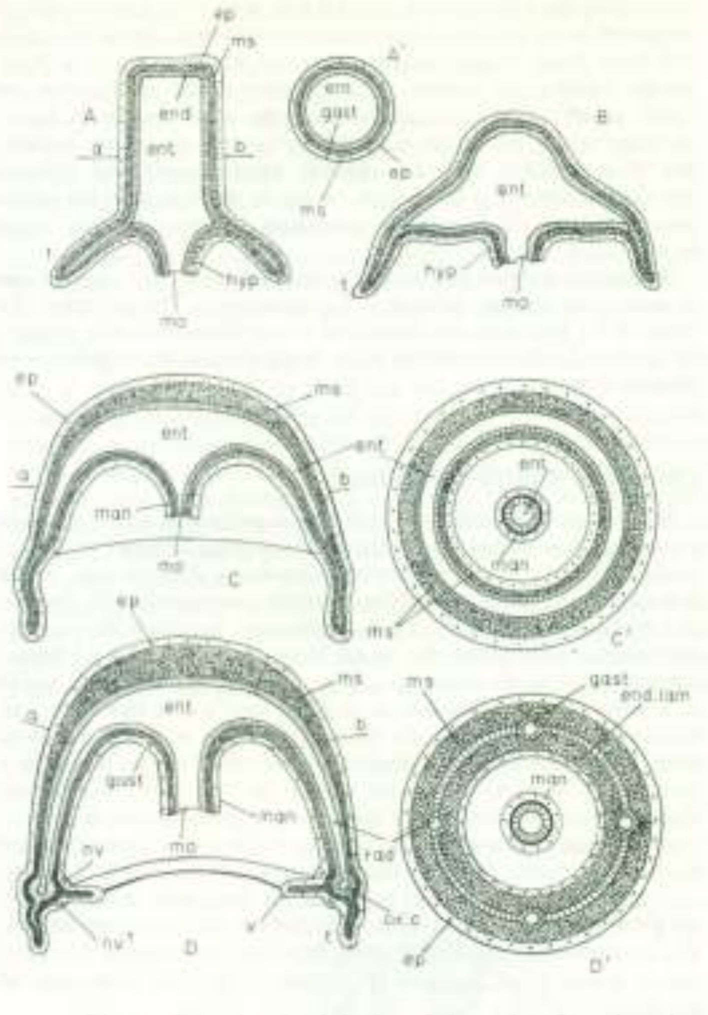
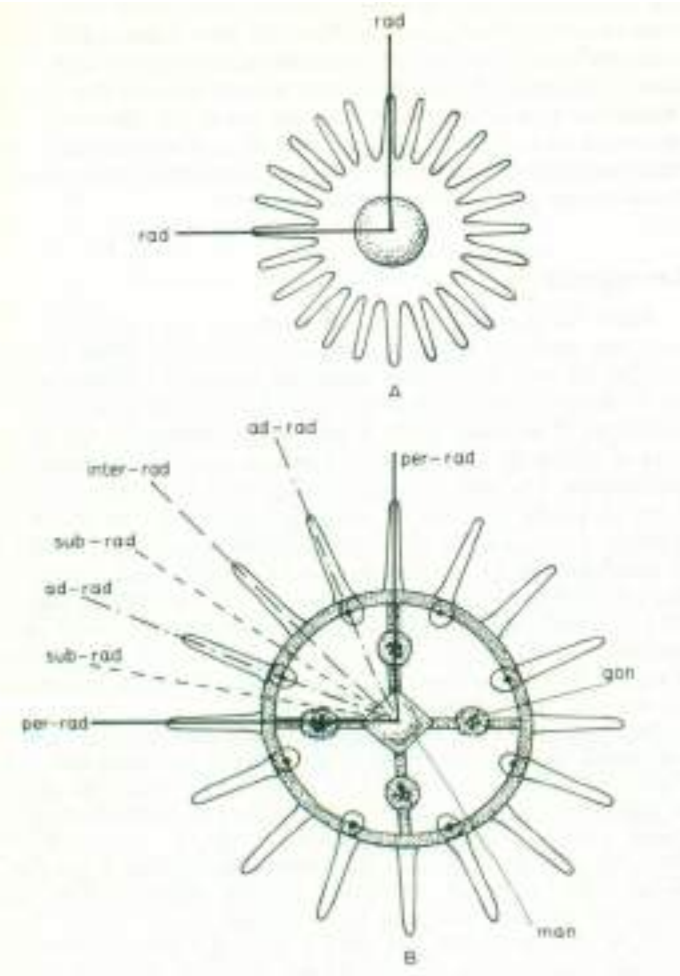


Diagram illustrating the derivation of the medusa from the polyp. A, longitudinal, and A', transverse section (along the line *ab*) of polyp-form; B, polyp-form with extended tentacular region; C, vertical, and C', transverse section (along the line *ab*) of form with tentacular region extended into the form of a bell; D, vertical, and D', transverse section (along the line *ab*) of medusa. The epidermis is dotted, the gastrodermis striated and the mesogloea stippled. *cir.c*, circular canal; *end.lam*, endoderm lamella; *ent*, enteric cavity; *ep*, epidermis; *hyp*, hypostome of manubrium; *man*, manubrium; mo, mouth; *ms*, mesogloea; *nr*, *nr*¹, nerve rings; *rad*, radial canal; *t*, tentacle; *v*, velum. (From Parker, *Biology*.)



Projections of polyp (A) and medusa (B), showing the various orders of radii. *gon*, gonad; *man*, manubrium; *ad-*, *inter-*, *per-*, *sub-*, *rad*, adradius, interradius, perradius, subradius and radius.

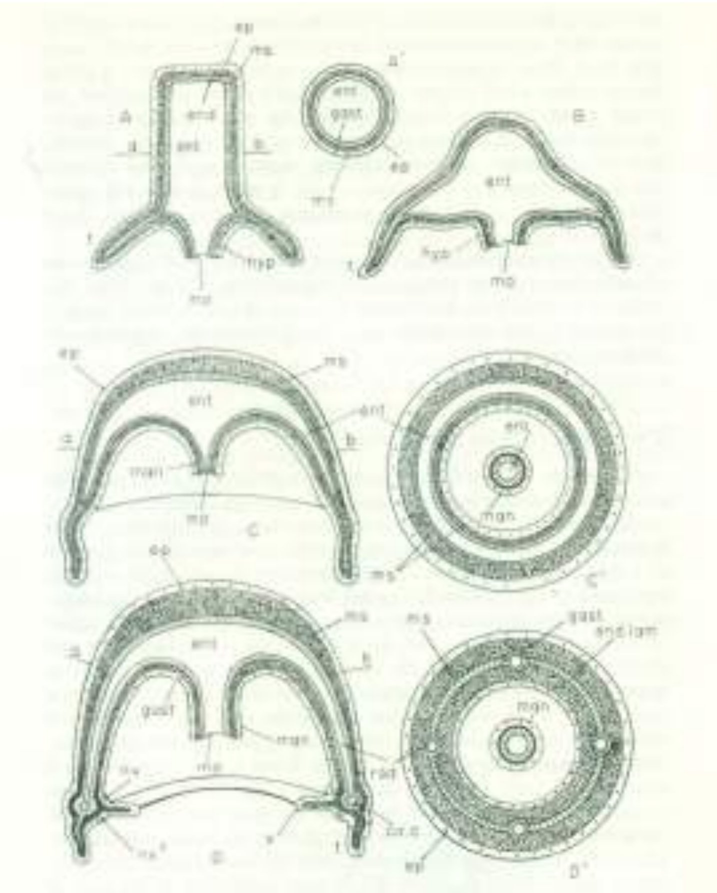
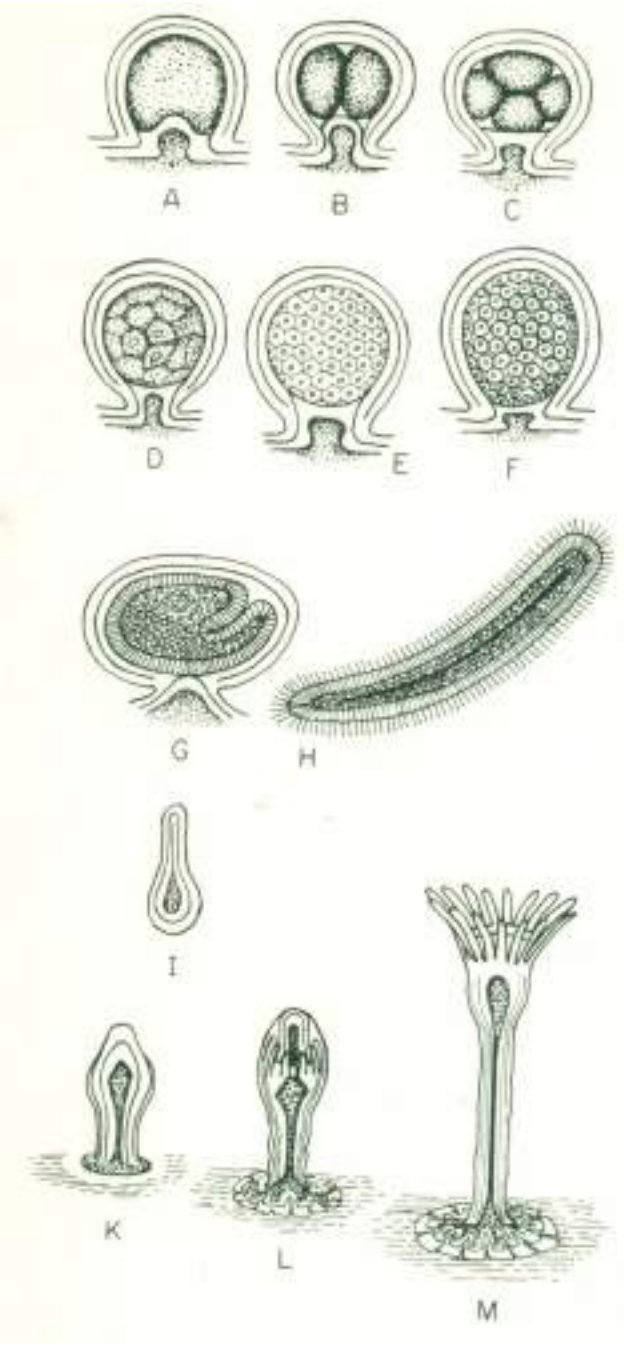
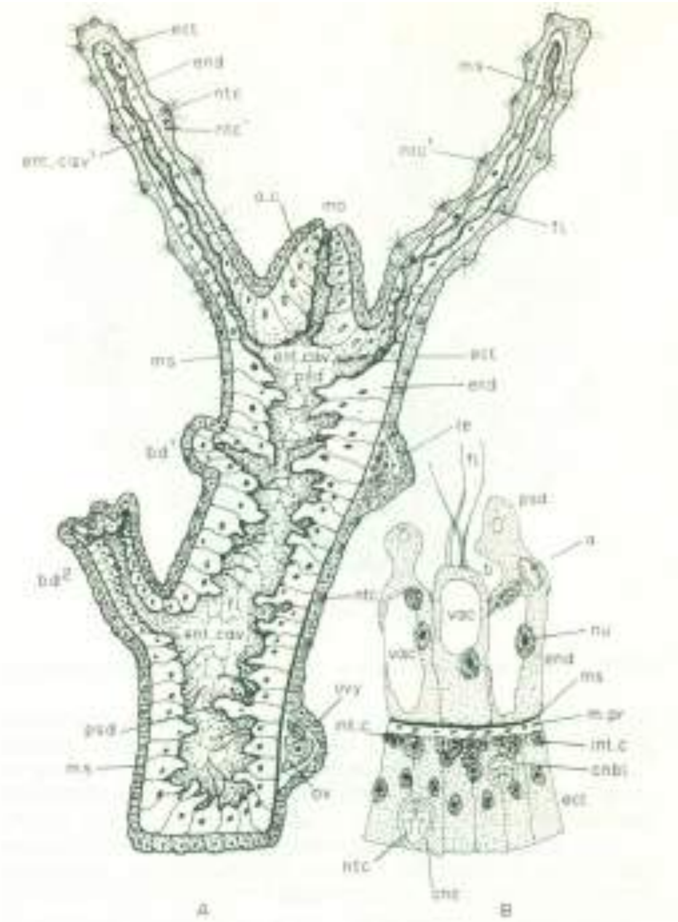


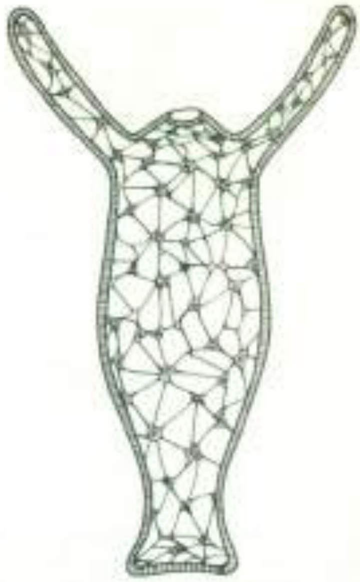
Diagram illustrating the derivation of the medusa from the polyp. A, longitudinal, and A′, transverse section (along the line *ab*) of polyp-form; B, polyp-form with extended tentacular region; C, vertical, and C′, transverse section (along the line *ab*) of form with tentacular region extended into the form of a bell; D, vertical, and D′, transverse section (along the line *ab*) of medusa. The epidermis is dotted, the gastrodermis striated and the mesogloea stippled. *cir.c*, circular canal; *end.lam*, endoderm lamella; *ent*, enteric cavity; *ep*, epidermis; *hyp*, hypostome of manubrium; *man*, manubrium; *mo*, mouth; *ms*, mesogloea; *nr*, *nr*[1], nerve rings; *rad*, radial canal; *t*, tentacle; *v*, velum. (From Parker, *Biology*.)



Stages in the development of two zoophytes (A–H, *Laomedea*, I–M, *Eudendrium*) allied to *Obelia*; A–F, stages in cleavage; G, the planula enclosed in the maternal tissues; H, the free swimming planula; I–M, fixation of the planula and its development. (From Parker, *Biology*, after Allman.)



Hydra. A, vertical section of entire animal; B, portion of transverse section, highly magnified. *a*, ingested diatom; *bd*[1], *bd*[2], buds; *cnc*, cnidocil; *cnbl*, cnidoblast; *ent.cav*, enteric cavity; *ent.cav*[1], its prolongation into the tentacles; *fl*, flagellum; *int.c*, interstitial cells; *m.pr*, muscle processes; *mo*, mouth; *ms*, mesogloea; *ntc*, large nematocyst; *ntc*[1], small nematocyst; *nu*, nucleus; *o.c*, oral cone; *ov*, ovum; *ovy*, ovary; *psd*, pseudopods; *te*, testis; *vac*, vacuole. (From Parker, *Elementary Biology*, after Lankester and Howes.)



Nerve-net of *Hydra*. (From Claus, Grobben and Kühn, *Lehrbuch der Zoologie*. Julius Springer.)

Phylum Ctenophora
characteristics, classification, examples

Ctenophora Definition

Ctenophores are free-swimming, transparent, jelly-like, soft-bodied, marine animals having biradial symmetry, comb-like ciliary plates for locomotion, the lasso cells but nematocytes are wanting. They are also known as sea walnuts or comb jellies.

Phylum Ctenophora Characteristics

- They are free-swimming, marine, solitary, pelagic animals. No polymorphism and no attached stages were found.
- The body is transparent, gelatinous, pear-shaped, cylindrical, or flat or ribbon-shaped.
- They have a biradially symmetrical body along an oral-aboral axis.
- They have an external surface with comb-like 8 ciliary plates for locomotion. Hence name as comb jellies.
- They have a pair of long, solid, retractile tentacles.
- Their body organization is cell-tissue grade.
- Their body is acoelomate and "diploblastic" having ectoderm and endoderm. The body wall has outer epidermis, inner gastrodermis, middle jelly-like mesoglea with scattered cells, and muscle fibers. So, Ctenophora may also be considered as "triploblastic".
- Their digestive system contains the mouth, stomodaeum, complex gastrovascular canals, and 2 aboral anal pores.
- They lack nematocysts.
- They have special adhesive and sensory cells i.e. colloblasts or lasso cells present in tentacles which helps in food captures.
- They lack skeletal, circulatory, respiratory, and excretory organs.
- Their nervous system is diffused types and the aboral end bears a sensory organ, called statocyst.

- They are monoecious (hermaphrodite); gonads are endodermal situated on walls of digestive canals.
- Their development direct with characteristic cydippid larva.
- They lack asexual reproduction and alternation of generation.
- Regeneration and paedogenesis are common in them.

Phylum Ctenophora Classification

Phylum Ctenophora contains about 100 know species and grouped in 2 classes

Class 1. Tentaculata

- Adults with 2 long aboral tentacles.
- In some larva has tentacles, while adults have oral lobes.
- Mouth narrow and pharynx small.

Order 1. Cydippida

- Body simple, round, and oval.
- Digestive canals terminate blindly; no anal pores.
- Tentacles are two long and branched.
- Tentacles are retractile into pouches or sheath.
- Examples: *Mertensia*, *Pleurobrachia*, *Hormiphora*

Order 2. Lobata

- Body oval, laterally compressed.
- Adults with 2 large oral lobes and 4 slender flap-like auricles around the mouth.
- Pouched or sheath tentacles in the larva.
- Tentacles reduced and without sheath in adults.
- Gastrovascular canals are connected by a ring at oral ends.
- Examples: *Mnemiopsis*, *Bolinopsis*

Order 3. Cestida

- Body elongated compressed/flat, ribbon-like.
- Two main tentacles in the sheath but reduced.
- Many small lateral tentacles along the oral edge.
- Combs plates in 4 rows but rudimentary.
- Examples: *Cestum*, *Velamen*

Order 4. Platyctenea

- Body greatly compressed/flat in the oral-aboral axis.
- 2 well- developed tentacles with sheath.
- Comb plates reduced in adults.
- Adapted for creeping.

- Examples: *Ctenoplana*, *Coeloplana*

Order 5. Thalassocalycida

- They are found surface waters down up to 2,765 Ms in Atlantic oceans and the Mediterranean Sea.
- The body is a bell of Medusa shaped and may be up to 15 cm in diameter.
- Mouth slit holds by a central cone-shaped peduncle.
- A pair of small tentacles hang from the side of the peduncle.
- Com jelly is with its transparent and colorless body. Usually different to see.
- They hold the bell wide opens to captures prey i.e. Zooplankton.
- Presumably hermaphroditic.
- This species has limited swimming ability compared to other comb jellies.
- Examples: *Thalassocalyce inconstans*.

Class 2. Nudu

- Body large, conical, and compressed laterally.
- Without tentacles and oral lobes.
- Wide mouth and large pharynx.
- Voracious feeder.

Order 1. Beroida

- No tentacles and oral lobes.
- Body large, conical, and laterally compressed.
- Mouth large.
- Voluminous Stomach.
- Examples: *Beroe*

References

1. Kotpal RL. 2017. Modern Text Book of Zoology- Invertebrates. 11th Edition. Rastogi Publications.
2. Jordan EL and Verma PS. 2018. Invertebrate Zoology. 14th Edition. S Chand Publishing.

Acoelomate Animals

several phyla share the following characteristics:

1. have 3 true tissue layers (=triploblastic):
ectoderm
mesoderm
endoderm
between epidermis and digestive cavity is filled with a 3rd tissue layer = mesoderm. mesoderm allows more elaborate organs. more specialization and greater division of labor than in Cnidaria

2. have true organs
each made of several different tissue layers; sponges have various specialized cells but no true tissues or organs. jellyfish and corals have 2 tissue layers and a few simple organs

3. acoelomate=without body cavity
Organs are embedded in tissue, not in any body space
like cnidaria and ctenophore. Only 1 "internal space" =digestive cavity

4. in terms of development these organisms are
Protostomes, mouth develops first in embryo during gastrulation

5. most have bilateral symmetry
such design allows for a "front end"= cephalization. head contains sense organs, simple brain was a major new design more efficient search for food, mates, etc. most animals before this were sedentary filter feeders.

Phylum Platyhelminthes
characteristics, classification, examples

Platyhelminthes (flatworms) definition

Platyhelminthes are triploblastic, bilaterally symmetrical, dorsoventrally flattened, acoelomate flatworms with organ grade of construction without a definite anus, circulatory, skeletal or respiratory system but with Protonephridial excretory system and mesenchyme filling the space between the various organ of the body.

Phylum Platyhelminthes (flatworms) characteristics

- They are free-living, commensal or parasitic.
- They are bilaterally symmetrical and dorsoventrally flattened, triploblastic worm.

- Bilaterally symmetrical with the definite polarity of head and tail ends.
- Triploblastic i.e. body derived from three embryonic germ layers; ectoderm, mesoderm, and endoderm.
- Dorsoventrally fattened i.e. well-developed ventral surface with mouth and gonopore.
- Their body generally shapes as a worm but varies from moderately elongated flattened to long ribbon-like and leaf-like.
- They are small to moderate in size varying from microscopic to extremely elongated form measuring up to 10-15 meters.
- Their body is unsegmented except in class Cestoda.
- The majority of them are white, colorless and some derive color from ingested food while free-living form are grey, brown-black or brilliantly colored.
- Their anterior end of the body is differentiated into the head.
- Mouth and genital pores on the ventral surface are well marked in turbellarians but less marked in cestodes and trematodes.
- Their parasitic form has adhesive structures like hooks, spines and suckers, and adhesive secretions.
- The body is covered with cellular or syncytial, frequently ciliated epidermis; while trematodes cestodes, lacks epidermis and their body covered with cuticle.
- Exo- and endoskeleton are completely absent, hence the body is generally soft. The hard part consists of cuticle, spines, thorns, hooks, teeth.
- They are acoelomate i.e. without any body cavity.
- Space between various organs filled with special mesodermal tissues, the mesenchyme, and parenchyma.
- Their digestive system is branched and incomplete without an anus and totally absent in acoela and cestode.
- They lack skeletal, respiratory and circulatory systems.
- The excretory system includes a lateral canal and a single or pair of protonephridia with flame cells or bulbs. Absent in some primitive form.
- Their nervous system is primitive, ladder-like. The main nervous system consists of a pair of ganglia or brain and one or three pairs of longitudinal nerve cords connected by transverse nerves.
- Their sense organs are simple. A common occurrence in tubellaria but greatly reduced in parasitic form. Chemo- and tangoreceptors commonly in the form of ciliated pits and grooves.
- They are mostly monoecious (hermaphrodite).
- Their reproductive system is highly evolved or complex in most of the forms.
- Asexual reproduction occurs by fission in many freshwater turbellaria.
- In the majority of form, eggs are devoid of yolk. They are produced separately in the yolk or vitelline glands.

- Fertilization is internal but cross-fertilization in trematodes and self-fertilization in cestodes.
- Their life cycle is complicated involves one or more hosts.
- Parthenogenesis and polyembryony commonly occur trematodes and tapeworms.
- Some tapeworm propagates by endogenous or exogenous budding.
- The flatworm is either free-living or ecto-or endocommensals or parasitic.

Phylum Platyhelminthes (flatworms) Classification

The classification is from Hyman, L.H., (1951) up to suborder only with certain modifications.

Class 1- Turbellaria (L., *turbella*= a little string)

- Mostly free-living but some ectocommensals and endocommensals or parasitic called
- Terrestrial marine or freshwater.
- Body unsegmented and covered with ciliated cellular or syncytial epidermis, containing mucus-secreting cells and rod-shaped body called
- Mouth ventral. intestine preceded by the muscular pharynx.
- Adhesive organs(suckers) abundantly present.
- Sense organ i.e. Tango, chemo, and photoreceptors common in free-living forms.
- The excretory system consists of protonephridia, the flame cells.
- Mostly reproduction sexual, asexual and by regeneration.
- Life cycle simple.

Order 1- Acoela

- Small, exclusively marine, less than 2 mm.
- Ventral mouth; no muscular pharynx and no intestine.
- The excretory system is totally absent.
- No flame cells, definite gonads, gonoducts, and yolk glands.
- Mostly free-living, found under stones or bottom mud, algae, some live in the intestine of sea-urchins and sea-cucumbers.
- Some colored or brown by symbiotic algae.
- Examples: *Convoluta, Ectocotyle, Afronta*.

Order 2- Rhabdocoela

- Small (less than 3mm) freshwater, marine, and terrestrial form.
- Simple pharynx and sac-like intestine without diverticula.
- Nervous system with 2 main longitudinal trunks.
- Protonephridia excretory system.
- Eye usually present.
- The reproductive system comprises few compact gonads, gonoducts and a cuticularized structure instead of penis papilla present. Yolk gland present or absent.
- Marine, freshwater or terrestrial. Free-living, commensal or parasitic form
- Examples: *Catenula*, *Microstomum, Macrostomum, Mesostoma*.

Suborder 1. Notandropora

- Exclusively freshwater forms.
- Simple pharynx.
- The excretory system consists of a single median protonephridia.
- Testes single compact mass, penis unarmed.
- No yolk gland.
- Asexual fission occurs with the formation of the chain of zooids.
- Examples: *Catenula*,

Suborder 2. Opisthandropora

- Freshwater or marine form.
- The excretory system consists of paired nephridia.
- Testes compact, penis armed with a stylet.
- No yolk gland.
- Asexual reproduction with a chain of zooids.
- Examples: *Macrostomum, Microstomum*.

Suborder 3. Lecithopora

- Freshwater, marine or terrestrial forms.
- Bulbose pharynx.
- The excretory system consists of paired nephridia.
- Separate ovaries and yolk glands.
- Reproduction is exclusively sexual.
- Mostly free-living, some commensals or parasitic form.
- Examples: *Anoplodium, Mesostoma*.

Suborder 4. Temnocephalida

- Freshwater ectocommensals form.
- The anterior end of the body provided with 2-12 tentacles.
- Posterior end of the body provided with 1-2 adhesive discs.
- Dolii form pharynx.
- Simple gonopore.
- Examples: *Temnocephala*, *Monodiscus*.

Order 3- Alloecoela

- Moderate-sized between 1 and 10mm.
- Mostly marine, freshwater and brackish water form.
- Pharynx simple, Bulbose or plicate; intestine straight or branched (short diverticula).
- The excretory system consists of paired protonephridia having 2 or 3 main branches and nephridiopores.
- Nervous system with 3or 4 pairs of longitudinal nerve cords provided with transverse connectives.
- The reproductive system consists of numerous testes and a pair of ovaries.
- Penis papilla is mostly present.
- Some are ectoparasitic or ectocommensals in the habit.
- Examples: *Prorhynchus, Plagiostomum*, *Geocentrophora*.

Suborder 1. Archophora

- Marine form.
- Plicate pharynx.
- Primitive female reproductive system, no female ducts.
- Male copulatory apparatus simple opening posteriorly.
- Examples: *Proporoplana* (only examples).

Suborder 2. Lecithoepitheliata

- Marine, freshwater or terrestrial form.
- Simple or Bulbose pharynx.
- Penis with the cuticular stylet.
- Simple or none female ducts.
- No yolk glands.
- Nutritive cells surround ova.
- Examples: *Prorhynchus*, *Geocentophora*.

Suborder 3. Cumulata

- Freshwater or marine form.
- Bulbose or plicate pharynx.
- Intestine usually devoid of diverticula.
- Unarmed penis.
- The female reproductive system consists of germovitellaria or separate ovaries and yolk glands.
- Examples: *Hypotrichina*.

Suborder 4. Seriata

- Mostly marine and freshwater form.
- Plicate pharynx.
- Intestine usually with lateral diverticula.
- The female reproductive system consists of separate ovaries and yolk glands.
- Statocyst is mostly present.
- Examples: *Otoplana*, *Bothrioplana*.

Order 4- Tricladida

- Large-sized turbellarians (2 to 60cm long).
- Marine, freshwater or terrestrial forms.
- Mouth mid-ventral.
- Pharynx plicate usually directed backward.
- Intestine with 3 branches, each with many diverticula.
- Eyes usually present.
- Protonephridia as lateral networks with many nephridiopores.
- The male reproductive system consists of 2 or numerous testes; a penis papilla present.
- The female reproductive organ consists of a pair of ovaries with yolk glands and a copulatory brusa.
- Single gonopore.

- Examples: *Gunda*, *Dugesia*, *Bdelloura*, *Geoplana*.

Suborder 1. Maricola

- Exclusively marine form.
- A pair of eyes and auricular grooves present.
- Typical penis papilla sometimes armed with the stylet.
- Rounded copulatory brusa present.
- Only sexual reproduction takes place.
- Examples: *Bdelloura*,

Suborder 2. Paludicola

- Mostly freshwater, rarely brackish water forms.
- Eyes 2 to many or completely absent.
- Brusa usually presents anterior to the penis.
- Mostly asexual reproduction.
- Examples: *Planaria* or *Dugesia*.

Suborder 3. Terricola

- Terrestrial, tropical and subtropical forms.
- Elongated body mostly.
- 2 to many eyes.
- Brusa is mostly absent.
- Male and female antra usually separate.
- Asexual reproduction may also occur.
- Examples: *Bipalium*, *Geoplana*.

Order 5- Polycladida

- Moderate -sized turbellarians (2 to 20 mm).
- Marine, many bottom dwellers or littoral zones.
- Plicate pharynx, intestine highly branched.
- The nervous system consists of numerous radially arranged nerve cords.
- Numerous eyes.
- Male and female gonopore separate.
- No yolk glands.
- Testes and ovaries are numerous and scattered.
- Examples: *Leptoplana*, *Notoplana*, *Cestoplana*, *Planocera*, *Thysanozoon*.

Suborder 1. Acotylea

- Usually vertical curtain-like pharynx.
- Suckers absent behind the gonopore.
- Nuchal type tentacles.
- Eyes never occur as a pair of clusters on the anterior margin.
- Examples: *Euplana*, *Leptoplana*, etc.

Suborder 2. Cotylea

- Tubular pharynx.
- Sucker present behind the female pore.
- A pair of marginal tentacles bearing eyes or a cluster of eyes at the anterior margin.

- Examples: *Thysanozoon*, *Yungia*.

Class 2- Trematoda (Gr., *trematodes*= having pore)

- Ectoparasitic or endoparasitic commonly called
- Body unsegmented dorsoventrally flattened leaf-like.
- Teguments thick but without cilia and rhabdites.
- Body undivided and covered with cuticle.
- Suckers and sometimes hooks present.
- Digestive tract incomplete consists of the anterior mouth, simple pharynx and two forked or many branches intestine; anus absent.
- 3 pairs of the longitudinal nerve cord.
- Protonephridial excretory system consisting of flame cells.
- Mostly hermaphrodites(monoecious).
- Single ovary, 2 to many testes.
- Development direct (in ectoparasites) or indirect (in endoparasites) with alternation of hosts.

Order 1. Monogenea

- Mostly ectoparasites in cold-blooded aquatic vertebrates.
- Oral suckers either weak or absent.
- Anterior end provided with a pair of adhesive structures.
- Posterior end provided with an adhesive disc usually with hooks.
- Excretory pores paired situated anteriorly on the dorsal side.
- Male and female gonopore usually separate.
- Vagina one or two. Uterus is small with a few shelled eggs.
- Only one host in the life cycle.
- Free-swimming ciliated larva called
- Examples: *Diplozon*, *Polystoma*, *Gyrodactylus*, *Dactylogyrus*.

Order 2. Digenea

- Endoparasites of vertebrates and invertebrates.
- 2 suckers without hooks; oral sucker around the mouth and ventral sucker or acetabulum.
- Single posterior excretory pore.
- No vagina. The uterus usually long with many shelled eggs.
- The life cycle complicated involving many larval stages.
- One to more intermediate hosts in the life cycle.
- Larval forms reproduce asexually before metamorphosis.
- Examples: *Fasciola*, *Bucephalus*, *Opisthorchis*, *Paragonimus*, *Schistosoma*.

Order 3. Aspidocotylea (=Aspidogastraea)

- No oral suckers.
- Large ventral suckers subdivided into several suckers without hooks.
- Only one testis in the male system.
- Endoparasites in the gut of fishes and reptiles.
- Examples: *Aspidogaster*, *Cotylapsis*, *Stichocotyle*.

Class 3- Cestoda (Gr., ketos, gridle+ eidos, form)

- Endoparasitic in the intestine of vertebrates.
- Commonly called tapeworm.
- Body divided into many segmented (proglottids) but rarely undivided, elongated, flat, ribbon-like.
- Tegument without microvilli.
- Body without epidermis and cilia but covered with cuticle.
- Anterior end (scolex) is provided with adhesive structures (hooks, suckers) except in cestodaria.
- Mouth and digestive systems totally absent.
- The excretory system consists of protonephridia with typical terminal flame
- The nervous system usually comprises a pair of ganglia and 2 lateral longitudinal nerve cords.
- Each mature segment or proglottids monoecious, with male and female organs.
- Life cycle complicates usually involving 2 or more hosts.
- Embryos with hooks.

Subclass 1. Cestodaria

- Endoparasitic in the coelom or intestine of vertebrates.
- Body unsegmented, leaf-like without scolex and strobila (monozoic).
- No alimentary canal.
- Only one set of the monoecious reproductive system.
- Larva lycophore with 10 hooks.

Order 1. Amphilinidea

- Endoparasitic forms in the coelom of fishes.
- Body flattened, oval or elongated.
- No sucker.
- Scolex absent.
- Protrusible pharynx.
- Anterior end bears frontal glands.
- Male and vaginal pores situated posteriorly.
- The uterus is very much coiled opening near the anterior end.
- Examples: *Amphilina*.

Order 2. Gyrocotylidea

- Endoparasitic forms in the intestine of fishes.
- Body elongated and flattened.
- An anterior sucker and a posterior rosette-shaped adhesive organ present.
- Anterior end bears eversible proboscis.
- Uterine, male and vaginal pores are together situated in the anterior half of the body.
- Uterus short straight runs directly to pores.
- Examples: *Gyrocotyle*.

Subclass 2. Eucestoda

- Endoparasitic form in the intestine of fishes.

- Body long, ribbon-like.
- The body is divided into scolex, neck, and strobila with many proglottids (polyzoic).
- Scolex expanded bearing adhesive structures.
- Mostly with several sets of monoecious reproductive organs.
- Larva with 6 hooks.

Order 1. Tetraphyllidea

- Endoparasitic forms; exclusively in the intestine of elasmobranch fishes.
- Scolex with 4 leaf-like bothria (sessile suckers) often provided with
- Testes are anterior to ovaries.
- Vitelline glands scattered.
- Cirrus armed with spines and hooks.
- Common genital atrium marginal.
- Examples: *Phyllobothrium*, *Myzophyllobothrium*.

Order 2. Diphyllidea

- Parasitic in the intestine of elasmobranch fishes.
- Scolex with 2 bothria and spiny head stalk.
- Strobila consists of not more than 20 proglottids.
- Examples: *Echinobothrium*.

Order 3. Trypanorhyncha

- Parasitic in the spiral valve of the digestive tract of elasmobranch fishes.
- Moderately sized body.
- Scolex with 4 bothria and 4 protrusible spiny proboscides.
- Vitellaria in cortical parenchyma placed in a continuous layer.
- Testes extend behind the ovary posteriorly.
- Lateral gonopores; ventrally open uterus.
- Examples: *Haplobothrium*, *Tetrarhynchus*.

Order 4. Pseudophyllidea

- Parasitic in the intestine of teleost fishes and terrestrial vertebrates.
- Body segmented into strobila or unsegmented.
- Scolex with 2 to 6 shallow bothria (Suckers) rarely without adhesive organs.
- Bilobed ovary, testes numerous, follicular and scattered in the mesenchyma of proglottids.
- Vitellaria follicular, numerous.
- Midventral gonopores.
- Examples: *Bothriocephalus*, *Dibothriocephalus*.

Order 5. Taenioidea or Cyclophyllidea

- Parasitic in the intestine of reptiles, birds, and mammals.
- Large-sized tapeworm.
- Scolex bears 4 larges in cupped suckers (acetabula) often with an apical rostellum armed with hooks.
- Ovary two or many lobed; uterine opening absent.
- Gonopores on one or both margins.

- The excretory system consists of 4 longitudinal vessels.
- Vitellaria (yolk gland) single and compact.
- Examples: Taenia, Echinococcus, *Hymenolepis*, *Moniezia*.

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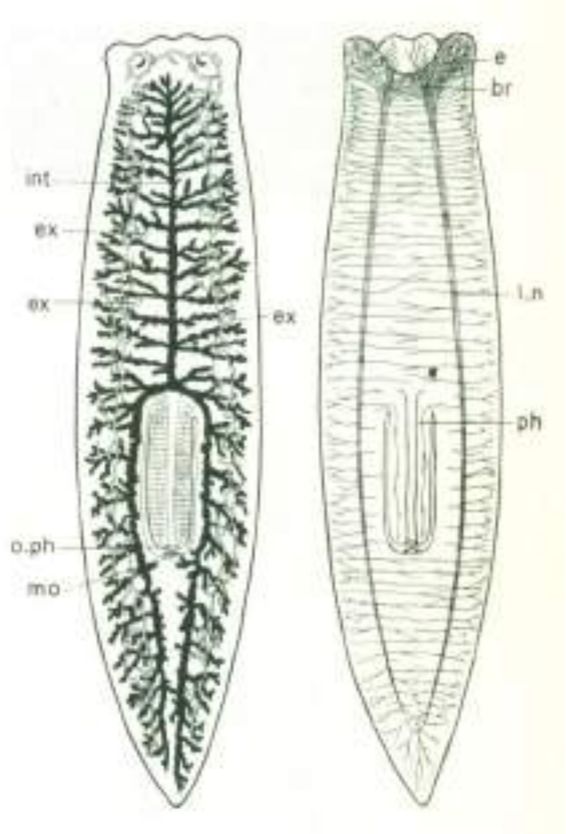
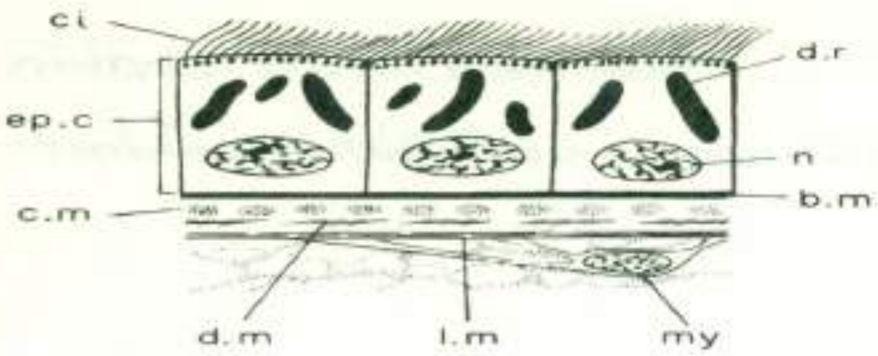
1. Kotpal RL. 2017. Modern Text Book of Zoology- Invertebrates. 11th Edition. Rastogi Publications.
2. Jordan EL and Verma PS. 2018. Invertebrate Zoology. 14th Edition. S Chand Publishing.

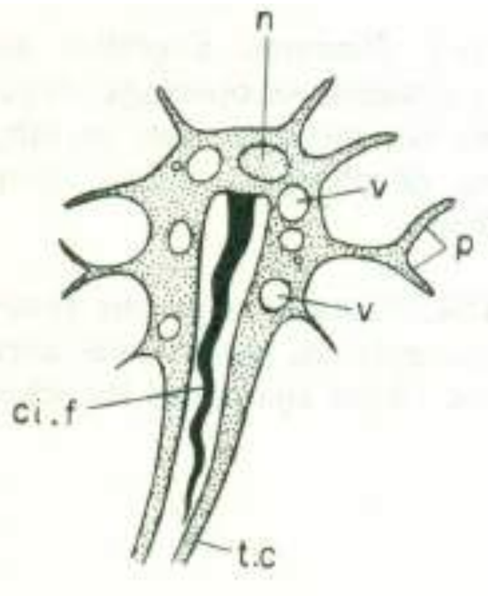


Planaria. Digestive and excretory systems. *ex*, openings of excretory system; *int*, intestine; *mo*, mouth; *o.ph*, opening of pharynx. (After Jijima and Hatschek.)

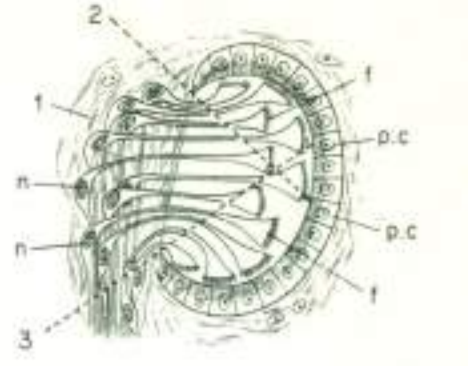
Planaria. Nervous system. *br*, brain; *e*, eye; *l.n*, longitudinal nerve; *ph*, pharynx. (After Jijima and Hatschek.)



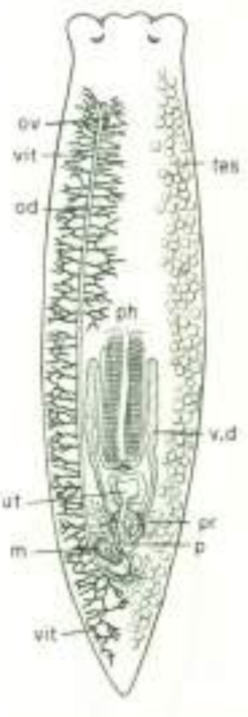
Section through the body wall of a turbellarian. *b.m*, basement membrane; *ci*, cilia; *c.m*, circular muscles; *d.m*, diagonal muscles; *d.r*, dermal rhabdites; *ep.c*, epithelial cell; *l.m*, longitudinal muscle; *my*, myoblast; *n*, nucleus of epithelial cell.



Flame cell of a turbellarian. *ci.f*, ciliary flame; *n*, nucleus; *p*, processes; *t.c*, termination of capillary; *v*, vacuoles. (After Lang.)

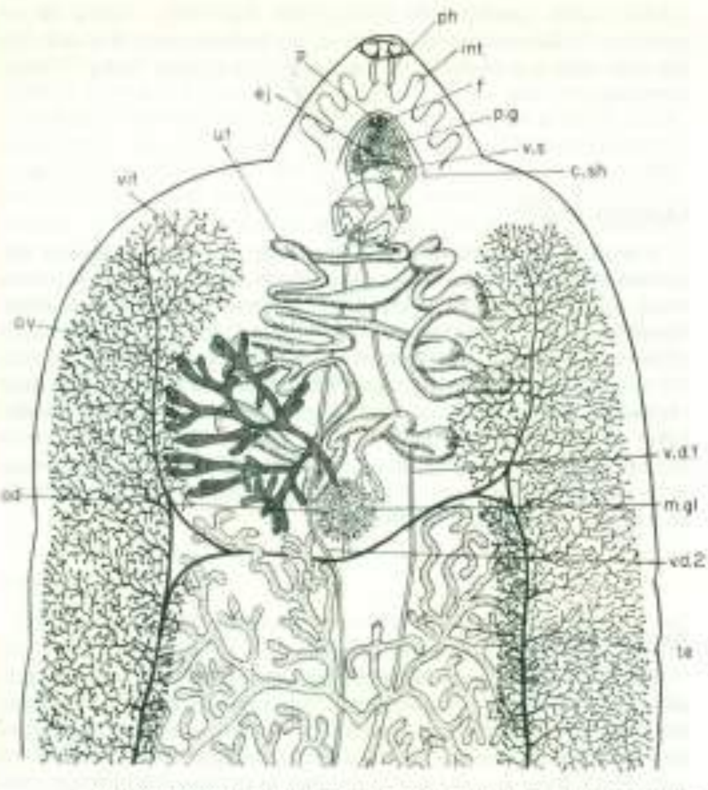


Eye of *Planaria gonocephala*. *f*, fribrillae; *n*, nuclei of light-sensitive cells; *p.c*, pigment cells. 1, 2 and 3, directions of light rays. Light from 1 stimulates all the sensory cells; light from 2 only those below; and light from 3 only those above the broken line. (After Hesse.)

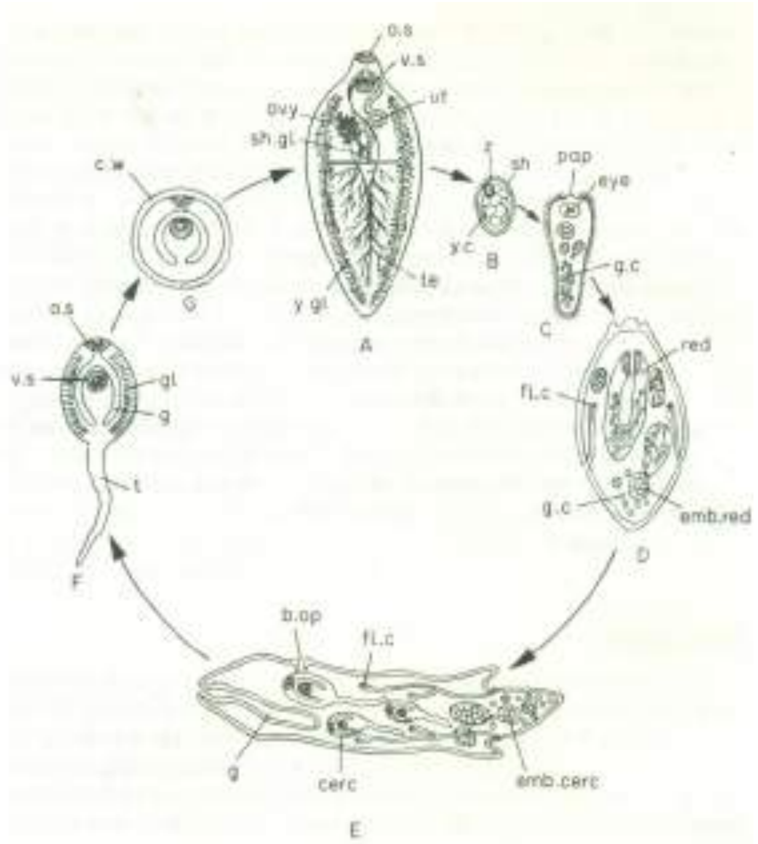


Planaria. Reproductive system. *m*, muscular sac; *od*, oviduct; *ov*, ovary; *p*, penis; *ph*, pharynx; *pr*, prostate; *tes*, testes; *ut*, copulatory bursa; *v.d*, vas deferens; *vit*, vitelline glands. (After Ijima and Hatschek.)

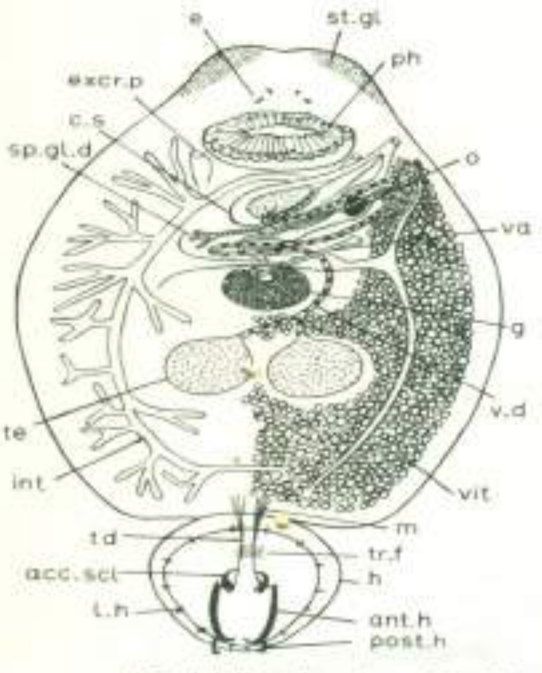
Fasciola hepatica, natural size. *excr.p*, excretory pore; *mo*, mouth; *r.a*, reproductive aperture; *v.s*, ventral sucker.



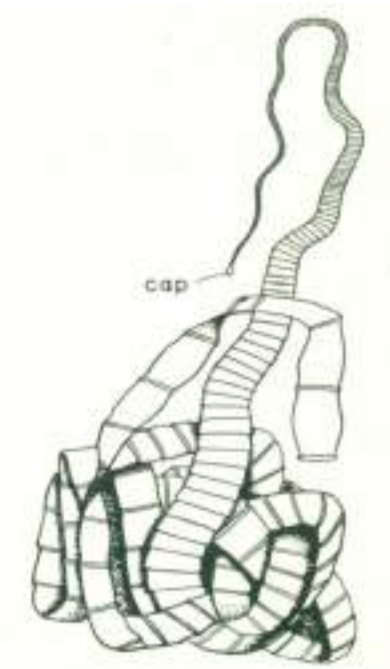
Fasciola hepatica. Internal organisation. General view of the anterior portion of the body, showing the various systems of organs as seen from the ventral aspect. *c.sh*, cirrus sheath; *ej*, ejaculatory duct; *f*, female reproductive aperture; *int*, anterior portion of intestine (the rest is not shown); *m.gl*, Mehlis' gland; *od*, commencement of oviduct; *ov*, ovary; *p*, cirrus; *p.g*, 'prostate' gland; *ph*, pharynx; *te*, testes; *ut*, uterus; *v.d.1*, left vas deferens; *v.d.2*, right vas deferens; *vit*, lobes of vitelline glands; *v.s*, vesicula seminalis. (After Sommer.)



Life history of *Fasciola hepatica.* A, adult; B, egg case with zygote; C, miracidium; D, sporocyst with rediae; E, rediae with cercariae; F, cercaria; G, encysted metacercaria; *b.op*, birth opening; *cerc*, cercaria; *c.w*, cyst wall; *emb.cerc*, embryo of cercaria; *emb.red*, embryo of redia; *fl.c*, flame cells; *g*, gut; *g.c*, germ-balls; *gl*, glands; *o.s*, oral sucker; *ovy*, ovary; *pap*, papilla; *red*, redia; *sh*, shell; *sh.gl*, Mehlis' gland; *t*, tail; *te*, testis; *ut*, uterus; *v.s*, ventral sucker; *y.c*, vitelline cells; *y.gl*, vitelline glands; *z*, zygote. (After Kühn.)

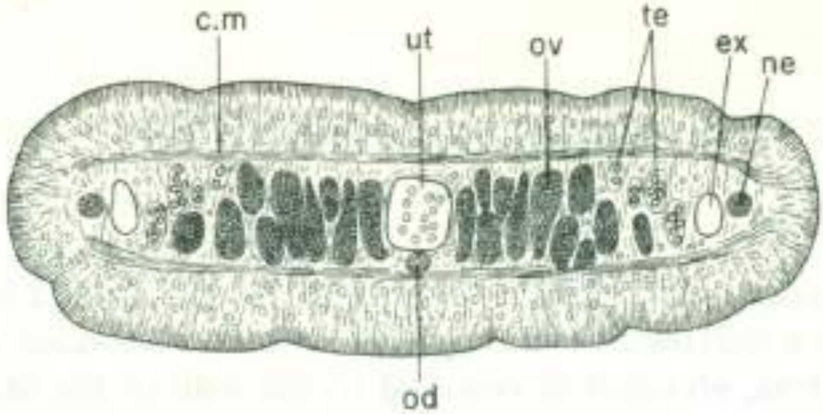


Entobdella soleae from the skin of *Solea*, ventral view. The gut is omitted from the animal's left, and the vitellaria from the right. *acc.scl*, accessory sclerite; *ant.h*, *post.h*, anterior and posterior hamuli; *c.s*, cirrus sac; *e*, eye; *excr.p*, excretory pore; *g*, germarium; *h*, haptor; *int*, intestine; *l.h*, persistent larval hook; *m*, muscle; *o*, egg in uterus; *ph*, pharynx; *sp.gl.d*, duct from spermatophore gland; *st.gl*, sticky glands; *td*, tendon; *te*, testis; *tr.f*, transverse fibres; *va*, vagina; *v.d*, vas deferens; *vit*, vitellarium.



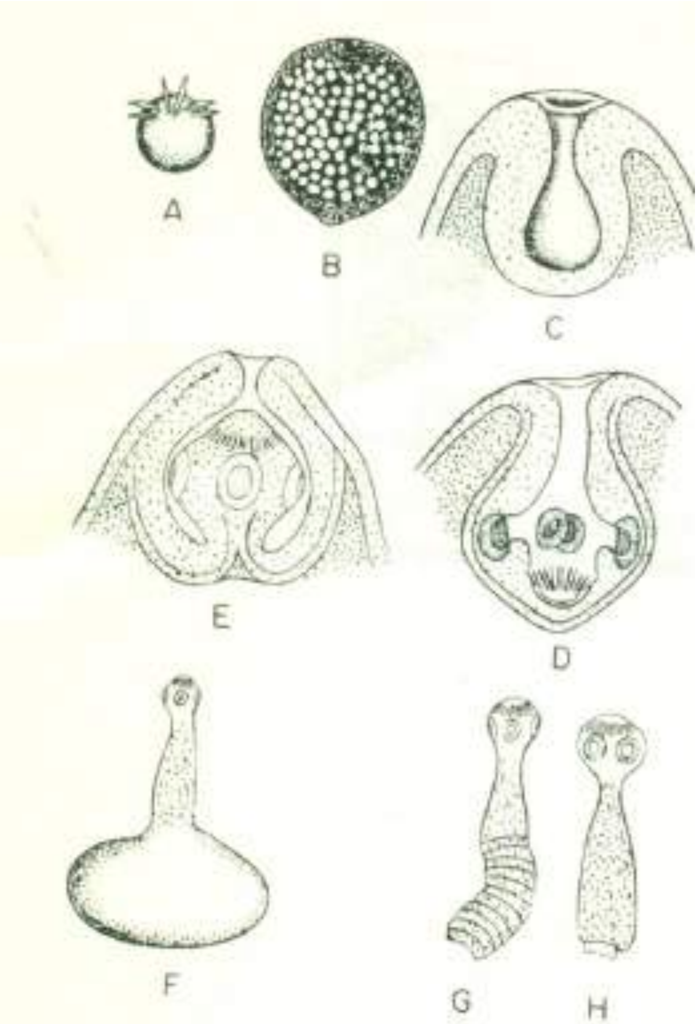
Taenia solium. Entire specimen, reduced. *cap*, head. (After Leuckart.)

Head of *Taenia solium*, magnified. (After Leuckart.)

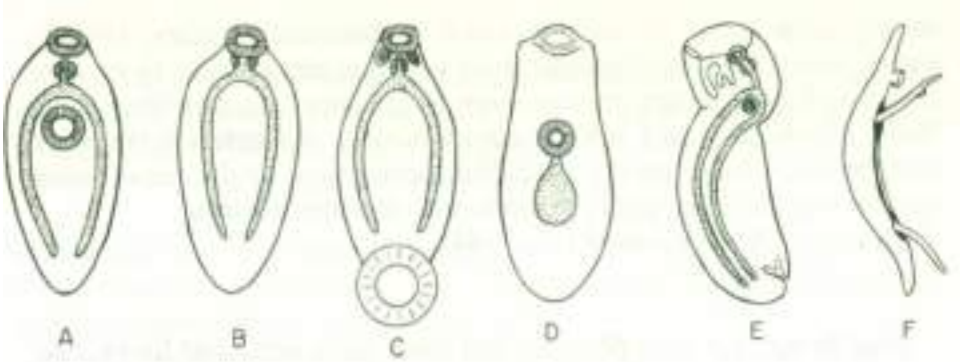


Transverse section of *Taenia solium*. *c.m*, circular layer of muscle; *ex*, longitudinal excretory vessel; *ne*, longitudinal nerve; *od*, oviduct; *ov*, ovary; *te*, testes; *ut*, uterus. (After Shipley.)

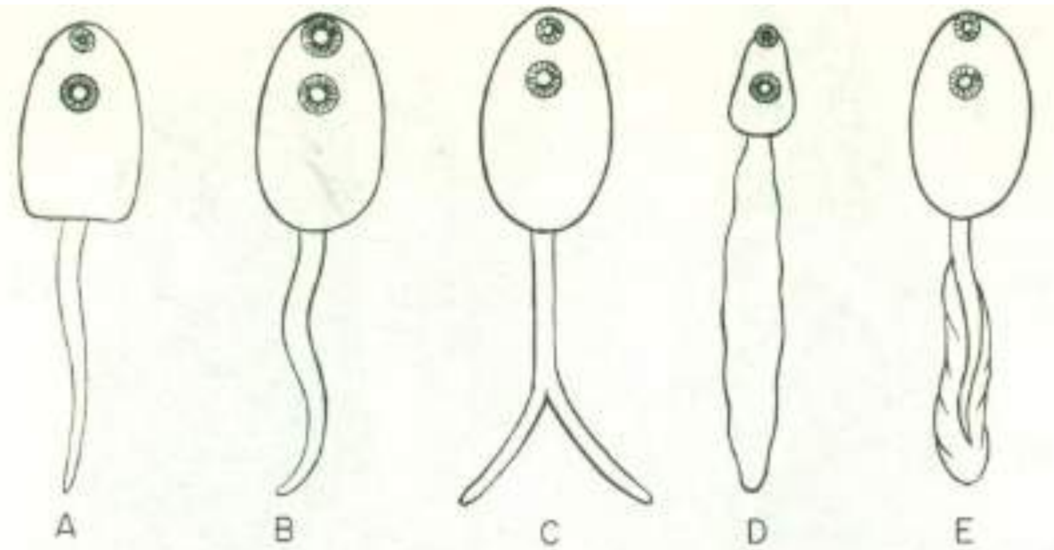
'Ripe' proglottid of *Taenia solium*. (After Leuckart.)



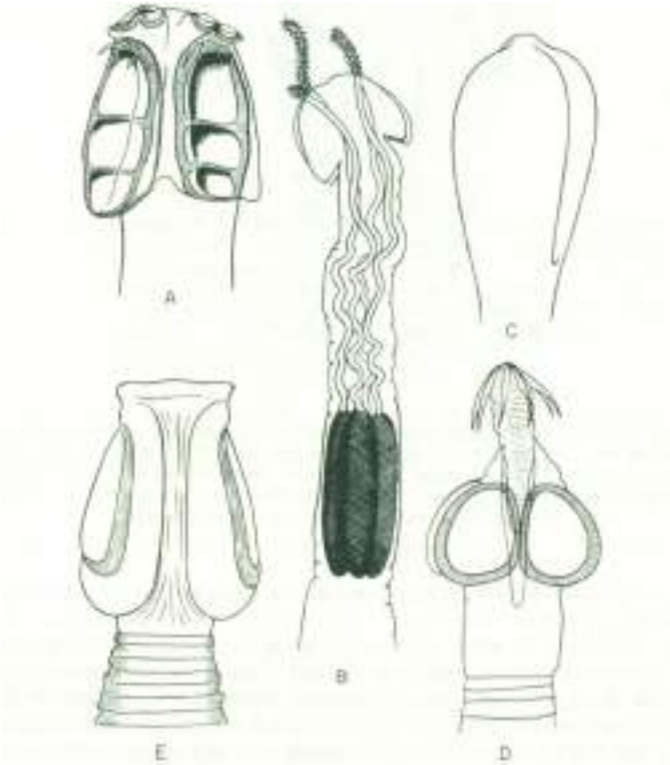
Development of a tapeworm. A, six-hooked embryo; B, early stage of bladder-worm of *Taenia* species; C, D, E, stages in the formation of the scolex of the same; C, the invagination before the hooks and suckers have become developed; D, after the appearance of the hooks and suckers; E, partly evaginated; F, fully evaginated scolex of *T. solium* with caudal vesicle; G, scolex of *T. serrata* with remains of the vesicle; H, young tapeworm of *T. serrata*. (After Leuckart.)



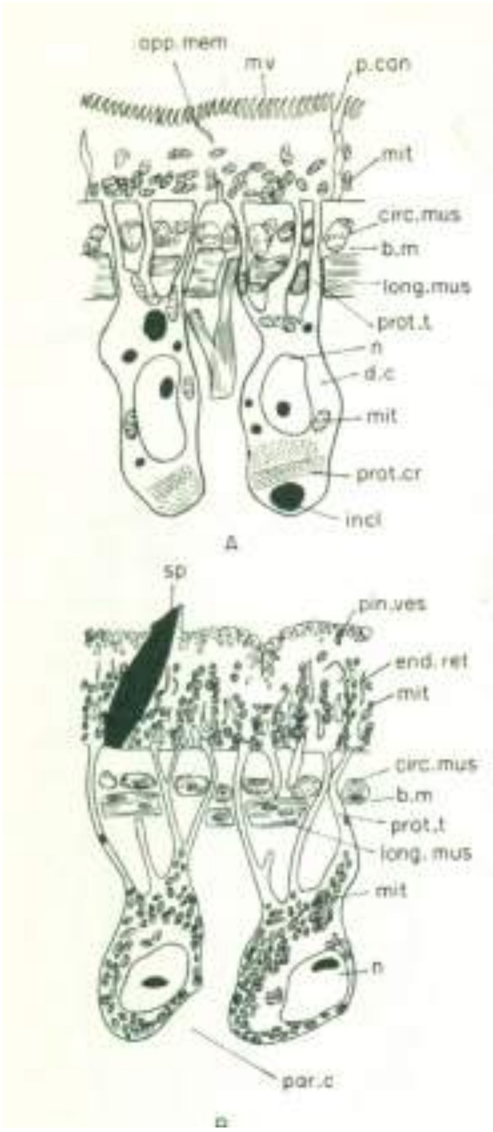
Some variations in the form of adult digeneans. A, distome (commonest form with two normally placed suckers); B, monostome (ventral sucker missing); C, amphistome (ventral sucker terminal and posterior); D, gasterostome (oral sucker in middle of body, 'pseudosucker' at anterior end, ventral sucker absent); E, strigeid (whole forebody is an attachment organ, ventral sucker small, tribocytic organ present, genital atrium terminal and posterior); F, schistosome (sexes separate, male retains female in a ventral 'gynaecophoral' groove).



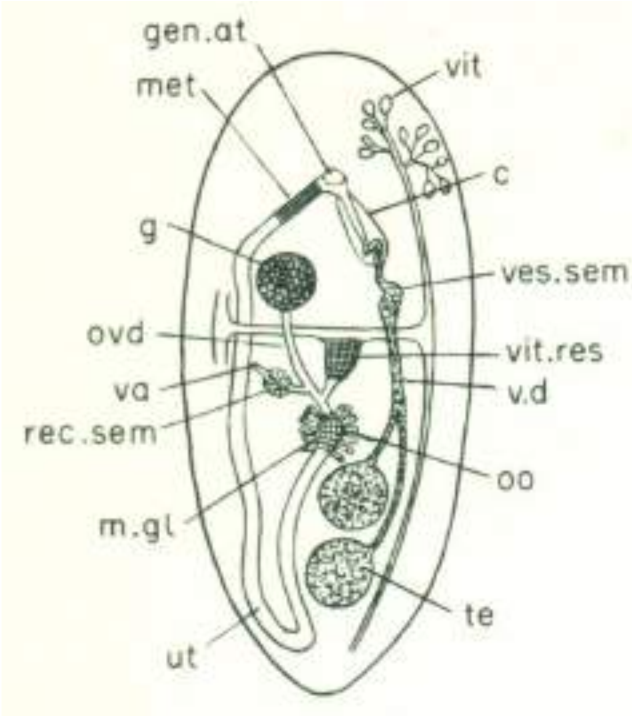
Some variations in the form of the cercaria larvae of digeneans. A, distome; B, with anterior boring stylet; C, fork-tailed; D, giant-tailed (the huge tail performs undulating 'fish-lure' movements that attract the second intermediate host); E, fin-tailed.



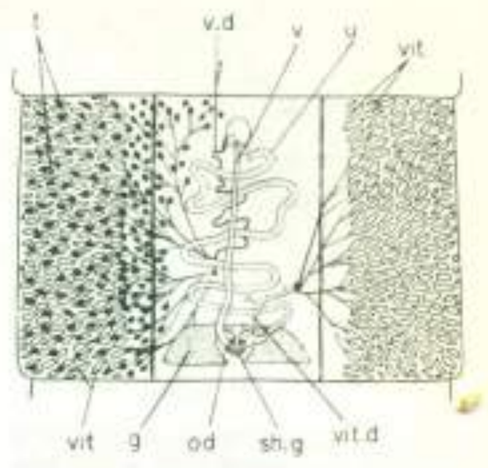
˙˙˙. Scolices of various cestodes. A, tetraphyllidean, *Acanthobothrium igimae* from *Raja*; B, tetrarhynchidean, *Tetrarhynchus* sp. from *Raja*; C, diphyllobothridean, *Diphyllobothrium* sp.; D, cyclophyllidean, *Hymenolepis macracanthos* from *Mergus*; E, bothriocephalidean, *Eubothrium crassum* from *Salmo*. (A–D from Kükenthal, *Handbuch der Zoologie*, Walter de Gruyter.)



A comparison of the teguments of (A) *Dipylidium caninum* and (B) *Fasciola hepatica*. *b.m*, basement membrane; *circ.mus*, circular muscle; *d.c*, 'dark' cell; *end.ret*, endoplasmic reticulum; *incl*, inclusion of fat or glycogen; *long.mus*, longitudinal muscle; *mit*, mitochondria; *mv*, microvillus; *n*, nucleus; *opp.mem*, opposed membranes; *par.c*, parenchymatous cell; *p.can*, pore canal; *pin.ves*, pinocytotic vesicle; *prot.cr*, protein crystalloid; *prot.t*, protoplasmic tubule; *sp*, spine. (After Threadgold, *Jl.micr. Sci*. 1962 and 1963.)



General plan of the reproductive organs of platyhelminths. *c*, cirrus; *g*, germarium; *gen.at*, genital atrium; *met*, metraterm; *m.gl*, Mehlis' gland; *oo*, ootype; *ovd*, oviduct; *rec.sem*, receptaculum seminis; *te*, testis; *ut*, uterus; *va*, vagina; *v.d*, vas deferens; *ves.sem*, vesicula seminalis; *vit*, vitellarium; *vit.res*, vitelline reservoir.



The arrangement of the genital organs in a sexually mature proglottid of *Diphyllobothrium*. For the sake of clarity the testes are omitted in the right half of the figure and the yolk ducts in the left half. *g*, germarium; *od*, oviduct; *sh.g*, Mehlis' gland; *t*, testes; *u*, uterus; *v*, vagina; *v.d*, vas deferens; *vit*, vitellarium; *vit.d*, vitelline duct. (From Kerr, G., *Zoology for Medical Students*, Macmillan & Co. Ltd.)

Phylum Aschelminthes
characteristics, classification, examples

What are Aschelminthes?
Aschelminthes are pseudocoelomate, bilaterally symmetrical, triploblastic, unsegmented, vermiform, organ- system grade of construction with complete digestive tubes.

Phylum Aschelminthes characteristics

- They are mostly aquatic, free-living or parasitic.
- They are bilaterally symmetrical, unsegmented worms.
- The body is slender, vermiform and usually worm-like or flattened.
- They are usually small, even microscopic, while some reach a meter or more in length.
- They are triploblastic and pseudocoelomate with organ system grade of body organization.
- Body wall with a syncytial or cellular epidermis, externally covered with the thick cuticle of scleroprotein.
- Cilia are absent except anterior cilia of rotifers.
- Muscles include mostly longitudinal fibers.
- The digestive canal is straight and complete with a mouth, straight non-muscular intestine, and anus, pharynx muscular and highly specialized.
- Respiratory and circulatory systems are absent.
- Excretory system includes a system of canals, protonephridia (in some) for osmoregulation. Cloaca present in some.
- The nervous system is simple and consists of circumenteric nerve ring with anterior and posterior longitudinal nerves.
- Sense organ are in the form of pits, papillae, bristles, and eyespots.
- They are mostly dioecious i.e. sexes separate. Gonads and ducts single or double.
- Asexual reproduction doesn't occur in them.
- Eggs have a chitinous shell, cleavage determinate and spiral.
- Their life cycle is simple or complicated usually with no special larval stages.

Classification of phylum Aschelminthes

This phylum includes a heterogenous assemblage of different animals, hence it has been classified differently by different zoologists. The classification here is based and modification from L. H. Hymann (1951) but Storer and Usinger (1971) have regarded different classification of Aschelminthes as separate phyla and rank Aschelminthes as superphylum.

Class 1. Nematoda (Gr., *nema*=thread+ *eidos*= form)

- Aquatic or terrestrial, free-living or parasitic, elongated roundworm.
- Body elongated, cylindrical and unsegmented.

- Body wall with thick cuticle, cellular or syncytial epidermis and longitudinal muscles in four bands.
- No cilia, no circulatory and respiratory system.
- The digestive system completes with **muscular pharynx** and
- Excretory system of glandular organs or canals or both.
- Nervous system with circumenteric ring and anterior and posterior nerves.
- Sense organs simple.
- Male with penial spicules and smaller than females.
- Gonads one or two. Male genital ducts lead into the cloaca, female genital duct with a separate opening.
- Fertilization
- Development is usually direct. No asexual reproduction or regeneration.
- Examples: *Ascaris*, *Necator*, *Wuchereria*, *Trichinella*.

Order 1. Enploidea

- Not ringed cuticle, often cuticular bristles.
- Anterior end with 6 labial papillae.
- 10 to 12 bristles in one or two circlets.
- Esophagus into two parts, anterior muscular and posterior glandular.
- A pair of cephalic slits and cyathiform amphids.
- Examples: *Enoplus*, *Anticoma*, *Synonchus*.

Order 2. Dorylaimoidea

- Smooth cuticle without bristles.
- Anterior end with two circlets of papillae of 6 and 10 each.
- Buccal cavity armed with a protrusible spear.
- The rear part of the pharynx enlarged.
- Cyathiform amphids.
- Examples: *Dorylamius*, *Tylencholaimus*, *Actinolaimus*.

Order 3. Mermithoidea

- Smooth, filiform nematodes, parasitic in invertebrates (mainly insects) in juvenile stages of free-living as an adult in soil or water.
- Head sense organs reduced to papillae, usually six.
- Long, blind pharynx.
- Blind intestine, altered into a food storing organs.
- Cyathiform or reduced amphids.
- Examples: *Mermis*, *Paramermis*, *Aproctonema*.

Order 4. Chromadoroidea

- The smooth or ringed cuticle.
- Usually, cuticle heavily ornamented with bristles, knobs, punctation.
- Pharynx with a posterior bulb.
- Amphids are spiral or derivable from a spiral.
- Examples: *Paracytholamius*, *Paracanthonchus*.

Order 5. Araeolaimoidea

- Smooth cuticle, sometimes bristles.
- Labial papillae present.
- Anterior end with 4 cephalic bristles.
- Spiral or loop-like amphids.
- Examples: *Plectus*, *Wilsonema*, *Odontophora*.

Order 6. Monhysteroidea

- Smooth or slightly ringed cuticle, often provided with bristles.
- Anterior end with 4, 6 or 8 bristles.

- Circular amphids.
- Examples: *Cylindrolaimus*, *Siphonolaimus*.

Order 7. Desmoscalecoidea

- Heavily ringed cuticle, with prominent bristles throughout or in a restricted area.
- Anterior end with 4 bristles.
- Crescentic amphids.
- Marine nematodes.
- Examples: *Desmoscolex*, *Tricoma*, *Greeffiella*.

Order 8. Rhabditoidea or Anguilluloidea

- Free-living or parasitic
- The ringed or smooth cuticle.
- Pharynx with posterior bulb and also usually with swelling anterior to the nerve ring.
- No caudal glands.
- Small pockets amphids.
- Examples: *Rhabditis*, *Diploscapter*, *Diplogaster*.

Order 9. Rhabdiasoidea

- Smooth nematodes with definite pharyngeal bulb.
- Hermaphrodites; pathogenesis also occurs.
- Parasitic stages in animals.
- Free-living stages may develop into males and females.
- Examples: *Rhabdias*, *Entomelas*.

Order 10. Oxyuroidea

- Valvulated pharynx with posterior bulb.
- Female with a long pointed tail; terminal parts of the female system often heavily muscularised.
- Male with one spicule or two equal spicules.
- Usually, caudal alae forming a cuticular brusa.
- Examples: *Oxyuris* or *Enterobius*.

Order 11. Ascaroidea

- Mouth surrounded by 3 prominent lips.
- Pharynx without posterior bulb or of present it is not Valvulated.
- Pharynx or intestine or both often with caeca.
- No buccal capsule.
- Blunt female tail; male without caudal alae and possesses two equal or nearly equal spicules.
- Examples: *Ascaris*.

Order 12. Strongyloidea

- Mouth without conspicuous lips but often with leaf crown.
- Pharynx without bulb.
- Females usually with ovijector.
- Male with copulatory brusa supported by muscular rays; typically, 13 in number.
- Examples: *Strongylus*, *Necator*, *Ancylostoma*.

Order 13. Spiruroidea

- Mouth usually contains 2 lateral lips; sometimes 4 or 6 small ones.
- Pharynx without bulb; anteriorly muscular and posteriorly glandular.
- Males without brays; spicules unequal and dissimilar.
- Examples: *Oxyspirura*, *Rictularia*, *Thelazia*.

Order 14. Dracunculoidea

- Without definite lips or cuticularized buccal capsules.
- Pharynx without bulb; anteriorly muscular and posteriorly glandular.

- The vulva is not functional usually present near or behind the middle of the body.
- Males with equal filiform spicules; brusa wanting.
- Examples: *Dracunculus*, *Philometra*, *Micropleura*.

Order 15. Filarioidea

- Filiform worm without lips.
- Small or rudimentary buccal capsules.
- The pharynx is anteriorly muscular and posteriorly glandular.
- Pharyngeal bulb absent.
- Vulva anterior in females.
- Brusa wanting, spicules unequal and dissimilar.
- Examples: *Wuchereria*, *Loa loa*.

Order 16. Trichuroidea or Trichinelloidea

- Body filiform anteriorly.
- Mouth without lips.
- Slender pharynx.
- Provided with a cirrus, spicule if present one only.
- Examples: *Trichinella*, *Trichuris*.

Order 17. Dioctophymoidea

- Moderate to very long-sized.
- Mouth without lips surrounded by 6,12 or 18 papillae.
- Elongated pharynx without bulb.
- Male with muscular brusa but without rays.
- Examples: *Dictyophyme*, *Hystrichis*,

Class 2. Nematomorpha or Gordiacea (Gr., *nema*=thread+ *morphe*= shape)

- **Hair worm, f**ound in freshwater. One genus (*Nectonema*) marine.
- Body very long, thin, slender and cylindrical.
- Body wall with thick cuticle bearing small papillae.
- Epidermis cellular, single-layered.
- The digestive system is complete in larva but degenerates in non-feeding adults. Cloaca present.
- Pseudocoel mostly filled with parenchyma.
- No circulatory, respiratory and excretory system.
- Nervous system with a circumenteric nerve ring and midventral nerve cord.
- Gonad and gonoducts paired. Oviducts also open into the cloaca.
- Juveniles parasitic in grasshoppers, crickets and other insects.
- Examples: *Gordius*, *Paragordius*, *Nectonema*.

Order 1. Cordioidea

- Swimming bristles are wanting.
- Pseudocoel is filled with parenchyma.
- Paired gonads.
- Examples: *Paragordius*, *Gordius.*

Order 2. Nectonematoidea

- Swimming bristles arranged in 2 rows.
- Unfilled pseudocoel.
- Only one gonad.
- Marine form.
- Examples: *Nectonema*.

Class 3. Rotifera (L., *rota*= wheel + *ferre*= to bear)

- Microscopic animals found in ponds, lakes, and streams. Rarely in oceans, commonly called **wheel bearers.**

- Body wall thickened into stiff plates or **lorica** into which head may
- Anterior end with ciliated **corona (wheel organ)** used for feeding and locomotion.
- Post- anal foot with toes and adhesive glands for attachments.
- Body musculature includes longitudinal and transverse muscle bands and strands.
- The digestive system with a grinding organ, **mastax**, lined internally by a strong cuticle.
- The excretory system with two protonephridia and two Protonephridial tubes which empty into bladders.
- The nervous system of 3 major ganglia and nerves.
- Sensory organs antennae and eyespots.
- Male smaller than females. Parthenogenesis common.
- Female oviparous, no larval stages.
- Examples: *Philodina*, *Asplanchna*, *Rotaria*.

Order 1. Seisonacea
- Body elongated with a long neck.
- Corona is small.
- Paired gonads.
- Found as commensals on crustaceans.
- Examples: *Seison*.

Order 2. Budelloidea
- Corona usually with 2 trochal discs.
- Pedal glands more than two.
- Male degenerate; female with paired germovitellaria.
- Swimming or creeping form.
- Examples: *Rotaria* or *Rotifera*, *Philodina*, *Mniobia*.

Order 3. Monogonontea
- Swimming or sessile forms.
- Male small or degenerate.
- Male usually with one testis.
- Female posses single germovitellaria.
- Examples: *Mytilina*, *Limnias*.

Class 4. Gastrotricha (L., *gaster*= stomach + *trichos*= hair)
- Microscopic, marine or freshwater.
- Body wall with cuticle bearing short, curved, dorsal spines.
- Corona absent cilia on the ventral surface for locomotion.
- Posterior end forked and with adhesive tubes and glands for attachments.
- Body musculature includes 6 pairs of longitudinal muscles.
- Mouth surrounded by bristles.
- The pharynx is triradiate and muscular.
- The excretory system with 2 protonephridia.
- Nervous system with saddle-shaped ganglion and 2 lateral nerves.
- Dioecious or Monoecious; parthenogenetic female occurs.
- Development direct. Young and adult are alike.
- Examples: *Chaetonotus*, *Macrodasys*.

Order 1. Macrodasyoidea
- Marine worm-like forms.
- Many adhesive tubes.
- No protonephridia.
- Examples: *Macrodasys*.

Order 2. Chaetonotoidea
- Mostly freshwater forms found on vegetation.

- Adhesive tubes on the tail.
- One pair of protonephridia.
- Reproduction by parthenogenesis.
- Examples: *Chaetonotus*, *Neodesys*.

Class 5. Kinorhyncha (Gr., *kineo*=more + *rhynchos*= beak)

- Marine, microscopic worm-like.
- Superficial segmentation of body into 13 or 14 overlapping rings (Zonites).
- Body surface with spiny cuticle but no cilia.
- **Mouth cone** or head protrusible and covered with **scalids**.
- A pair of adhesive tubes in the front part of the ventral surface.
- Pseudocoel with fluid containing amoebocytes.
- A nerve ring with a ventral cord with a ganglion in each Zonite. Eyespots in some.
- The digestive system completes with salivary glands.
- Gonads as a pair of tubular sacs.
- Penial spicules in males.
- Fertilization internal. Metamorphosis with several larval stages.
- The development includes a series of juvenile stages.
- Examples: *Echinoderes*, *Pycnophyes*.

Order 1. Homalorhagida

- Head and neck are both protrusible.
- Examples: *Trachydemus*.

Order 2. Cyclorhagida

- The only head ring is protrusible.
- Examples: *Echinoderes*.

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Eucoelomates

animals having a true coelom are referred to as being eucoelomates. eucoelomate animals have a body cavity that is completely lined with mesoderm. the mesoderm can develop into muscle layers & internal skeletal elements. a large fluid filled coelom surrounded by muscle layers makes a more effective hydrostatic skeleton in many worms. mesodermal layers lead to development of arteries and veins, ie circulatory systems; better blood supply to all internal organs. since mesoderm lines the digestive tract, this allows for the development of much more elaborate digestive organs eg. compare the digestive tract of earthworms to *Ascaris*. ! mesenteries to support internal organs.

There are 2 main ways that a true coelom can develop in an embryo:

In protostomes the coelom appears as a split in the mesoderm layer of the embryo of most invertebrate coelomates are protostomes

In deuterostomes, the coelom appears as outpocketings of the archenteron echinoderms and chordates and a few minor phyla are deuterostomes Animals .

Phylum Annelida

Characteristics, classification, examples

Annelida definition

Annelids are defined as triploblastic, bilaterally symmetrical, metamerically segmented, a coelomate worm with a thin flexible cuticle around the body.

Phylum Annelida Characteristics

- They are mostly aquatic; marine or freshwater some terrestrial, burrowing or tubicolous, sedentary or free-living, some commensal and parasitic.
- The body is elongated, triploblastic, bilaterally symmetrical, truly coelomate and vermiform.
- The body is metamerically segmented; externally by transverse grooves and internally by septa into a number of divisions; each division is called a segment, metamere or somite.
- Body organization is of organ grade system.
- The epidermis is of a single layer of columnar epithelial cells, covered by thin cuticle not made of chitin.
- The body wall is contractile or dermo-muscular consisting of outer muscle fiber circular and inner longitudinal.
- Appendages are jointed when present.
- Locomotory organs are segmentally repeated chitinous bristles called setae or chaetae, embedded in the skin. It may be bored by lateral fleshy appendages or parapodia.
- The presence of true schizocoelous coelom usually divided into compartments by transverse septa. Mostly well-developed in leeches. Coelomic fluid with cells or corpuscles.
- The alimentary canal is straight tube-like, complete, extending from mouth to anus. Digestion is entirely extracellular.
- Respiration occurs through moist skin or gills of parapodia and head.
- The blood vascular system is a closed type. Blood is red due to the presence of hemoglobin or erythromycin dissolved in plasma.
- Excretion is by metamerically disposed coiled tubes; nephridia which communicate the coelom to the exterior.

- The nervous system consists of a pair of cerebral ganglia; brain and double ventral nerve cord having segmentally arranged ganglia and lateral nerves in each segment.
- Receptor organs include tactile organs, taste buds, statocysts, photoreceptor cells and sometimes eyes with lenses in some.
- They are monoecious i.e. hermaphroditic or sexes separate cleavage spiral and determinate; dioecious or unisexual form also present.
- Their development is direct in monoecious form but indirect in dioecious form.
- Larva, when present is a trochophore is characteristics in case of indirect development, while in others this stage is passed through development.
- Regeneration is common.
- Asexual reproduction occurs in some.

Classification of Phylum Annelida

About 8,700 known species of Annelida are divided into four main classes, primarily on the basis of presence and absence of parapodia, setae, metameres, and other morphological features.

Class 1- Polychaeta (Gr., **poly=**many**, chaeta=**bristles/hair)

- Chiefly marine, some freshwater.
- Carnivorous
- Body segmentation is internal and external.
- Head consists of prostomium and peristomium and bears eyes, tentacles cirri, and palps.
- Setae numerous on lateral parapodia.
- The clitellum is absent.
- Cirri or branchiae or both may be present for respiration.
- The coelom is spacious usually divided by intersegmental septa.
- The alimentary canal provided with the eversible buccal region and protrusible pharynx.
- The excretory organ is segmentally paired nephridia.
- Sexes separate. Gonads temporary and in many segments.
- Fertilization external.
- Asexual reproduction by lateral budding.
- Trochophore larva present.

Polychaeta divided into two subclasses, Errantia and sedentaria after Fauvel (1959). However, according to Dab (1963), this division is artificial and not a natural one.

Subclass 1. Errantia

- Free-swimming, crawling, burrowing or tube-dwelling and predatory polychaetes.
- Segmentation similar, except at anterior and posterior ends.
- The prostomium is distinct with sensory organs.
- Parapodia, provided with cirri, are equally developed throughout.
- Pharynx protrusible, enlarged and usually with jaws and teeth.
- Examples: *Nereis*, *Aphrodite*, *Polynoe*, *Phyllodoce*, *Tomopteris*, *Syllis*, *Eunice*, *Histriobd ella.*

Subclass 2. Sedentaraia

- Burrowing and tube-dwelling form.
- Body made of 2 or more regions, with unlike segments and parapodia.
- Head is small or much modified without eyes and tentacles, prostomium small.
- No acicula and compound setae.
- Pharynx non-protrusible without jaws and teeth.
- Gills, when present, localized to the anterior segments.
- Feeding on plankton or organic detritus.

- Examples: *Chaetopterus*, *Arenicola*, *Owenia*, *Sabella*, *Terebella*, *Sabellaria*, *Pomatocerous*.

Class 2- Oligochaeta (Gr., **oligos**=few**+ chaete=**hair**)**

- Mostly terrestrial or some freshwater forms.
- Body with conspicuous external and internal segmentation.
- Head indistinct, without sensory organs.
- Setae few, embedded in the skin.
- Parapodia absent.
- Glandular clitellum present for cocoon formation.
- The pharynx is not eversible and without jaws.
- Hermaphroditic i.e. sexes united.
- Testes anterior to ovaries.
- Development is direct. fertilization external (in cocoon); no larval stage.

Order 1. Archioligochaeta

- Mostly freshwater form.
- The body consists of a few segments.
- Setae are present in bundles.
- The gizzard is poorly developed, non-muscular or absent.
- The clitellum is simpler consists of a single layer of cells and situated far towards.
- Eyespots are frequently present.
- Male reproductive openings lie in front of female reproductive openings.
- Reproduction asexual and sexual.
- Examples: *Tubifex*, *Aelosoma.*

Order 2. Neooligochaeta

- Usually terrestrial forms.
- The body is large and many segmented.
- Setae are managed in a lumbricine Manner.
- The gizzard is well developed.
- The clitellum is composed of two or more layers of cells and never begins before twelfth segments.
- Female genital aperture is always on the 14^{th} segment and the male pore lies a few segments behind them.
- Vasa differentia are elongated extending over 3 or 4 segments.
- Eyespots are never developed.
- Reproduction sexual. Asexual reproduction is not known.
- Examples: *Pheretima*, *Eutypheus*, *Megascolex*, *Lumbricus*.

Class 3- Hirudinea (L., hirudo= a leech**)**

- Mostly ectoparasitic, blood-sucking or carnivorous. Few are marine, freshwater or terrestrial.
- The body is elongated and usually flattened and dorso-ventrally or cylindrical.
- The body consists of a fixed number of segments (33). Each segment breaks up into 2 to 4 rings or annuli.
- Segmentation external without internal septa.
- Par podia and setae are absent.
- Both anterior and posterior ends of the body with ventrally situated suckers.
- The mouth opens on the ventral surface on anterior suckers, while anus opens dorsal to the posterior suckers.

- Coelom much reduced due to filling by botryoidal tissues, and form haemocoelomic sinuses.
- Hermaphrodite with one male and one female gonopore.
- Fertilization internal.
- Asexual reproduction is not known.
- Eggs are always laid in cocoons.
- Development is direct without a free-swimming larval stage.

Order 1. Acanthobdellida

- Mostly parasitic on the fins of salmon fishes.
- The body comprises 30 segments only.
- They are primitive, without anterior suckers, proboscis, and jaws.
- Double rows of setae are present in 5 anterior segments.
- The body cavity is spacious and incompletely divided by septa.
- The vascular system consists of the dorsal and ventral vessels.
- Nephridial opening situated on the surface between the segments.
- Examples: a single genus and species (*Acanthobdella*) parasitic on salmon.

Order 2. Rhynchobdellida

- Parasites on snails, frogs and fishes, marine and freshwater form.
- Each typical body segment consists of 3,6 or 12 rings.
- The mouth is a small median aperture situated in the anterior suckers.
- A protrusible proboscis with no jaws.
- Coelom without compartments.
- Blood vascular system separated from coelomic sinuses.
- Blood is colorless.
- Examples: *Placobdella*, *Helobdella*, *Piscicola*, *Branchellion.*

Order 3. Gnathobdellia

- Freshwater and terrestrial form. Ectoparasitic blood-sucking leeches.
- Each typical body segment consists of 5 rings or annuli.
- Anterior suckers with 3 jaws, 1 median dorsal and 2 ventrolateral.
- The proboscis is absent.
- Blood is red-colored.
- Botryoidal tissues present.
- Examples: *Hirudo*, *Hirudinaria*, *Haemadipsa*, *Herpobdella*.

Order 4. Pharyngobdellida

- Terrestrial and aquatic. Some predaceous.
- Pharynx non- protrusible. No teeth but one ore two styles may be present.
- Examples: *Erpobdella*, *Dina.*

Class 4- Archiannellida (Gr., **arch**=first**)**

- Exclusively marine form.
- Body elongated and worm-like.
- Setae and parapodia are usually absent.
- External segmentation is slightly marked by faint, while internal segmentation is marked by coelomic septa.
- Prostomium bears 2 or 3 tentacles.
- Sexes usually separate, hermaphrodite.
- Usually trochophore larva.
- Examples: *Polygordius*, *Dinophilus*, *Protodrilus.*

References

1. Kotpal RL. 2017. Modern Text Book of Zoology- Invertebrates. 11th Edition. Rastogi Publications.
2. Jordan EL and Verma PS. 2018. Invertebrate Zoology. 14th Edition. S Chand Publishing.

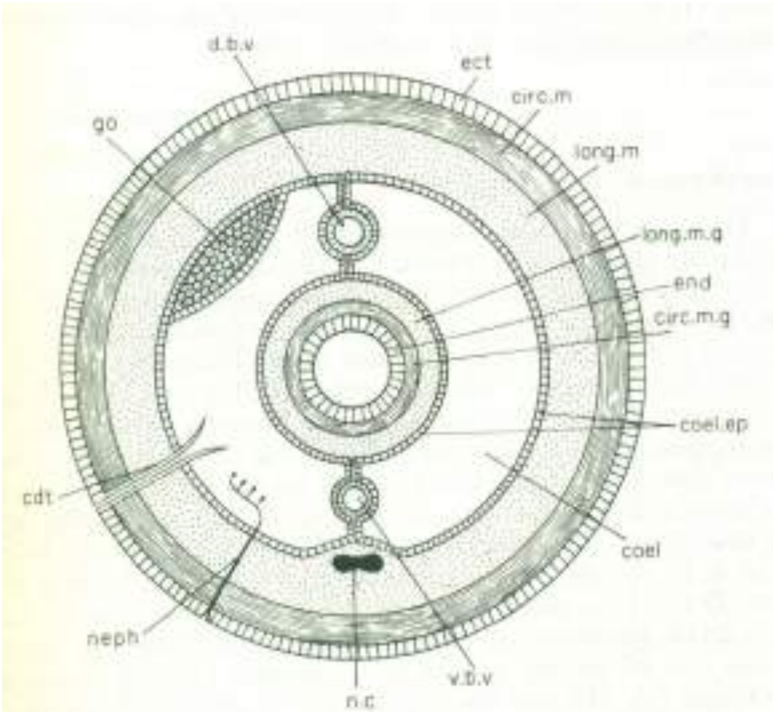
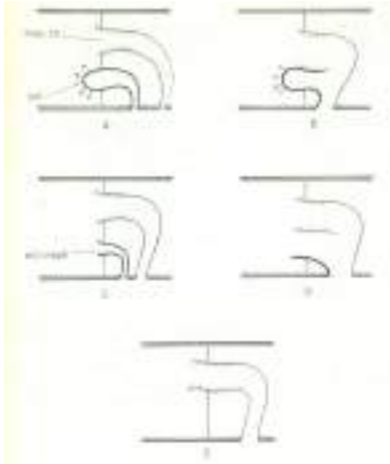
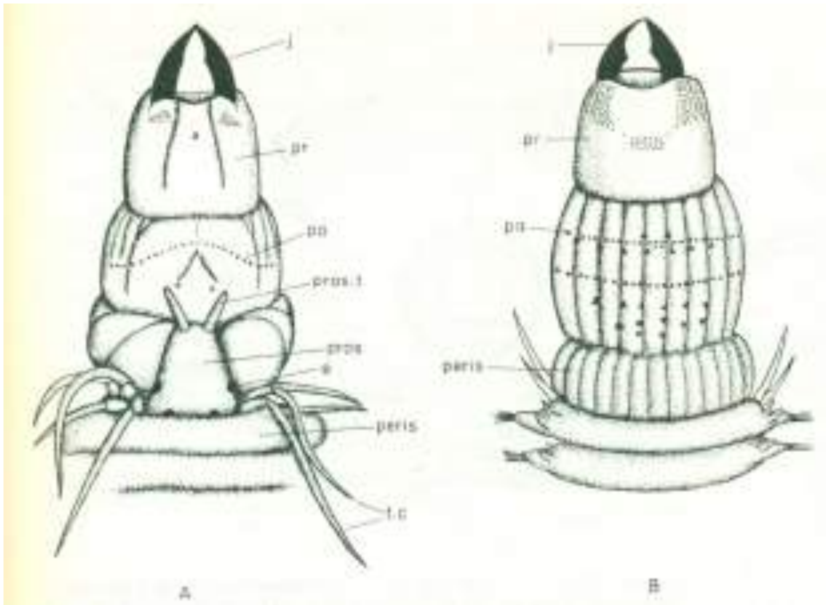


Diagram to illustrate the essential features of an annelid worm as seen in transverse section. *cdt*, coelomoduct; *circ.m*, circular muscle; *circ.m.g*, circular muscle of gut; *coel*, coelom; *coel.ep*, coelomic epithelium; *d.b.v*, dorsal blood vessel; *ect*, ectoderm; *end*, endoderm; *go*, gonad; *long.m*, longitudinal muscle; *long.m.g*, longitudinal muscle of gut; *n.c*, nerve cord; *neph*, nephridium; *v.b.v*, ventral blood vessel.



Types of excretory and reproductive ducts in various polychaetes. A, protonephridium and coelomoduct of *Vanadis*; B, protonephromixium of *Phyllodoce*; C, metanephridium and coelomoduct of *Notomastus*; D, metanephromixium of *Hesione*; E, mixonephridium of *Arenicola*. *ect.neph*, ectodermal nephridium; *mes.co*, mesodermal coelomoduct; *sol*, solenocyte. (After Goodrich.)



The anterior end of *Perinereis* with proboscis everted. A, dorsal view; B, ventral view. *e*, eye; *j*, jaws; *pa*, paragnaths; *peris*, peristomeum; *pr*, proboscis; *pros*, prostomium; *pros.t*, prostomial tentacle; *t.c*, tentacular cirri.

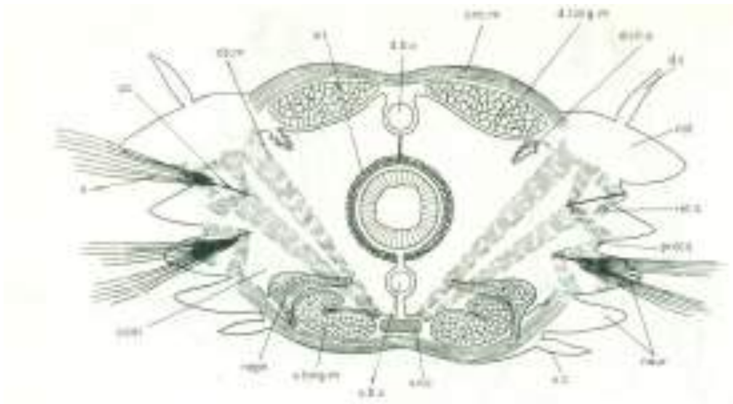
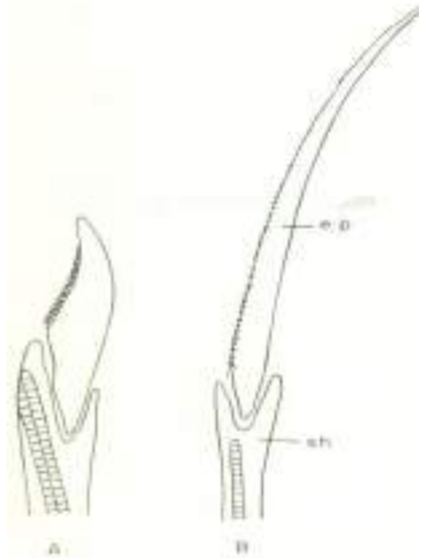
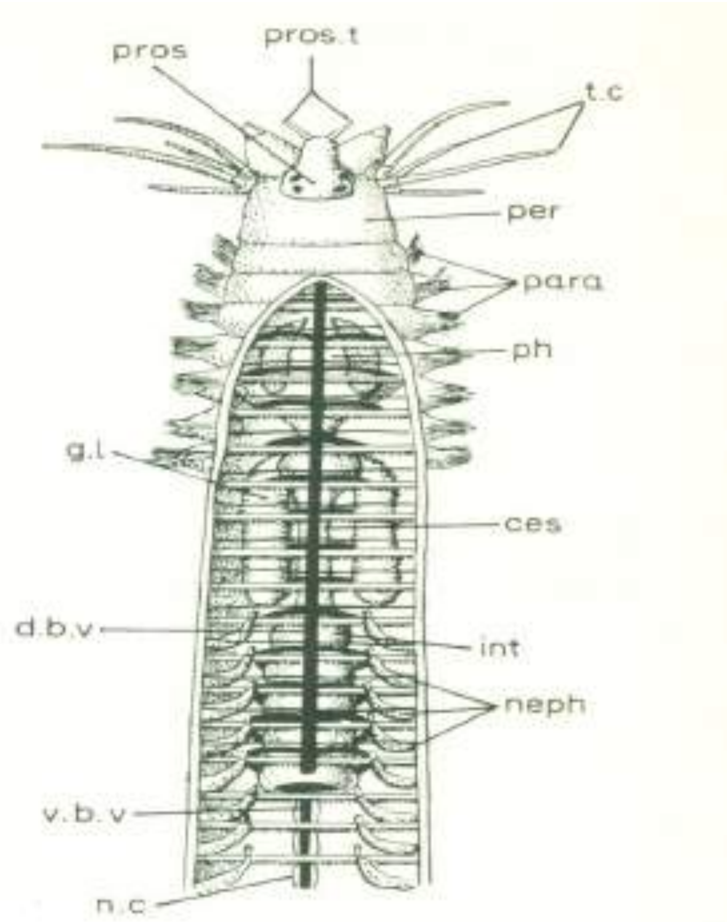


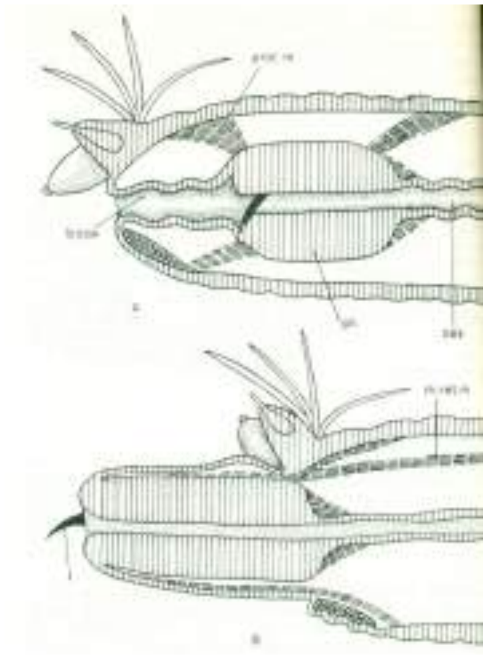
Fig. 261. Diagram of a transverse section of *Perinereis* to show the main structural features. *ac*, aciculum; *circ.m*, circular muscle; *coel*, coelom; *d.b.v*, dorsal blood vessel; *d.c*, dorsal cirrus; *d.cil.o*, dorsal ciliated organ; *d.long.m*, dorsal longitudinal muscle; *int*, intestine; *neph*, nephridium; *neur*, neuropodium; *not*, notopodium; *ob.m*, oblique muscle; *prot.s*, protractors of setae; *ret.s*, retractors of setae: *s*, setae; *v.b.v*, ventral blood vessel; *v.c*, ventral cirrus; *v.long.m*, ventral longitudinal muscle; *v.n.c*, ventral nerve cord. (After Chapman and Baker, *Zoology for Intermediate Students*, 1964. Longmans Green Co. Ltd., London.)



Compound setae of *Perinereis*. A, a neuropodial falciger; B, a notopodial spiniger. *e.p*, end-piece; *sh*, shaft.



Semi-diagrammatic view of the anterior portion of the body of a nereid worm with the dorsal body wall removed so as to show the alimentary canal, the septa, the blood vessels and the nephridia; a portion of the intestine is removed so as to show the ventral blood vessel and nerve cord which lie below. *d.b.v*, dorsal blood vessel; *gl*, oesophageal glands; *int*, beginning of the intestine; *n.c*, nerve cord; *neph*, nephridia; *oes*, oesophagus; *para*, parapodia; *per*, peristomium; *ph*, pharynx with its jaws; *pros*, prostomium; *pros.t*, prostomial tentacles; *t.c*, tentacular cirri; *v.b.v*, ventral blood vessel.



Diagrams to illustrate the eversion of proboscis as seen in sagittal section. A, retracted; B, extended. *b.cav*, buccal cavity; *j*, jaw; *m.ret.m*, main retractor muscle; *oes*, oesophagus; *ph*, pharynx; *prot.m*, muscle acting as protractor at beginning of eversion. (After Chapman and Baker, op. cit.)

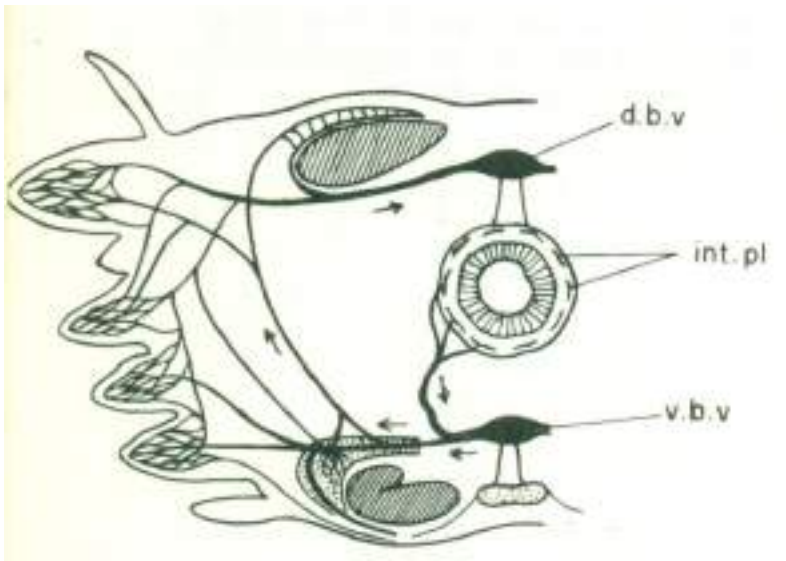
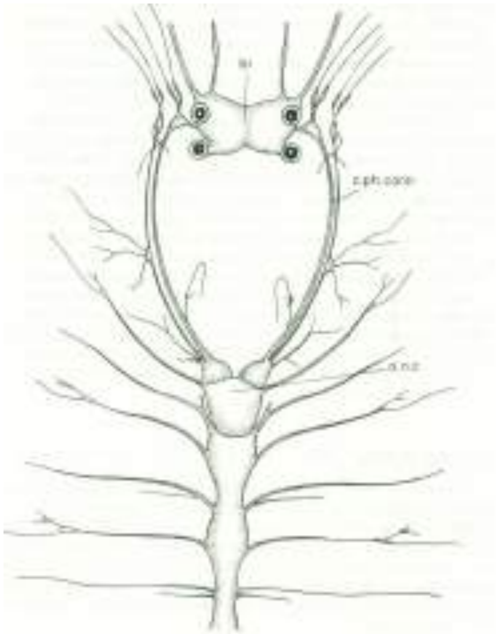
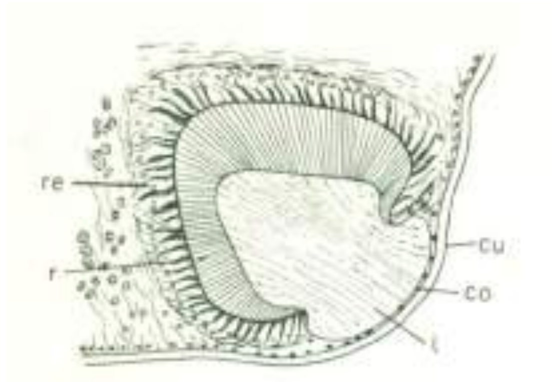


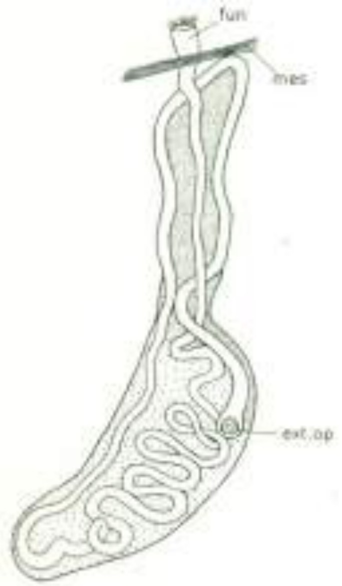
Diagram of the segmental blood system of *Perinereis*. *d.b.v*, dorsal blood vessel; *int.pl*, intestinal plexus; *v.b.v*, ventral blood vessel.



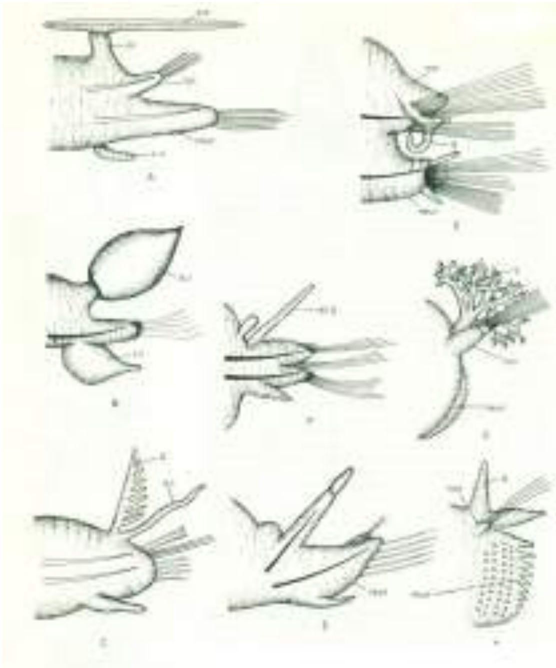
Anterior portion of the nervous system of *Nereis*. *a.n.c*, anterior part of nerve cord; *br*, brain; *c.ph.conn*, circum-pharyngeal connectives. (After Quatrefages.)



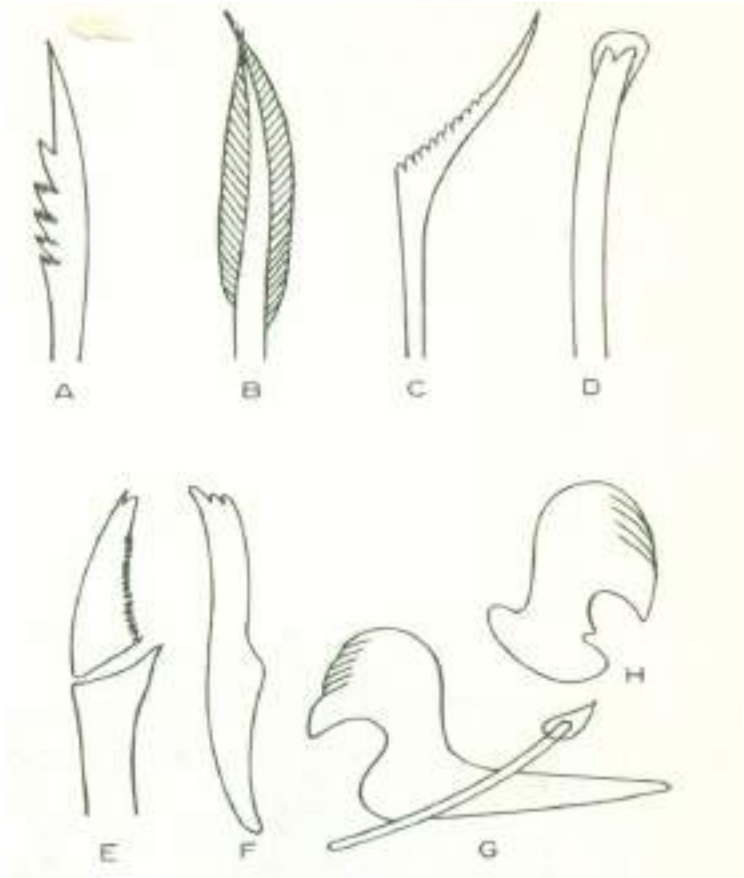
Nereis. Section through one of the eyes. *co*, cornea; *cu*, cuticle; *l*, lens; *r*, layer of rods; *re*, retina. (After Andrews.)



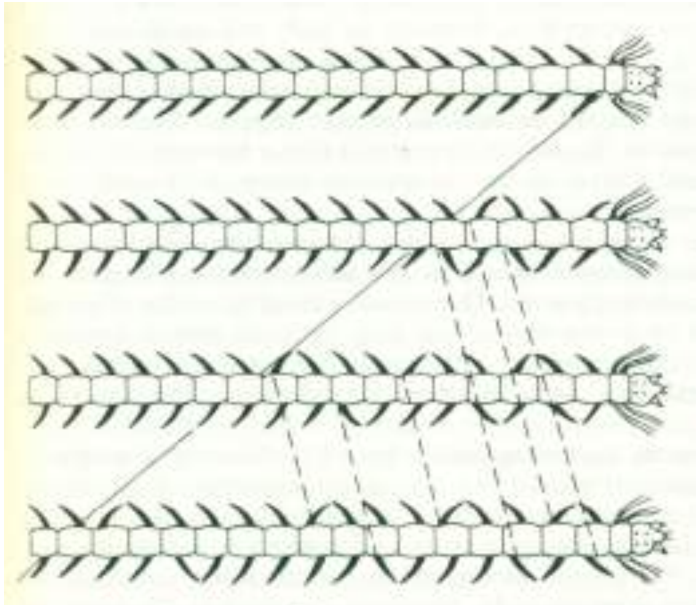
Platynereis dumerilli. One of the nephridia; *ext.op*, external opening or nephridiopore; *fun*, internal funnel or nephrostome opening into the coelom; *mes*, septum.



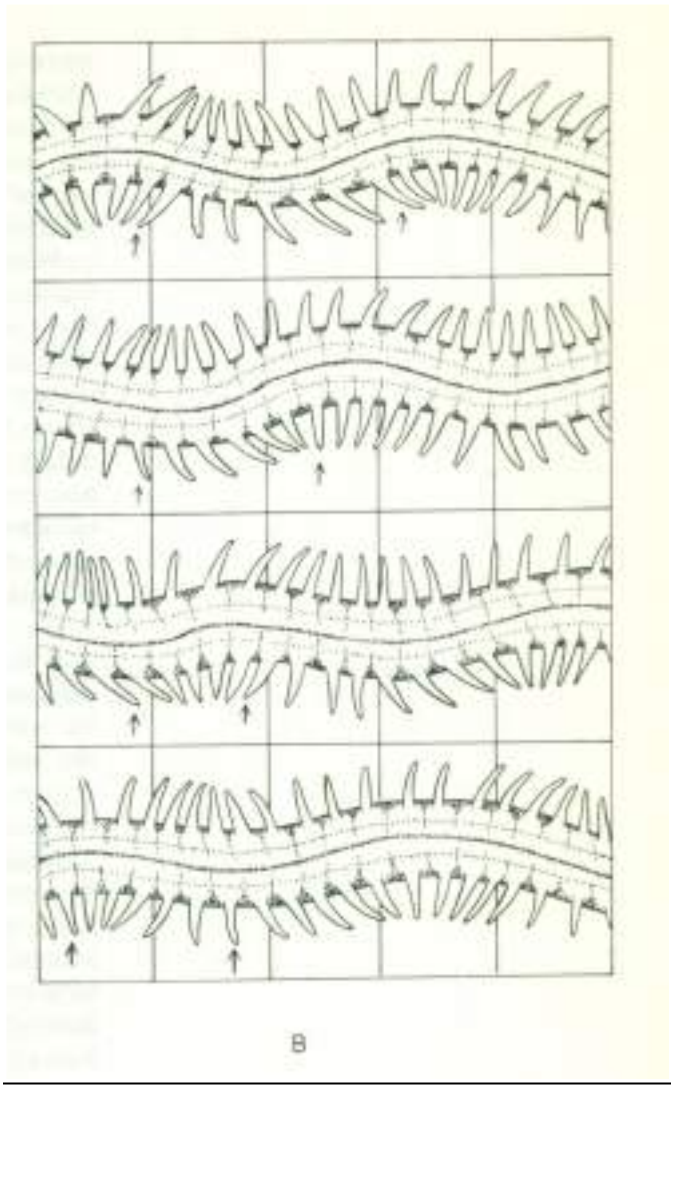
Parapodia of various polychaetes. A, *Lepidonotus* (Polynoidae); B, *Phyllodoce* (Phyllodocidae); C, *Eunice* (Eunicidae); D, *Dorvillea* (Eunicidae); E, *Aglaophamus* (Nephtyidae); F, *Glycera* (Glyceridae); G, *Arenicola* (Arenicolidae); H, *Aricia* (Aricidae). *d.c*, dorsal cirrus; *el*, elytrophore; *eln*, elytron; *g*, gill; *neur*, neuropodium; *not*, notopodium; *ret.g*, retractile gill; *v.c*, ventral cirrus.



Representative setae. A, neuroseta of *Lepidonotus* (Polynoidae); B, winged capillary setae of *Amphitrite* (Terebellidae); C, abdominal notoseta of *Vermiliopsis* (Serpulidae); D, simple hooded hook of *Eunice* (Eunicidae); E, compound seta of *Syllis* (Syllidae); F, neuropodial hook of *Arenicola* (Arenicolidae); G, avicular uncinus with its accompanying pick-axe seta of *Potamilla* (Sabellidae); H, lateral and end views of an uncinus of *Amphitrite* (Terebellidae).

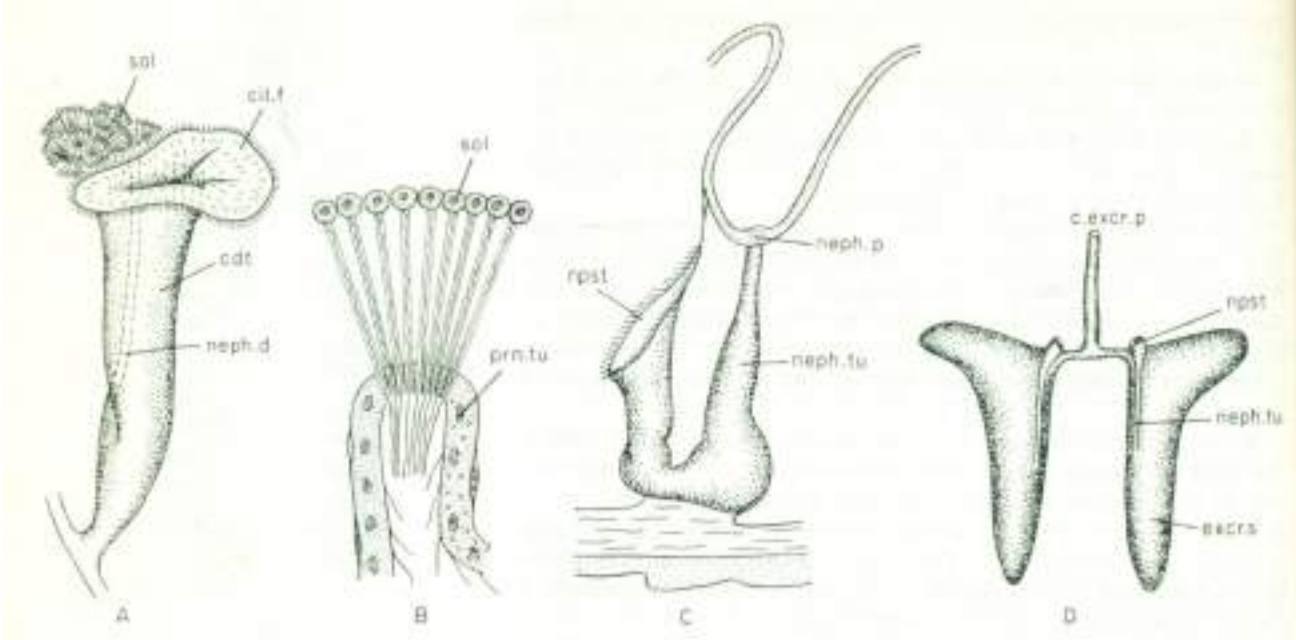


A

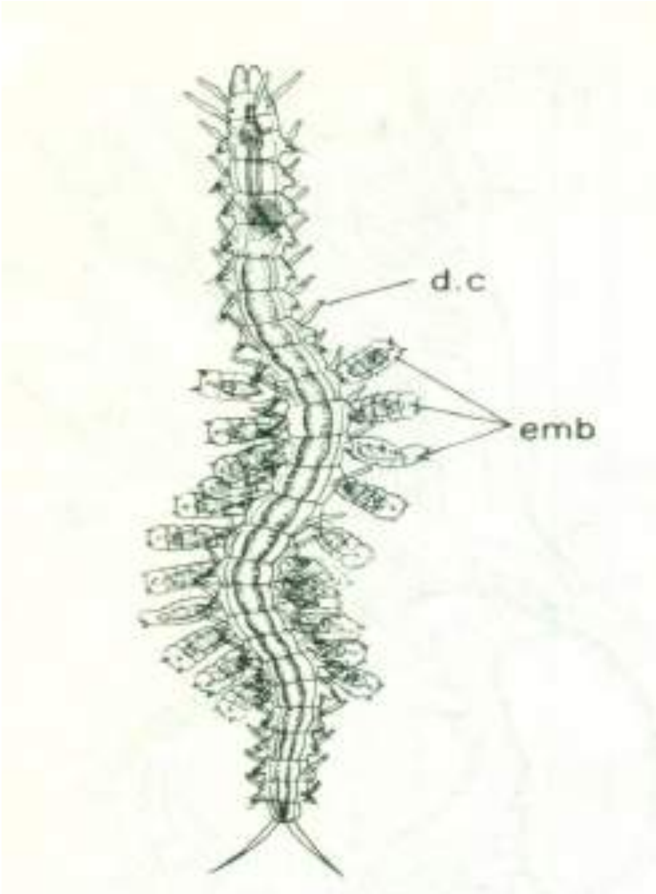


B

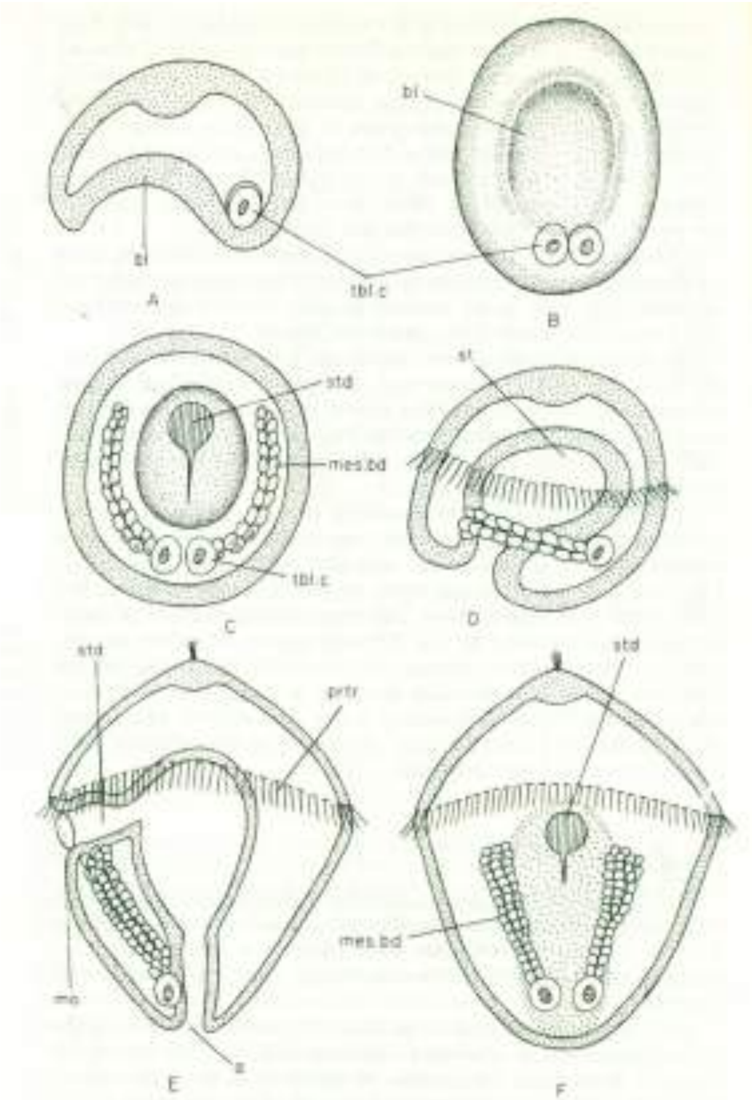
. Diagram illustrating movements and locomotion in *Nereis*. A, cycle of activity of parapodia during slow crawling. Broken lines connect successive parapodia which are about to execute a power stroke; the solid line marks the spread of excitation backwards along the body. B, inclination of parapodia during undulatory swimming movements; arrows indicate successive positions of two parapodia. (A after Gray, 1939, *J. exp. Biol.*, **16** (9); B after Clark, *Dynamics in Metazoan Evolution*, 1964. Clarendon Press, Oxford.)



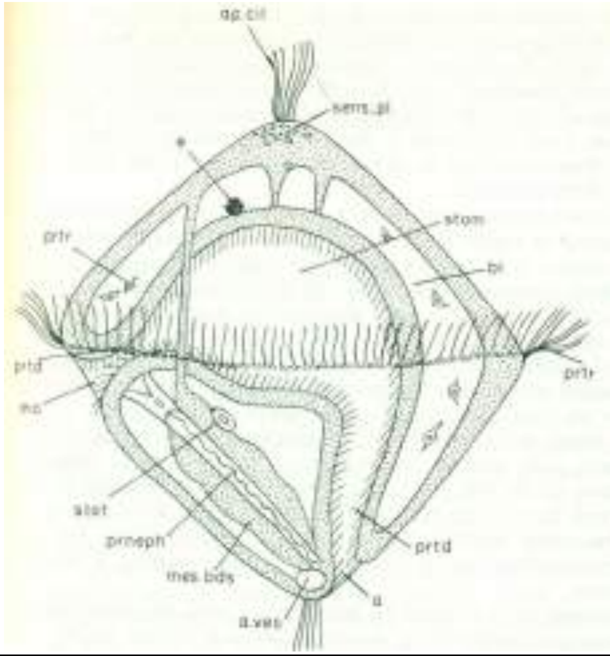
Nephridia of various polychaetes. A, protonephromixium of *Phyllodoce*; B, solenocytes of one protonephridial branch of A; C, metanephridium of *Nerine*; D, metanephridium of *Pomatoceros*. *cdt*, coelomoduct; *c. excr.p*, common excretory pore; *cil.f*, ciliated funnel; *excr.s*, excretory sac; *neph.p*, nephridiopore; *neph.d*, nephridial duct; *neph.tu*, nephridial tubule; *npst*, nephrostome; *prn.u*, protonephridial tubule; *sol*, solenocytes. (A, B, C, after Goodrich, 1945, *Q. Jl. microsc. Sci.* **86**, 113; D after Thomas, 1940, *Liverpool Mar. Biol. Comm. Mem. No. 33*.)



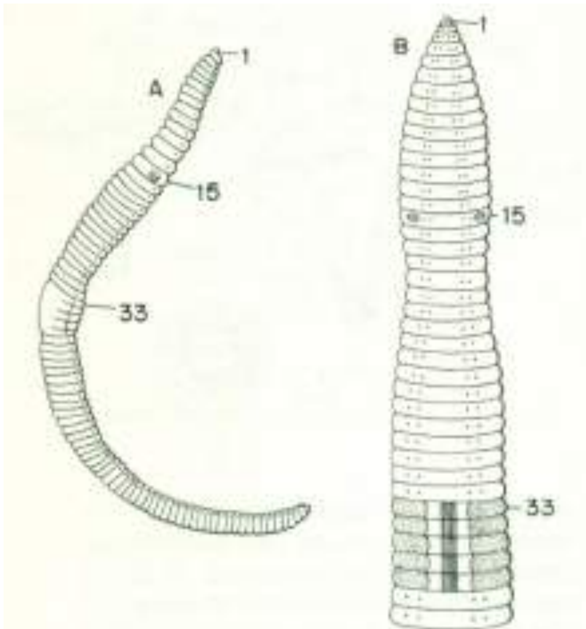
Pionosyllis elegans. Dorsal view of female with advanced embryos attached to the ventral surface. *d.c*, dorsal cirri; *emb*, embryos. (From Potts, after Pierantoni.)



The process of gastrulation leading to the formation of a trochophore. A, D, E, embryos viewed from the left side; B, C, F, the same embryos viewed from the animal pole (B) and the ventral surface (C and F). *a*, anus; *bl*, blastocoel; *mes.bd*, mesoderm band; *mo*, mouth; *prtr*, prototroch; *std*, stomodaeum; *st*, stomach; *tbl.c*, teloblast cell. (After Korschelt.)

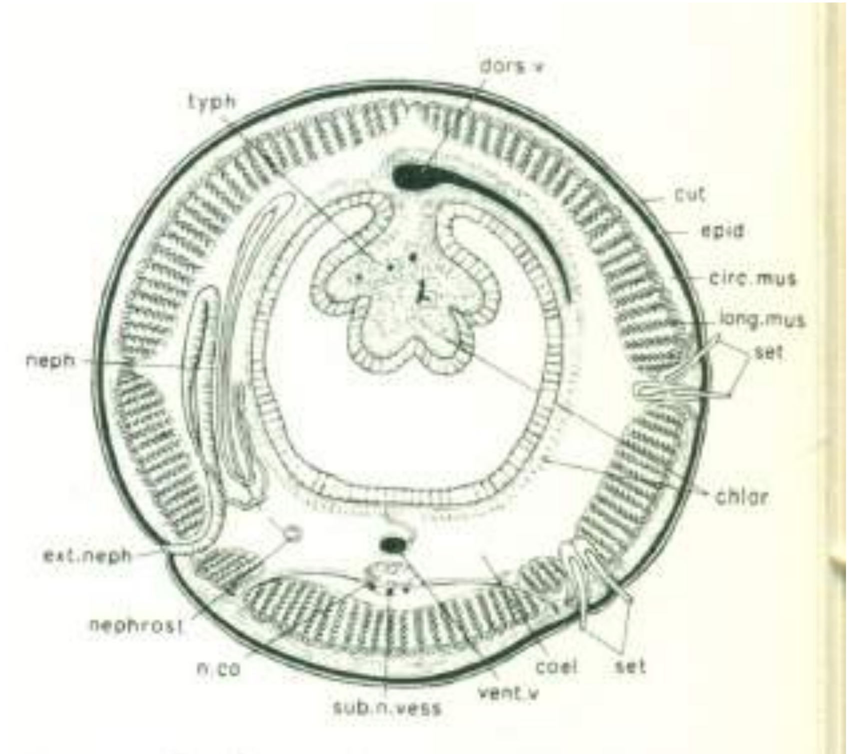


Trochophore. *a*, anus; *ap.cil*, apical tuft of cilia; *a.ves*, anal vesicle; *bl*, blastocoel; *e*, eye; *mes.bds*, mesodermal bands; *mo*, mouth; *prneph*, protonephridium; *prtd*, proctodaeum; *prtr*, prototroch; *sens.pl*, sensory plate; *stat*, statocyst; *stom*, stomach.

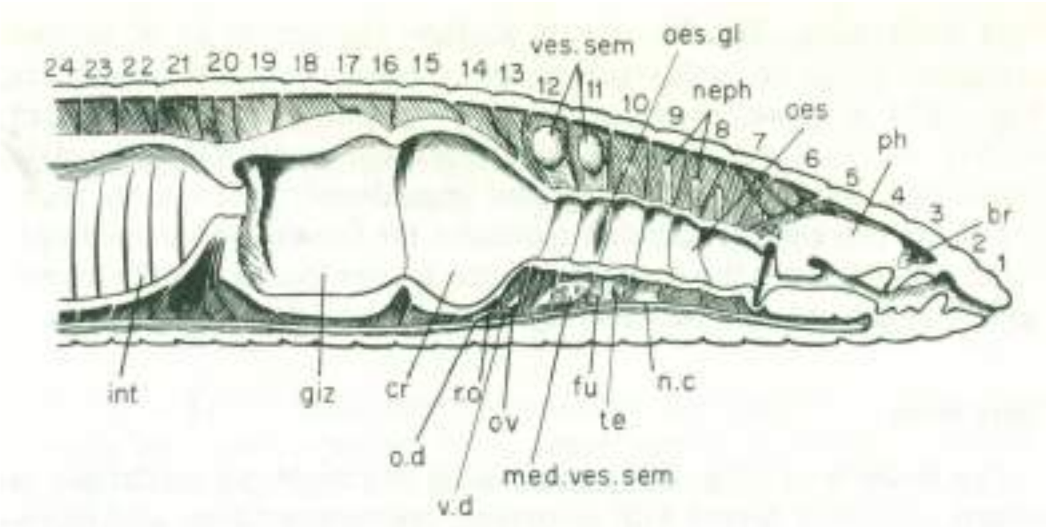


Lumbricus. A, entire specimen, lateral view; B, ventral view of anterior portion of the body, magnified. *1*, prostomium; *15*, *33*, fifteenth and thirty-third segments. Each of the black dots represents a pair of setae. (After Vogt and Jung.)

Lumbricus. Setae, highly magnified.



Lumbricus, transverse section of the middle region of the body. *chlor*, layer of chloragogenous cells; *circ.mus*, layer of circular muscular fibres; *coel*, coelom; *cut*, cuticle; *dors.v*, dorsal vessel; *epid*, epidermis; *ext.neph*, nephridiopore; *long.mus*, longitudinal muscle; *neph*, nephridium; *nephrost*, nephrostome; *n.co*, nerve cord; *set*, setae; *sub.n.vess*, subneural vessel; *typh*, typhlosole; *vent.v*, ventral vessel. (After Marshall and Hurst.)



Lumbricus. Longitudinal vertical section through the anterior half of the animal. *br*, brain; *cr*, crop; *fu*, seminal funnel; *giz*, gizzard; *int*, intestine; *med.ves.sem*, middle seminal vesicle; *n.c*, nerve cord; *neph*, nephridia; *o.d*, oviduct; *oes*, oesophagus; *oes.gl*, aperture of oesophageal pouch; *ov*, ovary; *ph*, pharynx; *r.o*, receptaculum ovorum; *te*, anterior testis; *v.d*, vas deferens; *ves. sem*, posterior lateral vesiculae seminales. (After Marshall and Hurst.)

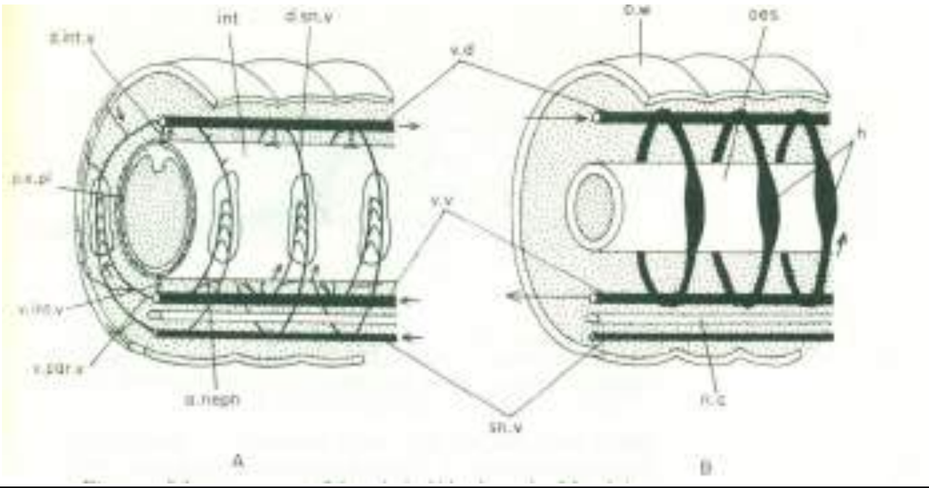
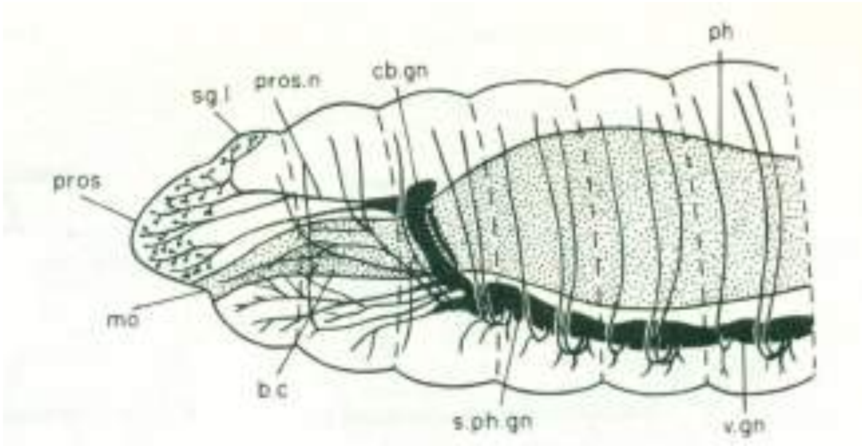
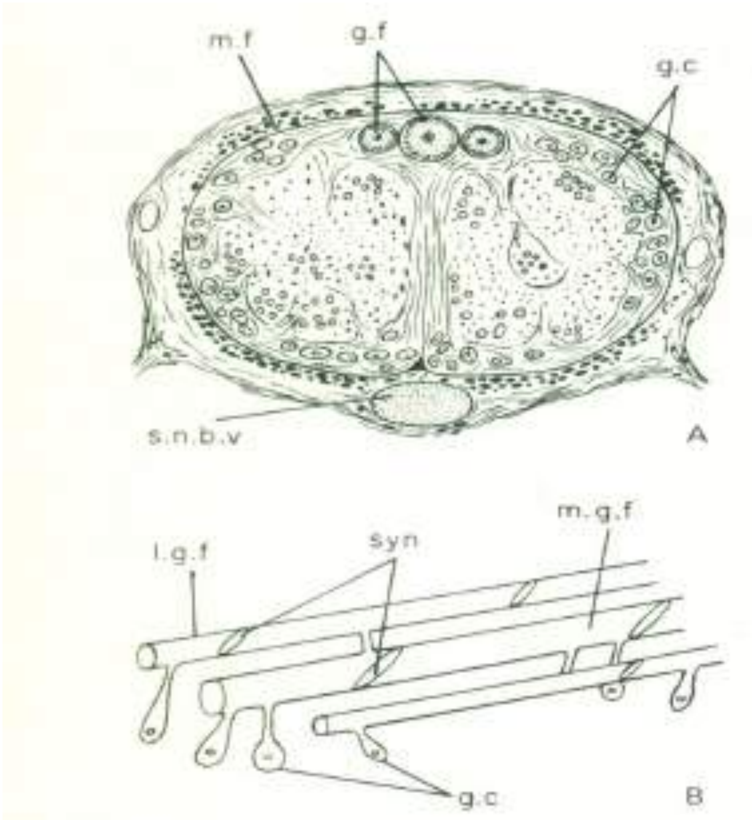


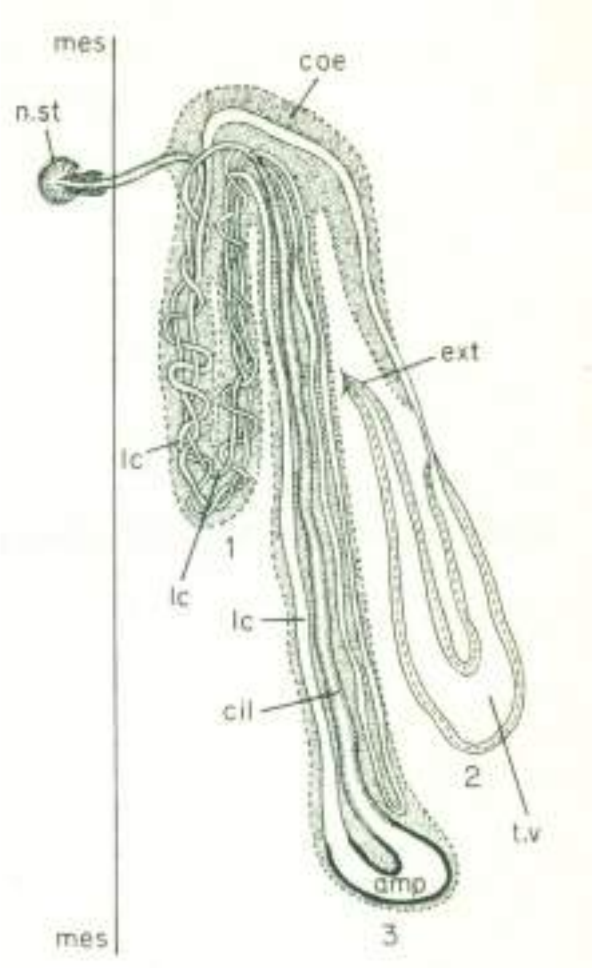
Diagram of the arrangement of the principal blood vessels of *Lumbricus*. Arrows indicate the direction of blood flow. A, the intestinal region; B, the oesophageal region. *a.neph*, afferent nephridial vessel; *b.w*, body wall; *d.int.v*, dorso-intestinal vessel; *d.sn.v*, dorso-subneural vessel; *h*, 'hearts'; *int*, intestine; *n.c*, nerve cord; *oes*, oesophagus; *p.e.pl*, peri-enteric plexus; *sn.v*, sub-neural vessel; *v.d*, dorsal vessel; *v.int.v*, ventro-intestinal vessel; *v.par.v*, ventro-parietal vessel; *v.v*, ventral vessel. (After Chapman and Baker, op. cit.)



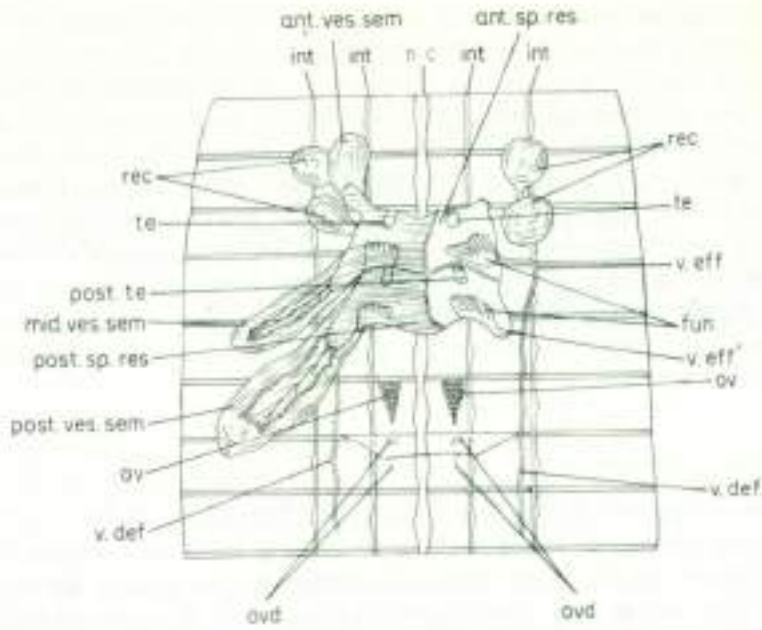
Anterior nervous system of *Lumbricus*. *b.c*, buccal cavity; *cb.gn*, cerebral ganglion; *mo*, mouth; *ph*, pharynx; *pros*, prostomium; *pros.n*, prostomial nerve; *sg.1*, segment 1; *s.ph.gn*, subpharyngeal ganglion; *v.gn*, ventral ganglion. (After Hesse, 1925, *J. Morph*. **40**, 235.)



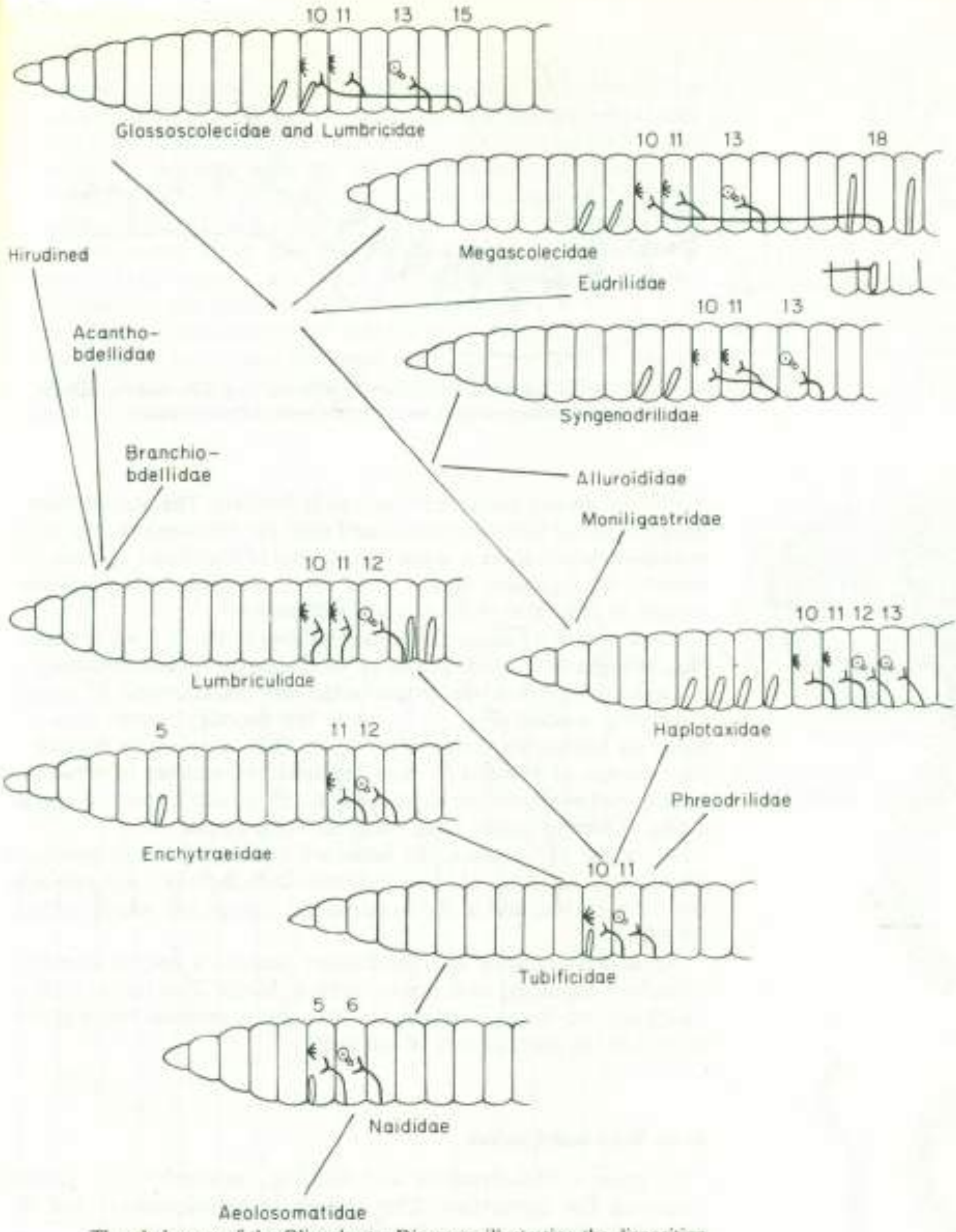
A, transverse section of the nerve cord of *Lumbricus* showing the giant fibres and nerve cells; B, diagram of the arrangement of the cells and synapses in the giant fibres. *g.c*, giant cells; *g.f*, giant fibres; *l.g.f*, lateral giant fibre; *m.f*, muscle fibre; *m.g.f*, median giant fibre; *s.n.b.v*, subneural blood vessel; *syn*, synapses. (B after Chapman and Baker, op. cit.)



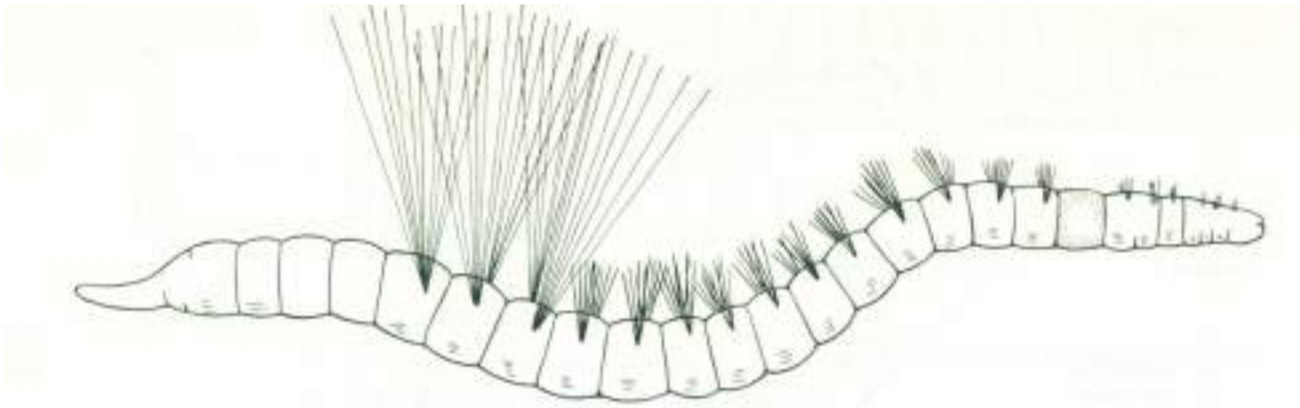
Nephridium of *Lumbricus* (diagrammatic). *amp*, ampulla between ciliated and non-ciliated parts of the intracellular canal; *cil*, ciliated part of the intracellular canal; *coe*, investment derived from the coelomic epithelium; *ext*, nephridiopore; *lc*, non-ciliated part of the intracellular canal; *mes*, septum; *n.st*, nephrostome; *t.v*, intercellular canal of the terminal vesicle. 1–3, the three principal loops. (From Meisenheimer, after Maziarski.)



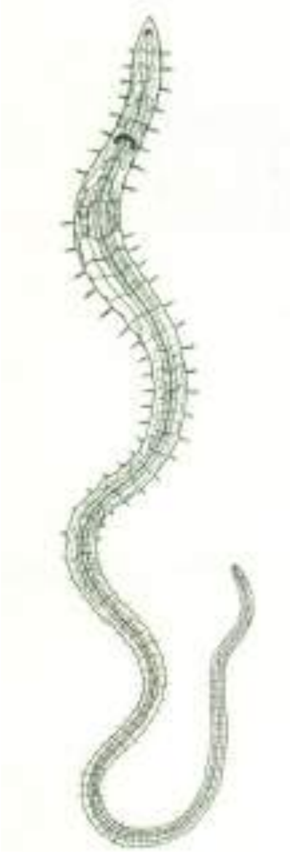
Lumbricus. Reproductive organs. *ant.sp.res*, anterior sperm reservoir; *ant.ves.sem*, anterior left vesicula seminalis; *fun*, funnel-like openings of vasa efferentia; *int*, intermuscular partitions; *mid.ves.sem*, middle vesicular seminalis; *n.c*, nerve cord; *ov*, ovaries; *ovd*, oviducts; *post.sp.res*, posterior sperm reservoir; *post.ves.sem*, posterior vesicula seminalis; *rec*, receptacular seminis; *te*, anterior testis; *post.te*, posterior testes; *v.eff*, anterior vas efferens and *p.v.eff'*, posterior vas efferens; *v.def*, vasa deferentia. (After Vogt and Jung.)



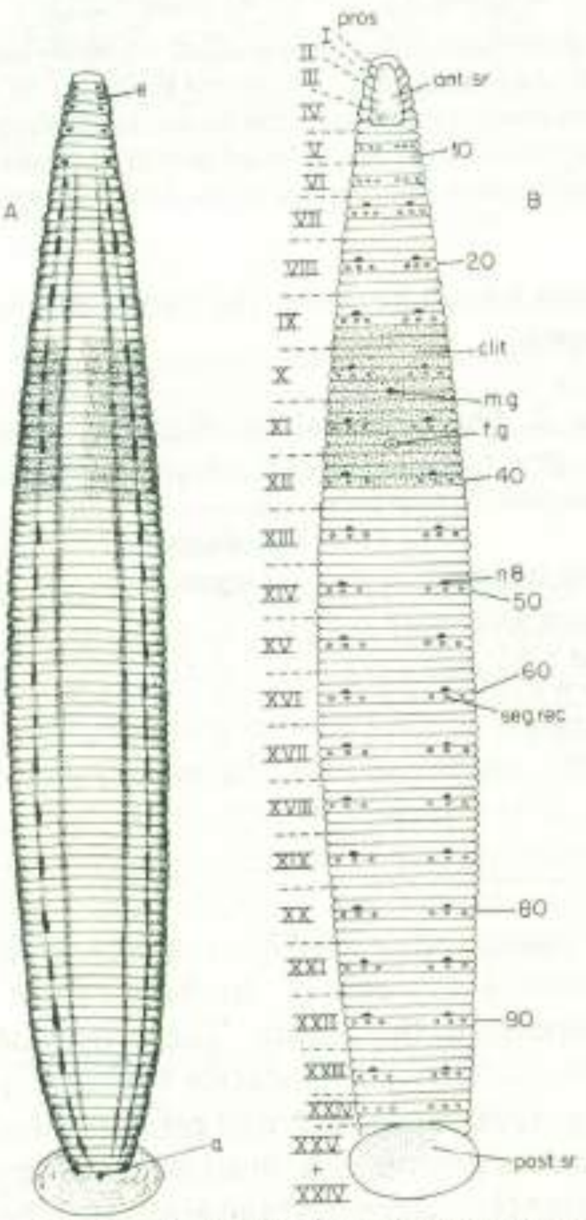
The phylogeny of the Oligochaeta. Diagrams illustrating the disposition of the reproductive organs in typical representatives of selected families. The Lumbriculidae is represented by *Lampodrilus* as the number and disposition of the testes and spermathecae is variable in this family. The Megascolecidae is represented by a typical holandric acanthodriline. The Glossoscolecidae and Lumbricidae are represented by *Lumbricus*; the number and position of the spermathecae are variable and the position of the male pore in the Glossoscolecidae is often far back. (After Pickford, in *Encyclopaedia Britannica*, vol. 1, 1962.)



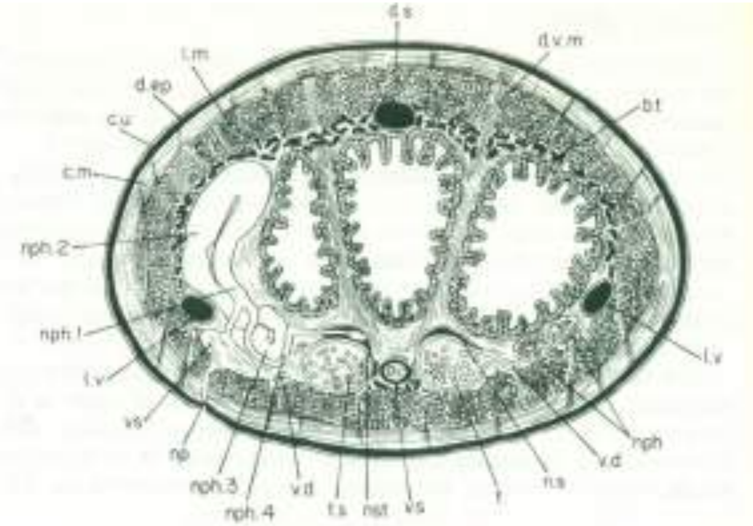
Ripistes parasitica (Naididae) showing the long hair setae on segment six, seven and eight, and a fission zone at the rear end.



Tubifex. General view of the entire animal. (After D'Udekem.)



Hirudo medicinalis. A, dorsal view. B, diagrammatic ventral view; the segments are numbered in roman numerals and the annuli in arabic. *a*, anus; *ant.sr*, anterior sucker; *clit*, clitellum; *e*, eye; *f.g*, female gonopore; *m.g*, male gonopore; *n.8*, eighth nephriodopore; *post.r*, posterior sucker; *pros*, prostomium; *seg.rec*, segmental receptor. (After Mann, K. H. *Leeches (Hirudinea). Their Structure, Physiology, Ecology and Embryology*, 1962. Pergamon Press, Oxford.)



Hirudo medicinalis; transverse section. *b.t*, botryoidal tissue; *c.m*, circular muscles; *cu*, cuticle; *d.ep*, epidermis; *d.s*, dorsal sinus; *d.v.m*, dorso-ventral muscles; *l.m*, longitudinal muscles; *l.v*, lateral vessel; *np*, nephridiopore; *nph.1–4*, nephridium; *n.s*, nephrostomial sinus; *nst*, ciliated funnel; *t*, testis; *v.d*, vas deferens; *vs*, vesicle of nephridium; *v.s*, ventral sinus. (After Marshall and Hurst.)

Phylum **Arthropod**
characteristics, classification, examples

Table of contents

Arthropod, any member of the phylum Arthropoda, the largest phylum in the animal kingdom, which includes such familiar forms as lobsters, crabs, spiders, mites, insects, centipedes, and millipedes. About 84 percent of all known species of animals are members of this phylum. Arthropods are represented in every habitat on Earth and show a great variety of adaptations. Several types live in aquatic environments, and others reside in terrestrial ones; some groups are even adapted for flight.

The distinguishing feature of arthropods is the presence of a jointed skeletal covering composed of chitin (a complex sugar) bound to protein. This nonliving exoskeleton is secreted by the underlying epidermis (which corresponds to the skin of other animals). Arthropods lack locomotory cilia, even in the larval stages, probably because of the presence of the exoskeleton. The body is usually segmented, and the segments bear paired, jointed appendages, from which the name arthropod ("jointed feet") is derived. About one million arthropod species have been described, of which most are insects. This number, however, may be only a fraction of the total. Based on the number of undescribed species collected from the treetops of tropical forests, zoologists have estimated the total number of insect species alone to be as high as 10,000,000. The 30,000 described species of mites may also represent only a fraction of the existing number.

The phylum Arthropoda is commonly divided into four subphyla of extant forms: Chelicerata, Crustacea, Hexapoda, and Myriapoda. Some zoologists believe that arthropods possessing only single-branched appendages, particularly the insects, centipedes, and millipedes, evolved from a separate ancestor and therefore group them within a separate phylum—the Uniramia, or Atelocerata; however, in this treatment these forms are dispersed among several subphyla. In addition, the phylum Arthropoda contains the extinct subphylum Trilobitomorpha. This group is made up of the trilobites, the dominant arthropods in the early Paleozoic seas (542 million to 251 million years ago). Trilobites became extinct during the Permian Period (299 million to 251 million years ago) at the end of the Paleozoic Era.

The myriapods (centipedes, symphylans, millipedes, and pauropods) live beneath stones and logs and in leaf mold; insects are found in all types of terrestrial habitats and some have invaded fresh water. The sea has remained the domain of the crustaceans, however, and only at its very edges are insects (subphylum Hexapoda) found.

The subphylum Crustacea contains mostly marine arthropods, though many of its members, such as the crayfish, have invaded fresh water, and one group, the pill bugs (sow bugs), has become terrestrial, living beneath stones and logs and in leaf mold. In the sea, large crustaceans such as crabs and shrimps are common bottom-dwelling arthropods. Many minute species of crustaceans (particularly the copepods) are an important component of the zooplankton (floating or weakly swimming animals) and serve as food for other invertebrates, fishes, and even whales.

Most members of the subphylum Chelicerata belong to the class Arachnida, containing the spiders, scorpions, ticks, and mites. They are largely terrestrial arthropods, living beneath stones and logs, in leaf mold, and in vegetation, but there are some aquatic mites that live in fresh water and in the sea. There are also many parasitic mites. Two small classes of chelicerates, the Merostomata, containing the horseshoe crabs, and the Pycnogonida, containing the sea spiders, are entirely marine. The merostomes are an ancient group and probably gave rise to the arachnids. Indeed, the earliest known fossil scorpions were aquatic.

This article discusses the arthropods as a group. For specific information on the most significant subphyla and classes of arthropods, *see* crustacean; arachnid; insect. *See also* myriapod.

General Features

Size range

Most arthropods are small animals. Only aquatic forms are able to attain substantial sizes, because their bodies are supported in part by the surrounding water. The extinct chelicerate Eurypterida, for example, reached a length of 1.8 metres (5.9 feet), and some modern spider crabs may weigh up to 6.4 kilograms (14 pounds) and span 3.8 metres or more. Terrestrial arthropods do not grow very large. The largest adult insects and spiders do not weigh more than 100 grams (0.22 pound); however, there is evidence that larvae of *Megasoma actaeon*, a type of rhinoceros beetle, can sometimes exceed 200 grams (0.44 pound). The beetle *Goliathus regius* measures 15 centimetres (5.9 inches) in length and 10 centimetres in width, while the butterfly *Ornithoptera victoriae* of the Solomon Islands has a wing span exceeding 30 centimetres (about 1 foot). One of the longest insects is the phasmid (walkingstick) *Phryganistria chinensis*, a specimen of which measured 62.4 centimetres (about 2 feet) in length. The phasmid *Phobaeticus chani* reaches a length of more than 30 centimetres. The smallest arthropods include some parasitic wasps, beetles of the family Ptiliidae, and mites that are less than 0.25 millimetre (0.01 inch) in length, despite their complex structures.

Distribution and abundance

Arthropods are found in almost all of the habitats that cover the Earth’s surface. Minute copepods (typically less than 1 millimetre long) are among the most abundant animals on

Earth, especially in marine surface waters. Many other crustaceans live in the sea at depths exceeding 4,000 metres, while the insect collembolans and jumping spiders have been found on Mount Everest at heights exceeding 6,700 metres. Collembolans and the oribatid mites are among the permanent inhabitants of Antarctica. Brine shrimp are found in some saltwater lakes, and beetles, mites, and various crustaceans have been taken from hot springs. Minute crustaceans inhabit underground waters in many parts of the world, and deserts support a large arthropod fauna, especially insects and arachnids. Arthropods are the only invertebrates capable of flight.

The numbers and diversity of arthropod insect pests are enormous. A bag filled with leaf mold from a forest floor, for example, will contain hundreds of arthropods, including mites, spiders, false scorpions, myriapods, a great variety of insects, and crustacean pill bugs. In the spring a temporary pool often teems with minute crustaceans.

Importance

Arthropods are of great direct and indirect importance to humans. The larger crustaceans—shrimps, lobsters, and crabs—are used as food throughout the world. Small planktonic crustaceans, such as copepods, water fleas, and krill, are a major link in the food chain between the photosynthetic phytoplankton and the larger carnivores, such as many fish and whales. Although many species of insects and mites attack food crops and timber, arthropods are of enormous benefit to human agriculture. Approximately two-thirds of all flowering plants are pollinated by insects, and soil and leaf-mold arthropods, which include insects, mites, myriapods, and some crustaceans (pill bugs), play an important role in the formation of humus from decomposed leaf litter and wood.

The stings and bites of arthropods may be irritating or painful, but very few inject dangerous toxins. Medically, arthropods are more significant as carriers of diseases such as malaria, yellow fever, dengue fever, and elephantiasis (via mosquitos), African sleeping sickness (via tsetse flies), typhus fever (via lice), bubonic plague (via fleas), and Rocky Mountain spotted fever and Lyme disease (via ticks). Many diseases of domesticated animals are also transmitted by arthropods.

Form And Function

The exoskeleton and molting

The success of arthropods derives in large part from the evolution of their unique, nonliving, organic, jointed exoskeleton (see figure), which not only functions in support but also provides protection and, with the muscle system, contributes to efficient locomotion. The exoskeleton is composed of a thin, outer protein layer, the epicuticle, and a thick, inner, chitin–protein layer, the procuticle. In most terrestrial arthropods, such as insects and spiders, the epicuticle contains waxes that aid in reducing evaporative water loss. The procuticle consists of an outer exocuticle and an inner endocuticle. In the exocuticle there is cross-bonding of the chitin–protein chains (tanning), which provides additional strength to the skeletal material. The hardness of various parts of the exoskeleton in different arthropods is related to the thickness and degree of tanning of the exocuticle. In crustaceans, additional rigidity is achieved by having the exoskeleton impregnated with varying amounts of calcium carbonate.

The formation of an exoskeleton required the simultaneous solution of two functional problems in the evolution of arthropods: If the animal is encased in a rigid covering, how can it grow and how can it move? The problem of growth is solved in arthropods by molting, or ecdysis, the periodic shedding of the old exoskeleton. The underlying cells release enzymes that digest the base of the old exoskeleton (much of the endocuticle) and then secrete a new exoskeleton beneath the old one. At the time of actual shedding, the old skeleton splits along specific lines characteristic of the group, and the animal pulls out of the old skeleton as from a suit of clothes. The old skeleton is usually abandoned but in some species is eaten. The new exoskeleton, which is soft and flexible, is then stretched by localized, elevated blood pressure augmented by the intake of water or air. Hardening occurs by stretching and especially by tanning within a number of hours of molting. In crustaceans, calcium carbonate is deposited into the new procuticle. (Soft-shell crabs are simply newly molted crabs.) Additional endocuticle may be added to the exoskeleton for some days or weeks following molting.

Molting is under hormonal control, and there is a long preparatory phase that precedes the process. The steroid hormone ecdysone, secreted by specific endocrine centres and circulated in the blood, is the direct initiator of molting. The actual timing of a molt, however, is regulated by other hormones and commonly by environmental factors. The interval between molts is called an instar. Because of the frequency of molts, instars are short early in life but grow longer with increasing age. Some arthropods, such as most spiders and insects, stop molting when they reach sexual maturity; others, like lobsters and crabs, molt throughout their lives. Most of the larger spiders of temperate regions, for example, molt about 10 times before reaching sexual maturity. As a result of molting, the length and volume of an arthropod display steplike increases over the life span, but internal tissue growth is continual as in other animals.

Loss of a limb is a common hazard in the life of many arthropods. Indeed, some arthropods, such as crabs, are capable of amputating an appendage if it is seized by a predator. The limb is then regenerated from a small, nipplelike rudiment formed at the site of the lost limb. The new limb develops beneath the old exoskeleton during the premolt period and then appears when the animal molts.

Muscles, appendages, and locomotion

Arthropods are unusual among invertebrates; they lack locomotory cilia, even as larvae. The problem that a rigid external covering imposes on movement has been solved by having the exoskeleton divided into plates over the body and through a series of cylinders around the appendages. At the junction, or joints, between the plates and cylinders the exoskeleton is thin and flexible because it lacks the exocuticle and because it is folded. The folds provide additional surface area as the joints are bent. The arthropod’s exoskeleton is therefore somewhat analogous to the armour encasing a medieval knight.

Most arthropods move by means of their segmental appendages, and the exoskeleton and the muscles, which attach to the inside of the skeleton, act together as a lever system, as is also true in vertebrates. The external skeleton of arthropods is a highly efficient system for small animals. The exoskeleton provides a large surface area for the attachment of muscles and, in addition to functioning in support and movement, also provides protection from the external environment. The cylindrical design resists bending, and only a relatively small amount of skeletal material need be invested in thickness to prevent buckling. The external skeleton imposes limits on the maximum size of an arthropod, especially in those that live on land. The largest arthropods live in the sea, where they gain considerable support from the buoyance of seawater. On land, an excessive amount of skeleton would be required to support a large bulk and, in addition, the new soft skeleton might collapse following a molt.

Appendages of arthropods have been adapted for all types of locomotion—walking, pushing, running, swimming, and burrowing. In most arthropods the legs move alternately on the two sides of the body; i.e., when one leg is in a power stroke, its mate on the opposite side of the body is in the recovery stroke (the same is true of mammals when walking). The legs in front or back are a little ahead or behind in the movement sequence. Because of the lateral position of the legs, the body of an arthropod tends to hang between them. Leg interference and trunk wobble tend to be problems in an animal with a long trunk and many legs, such as a millipede or a centipede. Most arthropods have evolved more-compact bodies and a smaller number of legs. The number of pairs of legs used in walking is not more than seven in pill bugs (terrestrial crustaceans), four or five in shrimps and crabs, four in arachnids, and three in insects. This reduces the problem of mechanical interference. When a ghost crab, for example, is running rapidly across a beach or dune, only the second, third, and fourth pairs of the five pairs of legs (counting the claws) are employed. Leg interference is further reduced in most arthropods by varying limb length and placement. For example, in *Scutigera,* the centipede commonly seen in houses, the legs increase in length from front to back and thus pass over or under one another in stepping. The tendency for the trunk to wobble has been reduced in some centipedes by having overlapping dorsal plates and in millipedes by having pairs of segments fused to form double segments. Many arthropods are capable of walking on vertical surfaces. Some simply grip minute surface irregularities with the claws at the end of the legs. Others, such as certain spiders and flies, have an array of specialized gripping hairs at the ends of the legs.

Insect wings are not segmental appendages as are the legs. The paired wings arise as lateral folds of the integument, one pair above each of the last two pairs of legs. Each wing thus consists of an upper and lower sheet of exoskeleton closely applied to each other. The two skeletal sheets are separated at various places, forming tubular supporting veins. Unlike the wings of an airplane, the wings of insects are flat plates, and lift is obtained by changing the angle at which the front margin of the wing meets the oncoming air stream. The evolution of flight is one of several adaptations that have enabled insects to become the most diverse and populous group of terrestrial animals.

A burrowing habit has evolved in some insects, such as mole crickets and ants, but the largest burrowers are crustaceans. Mole crabs and box crabs are rapid burrowers in soft marine sands, and various species of mantis shrimps, mud shrimps, and snapping shrimps create elaborate burrows below the bottom surface. Crustaceans also include the largest number of arthropod tube dwellers, surpassed only by certain marine worms (polychaetes). Most of the tube-dwelling crustaceans are amphipods. Their tubes are usually composed of sand or mud particles secreted together and attached to bottom objects; there are, however, some amphipods that carry their tubes with them like a portable house.

Digestive system and feeding

Arthropods exhibit every type of feeding mode. They include carnivores, herbivores, detritus feeders, filter feeders, and parasites, and there are specializations within these major categories. Typically, paired appendages around the mouth are used for collecting and handling food and are usually specialized in accordance with the particular diet of the animal. For example, the insect family Aphididae has mouthparts adapted for piercing vegetation and sucking out plant juices. The crustacean fiddler crabs, which emerge from burrows on sand flats at low tide, scoop up the surface sand with their small claws (only one in the male) and place the sand within their mouthparts, where it is sifted with fine hairs. The organic material is consumed, and the mineral material is ejected as a small "spitball." Where there is a large population of crabs, ejected material may cover the surface of a flat by the end of the low-tide period. The crustacean mole crabs, or sand crabs, of surf beaches use their antennae to filter plankton from the receding waves after reburying themselves. Planktonic crustacean copepods only a few millimetres long can collect up to several hundred thousand diatoms every 24 hours with certain appendages (maxillae) near the mouth. A number of carnivorous arthropods, notably spiders, pseudoscorpions, and centipedes, capture prey with poison, which is usually delivered with a pair of appendages; scorpions use a single stinger at the tip of the tail. In spiders, the poison is introduced through a pair of fangs (chelicerae) flanking the mouth, and in centipedes the poison claws lie beneath the head. Few of these species have a venom that is fatal to humans (*see* myriapod).

The front and back parts of the digestive tract (foregut and hindgut) are lined with the same skeletal material that is found on the outside of the body and that is molted with the rest of the skeleton. Only the relatively small middle section (midgut) lacks a chitinous lining. The digestive tract varies greatly in structure, depending upon the diet and feeding mode of the animal. In general, however, the midgut region is the principal site of enzyme production and absorption of digested food. The enzymes may pass forward into the front part of the gut and even outside into the body of the prey, in the case of spiders.

Respiratory system

Aquatic arthropods (crustaceans and the chelicerate horseshoe crabs) possess gills for respiration. Although they vary in structure and location, the gills are always outgrowths of the integument (skin) and are therefore covered by the exoskeleton, which is thin in this area and not a barrier to the exchange of gases. Terrestrial arthropods possess tracheae and book lungs as respiratory organs. Tracheae are a system of tiny tubes that permit passage of gases into the interior of the body. In some arthropods the tracheal tubes are bathed by blood, but in insects the minute terminal endings (tracheoles) are embedded in the tissues, even within muscle cells. The tracheal tubes (but not the tracheoles) are molted along with the rest of the exoskeleton. Tracheae are a unique arthropod invention and undoubtedly evolved numerous times in the phylum, for they are found in myriapods, insects, and arachnids. Tracheal systems are highly efficient for these small, terrestrial animals. The small, external openings (spiracles) reduce water loss, the chitinous lining prevents collapse, and the small size of the arthropod and consequent short length of the tubule eliminates the need for moving gases in and out by active ventilation (diffusion usually being sufficient). Book lungs are chitin-lined internal pockets containing many blood-filled plates over which air circulates.

Most spiders possess tracheae and book lungs, but large spiders (such as tarantulas) and scorpions possess book lungs alone.

Circulatory system

Arthropods possess an open circulatory system consisting of a dorsal heart and a system of arteries that may be very limited (as in insects) or extensive (as in crabs). The arteries deliver blood into tissue spaces (hemocoels), from which it eventually drains back to a large pericardial sinus surrounding the heart. A varying number of paired openings (ostia) are located along the length of the heart and permit blood to flow in when the valves are open. When the heart is contracting, closed valves prohibit the blood from flowing back and force it into the arteries of the tissues, from which it flows to other hemocoels. In the larger crustaceans, the blood then passes through the gills (where it becomes oxygenated) on its return to the heart. The blood of large arachnids and crustaceans contains the blue, oxygen-carrying pigment hemocyanin; insects lack a respiratory pigment since the tracheal system delivers oxygen directly to the tissues. A few insect larvae and some small crustaceans have blood containing hemoglobin.

Excretory system and water balance

Crustaceans and arachnids possess paired excretory organs (maxillary, antennal, or coxal glands) that open at the bases of certain appendages. Myriapods, insects, and some arachnids, such as spiders and mites, possess another type of excretory organ, Malpighian tubules, which open into the intestine. Thus in these animals both excretory and digestive wastes exit from the anus.

Water loss through evaporation is a major problem for animals that live on land, especially small ones like arthropods, and an array of defenses against desiccation have evolved. Both arachnids and insects possess waxy compounds in the epicuticle, the outer layer of the exoskeleton, which greatly reduce evaporative water loss. Arthropods that lack a waxy epicuticle, such as the pill bugs, and very small arthropods, such as mites, pseudoscorpions, and collembolans, live in leaf mold and soil, beneath logs, under stones, and in other areas where the danger of desiccation is reduced. The waxes in the epicuticle not only reduce water loss but can also act as a water repellent, reducing the danger of submersion in droplets of rain or dew. This resistance to wetting enables aquatic insects, such as beetles, to carry below the surface a film of air, which can then be used in respiration. It also contributes to the ability of water striders to move over the surface of water without breaking through the surface film.

Both insects and spiders eliminate their nitrogenous wastes as compounds insoluble in water (uric acid, guanine), thereby not requiring that water be excreted. Insects share with birds and mammals the ability to produce a urine that is saltier than the blood, which is of great value in conserving water because it permits the production of a concentrated urine.

Nervous system and organs of sensation

The arthropod nervous system consists of a dorsal brain and a ventral, ganglionated longitudinal nerve cord (primitively paired) from which lateral nerves extend in each segment. The system is similar to that of annelid worms, from which arthropods may have evolved. The neuromuscular organization of arthropods is quite different from that of vertebrates, in which one neuron supplies a number of muscle cells, together forming a functional motor unit. The small size of the muscles prohibits such an organization in arthropods. Instead, the state of contraction of an arthropod muscle is determined by which of several different types of neurons supplying one muscle cell are fired.

The sense organs (sensilla) on the body surface involve some specialization of the exoskeleton barrier. The sensory nerve endings are lodged in cuticular hairs (setae), peglike projections, cones, pits, or slits, which may occur in large numbers on antennae, mouthparts, joints, and leg tips. Changes in the tension of the surrounding cuticle stimulate the nerve endings. For example, the legs of spiders and scorpions possess slits in the exoskeleton that are covered by a thin membrane to which a neuronal receptor is attached below. Tension changes in the exoskeleton cause slight movements in the cuticular membrane and stimulate the receptors. Slits of varying length may be grouped together like the strings of a harp. Slit sense organs enable spiders to detect web vibrations produced by trapped insects, and they permit scorpions to detect ground vibrations produced by approaching prey. Chemoreceptive sensilla (taste and smell) have holes in the cuticle permitting the chemical substances being monitored to enter.

Most arthropods possess eyes, but in most species they function only to detect the intensity of light and the direction of the light source. The ability to detect objects is more restricted. Among arthropods the greatest visual acuity is found in the predaceous mantis shrimp, some crabs, and many insects, all of which possess compound eyes. Compound eyes are extremely effective in detecting motion. The eight eyes of spiders are not of the compound type, but in the case of the cursorial (hunting) wolf spiders and jumping spiders they are effective in locating and tracking prey.

Reproductive system and life cycle

With few exceptions, the sexes are separate in arthropods; i.e., there are both male and female individuals. The paired sex organs, or gonads, of each sex are connected directly to ducts that open onto the ventral surface of the trunk, the precise location depending upon the arthropod group.

In arthropods, sperm are commonly transferred to the female within sealed packets known as spermatophores. In this method of transfer the sperm are not diluted by the surrounding medium, in the case of aquatic forms, nor do they suffer from rapid desiccation on land. Among some arachnids, such as scorpions, pseudoscorpions, and some mites, the stalked spermatophore is deposited on the ground. Either the female is attracted to the spermatophore chemically or the deposition of the spermatophore occurs during the course of a nuptial dance, and the male afterward maneuvers the female into a position in which she can take up the spermatophore within her genital opening. Centipedes also utilize spermatophores with an accompanying courtship behaviour. Among insects there are some primitive wingless groups, such as collembolans and thysanurans, in which the spermatophore is deposited on the ground, but in most insects the spermatophores are placed directly into the female genital opening by the male during copulation. Many other invertebrates, including several gastropods and chaetognaths, also use spermatophores. Many arthropods transfer free sperm rather than spermatophores. These include many crustaceans, millipedes, some insects (such as dipterans and hemipterans), spiders, and some mites.

Arthropod eggs are usually rich in yolk, but in all groups there are species whose eggs have little yolk. Some specialized methods of reproduction found among certain arthropods include the development of unfertilized eggs (parthenogenesis), the birth of living young (viviparity), and the formation of several embryos from a single fertilized egg (polyembryony).

The eggs of many crustaceans hatch into larvae which have fewer segments than the adult. The earliest larval hatching stage is a minute nauplius larva, which possesses only the first three pairs of appendages. Additional segments and appendages then appear at regular intervals with molting. There are several advantages of larval stages in the development of aquatic animals: Currents disperse the larvae, enabling some to settle in different locations from the parents; because many larvae are capable of feeding, less yolk is required in the egg; and, moreover, planktonic larvae do not compete with benthic adults.

In most chelicerates and insects, almost all of the segments are present at hatching, although in insects the body form may differ from that of the adult. Primitive insects, such as collembolans, have the adult form on hatching. Many insects, such as grasshoppers, crickets, and true bugs, hatch as nymphs, which superficially resemble the adult but lack wings. They gradually acquire these adult features during the nymphal instars. Other insects, such as beetles, butterflies, moths, flies, and wasps, hatch as larvae (grubs, caterpillars, maggots) that differ markedly from the adult. The larvae inhabit different environments and eat different foods than the adults. In these insects a pupal stage with metamorphosis bridges the gap between the larva and the adult form.

Myriapods have the general body form of the adult on hatching though they may lack some of the segments. Most millipedes hatch with only seven trunk segments. Some centipedes hatch with all of the adult trunk segments, but others have fewer than the adult.

The young of most arachnids are similar to the adult. The female scorpion gives birth to her young, which immediately climb onto her back. Female wolf spiders also carry their young, and prior to hatching they carry the white egg case attached to the posterior spinnerets. Unlike other arachnids, mites and ticks hatch as six-legged larvae, which acquire the fourth pair of legs at a later molt.

Evolution And Paleontology

The arthropods share many features with the phylum Annelida. Both arthropods and annelids are segmented, and members of the annelid class Polychaeta have a pair of appendages on each segment. The plan of the nervous system in arthropods is very similar to that of annelids, and the basic plan in both groups shows a tubular, dorsal heart, which is then lost or modified in some. Annelids possess a coelom, which in arthropods is present only in the embryo. Its absence is probably related to the evolution of the exoskeleton and to the change in the mode of locomotion.

The first fossil arthropods appear in the Cambrian Period (542 million to 488 million years ago) and are represented by trilobites, merostomes, and crustaceans. Also present are some enigmatic arthropods that do not fit into any of the existing subphyla. The earliest terrestrial arachnid is from the Devonian Period (416 million to 359 million years ago), but it does not belong to any living order. Though a myriapod-like fossil has been found from the Devonian Period, it is not until the Carboniferous Period (359 million to 299 million years ago) that there is a good record of centipedes, millipedes, and insects. Specimens of plant-feeding mites dated to the Triassic Period (251 million to 199.6 million years ago) are among the oldest arthropod fossils preserved in amber.

Most zoologists recognize the trilobites, chelicerates, crustaceans, and myriapods as four major lines of arthropod evolution, but there is little agreement as to how those lines are related to one another or, indeed, if they had evolutionary origins independent from those of the annelids.

Classification

Distinguishing taxonomic features

Modification, specialization, number, and appearance of body segments and appendages (especially anterior ones such as antennae and mouthparts) are important criteria in distinguishing arthropod classes. Other structural features of taxonomic importance include location of the gonopores, structure of the head, and adaptations of the respiratory and excretory systems. In the classification below, the group marked with a dagger (†) is wholly extinct and known only from fossils.

Annotated classification

Bilaterally symmetrical invertebrates with jointed exoskeleton covering body and appendages; cilia absent; body segmented, though segmentation commonly reduced as a result of fusion; appendages typically specialized for different functions; coelom greatly reduced; nervous system consists of dorsal brain and a double or single (fused) ventral nerve cord; eggs typically rich in yolk; development highly modified.

†Subphylum Trilobitomorpha (trilobites)

Extinct; head (or cephalon) composed of 5 segments bearing a pair of antennae and compound eyes; oval, flattened body composed of cephalon, thorax, and pygidium, each segmented; dorsal surface molded longitudinally into 3 lobes; each segment bears a pair of similar, branched appendages; marine; Cambrian Period to the end of the Paleozoic Era; more than 4,000 fossil species known.

- Subphylum Chelicerata

Body divided into prosoma (cephalothorax) and opisthosoma (abdomen); no antennae; first pair of appendages consists of chelicerae flanking the mouth; in most chelicerates the other prosomal appendages are a pair of pedipalps and four pairs of legs.

- Class Merostomata

  Large marine chelicerates with book gills on the underside of the opisthosoma; prosoma covered by a dorsal carapace; opisthosoma bears a long terminal spine; 2 orders, Xiphosura (horseshoe crabs, 4 species) and Eurypterida (Gigantostraca), which is extinct and includes 200 fossil species from the Paleozoic Era.

- Class Arachnida (scorpions, spiders, ticks, mites)

  Chiefly terrestrial; book lungs and/or tracheae as gas exchange organs; opisthosoma (abdomen) segmented or unsegmented externally and broadly or narrowly joined to the prosoma; prosomal appendages consist of 1 pair of chelicerae, 1 pair of pedipalps, and 4 pairs of legs; gonopore always on the lower side of second abdominal segment; about 70,750 species; 0.25 mm–l8 cm.

- Class Pycnogonida (sea spiders)

  Marine; narrow trunk of 4 to 6 segments; greatly reduced abdomen; cephalon (head) with proboscis bearing a pair of chelicerae, palpi, and egg-carrying legs; usually 4 pairs of walking legs attached to lateral projections of the trunk; tubercle with 4 eyes located dorsally between the first pair of legs; no gas respiratory organs; commonly found crawling over sessile animals, such as hydroids and bryozoans; about 1,000 described species; 1 mm–10 cm.

o Subphylum Crustacea (crabs, shrimp, isopods, amphipods, krill, brine shrimp, copepods, barnacles)

Chiefly aquatic; head bearing 2 pairs of antennae, a pair of mandibles, and 2 pairs of maxillae; trunk highly variable but commonly covered in part or entirely by a posteriorly directed fold of the head (carapace); paired appendages biramous, often with 1 branch lost; 2 stalked or stalkless compound eyes present in most; when present, gas exchange organs are gills; mostly marine, but many freshwater species; some isopods terrestrial; 44,000 described species distributed among 6 subclasses.

o Subphylum Myriapoda

Chiefly terrestrial; segmental appendages primitively unbranched; head appendages comprise a pair of antennae, a pair of mandibles, and 1 or 2 pairs of maxillae; trunk and appendages variable; respiratory organs are tracheae.

- Class Chilopoda (centipedes)

  Elongate; many trunk segments, each with 1 pair of legs; 2 pairs of maxillae covered by a large pair of poison claws representing the first pair of trunk appendages; eyes, if present, are simple ocelli; gonopore on last segment; 5 mm to almost 30 cm; about 3,000 living species.

- Class Symphyla

  Mouthparts consist of a pair of mandibles and 2 pairs of maxillae; 12 leg-bearing trunk segments; terminal segment carries a pair of spinnerets; gonopore on fourth segment; l–8 mm; about 160 living species.
- Class Diplopoda (millipedes)

  Elongate; trunk containing many diplosegments, each bearing 2 pairs of legs and spiracles; single pair of maxillae fused to form a flattened plate (gnathochilarium); first 4 trunk segments not diplosegments, and third bears the gonopores; simple eyes (ocelli) present or absent; 2 mm–28 cm; about 10,000 living species.
- Class Pauropoda

  Antennae branched; a pair of maxillae; 9–11 trunk segments bearing legs; gonopores on third trunk segment as in diplopods; 0.5–1.5 mm; about 500 described species.

o Subphylum Hexapoda

- Class Insecta

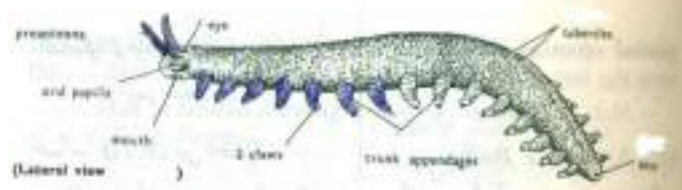
  Body composed of a head, thorax, and abdomen; head bears simple eyes and usually a pair of lateral compound eyes; 2 pairs of maxillae, the second pair fused (labium); thorax of 3 segments, each with a pair of legs, and the second and third usually bearing wings; abdomen of 11 segments without appendages in the adult; gonopore at end of abdomen; 0.25 mm–33 cm; at least 1 million described species.
- Class Entognatha

Critical appraisal

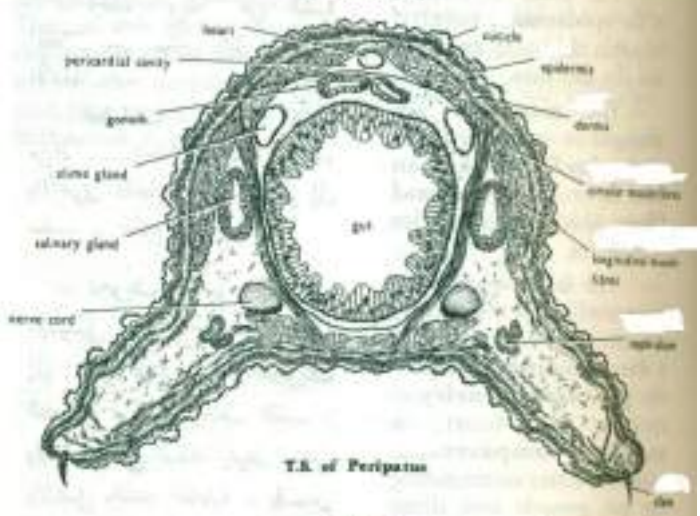
Arthropod relationships, both within the phylum and with other animal phyla, are uncertain. For many years arthropods and annelids were believed to be closely related, with arthropods likely evolving from annelid ancestors, or vice versa. Modern analyses question that assumption, suggesting that their similarly segmented body plans would have to have evolved independently.

Likewise, many relationships within the group are equally unsettled. For example, the terrestrial arthropods—insects and myriapods—are commonly believed to be closely related. It is possible that both groups derived from a common ancestor. On the other hand, accumulating molecular evidence allies insects more closely with crabs and other crustaceans and links the myriapods with horseshoe crabs and arachnids.

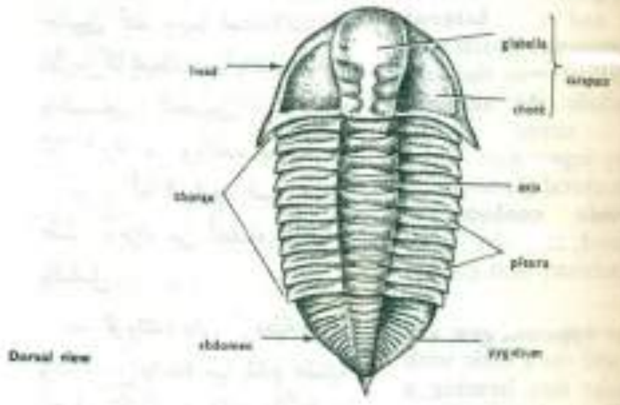
Furthermore, some groups of animals have been incorporated into the Arthropoda. A group of parasitic worms known as the pentastomids, for example, are considered to be highly modified crustaceans at present. In contrast, two other groups of animals, the microscopic water bears (tardigrades) and the onychophorans (such as *Peripatus*) are closely related to arthropods but will probably remain in one or more separate phyla



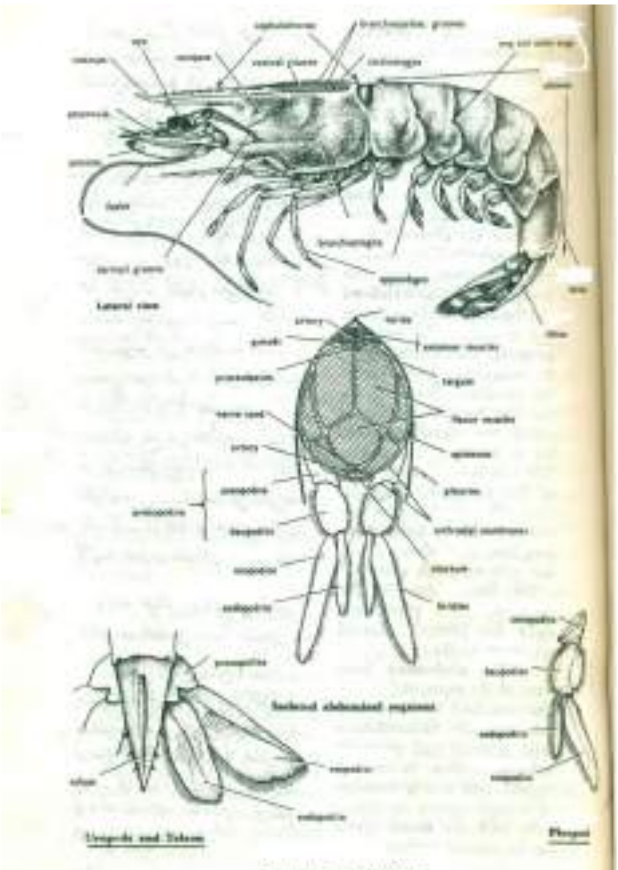
PERIPATUS



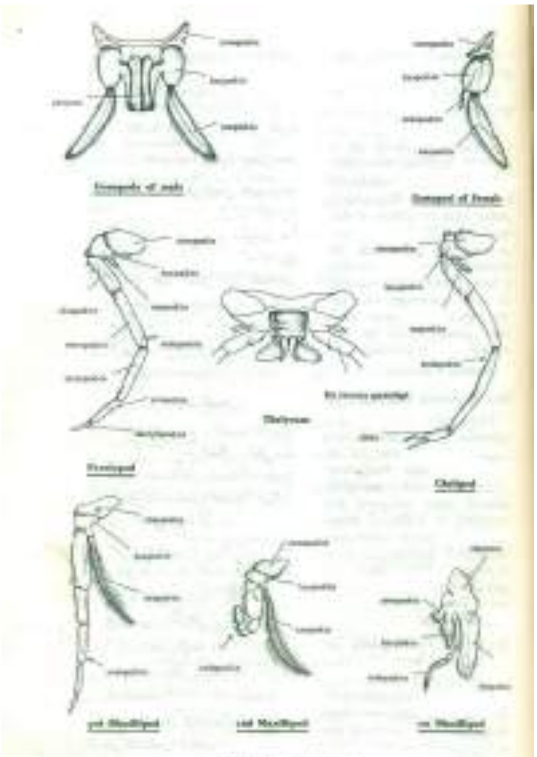
T.S. of Peripatus



A TRILOBITE



PENAEUS JAPONICUS



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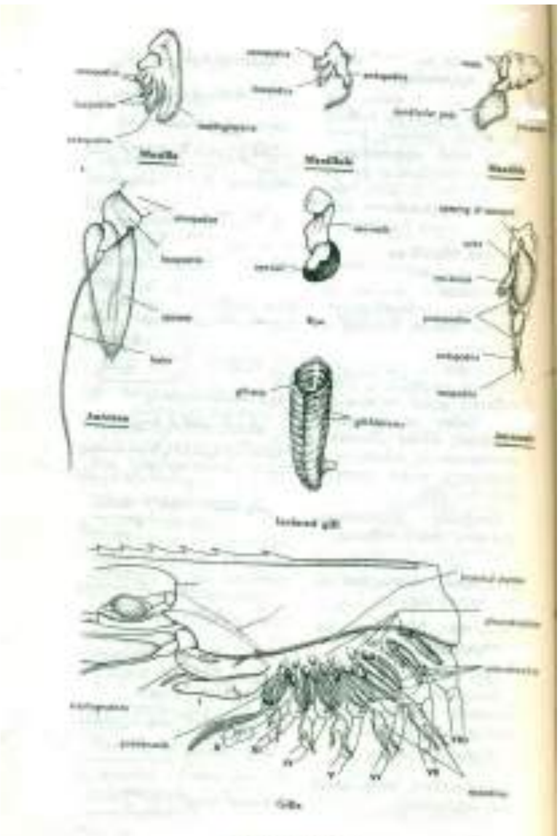
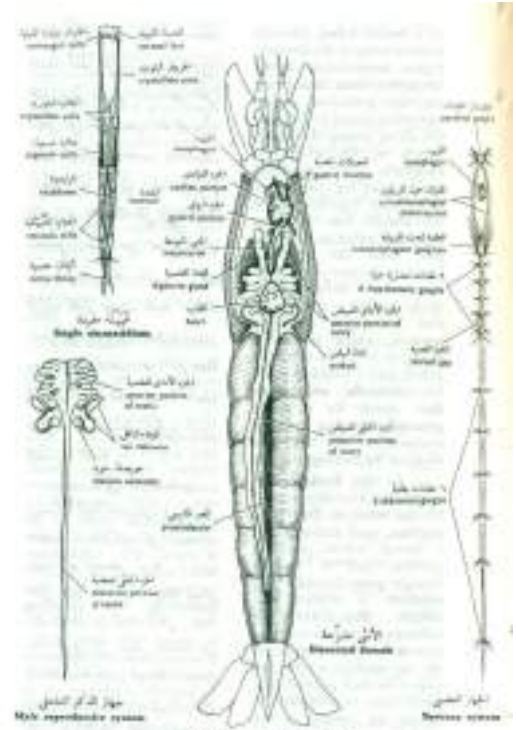
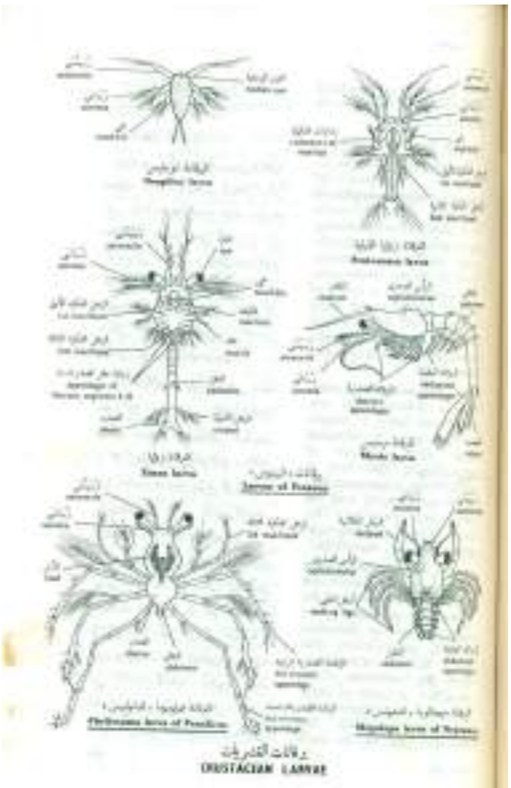


PENAEUS JAPONICUS

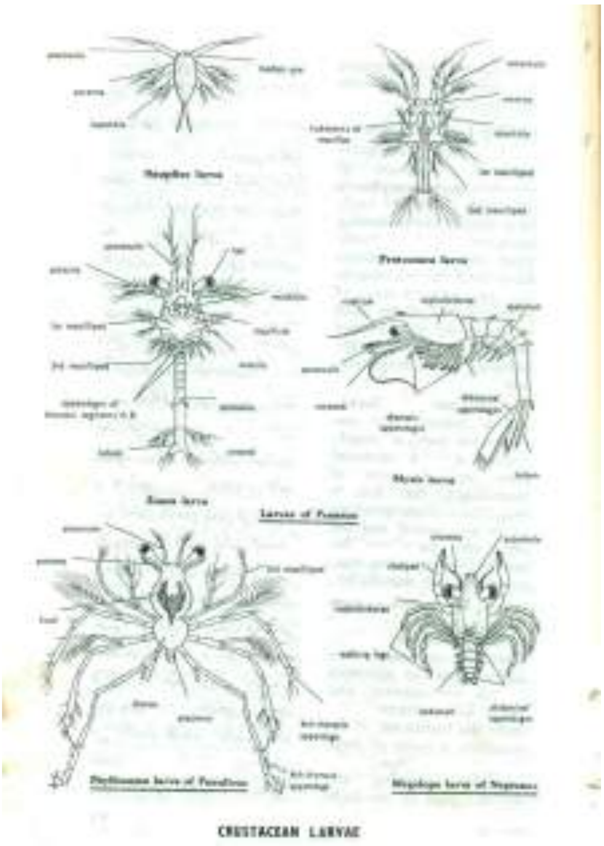
	Thoracic segment I	II	III	IV	V	VI	VII	VIII	Total
Pleurobranchiae	0	1	1	1	1	1	1	1	19 gills + 6 epipodites
Arthrobranchiae	1 reduced	1	2	2	2	2	1	0	
Podobranchiae	0	1	0	0	0	0	0	0	
Epipodites	1	1	1	1	1	1	0	0	

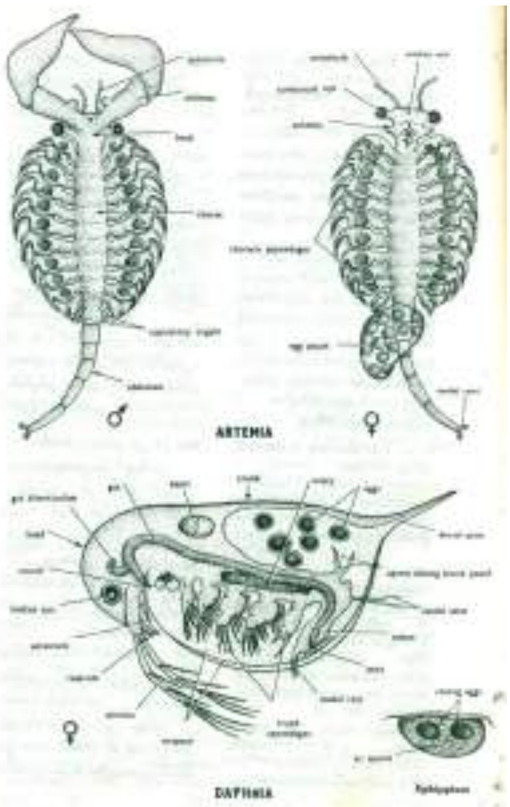


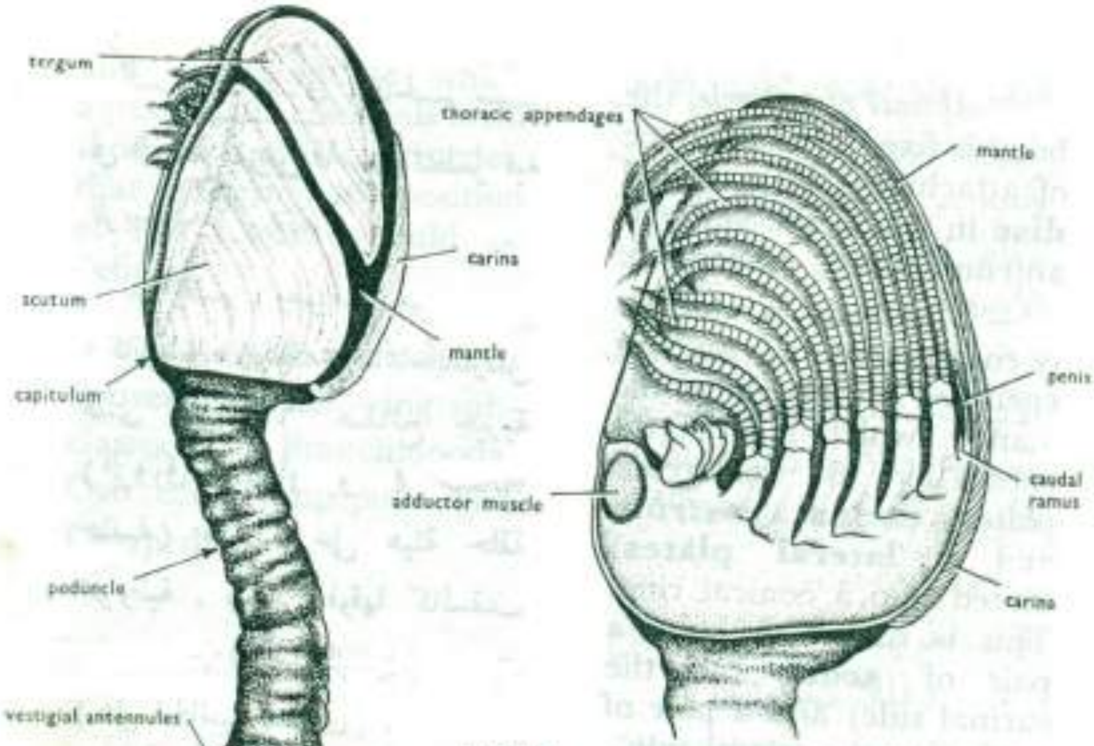
الجمبري «بينيوس جابونيكس»
PENAEUS JAPONICUS



يرقات القشريات
CRUSTACIAN LARVAE


CRUSTACEAN LARVAE

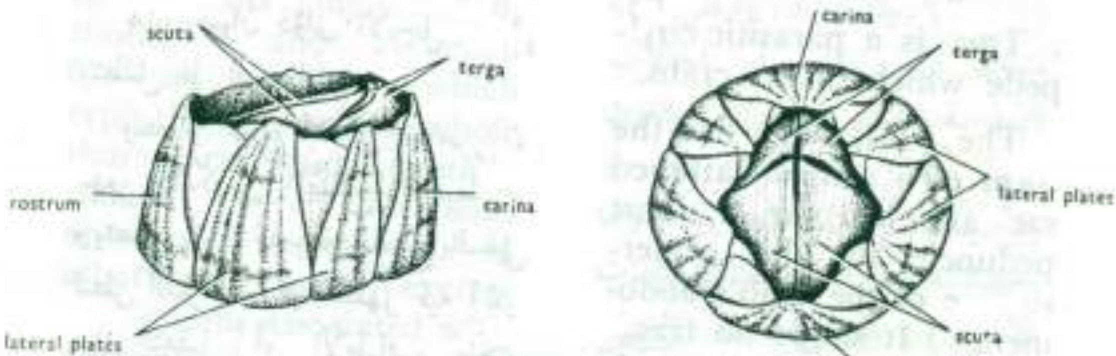

ARTEMIA
DAPHNIA



LEPAS

Lateral view

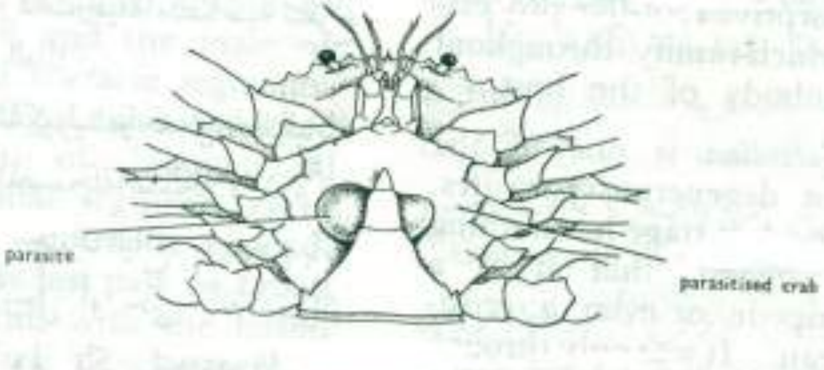
Opened capitulum



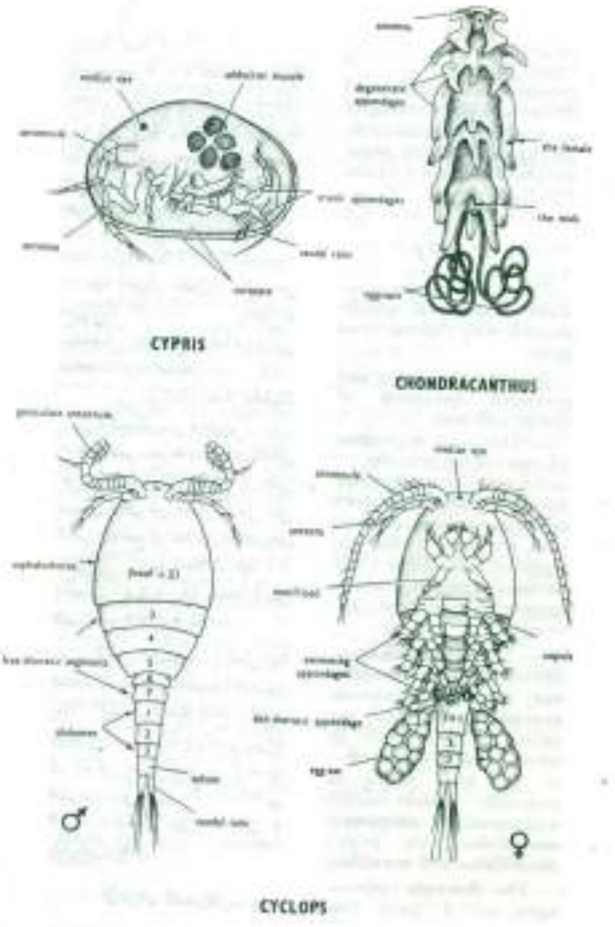
Lateral view

BALANUS

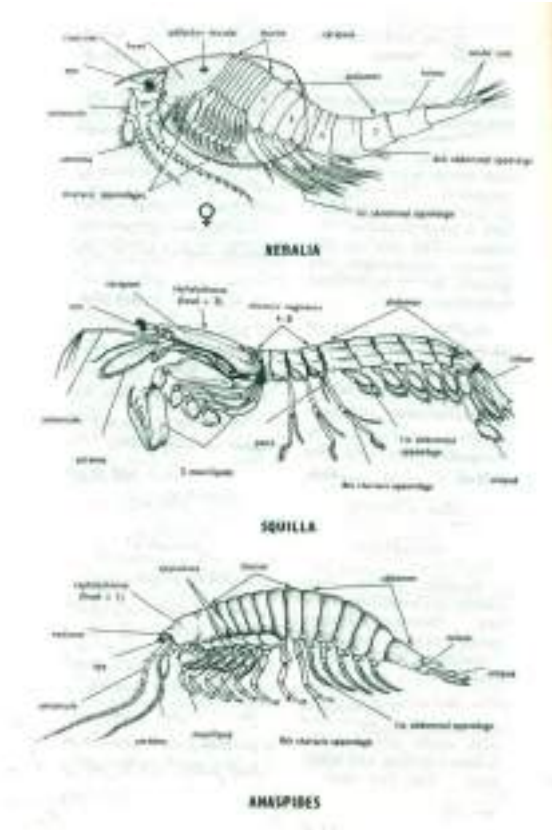
Upper view

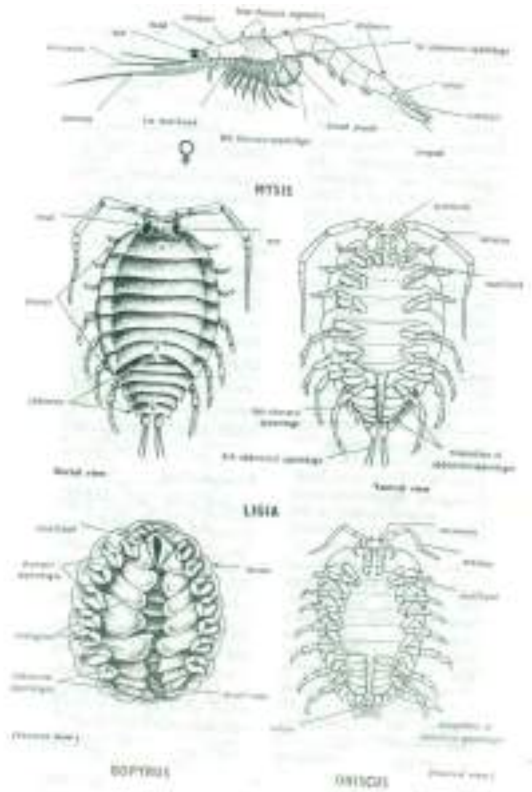


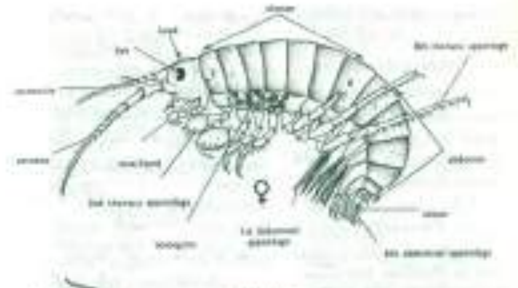
SACCULINA


CYPRIS
CHONDRACANTHUS
CYCLOPS


LEPAS
BALANUS
SACCULINA

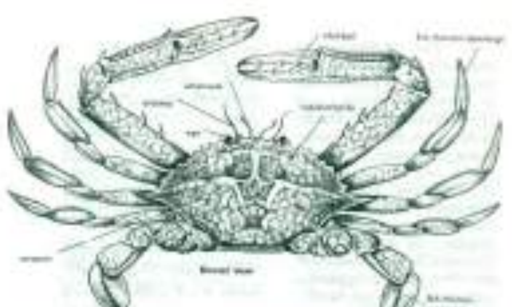

♀
NEBALIA
SQUILLA
ANASPIDES


♀
MYSIS
LIGIA
BOPYRUS
ONISCUS

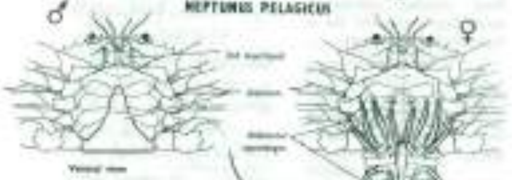


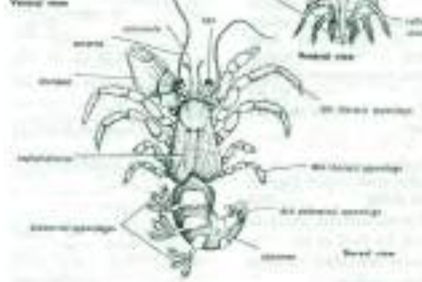
GAMMARUS

PANULIRUS

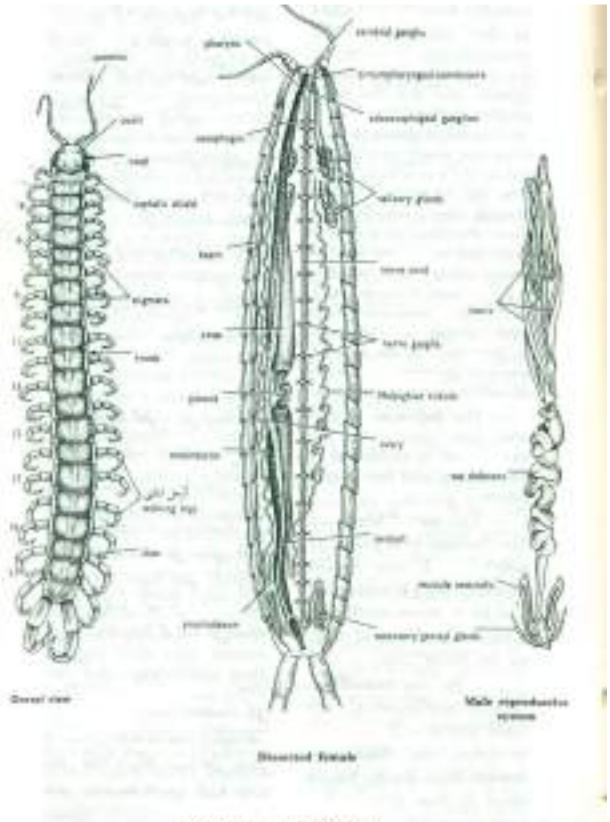


NEPTUNUS PELAGICUS

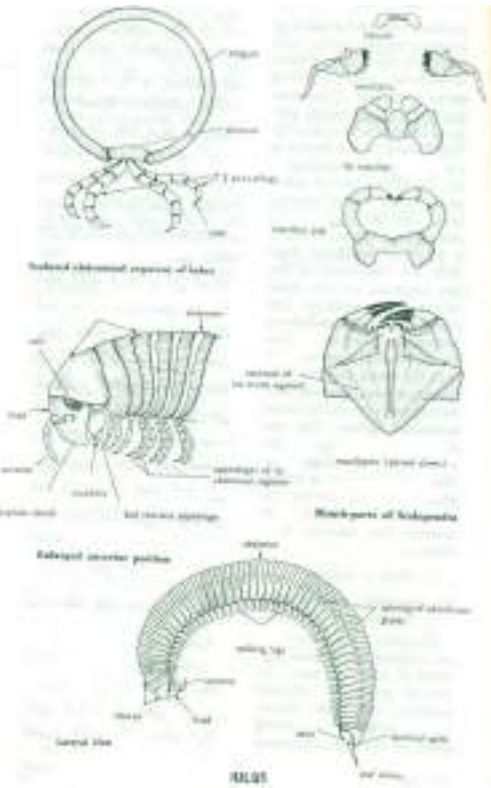




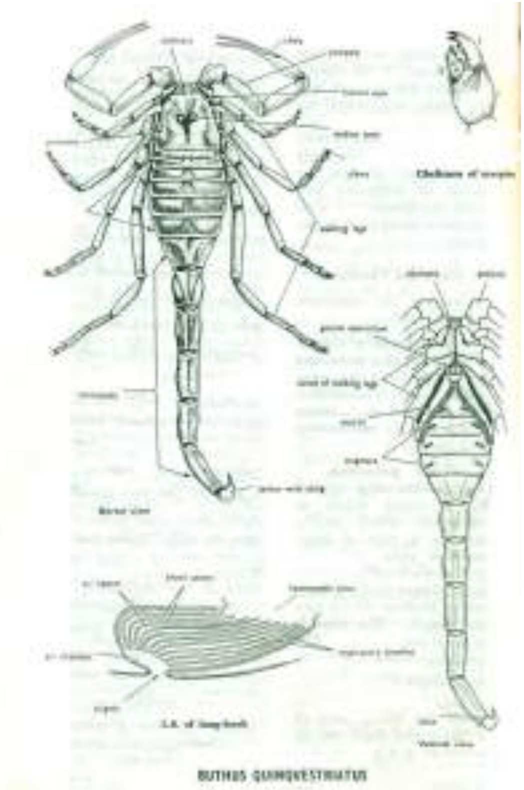
PAGURUS TINCTOR

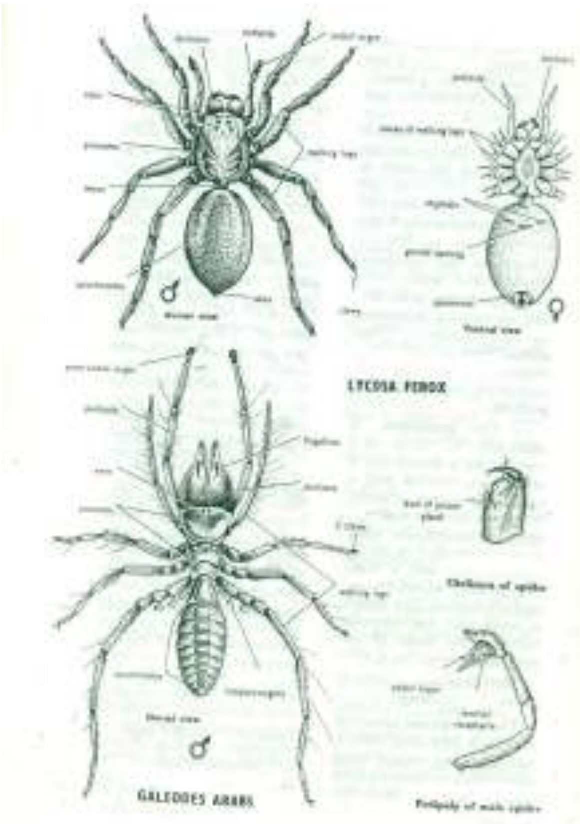


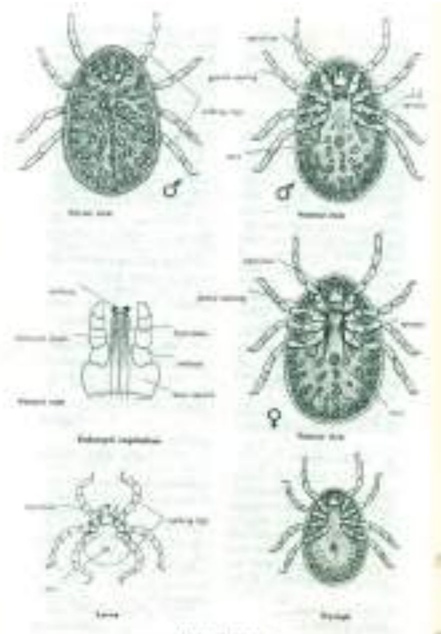
SCOLOPENDRA MORSITANS



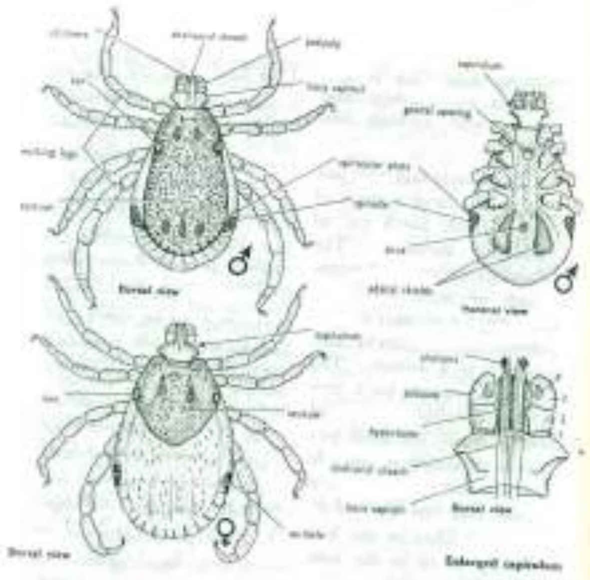
IULUS


BUTHUS QUINQUESTRIATUS

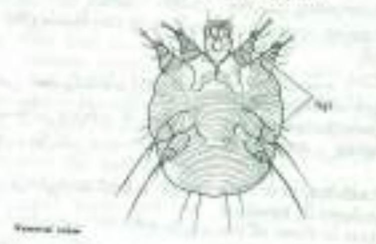

LYCOSA FEROX
GALEODES ARABS



ARGAS PERSICUS



RHIPICEPHALUS SANGUINEUS



SARCOPTES SCABIEI

Phylum Mollusca
characteristics, classification, examples

Mollusca (Mollusks) Definition

Molluscs (also know as mollusks) are soft-bodied, bilaterally symmetrical, segmented, coelomate animals; usually shelled having a mantle, ventral foot, anterior head, and a dorsal visceral mass.

Phylum Mollusca (Mollusks) Characteristics

- They are essentially aquatic mostly marine, few freshwater and some terrestrial form.
- They may be found as hidden parasites in the interior of other animals.
- They vary in size from giant squids and clams to little snails, a millimeter long.
- They have at least two characters radula and mantle not found elsewhere.
- The body is soft, unsegmented (except in Monoplacophora), bilaterally symmetrical, coelomate, triploblastic.
- They have tissue-system grade of body organization
- The body consists of head, foot, mantle, and the visceral mass.
- The body is clothed with one-layered often ciliated epidermis.
- The body is commonly protected by an exoskeleton calcareous shell of one or more piece secreted by the mantle.
- Head is distinct, bearing mouth, eyes, tentacles and other sense organs except in pelecypoda and scaphodoa.
- The ventral body is modified into a muscular plough-like surface, the foot which is variously modified for creeping, burrowing and swimming.
- Mantle or pallium is a fold of a body wall that leaves between itself the main body, mantle cavity.
- The visceral mass contains the vital organs of the body in the compact form taking the form of dorsal humps or dome.
- The body cavity is hemocoel. The coelom is reduced and represented mainly by the pericardial cavity, gonadial cavity, and nephridia.
- The digestive tract is simple with anterior mouth and posterior anus but in gastropods, scaphodos, and cephalopods the intestine becomes U-shaped bringing anus to anterior part.
- Rasping organs, radula usually present, except in pelecypoda.
- The circulatory system is open type except in cephalopods.
- Respiratory organs contain numerous gills or ctenidia usually provided with osphradiuma at the base. The lung is developed in terrestrial forms.

- Respiration is direct or by gills or lungs or both.
- Haemocyanin is their respiratory pigments.
- Excretion is by paired metanephridia (kidney).
- The nervous system consists of paired cerebral, pleural, pedal and visceral ganglia joined by longitudinal and transverse connections and nerves. Ganglia usually form a circumenteric ring.
- Sense organs consist of eyes, statocysts, and receptors for touch, smell, and taste.
- Sexes are usually separate (dioecious) but some are monoecious (hermaphroditic).
- Fertilization is external or internal.
- Development is direct or with metamorphosis through the trochophore stage called veliger larva.

Phylum Mollusca Classification

Mollusca (mollusks) are classified into 6 classes according to their symmetry and the characters of food, shell, mantle, gills, nervous system, muscles, and radula.

Class 1. Monoplacophora (Gr., monos, one+ plax, plate+ pherein, bearing)

- Body is bilaterally symmetrical and segmented.
- Mantle dome-shaped.
- The shell comprises a single piece or valve.
- Flattened limpet-shaped shell with spirally coiled Protoconch.
- Head without eyes and tentacles.
- Mantle encircles the body as a circular fold of the body.
- Foot broad and flat, with 8 pairs of pedal retractor muscles.
- Gills external. 5 pairs of gills in pallial grooves.
- 6 pairs of nephridia, two of which are gonoducts.
- Radula in a radular sac; intestine much coiled.
- Heart of 2 pairs of auricles and a single ventricle.
- Nervous system with longitudinal pallial and pedal cords.
- Sexes separate (dioecious)
- Examples: *Neopilina galatheae*.

Class 2. Amphineura (Gr., amphi, both + neuron, nerve)

- Body elongated with reduced head.
- Radula present.
- Shell as 8 dorsal plates or as spicules.
- Ventral foot, large, flat and muscular.
- Non- ganglionated nerve ring around the mouth with 2 pairs of the interconnected nerve cord.
- External fertilization: trochophore larva.

Subclass 1. Aplacophora

- Worm-like body with mantle
- No shell and foot.
- Calcareous spicules buried in the cuticle.
- Simple radula; marine cavity posterior, some with a pair of bipectinate ctenidia.
- Examples: *Neomenia*, *Nematomein*, *Chaetoderma*.

Subclass 2. Polyplacophora

- Dorso-ventrally flattened body; small head
- No eyes and tentacles.
- Radula, mantle, foot and external gills present.

- Posterior mantle cavity.
- Shell as 8 calcareous dorsal plates.

Order 1. Lepidopleurina

- Valves of the shell without insertion plates.
- Ctenidia a few and posterior.
- Examples: *Lepidopleurus.*

Order 2. Chitonida

- Valves of the shell with insertion plates.
- Gills along the whole length of mantle grooves
- Examples: *Chaetopleura*, *Chiton*, *Ischnochiton*.

Class 3. Scaphopoda (Gr., Scapha, boat + podos, foot)

- Exclusively marine.
- The body is bilaterally symmetrical, elongated and enclosed in a tusk-shell opens at both ends.
- No head; mouth with tentacles; no eyes.
- Conical foot, radula present; no gills.
- Mantle tubular completely enclosing the body.
- Mouth surrounded by lobular processes or outgrowths.
- Heart rudimentary.
- Kidneys paired; gonad single.
- Sexes separate(dioecious).
- Trochophore larva.
- Examples: *Dentalium*, *Cadulus*, *Pulsellum*.

Class 4. Gastropoda (Gr., gaster, belly + podos, foot)

- Marine, freshwater, terrestrial and few parasitic on echinoderms.
- Body unsegmented, asymmetrical typically with univalve, spirally coiled
- Head distinct bearing tentacles, eyes, and mouth.
- The foot is ventral, broad, flat and muscular forming the creeping sole and often bearing dorsally a hard piece, the operculum on its posterior end.
- Torsion (coiling) of body mass at sometimes in development.
- The mantle is a collar-like fold of body wall lining the body leaving a space, the mantle cavity, between itself and the body.
- The buccal cavity contains an odontophore with a radula bearing rows of chitinous teeth.
- The digestive system comprises muscular pharynx, long esophagus, stomach, long coiled intestine, and anteriorly placed anus.
- Respiration by gills (ctenidia) in most forms, through the wall of the mantle cavity in some forms and in many by
- The open circulatory system and heart is enclosed in a pericardium.
- The excretory system comprises metanephridia which are paired in primitive forms and reduced to a single nephridium in most forms.
- The nervous system comprises distinct cerebral and pleural besides buccal, pedal, parietal and visceral ganglia.
- Sexes separate (dioecious) in most forms while in some forms united.
- The development includes trochophore and veliger

Subclass 1.Prosobranchia(streptoneura)

- Mostly marine, few freshwater or terrestrial forms.
- Owing to torsion of the visceral mass, the visceral nerve commissures are twisted into a figure of “8”.
- Head with a single pair of tentacles.

- Mantle cavity opens anteriorly in front of the visceral mass.
- Shell closed by an operculum borne on foot.
- The foot is muscular, forms the ventral parts of the body.
- 2 ctenidia in mantle cavity situated anterior to the heart.
- Sexes separate (Dioecious); gonad single; larvae trochophore or veliger.

Order 1. Archaeogastropoda (Aspidobranchia)

- Prosobranchs without proboscis, siphon, penis and prostatic glands.
- One or two bipectinate ctenidia.
- The operculum is also absent in many forms with few exceptions.
- Shell usually coiled.
- 2 kidneys and heart with 2 auricles.
- 2 osphradia usually present.
- Nervous system not concentrated, with pedal cord.
- Sex cells discharged directly into the sea by way of the right nephridia.
- Examples: *Fissurella* (key-hole limpet), *Trochus* (top shell), *Haliotis*, *Acmaea*, *Patella*, *Turbo*.

Order 2. Mesogastropoda (Pectinibranchia)

- Prosobranchs usually with siphon, penis and a non-calcified operculum.
- One auricle, one kidney, and one mono-pectinate ctenidium.
- Radula taenioglossate type having 7 teeth in each row.
- Single ospharadium.
- A nervous system without pedal cords.
- Fertilization is internal; larva usually a free-swimming veliger.
- Mostly marine, some freshwater.
- Examples: *Crepidula* (slipper shell), *Pila* (apple snail), *Natica* (star shell), *Hydrobia*, *Jonthina*, *Viviparus*.

Order 3. Neogastropoda (Stenoglossa)

- Shell with a short to a very long siphonal canal.
- Radula consists of rows with 2 or 3 teeth in each row.
- Nervous system concentrated.
- Osphradium is large.
- Free-swimming veliger suppressed.
- Examples: *Murex*, *Nassarius*, *Oliva*, *Magilus*, *Buccinum*.

Subclass 2. Opisthobranchia

- Exclusively marine gastropods.
- Shell small without operculum or no shell.
- Shell when present covered with mantle or pedal cord.
- Body mass torted or detorted.
- Gills posterior to the heart.
- Heart with one auricle posterior to the ventricle.
- One kidney, one gonad.
- The nervous system concentrated due to detorsion.
- Monoecious; larva veliger.

Order 1. Cephalaspidea

- Shell present but may be partly or wholly enclosed by the mantle.
- Head with the tentacular shield.
- Lateral parapodial lobes prominent.
- Examples: *Acteon*, *Hydatina*, *Bulla*.

Order 2. Anaspidea

- Found mostly in tropical or subtropical waters.

- Shell usually reduced or less covered by mantles.
- Well-developed parapodial lobes.
- Anterior end bears a pair of tentacles, a pair of rhinophores and a pair of eyes.
- Sperm ducts open, running the body length to the penis located anteriorly.
- Examples: *Aplysia*, *Akera*.

Order 3. Pteropoda

- Pelagic snails with or without a shell.
- Parapodial fins for swimming.
- With or without a mantle cavity.
- Head with a pair of rhinophores.
- Protandrous, hermaphrodites with an open sperm groove.
- Examples: *Spiratella*, *Cavolina*, *Clione*, *Peraclis*.

Order 4. Sacoglossa

- With or without the shell.
- The pharynx is suctorial.
- Sperm duct closed.
- Parapodia and cerata present.
- Examples: *Oxynoe*.

Order 5. Acochilidiacea

- Minute to small-sized.
- Without shell or naked snail.
- Gills, parapodia and visceral sac projecting behind the foot.
- Sexes united or separate in a few.
- Inhabit coarse sand.
- Examples: *Acochlidium*.

Order 6. Notaspidea

- Shell external or reduced and internal.
- Parapodia absent.
- Mantle, but no mantle cavity.
- Gills bipectinate and osphradium on the right side.
- Examples: *Tylodina*, *Pleurobranchus*.

Order 7. Nudibranchia

- Shell absent or naked.
- Internal gills, mantle cavity and osphradium absent.
- Various dorsal growth.
- Respiration by secondary branchiae usually arranged in a circlet around the anus.
- Examples: *Doris*, *Eolis*, *Tritonia*, *Armina*.

Order 8. Pyramidellacea

- Shell typically spirally twisted.
- Operculum absent.
- Gills and radula are absent.
- Long invaginable proboscis.
- Semi- parasitic.
- Examples: *Turbonilla*, *Odostomia*.

Order 9. Philinoglossacea

- Minute naked snail.
- No gills and head appendages.
- Visceral mass separated from the foot only by a shallow groove.
- Examples: *Philinoglossa*.

Order 1o. Rhodopacea

- Vermiform snail.
- Without external appendages.
- Nephridia Protonephridial type.
- Anus on the right side of the body.
- Examples: *Rhodope*.

Order 11. Onchidiacea

- Slug-like, naked without shell opisthobranchs.
- Mantle projects widely beyond foot.
- Head bears a pair of retractile tentacles each tipped with an eye.
- Pulmonary sac, anus and female gonopores located at the posterior end.
- Male gonopore located anteriorly.
- Examples: *Onchidium*, *Onchidella*.

Order 12. Parasita

- Endoparasitic gastropods found in the interior of holothurians.
- Extremely degenerated snails.
- Shelled embryos.
- Examples: *Entoconcha*, *Thyonicola*.

Subclass 3. Pulmonata

- Mostly freshwater or terrestrial, a few marine forms.
- Shell typically spiral or reduced or absent, if present partly or completely concealed by the mantle.
- Np operculum.
- Mantle cavity transformed into a pulmonary sac with a narrow pore on the right side.
- Gills absent.
- Heart with one auricle anterior to the ventricles.
- Nervous system secondarily symmetrical owing to the shortening or connectives and concentration of ganglionic complex.

Order 1. Basommatophora

- Freshwater, brackish water and marine forms.
- Shell delicate with a conical spire and large aperture.
- One pair of non-invaginable tentacles with eyes at their bases.
- Male and female gonopore generally separate.
- Examples: *Siphonaria*, *Lymnaea*, *Planorbis*.

Order 2. Stylommatophora

- Terrestrial pulmonates.
- Shell with conical spire, internal or absent.
- 2 pairs of invaginable or retractile tentacles with eyes at tips of the posterior pair.
- Male and female gonopore usually united.
- Examples: *Limax*, *Helix*, *Partula*, *Retinella*.

Class 5. Pelecypoda (Gr., pelekus, batchet+ podoa, foot)

- Aquatic, mostly marine, some freshwater forms.
- The body is bilaterally symmetrical and laterally compressed.
- Bivalve shells hinged together and mid-dorsally.
- Head is not distinct; pharynx, jaws, radula, and tentacles
- The foot is ventral, muscular which is ploughshare.
- Mantle bilobed, consisting of paired, right and left lobes.
- Gills or ctenidia are paired, one on each side.
- The coelom is reduced to a dorsally placed pericardium.
- The alimentary canal is coiled with large paired digestive glands.

- The heart is contained within the pericardium and comprises a median ventricle and two auricles.
- The excretory organ is paired nephridia or kidneys opens at one end into pericardium at the other end to the exterior.
- The nervous system consists typically of 4 pairs of ganglia i.e. cerebral, pleural, pedal and visceral.
- Cerebral and pleural of each side usually fused into a single Cerebro-pleural ganglion.
- Sense organs are statocyst and osphradia.
- Sexes are separate or united.
- Mostly filter-feeding.
- Development is accompanied by metamorphosis which usually includes a trochophore larva.

Order 1. Protobranchia

- Single pair of plate-like ctenidia each consisting of 2 rows of flattened gills filaments.
- Mouth placed at the base of muscular proboscides.
- Stomach with style sac.
- The foot is not compressed but has a flattened ventral surface or sole for creeping.
- Two adductor muscles present.
- Examples: *Nucula*, *Solenomya*.

Order 2. Filibranchia

- Single pair of plume-like gills formed of distinct V-shaped filaments.
- Chitinous gastric shield in the stomach developed.
- Style sac with crystalline style.
- Inter-filamentar junctions are either absent or formed by groups of inter-locking cilia.
- The inter-lamellar junction is either absent or non-vascular.
- Two adductor muscles present, anterior may be reduced or absent.
- Foot small or poorly developed.
- Examples: *Mytilus*, *Arca*.

Order 3. Pseudolamellibranchia

- Gills are plaited so as to form vertical folds.
- Inter-filamentar junctions may be ciliary or vascular.
- Inter-lamellar junctions are vascular and non-vascular.
- Single large posterior adductor muscle present.'
- Shell valve are frequently equal.
- Foot rudimentary of feebly developed.
- Examples: *Pecten*, *Ostraea*, *Melagrina*.

Order 4. Eulamellibranchia

- Gills are firm and basket-like.
- Gills filaments reflexed and fused completely to form tissue sheets.
- Gills function for food gathering.
- Gills muscles are united by vascular inter-filamentar and inter-lamellar junctions.
- Siphon of small or large size present.
- Foot large, byssus small or absent.
- Style sac short.
- Examples: *Anodonta*, *Unio*, *Cardium*, Venus, Mya, *Teredo*.

Order 5. Septibranchia

- No gills.
- Two adductor muscles present.
- Stomach lined by chitin; style sac reduced.
- Footlong and slender and byssus rudimentary or absent.

- Sexes united.
- Examples: *Poromya*, *Cuspidaria*.

Class 6. Cephalopoda (=Siphonopoda) (Gr., kephale, head+ podos, foot)

- Marine and free-swimming.
- The body is bilaterally symmetrical with head and trunk.
- Body elongated dorso-ventrally.
- Shell external, internal or absent.
- Head distinct and large with well-developed eyes and mouth.
- The trunk consists of the symmetrical and uncoiled visceral mass.
- Mantle encloses posteriorly and ventrally a large mantle cavity.
- Foot altered into a series of suckers bearing arms or tentacles encircling the mouth.
- Moth bears jaws and radula.
- 2 or 4 pairs of bipectinate gills.
- Circulatory system closed, heart with 2 or 4 auricles.
- The excretory system comprises 2 or 4 pairs of nephridia.
- The nervous system is highly developed and the principal ganglia are concentrated around the esophagus.
- Sexes separate.
- Development meroblastic without metamorphosis.

Subclass 1. Nautiloidea (=Tetrabranchia)

- Shell external, spiral and chambered.
- Recent species with many suckers fewer tentacles.
- The main part of the foot encircling the mouth, divided into lobes bearing numerous tentacles.
- The funnel does not form a complete tube.
- 4 ctenidia or gills, 4 kidneys and 4 auricles present.
- Ink glands and chromatophores are absent.
- Eyes are simple.
- Examples: *Nautilus*.

Subclass 2. Smmonoidea

- Shell external and coiled with complex septa and sutures.
- Examples: *Pachydiscus*.

Subclass 3. Coeloidea (=Dibranchia)

- Shell usually internal and reduced, enveloped by mantle, when external its cavity is not divided by septa.
- The main part of the foot is modified into 8 or 10 suckers bearing arms encircling moth.
- The funnel forms a complete tube.
- 2 ctenidia or gills, 2 kidney, 2c auricle, and 2 branchial heart presents.
- Ink gland duct and chromophores present.
- Eyes are complex in structures.

Order 1. Decapoda

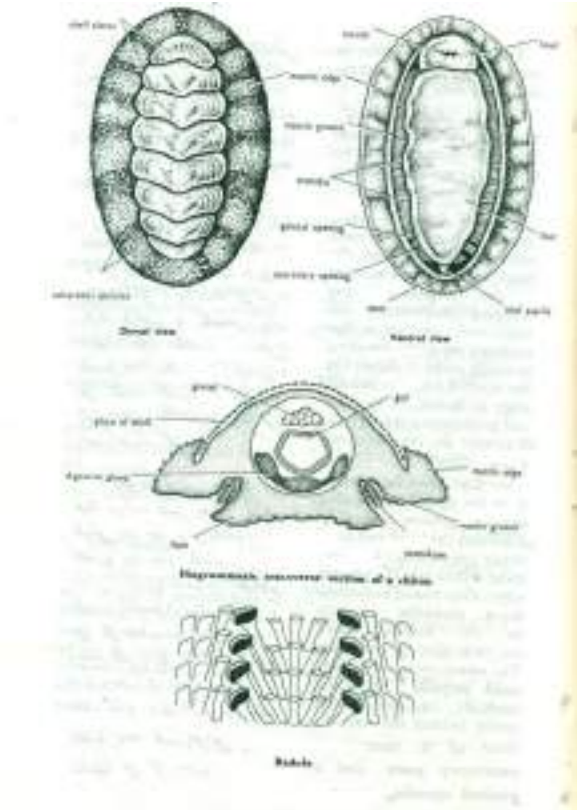
- Body elongated often with lateral fins.
- 10 arms- 2 elongated and called tentacles bearing suckers at their distal ends and 8 short arms bear stalked suckers provided with horny rims.
- Shell is internal and well-developed.
- Nidamental glands are usually present.
- Herat enclosed in the well-developed coelom.
- Examples: *Sepia*, *Loligo*, *Spirula*.

Order 2. Octopoda

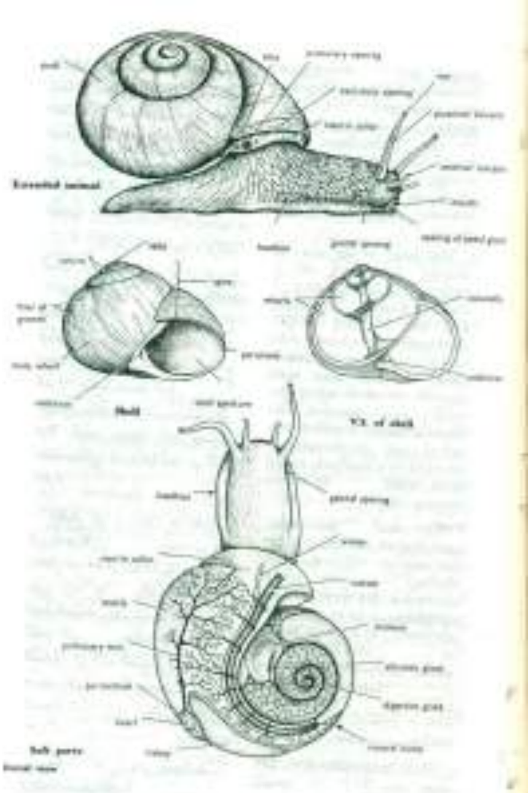
- Body globular and without fins.
- 8 arms with sessile suckers and devoid of horny rims.
- Shell absent except in female *Argonauta*.
- Nidamental glands absent.
- The heart does not lie in the reduced coelom.
- Examples: *Octopus*, *Agronauta*.

References

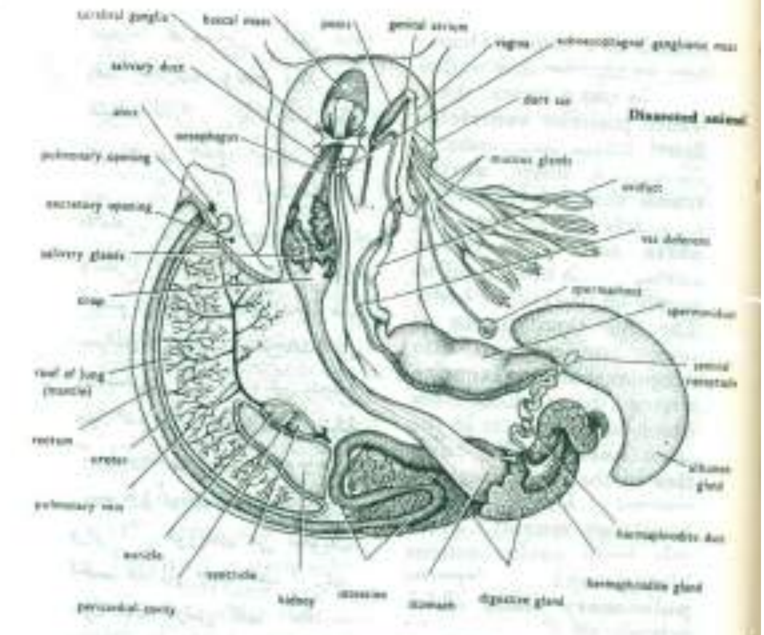
1. Kotpal RL. 2017. Modern Text Book of Zoology- Invertebrates. 11th Edition. Rastogi Publications.
2. Jordan EL and Verma PS. 2018. Invertebrate Zoology. 14th Edition. S Chand Publishing.



ACANTHOCHITON SPINIGERA



EREMINA DESERTORUM



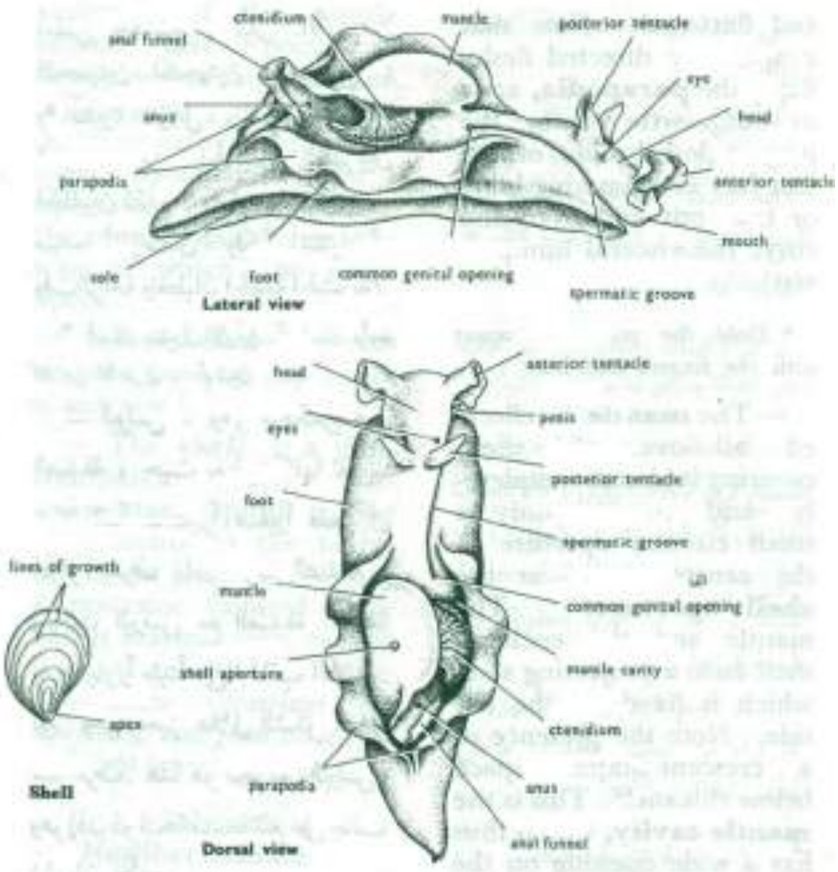
EREMINA DESERTORUM

Section of hermaphrodite gland

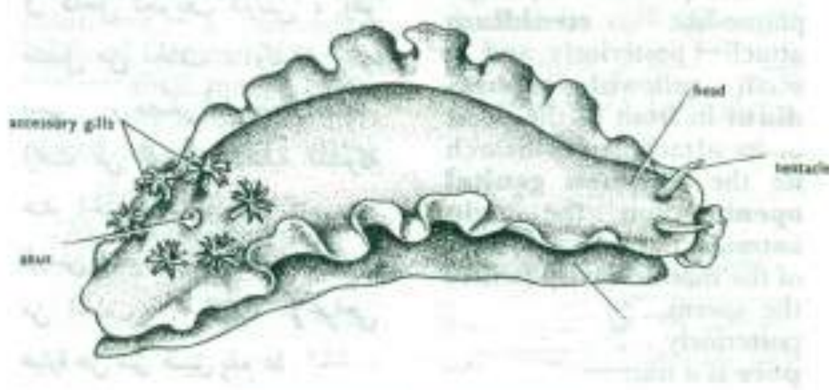
BIOMPHALARIA ALEXANDRINA

LIMNAEA CAILLIAUDI

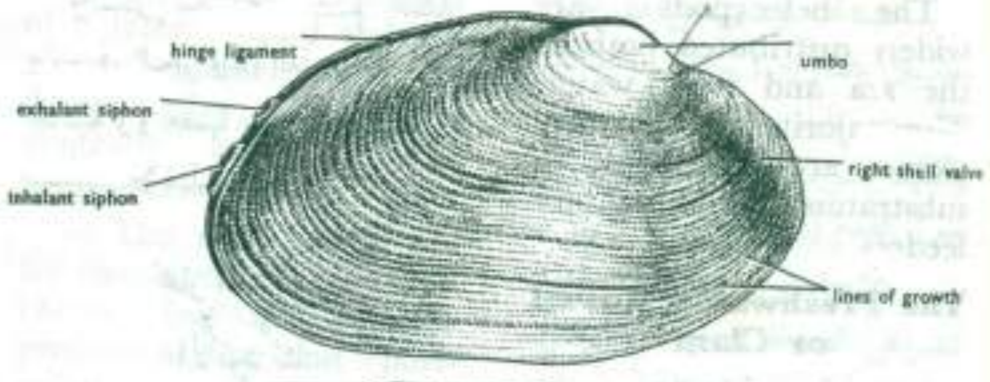
BULINUS TRUNCATUS

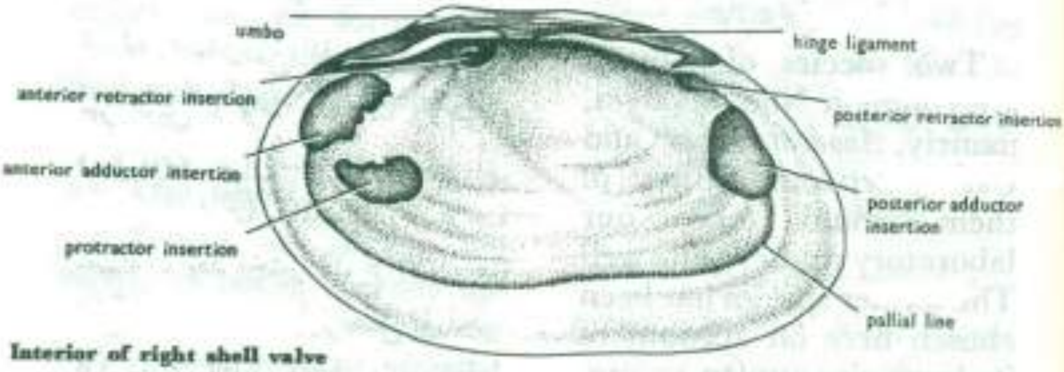


APLYSIA ARGUS

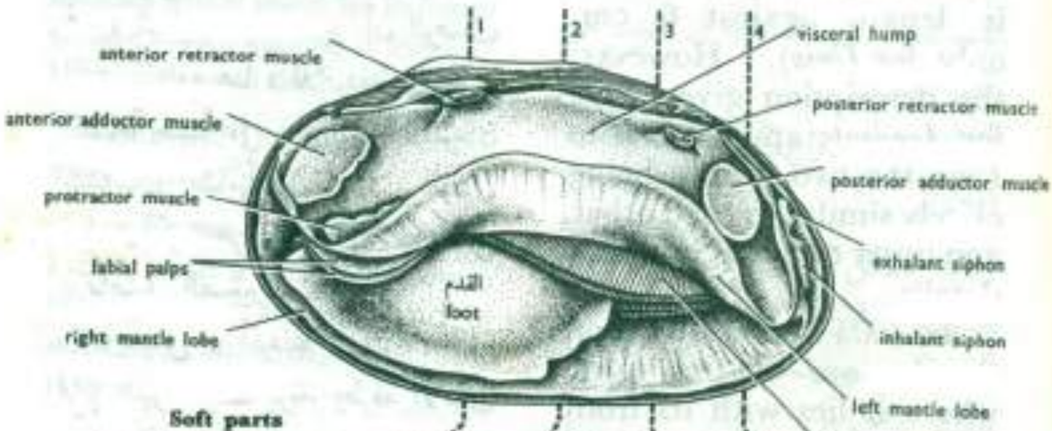


HEXABRANCHUS SANGUINEUS

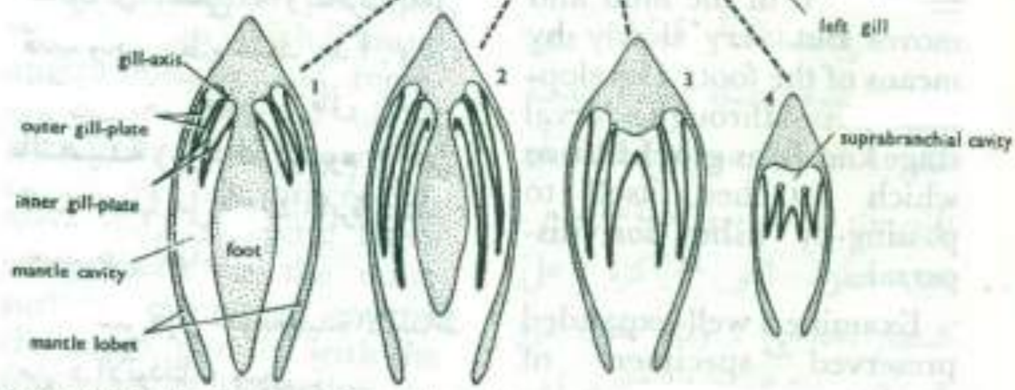




Interior of right shell valve



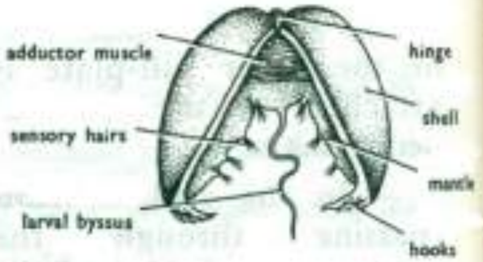
Soft parts



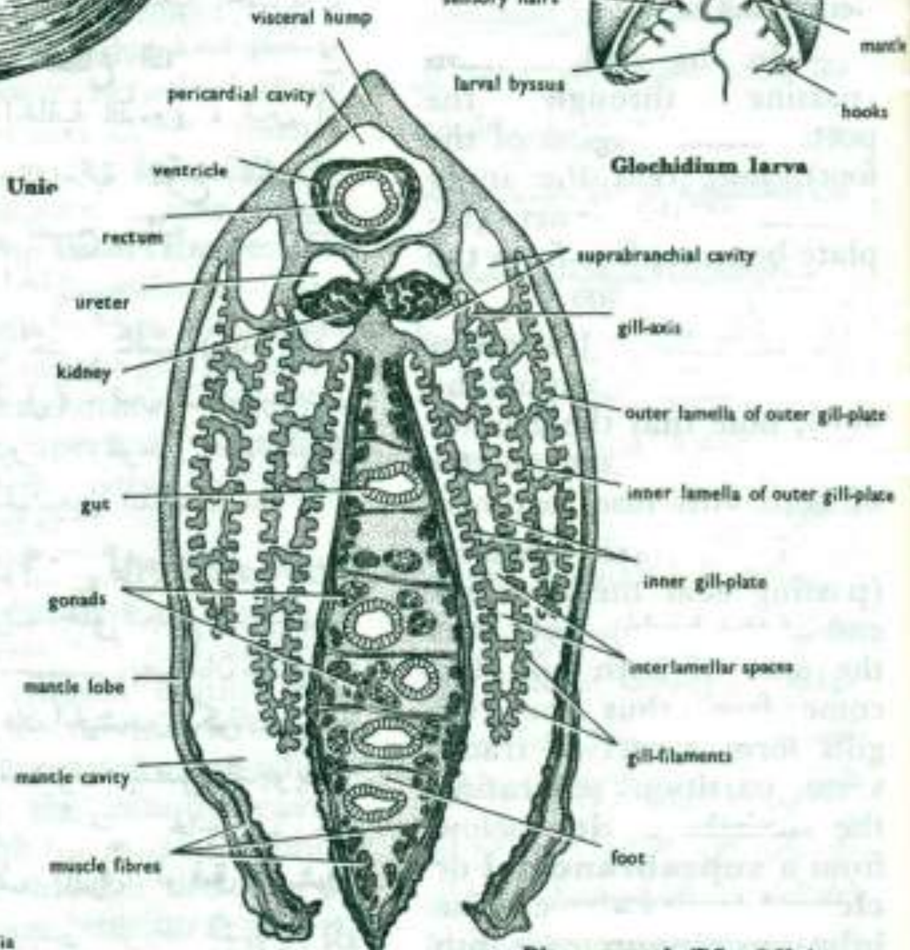
Diagrammatic transverse sections of Anodonta

ANODONTA RUBENS

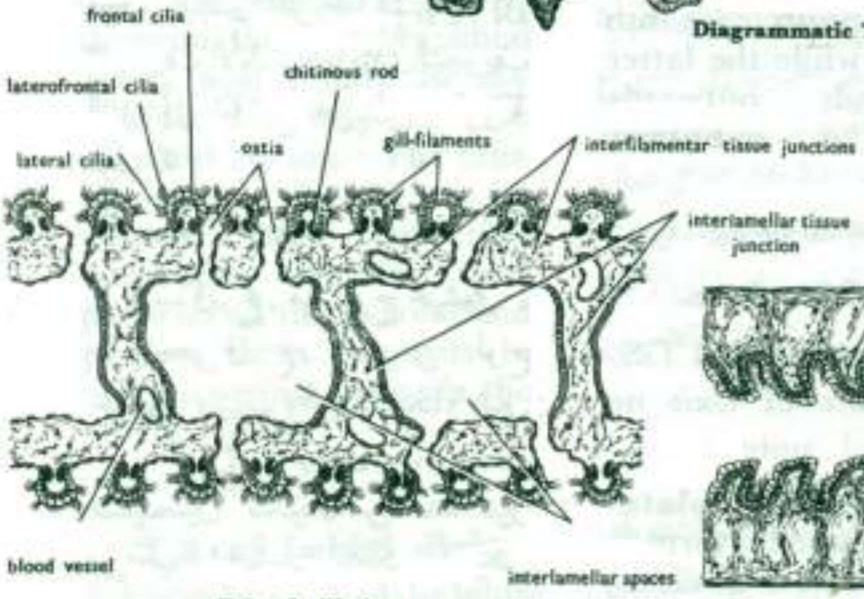
Shell of Unio



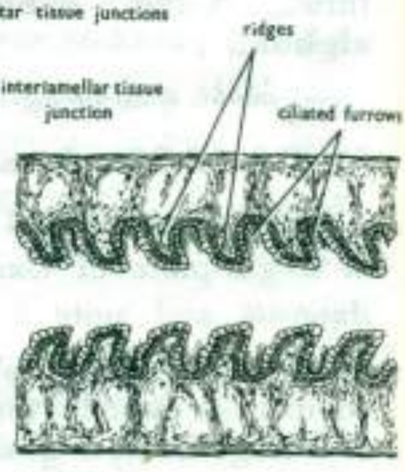
Glochidium larva



Diagrammatic T.S. of Unio

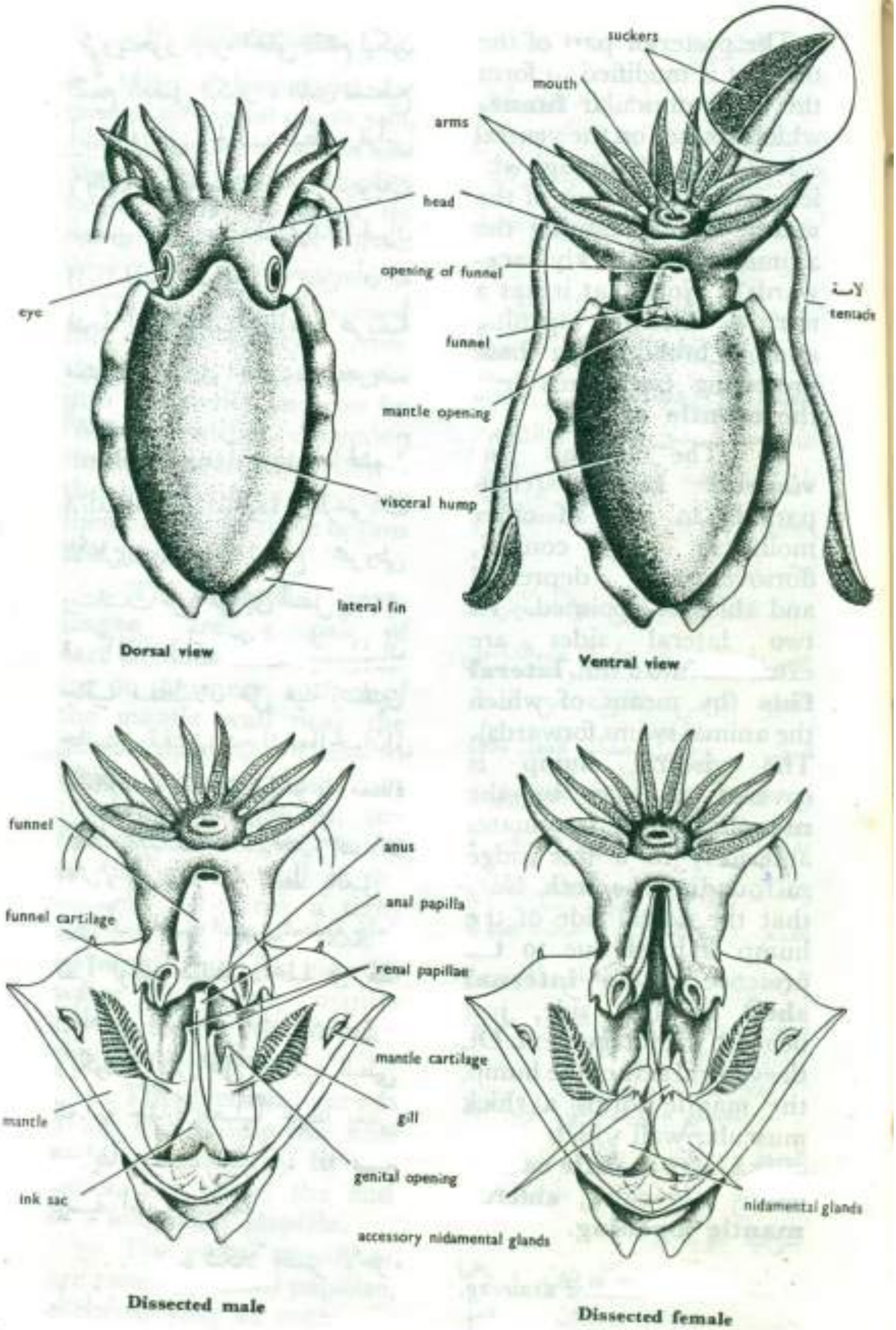


T.S. of gill-plate



T.S. of labial palps

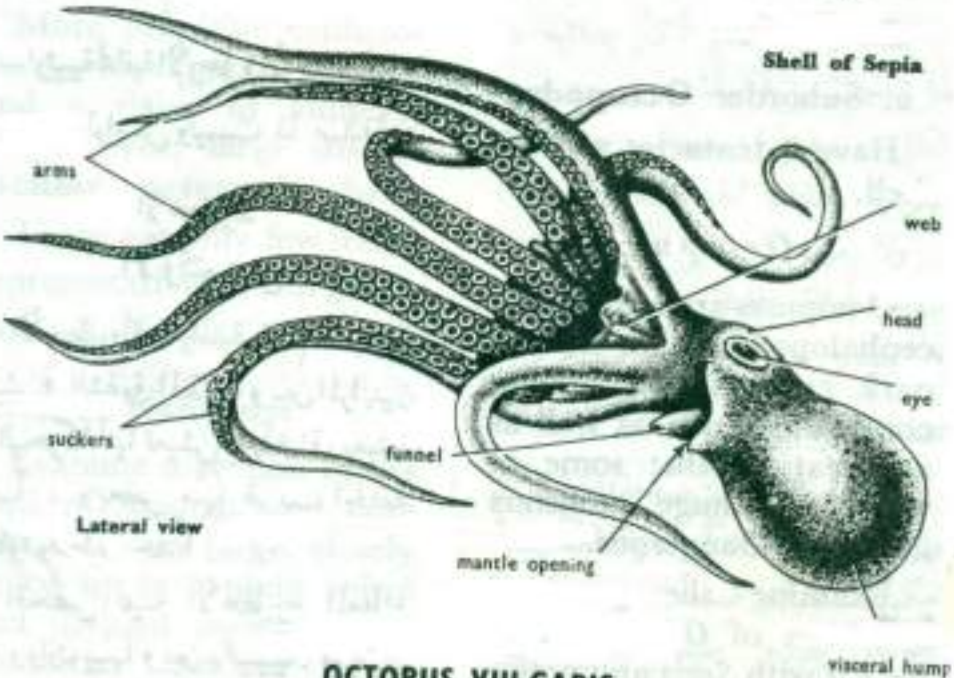
UNIO PRAESIDENS



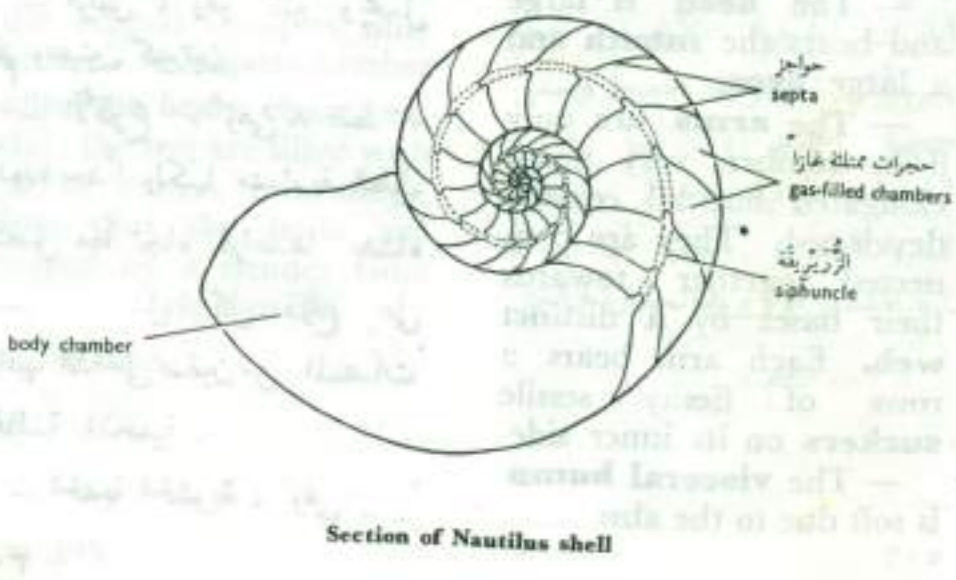
SEPIA SAVIGNYI

Eggs of Sepia

Shell of Sepia



OCTOPUS VULGARIS



Section of Nautilus shell

Phylum Echinodermata
Characteristics, classification, examples

Echinodermata (Echinoderms) Definition

Echinoderms are enterocoelous coelomates with pentamerous radial symmetry, without distinct head or brain having a calcareous endoskeleton of separate plates or pieces and a peculiar water vascular system of coelomic origin with podia or tube-feet projecting out of the body.

Phylum Echinodermata Characteristics

1. They are exclusively marine and are among the most common and widely distributed marine animals.
2. They occur in all seas from the intertidal zones to great depths.
3. They have an organ grade system of body organization.
4. Symmetry usually radial, nearly always pentamerous.
5. The body is triploblastic, coelomate with distinct oral and aboral surfaces, and without definite head and segmentation.
6. They are moderate to considerable size but none are microscopic.
7. Body shape globular, star-like, spherical, discoidal, or elongated.
8. The surface of the body is rarely smooth, typically covered by 5 symmetrically radiating grooves called ambulacra with 5 alternating inter-radii or inter-ambulacra.
9. The body wall consists of an outer epidermis, a middle dermis, and an inner lining of the peritoneum.
10. Endoskeleton consists of closely fitted, plates forming a shell usually called theca or test or may be composed of separate small ossicles.
11. The coelom is spacious lined by peritoneum, occupied mainly by the digestive and reproductive system, and develops from embryonic archenteron i.e. enterocoel.
12. Coelom of enterocoelous type constitutes the perivascular cavity of water vascular system; coelom fluid with coelomocytes.
13. Water -vascular system of coelomic origin, including podia or tube feet for locomotion and usually with a madreporite.
14. The alimentary canal is usually a coiled tube extending from the mouth located on the oral surface to the anus on the aboral or oral surface.
15. Vascular and haemal or blood lacunar system, enclosed in coelomic peripheral channels.
16. Respiratory organs include branchiae, tube-feet, respiratory tree, and bursae.
17. A nervous system without a brain and with a circumoral ring and radial nerve.
18. The excretory system is wanting.

19. Poorly developed sense organs include tactile organs, chemoreceptors, terminal tentacles, photoreceptors, and statocysts.
20. Sexes are usually dioecious with few exceptions.
21. Gonads large and single or multiple; fertilization external, while few echinoderms are viviparous.
22. Development is intermediate including characteristic larvae which undergo metamorphosis into the radially symmetrical adults.
23. Regeneration of lost parts, a peculiarity.

Phylum Echinodermata Classification

The classification is adopted from Hyman, L.H. (1995). Only living classes and orders have been described.

Subphylum 1. Pelmatozoa (Gr., *pelmatos*=stalk+ *zoon*=animals)

- Mostly extinct echinoderms.
- Sedentary echinoderms.
- Body attached by the aboral surface by an aboral stalk.
- Mouth and anal aperture present on the oral surface facing upwards.
- Viscera is enclosed in a calcareous test.
- No suckers.
- Tube feet or podia are primarily food catching.
- The main nervous system is aboral.
- Has only one living class.

Class 1. Crinoidea (Gr., *crinon*=lily+ *eidos*= form)

- Commonly called Sea Lillies or feather stars.
- Both extinct and living form.
- Living members are without stalk and free moving but extinct form attached by a stalk.
- The body consists of an aboral cup, the calyx and oral cover or roof, the tegmen, and strongly pentamerous in structures.
- Mouth and anus on the oral surface.
- Arms movable, simple, mostly branched, usually 5 or 10 in numbers with or without pinnules.
- Tube feet without suckers; no madreporite, spine, and pedicellariae.
- Ambulacral grooves are open and extend along arms and pinnules to their tips.
- Sexes are separate.
- Larva doliolaria.

Order 1. Articulata

- Extinct and living crinoids.
- Non-sessile and free swimming.
- Calyx pentamerous, flexible incorporating the lower arm ossicles.
- Tegmen leathery containing calcareous particles or small plates.
- Mouth and ambulacral grooves exposed.
- Examples: *Antedon* (sea lily), *Rhizocrinus*, *Metacrinus*.

Subphylum 2. Eleutherozoa (Gr., *eleutheros*=free+ *zoon*= animals)

- Free-living echinoderms.
- Stem or stalk absent, usually free-living forms.
- Pentamerous body strictures.
- The oral surface bearing mouth is downward or lying on one side.
- Anus usually on the aboral surface.
- Ambulacral grooves usually not for food gathering.
- Tube feet with suckers are chiefly locomotory organs.

- The main nervous system is oral.

Class 1. Holothuroidea (Gr., *holothurion*=water *polyp*+ eidos=form)

- Commonly called **sea cucumbers.**
- Body bilaterally symmetrical, usually elongated in the oral-aboral axis having a mouth at or near one end and anus at or near the other end.
- Coarse body surface.
- Endoskeleton reduced to microscopic spicules or plates embedded in the body wall.
- Mouth anterior, surrounded by tentacles attached to the water vascular system.
- Ambulacral grooves concealed.
- Podia or tube feet usually present and locomotory.
- The alimentary canal is long, coiled.
- cloaca usually with respiratory trees for respiration.
- Sexes separate and gonad single or paired tufts or tubules.

Order 1. Aspidochirota

- Podia or tube feet are numerous, sometimes forming a well-developed sole.
- Tentacles are peltate or leaf-like.
- The mouth is surrounded by 10-30 mostly 20 peltate or branched oral tentacles.
- Retractor muscles of the pharynx are absent.
- A well-developed respiratory tree is present.
- Examples: *Holothuria*, *Stichopus*, *Mesothuria*.

Order 2. Elasipoda

- Numerous podia or tube feet.
- Tentacles leaf-like.
- Tube feet webbed together to form fins.
- The mouth is usually ventral and surrounded by 10-20 peltate or branched tentacles.
- Oral retractors absent.
- No respiratory tree.
- Deep-sea dwellers.
- Examples: *Deima*, *Benthodytes*.

Order 3. Dendrochirota

- Podia or tube feet are numerous, on the sole or all ambulacral or entire surface.
- Tentacles irregularly branched.
- Oral retractors present.
- Respiratory trees are present.
- Examples: Thyone, *Cucumaria*, *Phyllophorus*.

Order 4. Molpadonia

- Podia or tube feet are absent except as anal papillae.
- 15 digitate or finger-shaped tentacles.
- Posterior end tail-like.
- Oral retractors are absent.
- Respiratory trees are present.
- Examples: *Molpadia*, *paracaudina*.

Order 5. Apoda

- Worm-like sea cucumbers.
- No tube feet and respiratory tree.
- Body vermiform having a smooth or warty surface.
- Oral tentacles are 10-20 simple, digitate or pinnate.

- Pharyngeal retractors are present in some forms.
- The water vascular system is greatly reduced.
- Examples: *Synapta*, *Chiridoata*.

Class 2. Echinoidea (Gr., *echinos*=hedgehog+*eidos*=form)

- Commonly called Sea urchins and sand dollars.
- The body is spherical, disc-like, oval, or heart-shaped.
- The body is enclosed in an endoskeletal shell or test of closely fitted calcareous plates covered by movable spines.
- Outer calcareous plates are distinguished into 5 alternating ambulacral and 5 inter-ambulacral areas.
- Podia or tube feet come out from pores of ambulacral plates and are locomotory in function.
- The mouth is centrally placed on the oral surface and surrounded by a membranous peristome.
- Chewing apparatus of Aristotle's lantern with teeth.
- Ambulacral grooves covered by ossicles; tube feet with suckers.
- The anus is located at the aboral pole and surrounded by a membranous periproct.
- Pedicellariae are stalked and 3 jaws.
- Sexes are separate. Gonads usually five or less.
- The development includes a free-swimming echinopluteus larva.

Subclass 1. Bothriocidaroida

- Each inter-ambulacral is with a single row of plates.
- No typical lantern.
- Radial madreporite.
- Include a single extinct Ordovician genus.
- Example: *Bothriocidaris*.

Subclass 2. Regularia

- Body globular, mostly circular and sometimes oval.
- Symmetry pentamerous with 2 rows of inter-ambulacral plates in existing members.
- Mouth central at the oral surface and surrounded by peristome.
- Aristotle's lantern is well developed.
- The anus is centrally placed at the aboral pole surrounded by periproct.
- Madreporite is ambulacral.

Order 1. Lepidocentroida

- Test flexible with overlapping plates.
- Ambulacral plates extend up to the mouth lip.
- Inter-ambulacral plates in more than 2 rows in extinct forms.
- Example: *Palaeodiscus*.

Order 2. Cidaroidea

- Test globular and rigid.
- Two rows of long narrow ambulacral plates and two rows of inter-ambulacral plates.
- Gills and sphaeridia are absent.
- Ambulacral and inter-ambulacral plates continue up to mouth lips.
- The anus is aboral and central.
- 5 bushy Stewart's organs are present appended to the lantern.
- Examples: *Cidaris*, *Notocidaris*.

Order 3. Aulodonta

- Test symmetrical and globular.
- Test composed of 2 rows each in an ambulacral and inter- ambulacral plates.
- Ambulacral and inter- ambulacral plates reach up to the margin of the peristome.
- Gills and sphaeridia are absent.
- Teeth of Aristotle's lantern are devoid of the keel.
- Examples: *Diadema*, *Astropyga*.

Order 4. Camarodonta

- The test is rigid and rarely oval.
- Epiphyses of the lantern are enlarged and meeting above pyramids.
- Teeth are keeled.
- All of the four types of pedicellariae are present,
- Examples: *Echinus*, *Strongylocentrotus*.

Subclass 3. Irregularia

- Body oval or circular, flattened oral-aborally.
- Symmetry is bilateral.
- Mouth central or displaced anteriorly on the oral surface.
- The anus is displaced posteriorly generally marginal at the oral or aboral surface and lies outside the apical system of plates.
- Podia or tube-feet generally not locomotor.

Order 1. Clypeastroida

- Test flattened with an oval or rounded shape and covered with small spines.
- Mouth and apical system are usually central and oral in position.
- Aboral ambulacral.
- Aristotle's lantern present.
- Gills are absent.
- Bottom dwellers.
- Examples: sand dollars: *Clypeaster*, *Echinarachinus*, *Echinocyamus*.

Order 2. Spatangoida

- Test oval or heart-shaped with excentric mouth and anus.
- 4 aboral ambulacral areas pataloid.
- No lantern.
- Gills absent.
- Burrowing.
- Examples: Heart urchins; *Spatangus, Echinocardium, Lovenia*.

Class 3. Asteroidea (Gr., *aster*=star+ eidos= form)

- Commonly called starfishes or sea stars.
- The body is flattened, pentagonal, or star-shaped.
- Oral and aboral; surfaces are distinct, the oral surface directed downwards and the aboral surface upwards.
- Arms 5 or more and not sharply marked off from the center disc.
- The mouth is centrally placed at the oral surface surrounded by a membranous peristome.
- The anus is small and inconspicuous located more or less eccentrically on the aboral surface.
- Tube feet in orally placed ambulacral grooves; with suckers.
- Ambulacra are restricted to the oral surface extending from the peristome top the tips of the arms.
- Endoskeleton is flexible, made of separate ossicles.
- Pedicellariae are small, movable spine-like always present.

- Respiration by papulae.
- Sexes separate, gonads radially arranged.
- The development includes bipinnaria or branchiolaria larva.

Order 1. Phanerozonia

- Body with marginal plates and usually with papulae, on the aboral surface.
- Arms are provided with 2 rows of conspicuous marginal plates.
- Oral plates are infra-marginal and aboral plates are supra-marginal.
- Pedicellariae sessile or alveolar type, not crossed.
- Podia or tube-feet are arranged in two rows without suckers.
- The mouth frame is well developed and adambulacral type.
- Mostly burrowers in soft bottoms.
- Examples: *Luidia*, *Astropecten*, *Archaster*, *Pentaceros*.

Order 2. Spinulosa

- Arms are generally without conspicuous marginal plates.
- The aboral skeleton is imbricated or reticulated with a single or group of spines.
- Pedicellariae are rare.
- Tube feet are in two rows with suckers.
- The mouth frame is of adambulacral type.
- Aboral surface with low spines.
- Ampullae single or bifurcated.
- Examples: *Aesterina*, *Echinaster*, *Hymenaster*, *Solaster*.

Order 3. Forcipulata

- No conspicuous marginal plates.
- The aboral skeleton is mostly reticulate with conspicuous spines.
- Pedicellariae are the pedunculate type with a basal piece.
- Podia or tube feet are arranged in four rows and provided with suckers.
- Papulae are on both surfaces.
- The mouth frame is of ambulacral type.
- Examples: *Brisingaster*, *Heliaster*, *Zoraster*, *Asterias*.

Class 4. Ophiuroidea (Gr., *ophis*=serpent+ *oura*=tail+ *eidos*= form)

- Commonly called brittle-stars and allies.
- The body is flattened with a pentamerous or rounded central disc.
- Oral and aboral surfaces are distinct.
- Body star-like with arms sharply marked off from the central disc.
- Pedicellariae absent.
- Ambulacral grooves are absent or covered by ossicles.
- No anus and intestine.
- Stomach sac-like.
- Tube feet without suckers.
- The madreporite is on the oral surface.
- Sexes are separate, gonad pentamerous.
- Bursa usually 10.
- Development included a free-swimming pluteus larva.

Order 1. Ophiurae

- Brittle and serpent stars.
- Arms are simple, mostly 5 in number, moving chiefly in the transverse plane.
- Arm ossicles articulated by pits and projections.
- Discs and arms are usually covered with distinct shields or scales.

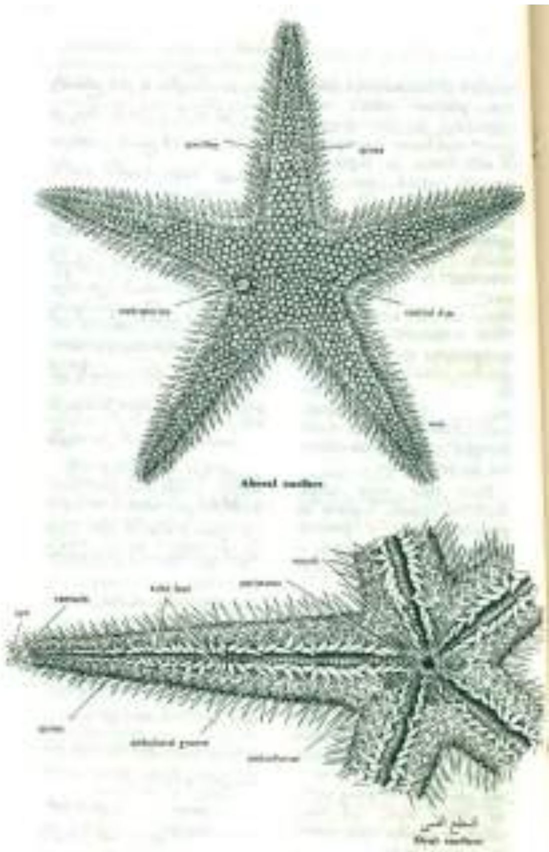
- Spines on arms are borne laterally and are directed outwards and toward the arm tips, not downwards.
- Single madreporite.
- Examples: *Ophioderma Ophioscolex*, *Ophiothrix*, *Ophiolepie*.

Order 2. Euryalae

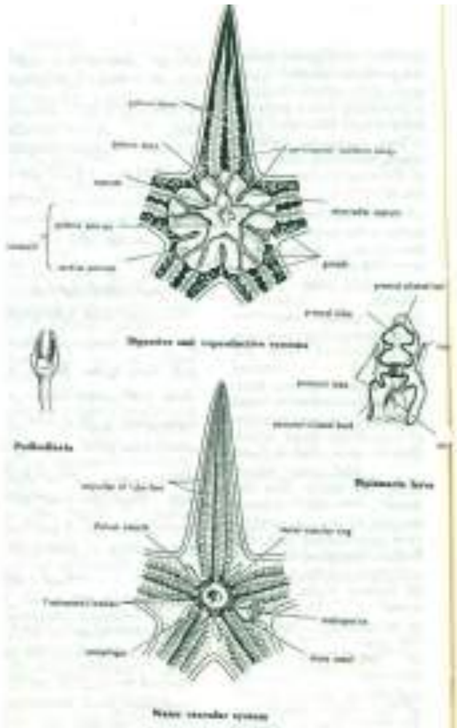
- Arms simple or branched, long and flexible, capable of coiling around objects and of rolling up in the vertical plane.
- Ossicles of arms are articulated in a streptospondylus manner.
- Discs and arms covered by soft skin.
- Spines are directed downward often forming hooks or spiny clubs.
- One madreporite in each inter-radius.
- Examples: *Asteronyx*, *Gorgonocephalus* (basket stars).

References

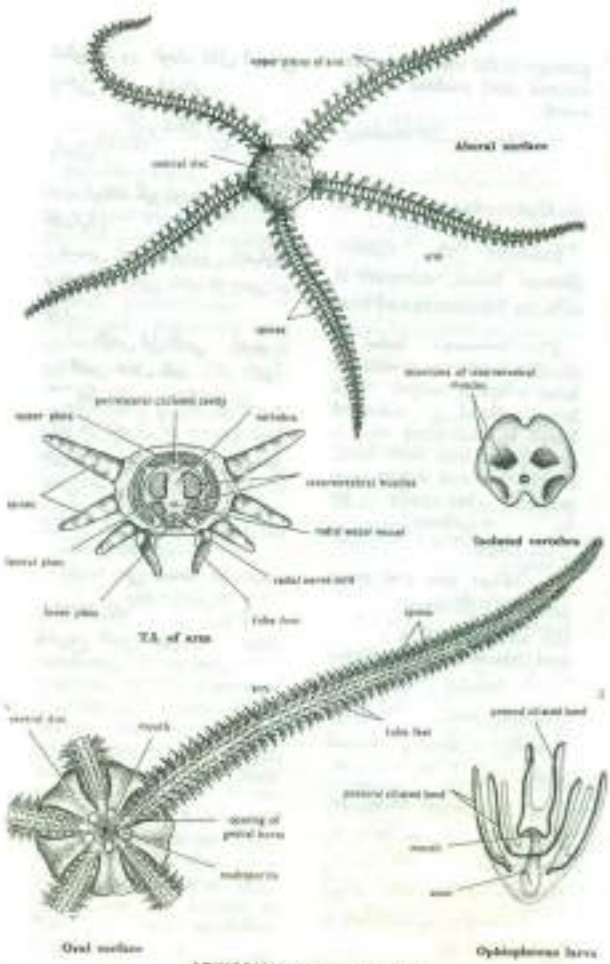
1. Kotpal RL. 2017. Modern Text Book of Zoology- Invertebrates. 11th Edition. Rastogi Publications.
2. Jordan EL and Verma PS. 2018. Invertebrate Zoology. 14th Edition. S Chand Publishing.



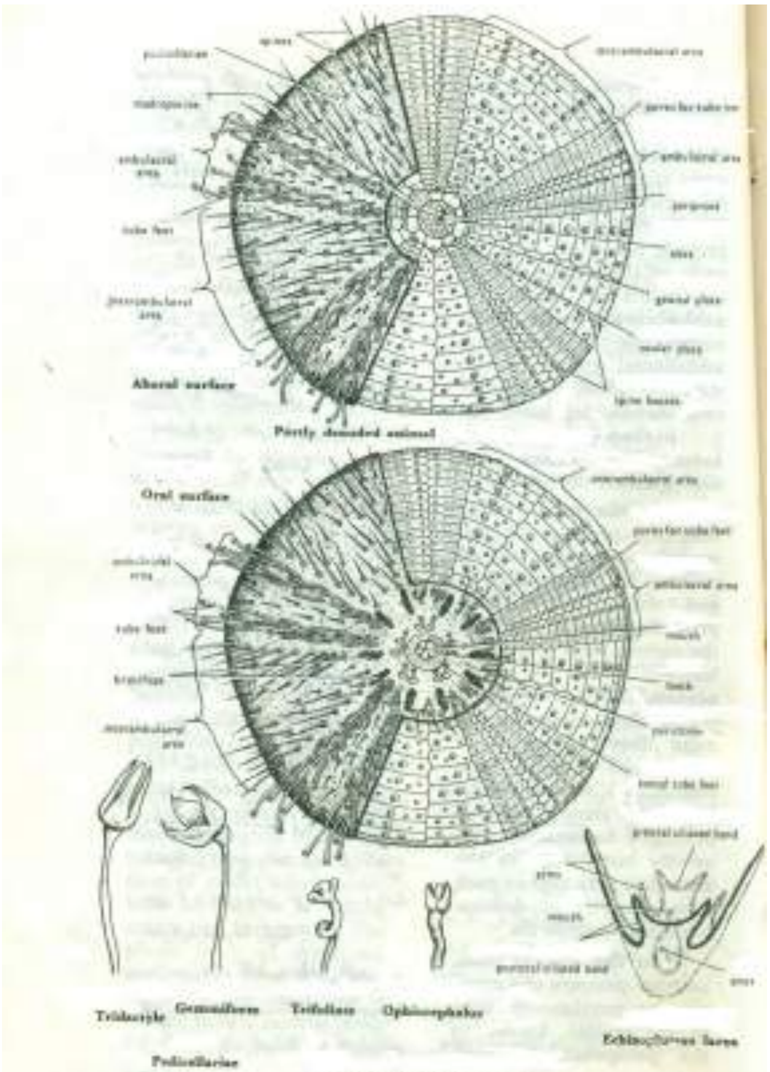
ASTROPECTEN RELITARIS



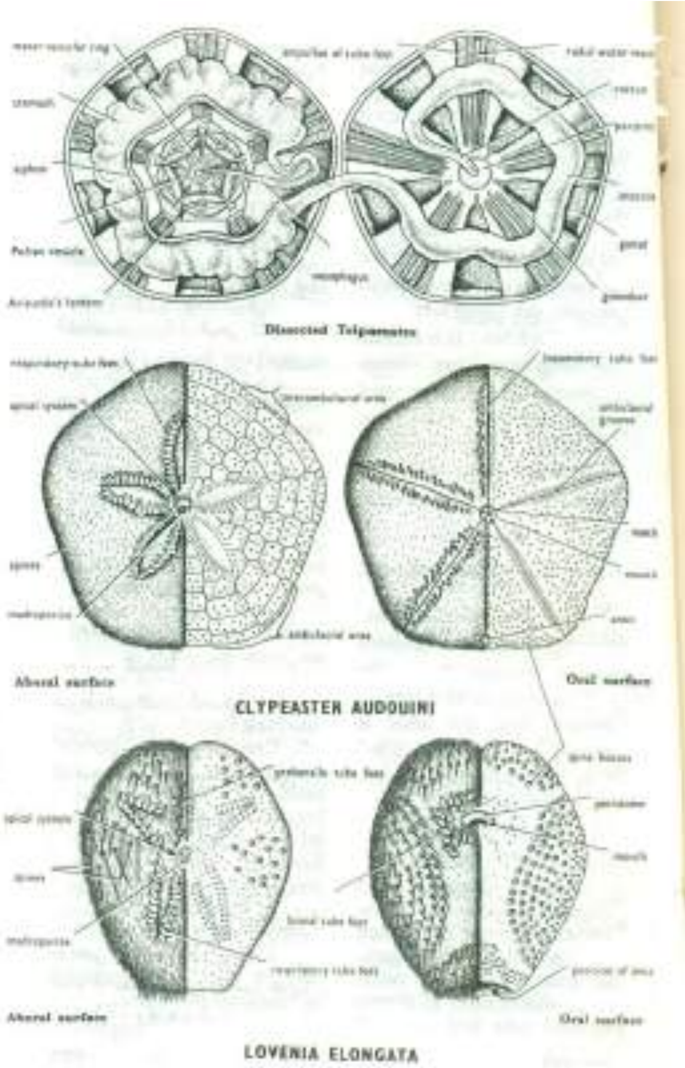
ASTROPECTEN RELITARIS

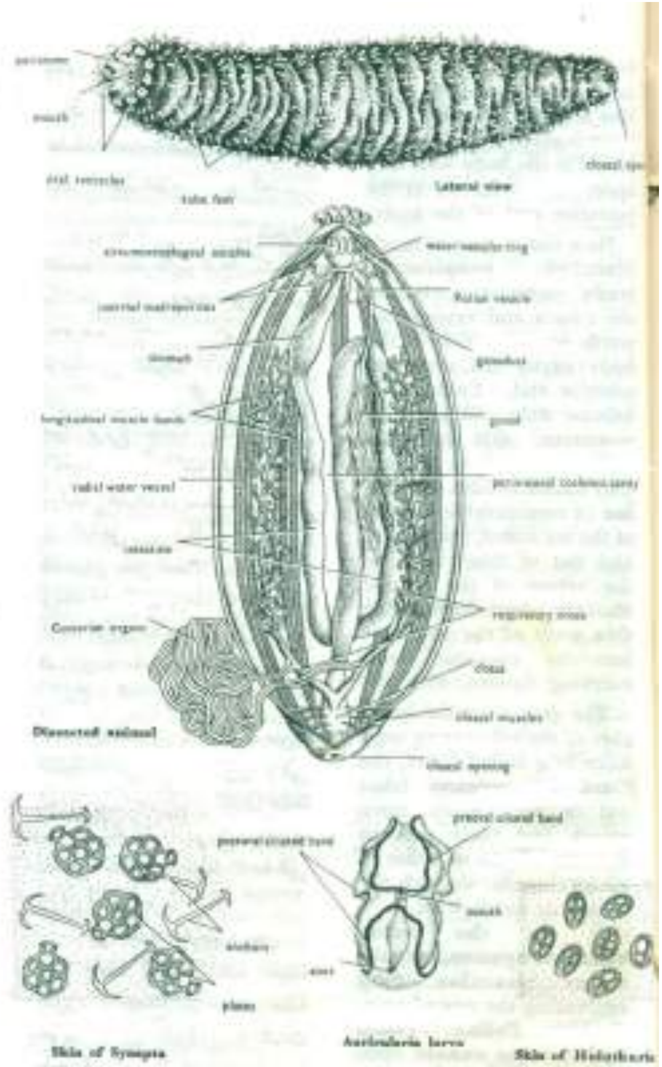


OPHIOCOMA SCOLOPENDRINA

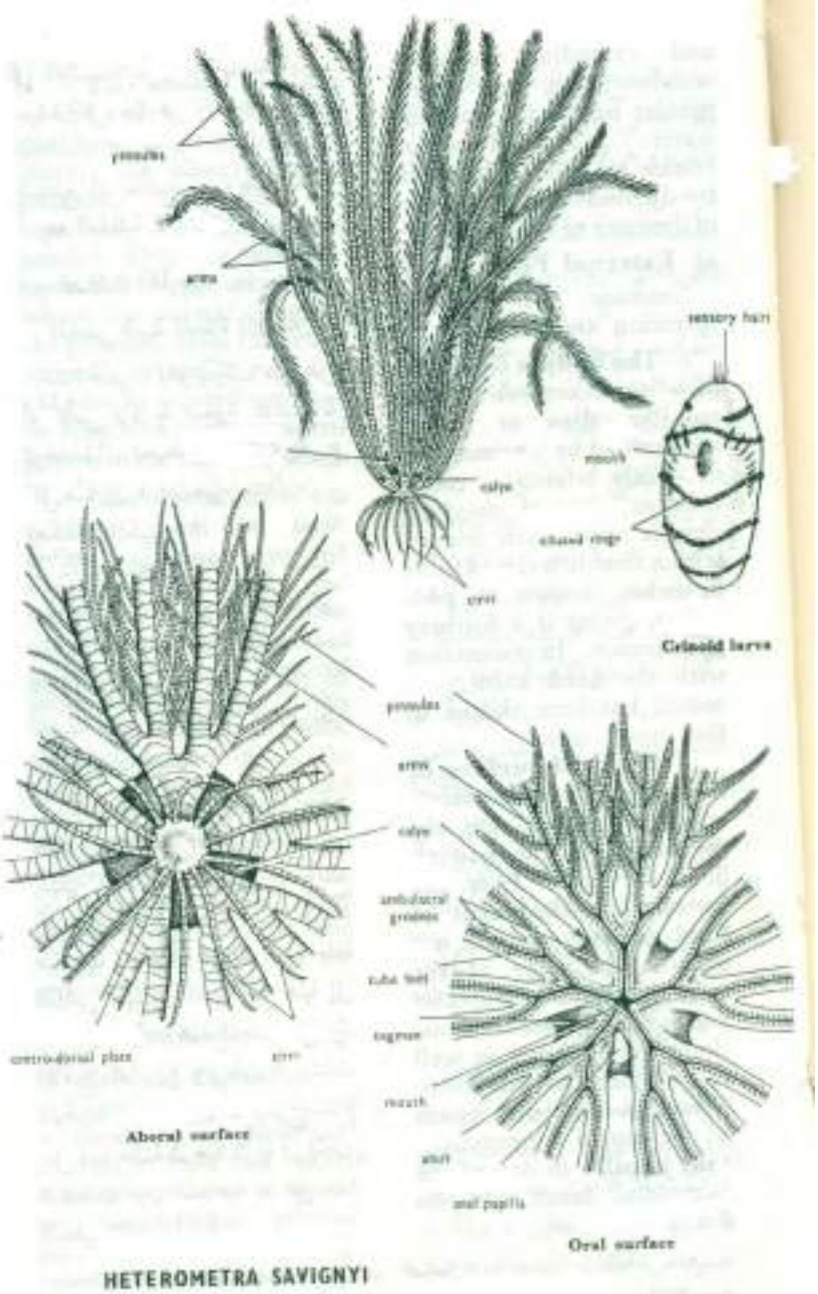


TRIPNEUSTES GRATILLA


Aboral surface
Oral surface
CLYPEASTER AUDOUINI
Aboral surface
Oral surface
LOVENIA ELONGATA



HOLOTHURIA CURIOSA



HETEROMETRA SAVIGNYI

GLOSSARY دليل المصطلحات *

A

aboral
لافمي (من L.: **ab** = من + **os** = **فم**)
الناحية المقابلة لمنطقة الفم .

acanthor
اليرقة الشوكية (من Gr.: **akantha** أى شوكة)
الطور اليرق الأول للرأسشوكيات Acanthocephala في العائل المتوسط .

acetabulum
محص – حُق (من L. : طبق صغير)
محص حقيقى ، خاصة فى الوشائع والعلق ؛ انخفاض فى عظم الحوض تستقر فيه رأس عظم الفخذ .

acoelomate
لا سيلومى ، لا جوفى أو عديم الجوف (من L.: **a** = بدون + koiloma = تجويف)
بدون تجويف حقيقى حول الأحشاء كما فى الديدان المسطحة والخرطومية .

acontium (pl acontia)
خيط سهمى (من L.: **akontion** = سهم)
تركيب خيطى يحمل أكياسًا لاسعة ويمتد من مساريق شقائق النعمان .

adductor
عضلة مقربة (من L.: **ad** = إلى + **ducere** = يقود)
عضلة تقرب جزءًا نحو المحور الأوسط ، أو تقرب مصراعى حيوان رخوى إلى بعضهما البعض .

afferent
وارد (من L.: **ad** = إلى + **ferre** = يحمل
صفة تشير إلى التأدية إلى أو الحمل فى اتجاه عضو ما ، مثل الأعصاب التى تحمل النبضات العصبية تجاه المخ ، أو الأوعية الدموية التى تحمل الدم إلى عضو (عكس صادر efferent)

alate
مجنح (من L.: **alatus** (من L.: **alatus** = جناح)

ambulacra
ممشاة ، الأسطح الحركية (من L.: **ambulare** = يسير)
الأخاديد الشعاعية فى شوكيات الجلد التى تبرز منها الأقدام الأنبوبية فى الجهاز الوعائى المائى

amoebocyte (amebocyte)
خلية أميبية (من Gr.: **amoibe** = تغير + **kytos** = وعاء مجوف)
أى جسم خلية حر ، قادر على الحركة بالأقدام الكاذبة ؛ أنواع معينة من خلايا الدم والأنسجة .

amoeboid (ameboid)
أميبى (من Gr.: **amoibe** = تغير + **oid** = مثل)
يشبه الأميبا فى حركتها ، أو فى شكلها ذى الأقدام الكاذبة .

amictic
لا خلطية – غير قابلة للاختلاط أو التلقيح (من Gr. : **a** بدون + **miktos** = مختلط)
تتعلق بإناث العجليات rotifers التى تضع فقط بيضًا ، ذا عدد كامل من الكروموسومات (الصبغيات) ، ولايمكن تلقيحه ، أو تتعلق بالبيض الذى تضعه تلك الإناث .

amphiblastula
البلاستولة المزدوجة (من Gr.: **amphi** = على كلا الجانبين + **blastos** جرثومة + L.: ula = صغير)
الطور اليرق الحر لبعض الإسفنجيات البحرية ، شبه البلاستولة عدا أن خلايا القطب الحيوانى وحدها هى التى تحمل أسواطًا دون خلايا القطب الخضرى .

الأمفيد **amphid**

واحد ضمن زوج من أعضاء الحس الأمامية فى بعض الديدان الخيطية .

قناعة - قارورة - حباية (من .L : قارورة) **ampulla**

حويصلة غشائية ؛ انتفاخ عند طرف كل قناة نصف هلالية ، تحتوى على طلائية حسية ؛ حويصلة عضلية فوق الأقدام الأنبوبية فى الجهاز الوعائى المائى لشوكيات الجلد .

تشابه وظيفى (من .L **analogus:** = نسبة) **analogy**

المشابهة فى الوظيفة دون الأصل .

غدة منشطة للذكورة (من .Gr **aner:** = ذكر + **gennaein** = ينتج) **androgenic gland**

غدة فى القشريات تسبب تكوين الصفات الذكرية المميزة .

الأمشاج غير المتساوية (من .Gr **anisos:** = غير متساو + **gametes** = زوج) **anisogametes**

أمشاج نوع ما مختلفة فى الشكل والحجم .

حلقة (من .L = حلقة) **annulus**

أى تركيب حلقى كالحلقات السطحية على العلق .

قرن استشعار - زبانى **antenna**

زائدة حسية على رأس مفصليات الأرجل ، وفى القشريات هى الزوج الثانى بالذات من هذه القرون .

قرن استشعار - زبانى **antenna**

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غدة قرنية **antennal gland**

غدة إخراجية فى القشريات ، تقع فى العقلة القرنية .

المركّب القمى **apical complex**

مجموعة من العضيّات فى شعبة البوغيات، من الحيوانات الأولية .

ثقب زفيرى (إخراجى) (من .Gr **apo:** = بعيد عن + **pyle** = بوابة أو مدخل) **apopyle**

فتحة القناة الشعاعية فى التجويف الإسفنجى فى الإسفنجيات .

خلايا قديمة (بدائية) (من .Gr **archaios:** = مبتدئ + **kytos** = وعاء مجوف) **archeocytes**

الخلايا الأميبية المتعددة الوظائف فى الإسفنجيات .

مشكاة أو مصباح أرسطو **Aristotle's lantern**

جهاز المضغ فى بعض قنافذ البحر

أسكونى (من .Gr **askas:** = حويصلة) **asconoid**

أبسط أنواع الإسفنج

لاجنسى - لاشقى **asexual**

بدون أعضاء جنسية محددة ؛ لا يتضمن تكوين أمشاج .

العقيم (من .Gr **a:** = بدون ، **tokos** = نسل) **atoke**.

القسم الأمامى غير المخصب فى عديدات الأهلاب-البحرية ، والمتميز عن القسم الخلفى الذى يتناسل (المخصب أو الخصب epitoke) خلال موسم التكاثر .

atrium — **دهليز – ردهة**

أذين القلب أو إحدى غرف القلب ، التجويف الطبلى للأذن ، وكذلك التجويف الكبير الذى يحتوى البلعوم فى القربيات أو الزقّيات (tunicates) والرأسحبليات .

auricularia — **اليرقة الأذينية – أوريكولاريا** (من auricula: L. = أذن صغيرة)

نوع من اليرقات فى خيار البحر .

autogamy — **إخصاب ذاتى** (من autos: Gr. = ذات + gamos = زواج)

اتحاد الأنوية المشيجية الناتجة بالانقسام الاختزالى فى نفس الفرد الذى أنتجها لاستعادة عدد الكروموسومات الأصلى .

autotomy — **البتر الذاتى** (من autos: Gr. = ذات + tomos = قطع)

قيام الفرد بذاته بفصل جزء من جسمه .

autotroph — **ذاتى التغذية** (من autos: Gr. = ذات + trophos = مغتذى)

كائن يكوّن غذاءه العضوى من مواد غير عضوية .

autotrophic nutrition — **التغذية الذاتية** (من autos: Gr. = ذات + trophia = تشير إلى التغذية)

تغذية تتصف بالقدرة على استخدام مواد غير عضوية بسيطة ، لتكوين مركبات عضوية – أكثر تعقيدًا – كما فى النباتات الخضراء وبعض البكتيريا .

avicularium — **حوين فقارى** (من avicula: L. = طير صغير + aria = مثل أو متصل بـ)

حوين متحور يلتصق بسطح الحوين الرئيسى فى خارجيات الشرج ويشبه منقار الطير .

axoneme — **الخيط المحورى** (من axis: L. = محور + nema: Gr. = خيط)

الأنيبيبات الدقيقة فى الهدب أو السوط ، وترتب عادة فى حلقة من ٩ أزواج ، تحيط بزوج مركزى ، أيضًا الأنيبيبات الدقيقة فى القديمة المحورية (القدم الكاذب ذى الخيط المحورى axopodium) .

axopodium (axopod) — **قديمة محورية** (من axis: L. = محور + podion: Gr. = قدم صغيرة)

قدم كاذب طويل رفيع دائم تقريبًا ، يوجد فى بعض الحيوانات الأولية من شعبة اللحميات .

B

basal body — **الجسم القاعدى**

ويعرف أيضًا بالجسم الحركى kinetosome ، والحبيبة القاعدية blepharoplast ، وهى حلقة من تسع ثلاثيات من الأنيبوبات الدقيقة توجد فى قاعدة السوط أو الهدب .

basis, basipodite — **القديمة أو الشدفة القاعدية** (من basis: Gr. = قاعدة + podos = قدم)

العقلة الثانية أو البعيدة من جذع قاعدة القديمة أو الشدفة الأولية protopodite فى زوائد القشريات .

biogenesis — **التكوين الحياتى** (من bios: Gr. = حياة + genesis = ميلاد)

مبدأ أن الحياة تنشأ فقط من حياة سبق وجودها .

bioluminescence — **الإضاءة الذاتية الحية**

طريقة تكوين الضوء فى الكائنات الحية ، حيث تتحول بعض البروتينات (ليوسيفيرينات) فى وجود الأكسجين وإنزيم ليوسيفيريز إلى ليوسيفيرينات مؤكسدة مع تولد الضوء .

bipinnaria — **اليرقة ذات الجناحين – بيبناريا** (من bi: L. = مزدوج + pinna = جناح + aria = مثل أو متصل بـ)

اليرقة الريشية المزدوجة . يرقة مهدبية حرة السباحة ذات تماثل جانبى فى نجوم البحر ؛ وتنمو إلى يرقة براكيولاريا (brachiolaria) الذراعية .

biramous ذو شعبتين – ثنائى الشعبة (من .L: **bi** = مزدوج + **ramus** = شعبة أو فرع)
صفة للأطراف ذات الشعبتين ، والمتميزة عن وحيدة الشعبة غير المتفرعة **uniramous**

blastocoel تجويف البلاستولة (من .Gr: **blastos** = بذرة أو جرثومة + **poros** = ممر أو ثقب)

blastopore ثقب البلاستولة (من .Gr: **blastos** = بذرة أو جرثومة **poros** = ممر أو ثقب)
الفتحة الخارجية للمعى القديم archenteron فى الجاسترولة .

blastula البلاستولة – المفلجة (من .Gr: **blastos** = بذرة أو جرثومة)
طور جنينى مبكر فى معظم الحيوانات ، ويتكون من كتلة جوفاء من الخلايا .

blepharoplast الحبيبة القاعدية (من .Gr: **blepharon** = جفن العين + **plastos** = متكون)
انظر basal body .

brachiolaria اليرقة الذراعية – براكيولاريا (من .L: **brachiola** = ذراع صغير + **aria** = يتعلق بـ)
يرقة نجوم البحر التى تنشأ من يرقة البايناريا ، ولها ثلاث زوائد ماصة قبلفمية

branchial خيشومى (من .Gr: **branchia** = خياشيم)
متعلق بالخياشيم

buccal فمى (من .L: **bucca** = وجنة أو خد)
متعلق بالتجويف الفمى .

C

capitulum رؤيس (من .L : رأس صغير)
تراكيب صغيرة تشبه الرأس فى عديد من الكائنات ، وضمنها بروز فى جسم القراد والحلم يحمل أجزاء الفم .

carapace الدرقة – القصعة (من .F عن .Sp: carapacho = قشرة أو صدفة)
صفيحة تشبه الدرع ، تغطى الرأسصدر بعض القشريات ، الجزء الظهرى من درع الترسة .

cephalization تكوين الرأس (الترئيس) (من .Gr: **kephale** = رأس)
العملية التى يتركز بها التخصص ، خاصة فى الأعضاء والزوائد الحسية ، ناحية الرأس فى الحيوانات .

cephalothorax الرأسصدر (من .Gr: **kephale** = رأس + thorax = صدر) .
أحد أجزاء الجسم فى كثير من العنكبيات والقشريات العليا ، حيث تلتحم الرأس ببعض أو كل الحلقات الصدرية .

cercaria سركاريا – المذنبة (من .Gr: **kerkos** = ذيل + .L: **aria** = مثل أو متصل بـ)
يرقة ديدان التريماتودا (الوشائع) التى تشبه أبا ذنيبة .

chelicera (pl. chelicerae) كلاب قرنى (من .Gr: **chele** = مخلب + **keras** = قرن) .
الزوج الأول من الزوائد الأمامية للرأس فى أفراد شعبة كلابيات القرون **Chelicerata** .

chelipeds الأرجل الكلابية (من .Gr: **chele** = مخلب + .L: **pes** = رجل أو قدم) .
الزوج الأول من الأقدام ذات الكلابات فى معظم القشريات العشرية الأرجل ، وهى متخصصة فى القبض على الفرائس وتمزيقها .

chitin **كيتين** (من .chitine: Fr ؛ من .chiton: L = سترة ضيقة)

مادة قرنية تكون جزءًا من جليد cuticle مفصليات الأرجل ، وتوجد بنسبة أقل فى بعض اللافقاريات الأخرى . وهى سكريات عديدة نيتروجينية لا تذوب فى الماء ، أو الكحول ، أو الأحماض المخففة ، أو العصارات الهاضمة لمعظم الحيوانات .

chlorogogue cells **الخلايا الصفراء أو الخضراء** (من .chloro: Gr = أخضر فاتح + agogos = مرشد أو موجه)

خلايا بريتونية متحورة خضراء أو بنية اللون ، تتجمع حول القناة الهضمية لبعض الديدان الحلقية ، وهى تساعد فى التخلص من الفضلات النتروجينية ونقل الطعام .

chlorocruorin **كلوروكرورين** (**الدم الأخضر**) (من .chloros: Gr = أخضر فاتح + .cruor: L = دم)

صبغ تنفسى مخضر ، يحتوى على الحديد ويوجد – ذائبًا – فى بلازما دم بعض الديدان البحرية العديدة الأشواك .

chlorophyll **كلوروفيل أو يخضور** (من .chloros: Gr = أخضر فاتح + phyllon = ورقة)

الصبغ الأخضر فى النباتات وبعض الحيوانات ، وهو ضرورى للتمثيل الضوئى .

chloroplast **بلاستيدة خضراء** (من .chloros: Gr = أخضر فاتح + plastos = مصبوب فى قالب)

حبيبة تحتوى على اليخضور ، وأصباغ أخرى وتوجد – عادة – فى سيتوبلازم الخلايا النباتية .

choanocyte **خلية مطوقة قمعية** (من .choane: Gr = قمع + kytos = وعاء مجوف)

إحدى الخلايا السوطية المطوقة التى تبطن تجاويف وقنوات الإسفنجيات

chromatophore **حاملة الألوان أو الأصباغ ، أو خلية صبغية** (**ملوّنة**) (من .chroma: Gr = لون + pherein)

حبيبة صبغية توجد عادة فى الأدمة ، ويمكن فيها لصبغ أن ينتشر أو يتركز .

chromoplast **حبيبة لونية** (**من** .chroma: Gr = لون + plastos = مصبوب فى قالب)

حبيبة تحتوى على صبغ .

chrysalis **العذراء الذهبية – الخادرة** (**من** .L : عن .chrysos: Gr = ذهب)

طور العذراء فى الفراشات .

cilium (**cilia** وجمعها) **هدب وأهداب** (من .L : جفن العين)

زائدة متحركة تشبه الشعرة ، توجد على كثير من الخلايا الحيوانية . تستخدم الأهداب فى تحريك الحبيبات على سطح الخلية ، أو للحركة فى الأوليات الهدبية .

cirrus **ذؤابة**

خصلة تشبه الشعر على زوائد الحشرة ؛ عضى حركة من أهداب مندمجة ؛ عضو السِّفاد الذكرى فى بعض اللافقاريات

clitellum **السَّرْج** (من .clitellae: L = سرج)

جزء مغلظ يشبه السرج – فى بعض قطع الجسم الوسطى – فى كثير من قليلات الأهلاب ، العلقيات .

cloaca **المجمع** (**من** .L : بالوعة)

الغرفة الخلفية من القناة الهضمية فى كثير من الفقاريات والتى تتجمع فيها النواتج البرازية ، والبولية ، والتناسلية . فى بعض اللافقاريات ، يكون المجمع هو الجزء الأخير من القناة الهضمية الذى يعمل – أيضًا – كقناة تنفسية أو إخراجية أو تناسلية .

cnidocil **الزناد – هُدْبة اللسع** (من .knide: Gr = نبات القراص أو اللاسع ذو الأوراق الشائكة + .cilium: L = شعرة) شوكة تشبه الزناد فى الخلية اللاسعة .

cnidocyte **خلية لاسعة** (من .knide: Gr = القراص أو اللاسع + kytos = وعاء مجوف)
خلية بينية متحورة ، تحتوى على الحوصلة الخيطية . وخلال تكوين الحويصلة الخيطية تكون الخلية اللاسعة .

cocoon **شرنقة** (من .cocon: Fr = قشرة)
غلاف واقٍ لطور ساكن أو تكوينى ، ويستخدم أحيانًا للإشارة إلى الغلاف وما يحتويه ، على سبيل المثال شرنقة أبى دقيق ، أو الغلاف الواقى للأجنة المتكونة فى بعض الحلقيات .

coelenteron **جوفمعى** (من .koilos: Gr = مجوف + enteron = معى)
التجويف الداخلى فى أحد اللواسع ، وكذلك التجويف الوعائى المعدى ، والمعى القديم archenteron .

coelomocyte **خلية سيلومية أو جوفية** (من .koiloma : Gr = تجويف + kytos = وعاء مجوف)
اسم آخر للخلية الأميبية ؛ خلية بدائية ، أو غير متميزة فى السيلوم والجهاز الوعائى المائى .

coelomoduct **قناة سيلومية** (من .koilo = Gr = مجوف + .ductus :L = موصل)
قناة تحمل الأمشاج أو النواتج الإخراجية (أو كليهما) من السيلوم إلى الخارج .

coenecium, coenoecium **البيت المشترك** (من .koinos: Gr = مشترك + oikon = بيت)
الغلاف المشترك الذى تفرزه مستعمرة خارجيات الشرج ectoproct ، وقد يكون كيتينًا ، أو هلاميًا أو كلسيًّا .

collencyte **خلية صمغية** (من .kolla: Gr = غراء أو صمغ + en = فى + kytos = وعاء أجوف)
نوع من الخلايا الإسفنجية ، نجمى الشكل ، وهو انقباضى فيما يبدو .

colloblast **خلية لاصقة أو غرائية** (من .kolla: Gr = غراء + blasta = جرثومة)
خلية تفرز مادة لاصقة على لوامس المشطيات ctenophores .

columella **عُميد** (من .L : عمود صغير)
العمود الأوسط فى القواقع ، وهيكل المرجان الحقيقى .

comb plate **صفيحة مشطية**
إحدى صفائح الأهداب المندمجة المرتبة فى صفوف ، والتى تستخدمها المشطيات فى حركتها .

conjugation **الاقتران** (من .conjugare:L = يرتبط معًا)
الاتحاد المؤقت لحيوانين أوليين هدبيين أثناء تبادل المادة الكروماتينية ، واجتيازهما الظواهر النووية المؤدية إلى الانقسام الثانى ؛ أيضًا تكوين الجسور السيتوبلازمية بين البكتريا لانتقال البلازميدات .

contractile vacuole **فجوة منقبضة أو متقبضة أو انقباضية أو فجوة خلوية**
فجوة ممتلئة بسائل رائق توجد فى الحيوانات الأولية وبعض البعديات الدنيا ، وهى تجمع الماء وتطرده إلى الخارج بصورة دورية للتنظيم الأزموزى والإخراج الجزئى .

copulation **تسافد** (من .Fr من .copulare L = يقترن)
الاتحاد الجنسى الذى ييسر للأنثى استقبال الحيوانات المنوية .

cornea **قرنية** (من .L: corneus = قرنى)
غلاف العين الخارجى الشفاف .

D

Darwinism **النظرية الداروينية**

نظرية التطور بالانتقاء الطبيعي .

definitive host **العائل النهائي أو المحدد**

العائل الذي يتم فيه التكاثر الجنسي للطفيل . إذا لم يكن هناك تكاثر جنسي .. فهو العائل الذي ينضج فيه الطفيل ويتكاثر . قارن بالعائل المتوسط intermediate host

dermis (corium) **الأدمة**

الطبقة الميزودرمية الحساسة الداخلية من الجلد .

determinate cleavage **التفلج (الانقسام) المحدد**

طراز من التفلج ، حلزوني عادة ، حيث يتحدد فيه مصير خلايا البلاستولة مبكرًا جدًا أثناء النمو ؛ التفلج الفسيفسائي (الموزايكي mosaic)

Deuterostomia **ثانويات الفم** (من Gr. **deuteros:** = ثاني أو ثانوي + **stoma** = فم)

مجموعة من الشعب الراقية ، حيث يكون التفلج غير محدد ، وبدائيًا ، شعاعي ، ويكون الميزودرم معوي السيلوم . ويشتق الفم بعيدًا عن ثقب البلاستولة ، وتشمل : شوكيات الجلد ، والحبليات ، وعددًا من الشعب الصغيرة . قارن بأماميات الفم Protostomia .

dextral **يميني** (من L. dexter: = يمنى اليد)

متعلق باليمين ؛ في بطنية الأقدام .. تكون القوقعة يمينية إذا كانت الفتحة إلى يمين العُمَيْد columella ، عندما تُمسك القوقعة وقمتها إلى أعلى في مواجهة المشاهد .

diapause **فترة الكمون** (من Gr. **diapausis:** = فترة توقف)

فترة يتوقف فيها التكوين في دورة حياة الحشرات ، وحيوانات معينة أخرى ، حيث يكون النشاط الفسيولوجي منخفضًا جدًا ، وتكون مقاومة الحيوان عالية للظروف الخارجية غير الملائمة .

dimorphism **ازدواج الشكل** (من Gr. **di:** = اثنان + **morphe** = شكل)

احتواء النوع على شكلين متميزين حسب اللون ، أو الجنس ، أو الحجم ، أو التركيب .. وهكذا . وجود نوعين من الحوينات zooids في مستعمرة .

dioecious **ثنائي المسكن** (من Gr. **di:** = اثنان + **oikos** = مسكن)

وجود الأعضاء الذكرية والأنثوية في أفراد منفصلة .

dipleurula **اليرقة ذات الضلعين** (من Gr. **di:** = اثنان + **pleura** = ضلع ، جانب + L. **ula:** = صغيرة)

شكل افتراضي بسيط لأسلاف شوكيات الجلد ؛ مستطيل ومتماثل الجانبين ، ذو ثلاثة أزواج من الأكياس السيلومية .

diploblastic **ثنائية الطبقات** (من Gr. **diploos:** = مزدوج + **blastos** = برعم)

كائن ذو طبقتين جرثوميتين : الإندودرم والإكتودرم .

E

ecdysiotropin هرمون محفز للانسلاخ (من ekdysis: Gr. = يخلع ، يتجرد ، يهرب + tropos = تحول ، تغير)

هرمون يفرز فى مخ الحشرات التى تنشط غدة الصدر الأمامى لإفراز هرمون الانسلاخ . (ويسمى أيضًا prothoracicotropic hormone الهرمون المحفز لإفراز غدة الصدر الأمامى) .

ecdysis انسلاخ (من ekdysis: Gr. = يتجرد ، يهرب)

خلع الطبقة الجليدية الخارجية كما فى الحشرات أو القشريات .

ecdysone هرمون الانسلاخ (من ekdysis: Gr. = يتجرد)

هرمون الانسلاخ فى المفصليات الذى يُحفز النمو والانسلاخ ، وتفرزه غدد الصدر الأمامى فى الحشرات ، وأعضاء واى (Y) فى القشريات .

ectoderm إكتودرم (الأدمة الخارجية) (من ektos: Gr. = خارج + derma جلد)

الطبقة الخارجية من الخلايا لجنين فى مراحله المبكرة (طور الجاسترولة) ؛ إحدى الطبقات الجرثومية ، ويستخدم أحيانًا للإشارة إلى الأنسجة التى تنشأ من الإكتودرم .

ectolecithal خارجى المح (من ektos:Gr. = خارج + lekithos = مح)

المح لتغذية الجنين توفره خلايا منفصلة عن الخلية البيضية وترتبط بالزيجوت باحتوائها داخل غلاف البيضة .

ectoplasm إكتوبلازم – الجبلة الخارجية (من ektos: Gr. = خارج + plasma = هيئة)

قشرة الخلية ، أو ذلك الجزء من السيتوبلازم تحت سطح الخلية مباشرة ، ويقابله البلازمة الداخلية (إندوبلازم)

efferent صادر (من ex: L. = خارج + ferre = يحمل)

يؤدى أو يوصل بعيدًا عن عضو ما ، مثل : النبضات العصبية التى تنقل بعيدًا عن المخ ، أو الدم الذى يُحمل بعيدًا عن عضو ما ؛ يقابله وارد afferent .

eleocyte خلية زيتية (من elaion: Gr. = زيت + kytos = وعاء أجوف)

خلايا دهنية فى الحلقيات ، ناشئة من نسيج الخلايا الصفراء .

elephantiasis داء الفيل

تشويه تسببه إصابة مزمنة بديدان الفلاريا **Wuchereria bancrofti** و **Brugia malayi**

endite نتوء الشعبة الداخلية (من endon: Gr. = داخل)

زائدة الشعبة الداخلية فى طرف مفصليات الأرجل .

endoderm إندودرم (الأدمة الداخلية) (من endon: Gr. = داخل + derma = جلد)

الطبقة الجرثومية الداخلية فى الجنين ، والتى تكوّن المعى البدائى ؛ وقد تشير أيضًا إلى الأنسجة التى تنشأ من الإندودرم .

endoplamsa الجبلة الداخلية (من endon: Gr = داخل + plasma = قالب أو هيئة)

جزء السيتوبلازم الذى يحيط بالنواة مباشرة .

endopod,endopodite شعبة (أو شدفة) داخلية (من endon: Gr. = داخل + pous ، podos = قدم)

قدم الفرع الداخلى فى زائدة القشريات ذات الشعبتين.

endopterygote حشرات داخلية الأجنحة (كاملة التحور) (من endon: Gr. = داخل + pteron = ريشة ، جناح)

حشرات تنشأ فيها بدايات الجناح من الداخل ؛ وهى ذوات تحور كامل holometabolous

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زائدة الشعبة الداخلية فى طرف مفصليات الأرجل .

endoderm إندودرم (الأدمة الداخلية) (من .endon: Gr = داخل + derma = جلد)
الطبقة الجرثومية الداخلية فى الجنين ، والتى تكوّن المعى البدائى ؛ وقد تشير أيضًا إلى الأنسجة التى تنشأ من الإندودرم .

endoplamsa الجبلة الداخلية (من endon: Gr = داخل + plasma = قالب أو هيئة)
. جزء السيتوبلازم الذى يحيط بالنواة مباشرة .

endopod,endopodite شعبة (أو شدفة) داخلية (من .endon: Gr = داخل + pous ، podos = قدم)
قدم الفرع الداخلى فى زائدة القشريات ذات الشعبتين.

endopterygote حشرات داخلية الأجنحة (كاملة التحول) (من .endon: Gr = داخل + pteron = ريشة ، جناح)
حشرات تنشأ فيها بدايات الجناح من الداخل ؛ وهى ذوات تحول كامل holometabolous

endosome — **الجسم الداخلى – إندوسوم** (من .endon: Gr = داخل + soma = جسم)

النوية فى نواة بعض الحيوانات الأولية التى تحتفظ بهويتها خلال الانقسام غير المباشر .

enterocoel — **السيلوم المعوى** (من .enteron: Gr = معى + koilos = مجوف)

نوع من السيلوم ، يتكون من بروز للكيس الميزودرمى من إندودرم المعى القديم (الأولى) .

enterocoelic mesoderm formation — **تكوين السيلوم المعوى الميزودرمى**

التكوين الجنينى للميزودرم من ثنية خارجية ، تشبه الجيب ، من المعى القديم التى تمتد وتسد تجويف البلاستولة ، وبالتالى .. تكون تجويفًا كبيرًا ، هو السيلوم ، ويبطنه الميزودرم .

enterocoelomate — **ذوات السيلوم المعوى** (من .enteron: Gr = معى + koiloma = تجويف + من .ate: Eng = كونه) تطلق على الحيوانات ذوات السيلوم المعوى كشوكيات الجلد .أو تطلق على الحيوانات ذوات السيلوم المعوى كشوكيات الجلد او الفقاريات .

enteron — **تجويف المعى** (من .L : = معى)

التجويف الهضمى داخل حيوان

entozoic — (من .entos:Gr = داخل + zoon = حيوان)

تُطلق على الحيوانات التى تعيش داخل حيوانات أخرى ؛ طفيل داخلى (الديدان المتطفلة بصورة رئيسية)

ephyra — **إيفيرا** (من .Ephyra: Gr = مدينة يونانية)

برعم ميدوسى من بوليب الحيوانات الفنجانية Scyphozoa

epidermis — **بشرة** (من .epi: Gr = على + derma = جلد)

الطبقة غير الوعائية الخارجية من الجلد من أصل إكتودرمى ؛ فى اللافقاريات : طبقة وحيدة من الطلائية الإكتودرمية .

epipod, epipodite — **قُديمة أو شدفة فوقية أو علوية** (من .epi: Gr = على + pous, podos = قدم)

زائدة جانبية على القديمة الأولية فى طرف القشريات ، وغالبًا ما تتحور لخيشوم .

epithelium — **بشرة طلائية** (من .epi: Gr = على + thele = حلمة)

نسيج خلوى يغطى السطح الخارجى ، أو يبطن أنبوبة أو تجويفًا .

epitoke — **المخصب أو الخصب** (من .epitokos: Gr = مثمر)

الجزء الخلفى من دودة بحرية عديدة الأهلاب عندما ينتفخ بالمناسل الناضجة أثناء موسم التوالد ، يقابله العقيم atoke .

eukaryotic (eucaryotic) — **كامل النواة (حقيقى النواة)** (من .eu: Gr = حقيقى أو جيد + karyon = لب ، نواة)

كائن تتميز خلاياه باحتوائها على نواة أو أنوية ، تحيطها أغشية . يقابلها بدائى النواة prokaryotic .

eutely — **الثبات العددى الخلوى أو النووى** (من .euteia: Gr = اقتصاد)

حالة تكوين الجسم من عدد ثابت من الخلايا أو الأنوية فى كل الأفراد اليافعة من النوع ، كما فى العجليات rotifers ، والرأسشوكيات acanthocephalans ، والديدان الخيطية .

exopod, exopodite — **قُديمة (شعبة أو شدفة) خارجية** (من .exo: Gr = خارج + pous, podos = قدم)

الفرع الجانبى للزائدة ذات الشعبتين فى القشريات

exopterygote **حشرات خارجية الأجنحة** (من .exo: Gr = خارج + pteron جناح ، ريشة)

حشرة تنشأ براعم أجنحتها خارجيًا خلال أطوار التكوين ، وهى ذات تحور نصفى .

exoskeleton **هيكل خارجى** (من .exo: Gr = خارج + skeletos = صلب)

تركيب دعامى تفرزه البشرة أو الإكتودرم ، خارجى غير مغلف بنسيج حى على عكس الهيكل الداخل endoskeleton

F

filopodium **قدم كاذب خيطى** (من .filum: Gr = خيط + podos, pous = قدم)

نوع من الأقدام الكاذبة الرفيعة ، وقد تتفرع ولكنها لا تكون شبكة .

filter feeding **التغذية بالترشيح**

طريقة التغذية التى تُصفّى فيها حبيبات الطعام التى تكون عالقة فى الماء .

fission **الانقسام ، الانشقاق** (من .fissio: L = انشقاق)

تكاثر لا شقى بانقسام الجسم إلى جزءين أو أكثر .

flagellum **سوط** (من .L)

عضى حركة يشبه السوط

flame bulb **بصيلة لهبية**

تركيب مجوف متخصص بالإخراج أو التنظيم الأزموزى ، مكون من خلية صغيرة ، أو أكثر ، تحتوى على خصلة من الأهداب « اللهب » ، تقع عند نهاية أنيبية دقيقة . وفى النهاية تفتح الأنابيب إلى الخارج . انظر الخلية الأنبوبية solenocyte ، الفريدة الأولية protonephridium .

fluke **من الوشائع** (**دودة مفلطحة**)

نوع من طائفة التريماتودا أو طائفة وحيدات العائل . أيضًا بعض الأسماك المفلطحة (رتبة Pleuronectiformes) .

food vacuole **فجوة غذائية**

عضى هضمى فى الخلية .

fouling **تلوث – تراكم الحشف**

تلوث المناطق الغذائية أو التنفسية بالمواد الإخراجية أو الترسيبية أو غيرها . أيضًا ، تراكم الأحياء البحرية الجالسة على جسم المركب أو السفينة مما يعوق تقدمها فى الماء .

G

gamete **مشيج – جاميطة** (**جامية**) (من .gamos: Gr = زواج)

خلية جنسية ناضجة أحادية الصبغيات (الكروموسومات) ؛ عادة ، يمكن التمييز بين الأمشاج الذكرية والأنثوية : بيضة أو حيوان منوى .

gametocyte **الخلية المشيجية** (**مولدة المشيج**) (من .gametes: Gr = قرين + kytos = وعاء أجوف)

الخلية الأم للمشيج ؛ أى المشيج غير الناضج .

gasatrodermis **الأدمة المعوية** (من .gaster: Gr = معدة + lithos = حجر)

بطانة التجويف الهضمى للاسعات .

gastrolith **الحصاة المعدية** (من .gaster: Gr = معدة + lithos = حجر)

جسم كلسي في جدار المعدة الفؤادية للإربيان (الجمبري) ، وغيره من القشريات اللينة الهيكل ، يسبق الانسلاخ .

gastrovasculer cavity **التجويف الوعائي المعدي** (من .gaster: Gr = معدة + vasculum: L. = وعاء صغير)

تجويف الجسم في بعض اللافقاريات الدنيا ، ووظيفته الهضم والدوران ، وله فتحة وحيدة تعمل كفم وإست معًا .

gastrula **جاسترولة – بطنية** (من .gaster: Gr = معدة)

طور جنيني ، قلنسوي أو كيسي الشكل عادة ، يتكون جداره من طبقتين من الخلايا ، تحيطان بتجويف (المعى القديم أو الأولي) له فتحة واحدة (فتحة البلاستولا) .

gastrulation **التبطين – تكوُّن الجاسترولة** (من .gaster: Gr = معدة)

عملية يتحول بها جنين الحيوان البعدي المبكر إلى بطنية (جاسترولة) ، والتي تتكون – في البداية – من طبقتين ، ثم ثلاث طبقات من الخلايا .

gemmule **دريرة** (من .gemma L = برعم)

وحدة تكاثرية لا شقية ، تشبه الحوصلة ، في إسفنجيات الماء العذب ، وتتكون في الصيف أو الخريف ، تستطيع أن تعبر فصل الشتاء .

genus (pl.genera) **جنس** (من .L: سلالة)

مجموعة من الأنواع المتقاربة ، وتقع في الترتيب التصنيفي بين الفصيلة family والنوع species .

glochidium **يرقة الجلوكيديم** (من .glochis: Gr = نقطة)

طور يرقي ذو مصراعين لمحار الماء العذب .

gnathobase **قاعدة فكية** (من .gnathos: Gr = فك + base = قاعدة)

زائدة قاعدية على الناحية الداخلية لبعض الأطراف في بعض مفصليات الأرجل ، وتُستخدم عادة لتمزيق أو طحن الطعام .

gonad **منسل** (من .gonas: L = عضو جنسي ابتدائي)

عضو ينتج الأمشاج (المبيض في الأنثى ، والخصية في الذكر) .

gonangium **البوليب المنسل** (من .gonas: L = عضو جنسي ابتدائي + angeion = وعاء صغير)

الحوين التكاثري في مستعمرة الهدريات (اللاسعات) .

gonoduct **قناة منسلية** (من .gonos: Gr = بذرة ، نسل + duct = قناة)

القناة التي تصل المنسل بالخارج .

gonopore **ثقب تناسلي** (من .gonos: Gr = بذرة ، نسل + poros = فتحة)

ثقب تناسلي يوجد في كثير من اللافقاريات .

green gland **الغدة الخضراء – الغدة القرنية**

غدة إخراجية في بعض القشريات .

gynecophoric canal **قناة الاحتضان** (من .gyne: Gr = امرأة + pherein = يحمل)

ميزاب في ذكر ديدان البلهارسيا (من التريماتودا) تُحمل فيه الأنثى .

H

halter (pl. halteres) (balancer)

دبوس التوازن

فى الحشرات ذوات الجناحين ، تركيب صولجانى صغير على كل جانب من الصدر الخلفى ، ويمثل الجناح الخلفى ، ويعتقد أنه عضو حسى للتوازن .

hectocotylus

متوى الممصات (من .hekaton: Gr = مئة + kotyle = كأس)

ذراع متخصص ، وأحيانا ذراع مستقل ، يُستخدم كعضو سفادى ذكرى فى الرأسقدميات .

hemal system

الجهاز الدموى (من .haima: Gr = دم)

جهاز من الأوعية الصغيرة فى شوكيات الجلد بلا وظيفة معروفة .

hemerythrin

صبغ الدم الأحمر (من .haima: Gr = دم + erythros = أحمر)

صبغ تنفسى أحمر ، يحتوى على الحديد فى دم بعض الديدان عديدة الأهلاب ، وذراعيات الأقدام وغيرها .

hemimtabolous

حشرات نصفية التحور (من .hemi: Gr = نصف + metabole = تغير)

يتعلق بالتحور التدريجى خلال تكوين الحشرات ، وهو لا يحتوى على طور عذراء .

hemolymph

الليمف الدموى (من .haima: Gr = دم + من اللاتينية .lympha L = ماء)

سائل فى السيلوم ، أو السيلوم الدموى ، لبعض اللافقاريات ، ويمثل دم وليمف الحيوانات الأرقى .

hemozoin

هيموزوين (من .haima: Gr = دم + zoon = حيوان)

ناتج هضمى لا يذوب ، تنتجه طفيليات الملاريا من الهيموجلوبين .

hermatypic

يتعلق بتكوين الشعاب المرجانية (من .herma: Gr = شعاب + typos = نمط) .

hermaphrodite

خنثى (من .hermaphroditos: Gr = يحتوى على كلا الجنسين ؛ عن الأساطير الإغريقية : هيرمافروديتوس Hermphroditos ، ابن هرمس Hermes ، وآفروديت Aphrodite)

حيوان يحتوى على الأعضاء التناسلية الذكرية والأنثوية معًا . قد يشير التخنث hermaphroditism إلى شذوذ فى الحيوانات وحيدة الجنس ؛ أما أحادية المسكن monoecism فتدل على أن هذه هى الحالة العادية للنوع .

heterotroph

متباين التغذية (من .heteros: Gr = مختلف + trophos = مغتذى)

كائن يحصل على المواد العضوية واللاعضوية من البيئة لكى يعيش ؛ يضم معظم الحيوانات ، والنباتات التى لا تمثل ضوئيًا .

hexamerous

سداسى التماثل (من .hex: Gr = سته + meros = جزء)

تماثل سداسى الأجزاء ، مبنى على الستة أو مضاعفاتها .

holometabotous

كامل التحور (من .holo: Gr = كلى + metabole = تغير)

تحور كامل خلال التكوين .

holophytic nutrition

تغذية نباتية (من .holo: Gr = كلى + phyt = نبات)

عملية تتم فى النباتات الخضراء ، وبعض الحيوانات الأولية ، وتتضمن تمثيل الكربوهيدرات من ثانى أكسيد الكربون والماء فى وجود الضوء ، والكلوروفيل ، وبعض الإنزيمات .

holozoic nutrition

تغذية حيوانية (من .holo: Gr = كلى + zoikos = للحيوانات)

نوع من التغذية يتضمن ابتلاع حبيبات الطعام العضوية الصلبة أو السائلة .

corona
إكليل (من L. = تاج)
الجزء العلوى ، أو قمة تركيب ما ؛ أو القرص المهدب فى الطرف الأمامى للعَجَليات rotifers .

corpora allata
الأجسام المساعدة (من L. **corpus:** = جسم + **allatum** = مساعد)
غدد صماء فى الحشرات ، تنتج هرمون الحداثة Juvenile hormone الذى يحافظ على صفات اليرقة والحورية .

coxa, coxopodite
الحرقفة ، قُديمة أو شدفة حرقفية (من L. **coxa:** إلية + من Gr : **podos, pous** = قدم) .
العقلة القربية فى أقدام الحشرات أو العنكبيات ، والعقلة القربية فى القديمة الأولية للقشريات .

cuticle
جُليْد (كيوتيكل) (من L. **cutis:** = جلد)
طبقة عضوية لا خلوية واقية ، تفرزها البشرة الخارجية للعديد من اللافقاريات . فى الحيوانات الراقية .. يشير هذا المصطلح إلى البشرة ، أو الجلد الخارجى .

cydippid larva
يرقة (يرقانة) سيديبيد (من Gr. **kydippe:** = فتاة أثينية أسطورية)
يرقة معظم المشطيات الحرة المعيشة . وهى تشبه الحيوان البالغ إلى حد ما .

cyrtocyte
خلية سلّية (من Gr. **kyrte:** = سلة السمك ، قفص + **kytos** = وعاء أجوف)
خلية تفريدية أولية ذات سوط واحد تحتويه أسطوانة من القضبان السيتوبلازمية ؛ يوجد فى البطنهدبيات Gastrotricha .

cysticercoid
الحوصلة المذنبة أو الدودة المثانية المصمتة
(من Gr. **kystis;** = مثانة + **kerkos** = ذيل + **eidos** = شكل)
طراز من صغار الديدان الشريطية ، يتكون من حوصلة مصمتة ، تحتوى على دويدة (رأس دودة) منغمدة invaginated ؛ قارن بالدودة المثانية .

cysticercus
الحوصلة المذنبة أو الدودة المثانية المجوفة (من Gr. **kystos:** = مثانة + kerkos = **ذيل**)
طراز من صغار الديدان الشريطية حيث تُحتوى الرأس المنغمدة والمنطلقة فى مثانة ممتلئة بسائل ؛ قارن بالدودة المثانية المصمتة .

cystid
الحوصلة ، مستد (من Gr. **kystis:** = مثانة)
فى خارجيات الشرج ectoprocts ، الأجزاء الخارجية المفرزة الميتة ، اضافة إلى الطبقات الحية الملتصقة أسفلها .

cytopharynx
البلعوم الخلوى (من Gr. **kytos:** = وعاء مجوف + **pharynx** = بلعوم)
البلعوم الأنبوبى الصغير فى الأوليات الهدبية .

cytoproct
الشرج الخلوى (من Gr. **kytos:** = وعاء أجوف + **proktos** = إست)
موقع على الحيوان الأولى ، حيث تطرد المواد غير القابلة للهضم .

cytosome
الجسم الخلوى (من Gr. **kytos** = وعاء أجوف + **soma** = جسم)
جسم الخلية داخل الغشاء البلازمى .

cytostome
الفم الخلوى (من Gr. **kytos** = وعاء أجوف + **stoma** = فم)
فم الخلية فى كثير من الحيوانات الأولية .

homology المضاهاة – التماثل (من .homologos: Gr = متفق)

تماثل الأجزاء أو الأعضاء بين الكائنات المختلفة ، نتيجة تماثل في الأصل الجنيني والتكوين التطوري من جزء متطابق في بعض الأسلاف البعيدة . وقد يشير – أيضًا – إلى زوج متماثل من الكروموسومات . والمضاهاة (التماثل) المتتابعة (المتسلسلة) serial هي احتواء نفس الفرد – أيضًا – على تراكيب متكررة لها نفس الأصل والتكوين ، مثل أطراف مفصليات الأرجل (homologous : مضاهي – متماثل)

hydatid cyst حويصلة مائية (من .hydatis: Gr = حويصلة مائية)

نوع من الحويصلات ، تكونه صغار بعض الديدان الشريطية (إيكينوكوكس Echinococcus) في عائلها الفقاري .

hydranth هدر زهري (من .hydor: Gr = ماء + anthos = زهرة)

البوليب المغتذي في مستعمرة هدرية .

hydroid هدراني (هدري)

الشكل البوليبي لأحد اللواسع ، والمتميز عن الشكل الميدوزي . أي فرد من طائفة الحيوانات الهدرية – رتبة الهيدرات (شعبة اللاسعات Cnidaria)

hydrostatic skeleton هيكل مائي

كتلة من سائل أو بارنشيما مرنة داخل جدار عضلي توفر الدعامة الضرورية للفعل العضلي المضاد ، مثل : النسيج الحشوي في اللاسيلوميات ، والسوائل الجول أحشائية في السيلوميات الكاذبة ، تعمل كهياكل هيدروستاتيكية .

hyperparasitism التطفل الفائق (فرط التطفل) (من .hyper: Gr فوق + para = بجوار + sitos = طعام)

تطفل طفيل على طفيل آخر .

hypodermis تحت البشرة (من .hypo: Gr = تحت + .dermis: L = جلد)

الطبقة الخلوية التي تقع أسفل الجليد وتفرزه ، في الحلقيات ، ومفصليات الأرجل ، وبعض اللافقاريات الأخرى .

hypostome تحتفم – مخروط فمي (من .hypo: Gr = تحت + stoma = فم)

اسم يُطلق على تركيب في عديد من اللافقاريات (مثل : الحلم ، والقراد) ، ويقع على المنطقة الخلفية ، أو البطنية للفم .

I

imago الحشرة الكاملة

الحشرة البالغة الناضجة جنسيًّا .

indeterminate cleavage التفلج غير المحدد

نوع من التكوين الجنيني لا يتحدد فيه مصير الفلجات البلاستولية مبكرًا جدًّا لتكون أنسجة وأعضاء ، على سبيل المثال : شوكيات الجلد والفقاريات ؛ التفلج المنتظم (لا حلزوني أو شعاعي) .

infraciliature تحت هدبية (من .infra: L = تحت + cilia = رموش العين)

العضيات التي تقع تحت طبقة الأهداب مباشرة في الأوليات الهدبية .

instar طور (من .L : شكل أو هيئة)

طور في حياة حشرة ، أو غيره من مفصليات الأرجل بين الانسلاخات .

integument

غطاء (من .integumentum: L = غطاء)

غطاء خارجى أو طبقة مغلّفة .

intermediate host

عائل متوسط

العائل الذى يتم فيه بعض نمو الطفيل ، ولكن لا يحدث فيه نضجه وتكاثره الجنسى (قارن بالعائل النهائى definitive) .

interstitial

بينى (من .inter: L = بين + sistere = يقف)

يقع فى المسافات بين التراكيب ، مثل الخلايا ، أو الأعضاء ، أو حبيبات الرمل .

introvert

المنسحب (من .intro: L = إلى الداخل + vertere = يلف)

الجزء الأمامى الضيق الذى يمكن سحبه إلى جذع الدودة فى شعبة السيهوبيات Sipuncula .

invagination

تغمد أو انغماد (من .in: L = فى + vagina = غمد)

انثناء طبقة من نسيج إلى الداخل لتكون تركيبًا يشبه الكيس .

inversion

انقلاب (من .invertere:L = ينقلب داخله خارجه)

ينقلب من الداخل إلى الخارج كما فى التكوين الجنينى للإسفنج ؛ أيضًا ، انقلاب فى ترتيب الجينات ، أو قطعة كروموسومية .

irritability

حساسية – انفعال (من .irritare: L = يستثير)

صفة عامة فى كل الكائنات ، تتضمن القدرة على الاستجابة للمنبهات ، أو التغيرات فى البيئة .

isogametes

أمشاج متشابهة (من .isos: Gr = يساوى + gametes = قرين)

أمشاج نوع ، يتشابه فيه الجنسان فى الحجم والمظهر .

J

juvenile hormone

هرمون الأطوار الصغيرة (هرمون الحداثة)

هرمون تنتجه الأجسام المساعدة corpora allata فى الحشرات ، ومن تأثيراته الإبقاء على صفات اليرقة أو الحورية خلال التكوين .

K

kinetodesma pl. kinetodesmata)

الرباط الحركى (من .kinein: Gr = يتحرك + desma = رباط)

ليفة تنشأ من الحبيبة القاعدية لهدب من الأوليات الهدبية ، ويمتد إلى الحبيبات القاعدية للأهداب فى نفس الصف .

kinetosome

الجسم الحركى (من .kinetos: Gr = متحرك + soma = جسم)

الحبيبة الذاتية الازدواج عند قاعدة السوط ، أو الهدب ؛ شبيه الجسم المركزى centriole ، وتسمى – أيضًا – الجسم القاعدى basal body أو blepharoplast .

kinety

المجموعة الحركية أو المحرك (من .kinein :Gr = يتحرك)

كل الأجسام والأربطة الحركية التى توجد فى صف من الأهداب .

labium **شفة سُفلى أو خلفية** (من .L : شفة)
الشفة السفلى فى الحشرات المتكونة من اتحاد الزوج الثانى من الفكوك السفلى أو الخلفية maxillae .

labrum **شفة عليا أو أمامية** (من .L : شفة)
الشفة العليا فى الحشرات والقشريات التى تقع فوق أو أمام الفكوك العليا أو الأمامية (اللحى) mandibles ، وتشير – أيضًا – إلى الشفة الخارجية لقوقعة البطنقدميات .

lamella **رقاقة – صفيحة** (من .L : تصغير **lamina** = صفيحة)
واحدة من الرقاقتين اللتين تكونان الخيشوم فى الحيوان الرخو ذى المصراعين ؛ أيضًا : واحدة من طبقات العظم الرقيقة التى تترسب – حلقيًا – حول قناة هافيرس Haversian canal ؛ أى تركيب رقيق يشبه الصفيحة .

larva (pl. larvae) **يرقة – يرقانة** (من .L: شبح)
طور غير ناضج مختلف تمامًا عن الحيوان اليافع .

lemniscus **الشريحة – الشريط** (من .L : شريط)
أحد اثنين من البروزات الداخلية للبشرة فى منطقة العنق فى الرأسشوكيات Acanthocephala ، ويتحكم فى السائل عند بروز وتغمد الخرطوم .

lopopodium **قدم كاذب فصى** (من .Gr: **lobos** = فص + **podos** = قدم)
قدم كاذب كليل فصى الشكل .

lophocyte **خلية عُرفية** (من .Gr: **lophos** = عرف + **kytos** = وعاء أجوف)
نوع من الخلايا الأميبية فى الإسفنج ، تفرز حزمًا من الليفات .

lophophore **حامل العُرف** (من .Gr: **lophos** = عرف أو خصلة + **phoros** = يحمل)
جيد أو ذراع يحمل لوامس ، يمتد فيه التجويف السيلومى ، ويوجد فى الحيوانات العُرفية (خارجيات الشرج Ectoprocta أو الحيوانات الحزازية Bryozoa ، وذراعيات الأقدام Brachiopoda والفورونيدا Phoronida)

lorica **عباءة – لوريكا**
غلاف خارجى واقٍ فى بعض الأوليات ، والعجليات ، وغيرها .

madreporite **المصفاة – المنخل** (من .Fr: **madrepore** = مرجان الشعاب + **ite** = نهاية كلمة تتعلق ببعض أجزاء الجسم .)
تركيب يشبه الغربال وهو مدخل الجهاز الوعائى المائى فى شوكيات الجلد .

malacostracan **قشرى لين الهيكل** (من .Gr: **malako** = لين + **ostracon** = قشرة)
أى فرد قشرى من طويئفة القشريات اللينة الهيكل التى تضم أنواعًا مائية وأرضية ، مثل : السرطان ، والإربيان ، والجمبرى ، وبراغيث الرمل ، وغيرها .

malpighian tubules **أنيبيات مالبيجى**
نسبة إلى مكتشفها عالم التشريح الإيطالى مارسلو مالبيجى Marcello Malpighi (١٦٢٨ – ١٦٩٤) ، وهى أنيبيات بلا فتحة خارجية ، تتصل بالمعى الخلفى لكل الحشرات تقريبًا ، وبعض عديدات الأقدام Myriapoda ، والعنكبيات ، وتعمل أساسًا كأعضاء إخراجية .

mantle

برنس – عباءة – رداء

امتداد لين من جدار الجسم فى بعض اللافقاريات ، مثل : ذراعيات الأقدام ، والرخويات ، يفرز فى العادة صدفة ، وجدار الجسم الرقيق فى القربيات أو الزقيات tunicates .

mastax

بلعوم فكى (من .Gr : فكوك)

الطاحونة البلعومية فى العجليات (الدوارات rotifers)

maxilla

فك علوى أو خلفى (من .L – تصغير mala – فك)

الفك العلوى فى الفقاريات ، وإحدى زوائد الرأس (الفك الخلفى) فى مفصليات الأرجل .

maxilliped

رجل فكية (من .L: maxilla = فك + pes = قدم)

أحد أزواج الزوائد فى رأس القشريات ، ويقع مباشرة خلف الفك الخلفى ، أو طرف صدرى يندمج ضمن أجزاء الفم المختلفة .

ميدوسا – ميدوزا (من .Gr : فى الأساطير الإغريقية هى أنثى التنين المزودة بشعرة ثعبانية ملفوفة)

قنديل البحر Jellyfish ، أو الطور الحر فى دورة حياة اللاسعات .

Mehlis' gland

غدة ميلس

غدد ذات وظيفة غير مؤكدة ، تحيط بمباض ootype ديدان التريماتودا ، والديدان الشريطية .

meiofauna

الفونا الدقيقة – مجموعة الحيوانات الدقيقة (من .Gr: meion – أصغر + .L: faunus = إله الغابات)

اللافقاريات الصغيرة التى توجد بين حبيبات الرمل .

merozoite

ميروزويت (من .Gr: meros = جزء + zoon = حيوان)

تروفوزويت صغير جدًا فى الطور الذى يلى مباشرة الانقسام العديد فى الأوليات .

mesenchyme

نسيج حشوى (**ميزنكيم**) (من .Gr: meso = متوسط + enchyma = تشرّب)

النسيج الضام الجنينى ، خلايا غير منتظمة ، أو أميبية ، مطمورة فى مادة هلامية .

mesocoel

السيلوم الأوسط (من .Gr: mesos = متوسط + koilos = أجوف)

الحجرة السيلومية للجسم الأوسط فى بعض ثانويات الفم deuterostomes ، وهى الأمامية فى العرفيات lophophorates ، وتقابل السيلوم المائى فى شوكيات الجلد .

mesoglea

ميزوجليا (**الرقاقة الداعمة – الغرالية الوسيطة**) (من .Gr: mesos – متوسط + glia = صمغ)

طبقة المادة الهلامية ، أو اللاصقة ، بين البشرة والأدمة المعدية فى الجوفمعويات . وقد تشير – أيضًا – إلى المادة الهلامية بين الطبقات الطلائية فى الإسفنجيات .

mesohyl

الهلام المحيط (من .Gr: mesos = متوسط + hyle = غابة)

مادة هلامية تحيط بخلايا الإسفنج ؛ ميزوجليا ، نسيج حشوى .

metacercaria

ميتاسركاريا (**سركاريا متحوصلة**) (من .Gr: meta = بعد + kerkos = ذيل + .L: aria = متصل بـ)

صغير الوشائع (سركاريا) الذى فقد ذيله وتحوصل .

metacoel

السيلوم الخلفى (من .Gr: meta = بعد + koilos = أجوف)

الحجرة السيلومية الخلفية فى بعض ثانويات الفم ، والعُرفيات ، وهو يقابل سيلوم الجسم somatocoel فى شوكيات الجلد .

metamere

قطعة – عقلة متكررة (من meta: Gr. = بعد + meros = جزء)

وحدة جسمية متكررة على امتداد المحور الطولى لحيوان ؛ أو عقلة أو قطعة

metamerism

تعقيل تكرارى (من meta: Gr. = بعد أو بين + meros = جزء)

الحالة التى يتكون فيها الحيوان من قطع متكررة تسلسليًّا (metameres) ؛ التعقيل التسلسلى .

metamorphosis

تحور – تحول (من meta: Gr. = بعد + morphe = هيئة أو شكل + osis = حالة)

تغير حاد فى الشكل أثناء التكوين بعد الجنينى ، مثل تحول أبى ذنيبة إلى ضفدع ، وتحول يرقة الحشرة إلى الطور اليافع .

metanephridium

نفريدة بعدية (متقدمة) (من meta: Gr. = بعد + nephros = كلية)

نوع من النفريدات الأنبوبية ، له فتحة داخلية ، تتصل بالسيلوم ، وخارجية تطرد إلى الخارج .

microneme

خيط رقيق (من mikros: Gr. = صغير + nema = خيط)

أحد أنواع التراكيب التى تكون المركّب القمى apical complex فى شعبة البوغيات Apicomplexa ، وهو رفيع وطويل ويمتد إلى الأمام ، ويظن أنه يعمل على اختراق خلايا العائل .

micronucleus

نواة صغيرة

توجد فى الأوليات الهدبية ، وتتحكم فى الوظائف التناسلية لهذه الكائنات .

microthrix (pl. microtriches)

شعيرة دقيقة (من mikros: Gr. = صغير + thrix = شعيرة)

تركيب الخملة الدقيقة على سطح جلد الدودة الشريطية .

microtubule

أنيبية دقيقة (من mikros: Gr. = صغير + tubule: L. = أنبوبية)

جزء أنبوبى طويل هيكلى خلوى ، قطره الخارجى يتراوح بين ٢٠ و ٢٧ ميكرون . وتؤثر على شكل الخلية ، وتلعب أدوارًا مهمة خلال الانقسام الخلوى .

mictic

خلطية ، مكتية ، قابلة للاختلاط والتفلج (من miktos: Gr. = مختلط أو يمتزج)

يتعلق ببويضات العجليات rotifers ، والتى تحتوى على العدد الفردى من الكروموسومات (الصبغيات) ، أو الإناث التى تضع هذا النوع من البويضات .

miracidium

ميراسيديوم (من meirakidion: Gr. = شخص ممتلئ شبابًا)

طور يرقى مهدب صغير فى حياة ديدان التريماتودا .

monoecious

أحادى المسكن – خنثى (من monos: Gr. = وحيد + oikos = مسكن)

يحتوى على كل من المناسل الذكرية والأنثوية .

monophyletic

أحادى الأصل (من monos: Gr. = وحيد + phyletikos = يتعلق بشعبة)

يشير إلى مجموعة نشأت كل وحداتها من أصل واحد مشترك ؛ قابل مع متعدد الأصول polyphyletic .

monozoic

وحيد الأسلة – ذو جسم غير مقسم (من monos: Gr. = وحيد + zoon = حيوان)

ديدان شريطية ، تتكون من أسلة واحدة ، ولا تجرى عملية تبرعم لتكوين سلسلة من الأسلات .

mosaic cleavage

التفلج الفسيفسائى (الموزايكى)

نوع من الانقسام ، يتصف بالتميز المستقل الذاتى لكل جزء من الجنين ؛ التفلج المحدد determinate .

Müller's larva

يرقة ميلر

يرقة مهدبة حرة السباحة ، تشبه المشطيات المحورة ، وتتميز بها بعض الدواميات البحرية المتشعبة المعى polyclad turbellarians

N

nacre **أم اللؤلؤ**

الطبقة الداخلية اللامعة فى صدفة الرخويات ، وتفرزها طلائية البرنس (الصفة : لؤلؤى **nacreous**) .

nauplius **يرقة نوبليس**

طور يرق مجهرى ، حر السباحة ، فى بعض القشريات ، ويتميز بوجود ثلاثة أزواج من الأطراف (قرنى استشعار أوليين ، وقرنى استشعار ثانيين ولحيين) ، وعين فى الوسط . وهذه اليرقة مميزة للقشريات الصدفية ostracods ، ومجدافيات الأرجل copepods ، والأطلومات barnacles ، وغيرها .

nematocyst **كيس اللسع** (من .Gr **nema:** = خيط + **kystis** = مثانة ، حويصلة)

عُضَى اللسع فى اللواسع cnidarians .

nephridium **نفريدة – كلية** (من **nephridios** = ينتسب إلى الكلية)

إحدى الأنيبيات الإخراجية المرتبة – عُقليًا – فى بعض اللافقاريات وبالذات الحلقيات ؛ وبصورة أعم – أى أنيبية مخصصة للإخراج أو التنظيم الأسموزى أو كليهما ؛ وهى ذات فتحة خارجية ، وذات فتحة داخلية ، أو بدونها .

neuropodium **فص القَديمة العصبى** (من .L **neuron:** = عصب + **pous, podos** = قدم)

فص القديمة الأقرب للناحية البطنية فى الحلقيات العديدة الأهلاب .

notopodium **فص القَديمة الظهرى** (من .L **notos:** = ظهر + **podos, pous** = قدم)

فص القديمة الأقرب للناحية الظهرية فى الحلقيات العديدة الأهلاب .

nuptial flight **رحلة العرس (طيران التزاوج)**

رحلة التزاوج فى الحشرات ، خاصة رحلة الملكة ومعها ذكر أو أكثر .

nymph **حُورِيّة** (من .L **nympha:** = عروس)

طور غير ناضج (يلى الفقس) لحشرة نصفية التحول ، لا تمر بطور العذراء .

O

ocellus **عُيينة – عين بسيطة** (من .L تصغير **oculus** = عين)

عين بسيطة أو بقعة عينية فى أنواع كثير من اللافقاريات .

octomerous **ثمانى التماثل** (من .Gr **oct:** = ثمانية + **meros** = جزء)

تماثل ثمانى الأجزاء .

ommatidium **عيينة – وحدة بصرية** (من .Gr **omma:** = عين + **idium** = صغير)

إحدى الوحدات البصرية فى العين المركبة لمفصليات الأرجل .

oncomiracidium **ميراسيديم خطاف او شوكى** (من .Gr **onkos:** = خطاف – شوكة + **meirakidion** = ممتلئ شبابًا) .

يرقة مهدبة لديدان التريماتودا الوحيدة العائل **Monogenea** .

oocyst **الكيس البيضى – أو أسست – حويصلة الاقتران** (من .Gr **oion:** = بيضة + **kystis** = مثانة)

كيس يحيط بزيجوت طفيل الملاريا وأشباهه .

ooecium **مسكن البويضة** (من .oion: Gr = بيضة + oikos = مسكن + .ium: L = للتصغير)
كيس الحضانة ؛ حجرة لتكوين الأجنة في خارجيات الشرج ectoprocts .

oogonium **مولّدة البيض** (من .oion: Gr = بيضة + gonos = صغار)
خلية بانقسامها المستمر ، تنتج خلايا بيضية ، بويضة في حويصلة أولية قبل النضج مباشرة .

ookinete **بويضة متحركة – أأكينيت** (من .oion: Gr.Gr = بيضة + kinein = يتحرك)
الزيجوت المتحرك في طفيل الملاريا .

ootype (oogenotop) **مبياض** (من .oion: Gr بيض + typos = قالب)
جزء من قناة البيض في الديدان المفلطحة ، والتي تستقبل قنوات الغدد المحية ، وغدد ميلس Mehlis .

operculum **غطاء – غطاء خيشومي** (من .L :. = غطاء)
صفيحة قرنية في بعض القواقع ؛ غطاء الخياشيم الأسماك العظمية .

opisthaptor **ممص خلفي** (من .opisthen: Gr = خلف + haptein = يثبت)
عضو الالتصاق الخلفي في دودة مفلطحة وحيدة العائل monogenetic trematode .

opisthosoma **الجسم الخلفي** (من .opisthe: Gr = خلف + soma = جسم)
المنطقة الخلفية من الجسم في العنكبيات والملتحيات pogonophorans .

organelle **عُضَيّ** (من .organon: Gr = عضو + من .ella: L = للتصغير)
جزء متخصص في خلية ؛ حرفيًا – عضو صغير يؤدي وظائف مماثلة لأعضاء الحيوانات العديدة الخلايا.

osphradium **الباقة الشمية** (من .osphradion: Gr = باقة صغيرة ، تصغير osphra = شم)
عضو حسي في القواقع والأصداف المائية ، لاختبار الماء الداخل .

ossicles **عظيمات** (من .ossiculum: L = عظم صغير)
قطع منفصلة صغيرة في الهيكل الداخلي لشوكيات الجلد ؛ أيضًا ، العظيمات الدقيقة في الأذن الوسطى للفقاريات .

otolith **حُصية سمعية** (من .otos: Gr = أذن + lithos = حجر ، حصاة)
عضو السمع في بعض اللافقاريات ؛ أو تراكمات كلسية في التيه الغشائي في الأذن الداخلية للفقاريات الدنيا .

oviger **حامل البيض** (من .ovum: L = بيضة + gerere = يحمل)
تطلق على القدم الذي يحمل البيض في البكنوجونيدا Pycnogonida .

ovipositor **واضع البيض** (من .ovum: L بيضة + positor = باني ، واضع)
تركيب في نهاية بطن كثير من إناث الحشرات لوضع البيض .

P

paedogenesis (progenesis) **تناسل الصغار** (من .pais: Gr = طفل + genes = مولود)
تكاثر بواسطة حيوانات غير ناضجة أو يرقية ، يتم تعجيل نضجها .

pallium **برنس – عباءة** (من .mantle: L)
برنس الرخويات ، وذراعيات الأقدام .

papula **بثرة – حلمة** (من .pimple: L = بثرة)
زائدة تنفسية على جلد نجوم البحر ؛ أيضًا ، دمامل على الجلد .

parapodium — **قديمة – نظير قدم – شبه قدم** (من .Gr: **para** = بجانب + **podos** = قدم)

إحدى الزوائد الجانبية المزدوجة – على كل جانب – على معظم حلقات عديدات الأهلاب polychaete annelids ، وتتحور للحركة ، أو التنفس ، أو التغذية .

parasitism — **تطفل** (من .Gr من :**parasitos** ، **para** = بجانب + **sitos** = طعام)

حالة كائن يعيش على أو فى كائن آخر (عائل) ، والذى يضمن الطفيل حياته على حسابه ؛ التعايش الهدمى destructive symbiosis .

parenchyma — **بارنشيما – نسيج حشوى**

فى الحيوانات الدُّنيا ، كتلة إسفنجية من الخلايا الحشوية ذات التجاويف ، تملأ المسافات بين الأحشاء والعضلات ، أو الأنسجة الطلائية . فى بعض الحيوانات ، تكون هى الأجسام الخلوية للخلايا العضلية . أيضًا ، النسيج المتخصص لعضو ، والذى يتميز عن النسيج الضام الدعامى .

parenchymula — **يرقة بارنكميولا** (من .Gr: **para** = بجانب + **enchyma** = نقع)

يرقة مصمتة مهدبة لبعض الإسفنجيات .

parthenogenesis — **التوالد البكرى أو العذرى** (من .Gr: **parthenos** = عذراء + .L ؛ عن .Gr : **genesis** = تكوين)

تكاثر أحادى الجنس ، يتضمن إنتاج صغار بدون تلقيح من الذكور ، وهو شائع فى العجليات ، ومتفرعات القرون ، والمن ، والنمل ، والزنابير . وقد تحتوى البيضة المتوالدة – عذريًا – على عدد زوجى أو أحادى من الكروموسومات .

pectines (pl. **of pecten** — **أمشـــاط**

زوائد حسية على بطن العقارب .

pedicel — **خصر** (من .Gr: **pediculus** = قدم صغيرة)

عنق أو ساق صغيرة أو قصيرة . فى الحشرات ، هى العقلة الثانية فى قرن الاستشعار ، أو خصر النملة . فى العناكب ، يصل الخصر بين الجسمين الأمامى والخلفى .

pedicellaria — **ملاقط** (من .L: **pediculus** = قدم صغيرة + **aria** = يتصل بـ)

أحد الأعضاء الملقطية الدقيقة الكثيرة التى تنتشر على سطح بعض شوكيات الجلد .

pedipalps — **أقدام ملماسية أو لامسة** (من .L: **pedis, pes** = قدم + **palpus** = ربت ، ملاطفة ، عناق)

الزوج الثانى من الزوائد فى العنكبيات .

pellicle — **قشيرة** (من .Gr: **pellicula** ، تصغير **pellis** = جلد)

غلاف رقيق شفاف ، يغطى الكثير من الحيوانات الأولية التى تفرزه .

periostracum — **قشرة الصدفة** (من .Gr: **peri** = حول + **ostracon** = صدفة)

الطبقة القرنية الخارجية لقشرة أو صدفة الرخويات .

periproct — **حول إست – حوقة الشرج** (من .Gr: **peri** = حول + **proktos** = إست ، شرج)

تُطلق على منطقة الصفائح اللافمية حول الإست فى قنافذ البحر .

perisarc — **حوق الساق – غلاف الجسم** (من .Gr: **peri** = حول + **sarx** = لحم)

peristomium — **حولفم** (من .Gr: **peri** = حول + **stoma** = فم)

الحلقة الأمامية فى دودة حلقية ؛ وهى التى تحمل الفم .

podium **قديمة – قدم أنبوبى** (من .Gr: podos, pous = قدم)

تركيب يشبه القدم ، كالأقدام الأنبوبية فى شوكيات الجلد .

Polian vesicles **حويصلات بولى** (سُميت باسم مكتشفها العالم الطبيعى الإيطالى G.S.Poli)

حويصلات تفتح فى القناة الدائرية فى معظم نجوم البحر ، وخيار البحر ، فى الجهاز الوعائى المائى .

polyp **بوليب** (من .Fr: polype = أخطبوط ، ومن .L: polypus = عديد الأقدام)

الطور الجالس فى دورة حياة اللاسعات .

polyphyletic **متعدد الأصول** (من .Gr: polys = عديد + phylon = قبيلة)

ينحدر من أكثر من أصل سلفى واحد عكس وحيد الأصل .

polypide **بوليبد** (من .L: polypus = عديد الأقدام)

فرد أو حوين فى مستعمرة خاصة فى خارجيات الشرج ectoprocts ، وهو ذو عرف ، وقناة هضمية ، وعضلات ، ومراكز عصبية .

polyzoic **متعدد الأسلات أو الأفراد** (من .L: polys = عديد + zoon = حيوان)

دودة شريطية ذات متخرطة strobila ، تتكون من بعض إلى عديد من الإسلات ؛ – أيضًا ، مستعمرة مكونة من حوينات كثيرة .

proboscis **خرطوم** (من .L: pro = أمام + boskein = يتغذى)

بوز أو جذع ؛ أيضًا عضو أنبوبى خاص ، أو عضو ينتهى وينثنى بالفم كما فى الدواميات ، والعلقيات ، والحشرات ، وأيضًا العضو الحسى ، أو الدفاعى عند الطرف الأمامى لبعض اللافقاريات .

proglottid **أسلة** (من .Gr: proglottis = طرف اللسان)

جزء من دودة شريطية (أسلة) ، يحتوى على مجموعة من الأعضاء التناسلية ، تقابل عادة القطعة segment .

prokaryotic, procaryotic **بدائى النواة** (من .Gr: pro = قبل + karyon = لب ، نواة)

كائن لا يحد نواته أو أنويته أغشية . الخلايا ذات الأنوية البدائية أدنى من الخلايا كاملة أو حقيقية الأنوية eukaryotic وتمثلها البكتيريا والسيانوبكتيريا .

prosoma **الجسم الأمامى** (من .Gr: pro = أمام + soma = جسم)

الجزء الأمامى فى حيوان لافقارى لا يظهر فيه التعقيل ؛ الرأس والصدر المندمجان لإحدى مفصليات الأرجل ؛ الرأسصدر .

prosopyle **ثقب خارجى** (من .Gr: proso = أمامى + pyle = بوابة)

ثقوب توصل بين القنوات الشهيقية والشعاعية فى بعض الإسفنجيات .

prostomium **قبلفم** (من .Gr: pro = أمام + stoma = فم)

جزء الرأس الذى يقع أمام الفم فى معظم الحلقيات وبعض الرخويات .

prothoracic glands **غدد الصدر الأمامى**

غدد توجد فى الصدر الأمامى للحشرات ، وتفرز هرمون الانسلاخ ecdysone .

prothoracicotropic hormone **الهرمون المحفز لإفراز غدة الصدر الأمامى**

(انظر : ecdysiotropin) .

protist **بروتست (كائن أولى)** (من .Gr ‏protos: = أول)

عضو فى مملكة البروتستا Protista ، والتى تضم الكائنات الوحيدة الخلية من ذوات النواة الحقيقية (وتشمل الحيوانات الأولية والطحالب وذوات النواة الحقيقية) .

protocoel **السيلوم الأمامى** (من .Gr ‏protos: = أول + koilos = مجوف)

الحجرة السيلومية الأمامية فى بعض ثانويات الفم (deuterostomes) ؛ يقابل السيلوم المحورى فى شوكيات الجلد .

protonephridium **نفريدة (كلية) أولية** (من .Gr ‏protos: = أول + nephros = كلية)

عضو تنظيم أزموزى أو إخراجى بدائى ، يتكون من أنيبيبة تنتهى داخليًا بيصيلة لهبية ، أو خلية أنبوبية ؛ وحدة جهاز البصيلات اللهبية .

protopod, protopodite **جذع القدم أو الشدفة الأولية** (من .Gr ‏protos: = أول + podos, pous = قدم)

القطعة القاعدية فى زائدة الحيوان القشرى ، وتتكون من الحرقفة والقاعدة .

Protostomia **أوليات الفم** (من .Gr ‏protos: = أول + stoma = فم)

سـرعه من الشعب يكون فيها التفلج محددا ، وينشأ السيلوم (فى الأنواع السيلومية) بانقسام الشرائط الميزودرمية (سيلوم انشقاقى) وينشأ الميزودرم من فلجة معينة تسمى ٤ د (4d) ، ويشتق الفم من أو قرب ثقب البلاستولة ؛ تشمل : الحلقيات ، ومفصليات الأرجل ، والرخويات ، وعددًا من الشعب الصغيرة . قارن مع ثانويات الفم .

proventriculus **المعدة الأمامية الهضمية** (من .L ‏pro: = أمام + ventriculum = بطين)

المعدة الغدية فى الطيور بين الحوصلة والقانصة . فى الحشرات : انتفاخ عضلى للمعى الأمامى مسلح داخليًا بأسنان كيتينية .

pseudocoel **سيلوم كاذب** (من .Gr ‏pseudes: = زائف + koiloma = تجويف)

تجويف جسم لا يبطنه البريتون ، ولا يكون جزءًا من الأجهزة الدموية أو الهضمية : ينشأ فى الجنين من تجويف البلاستولة .

pseudopodium **قدم كاذب** (من .Gr ‏pseudes: = زائف + podion = قدم صغير + eidos = هيئة ، شكل)

بروز سيتوبلازمى مؤقت ، يمتد من حيوان أولى أو خلية أميبية ، ويستخدم فى الحركة أو احتواء الطعام .

pupa **عذراء** (من .L : بنت ، دمية ، عروسة)

طور ساكن غير نشط لحشرة كاملة التحور ، ويلى الأطوار اليرقية ، ويسبق الطور اليافع

Q

queen **ملكة**

فى علم الحشرات ، الأنثى كاملة النمو ، الوحيدة فى مستعمرة للحشرات الاجتماعية : كالنحل ، والنمل ، والترميتات ، وتتميز عن الشغالة ، والإناث غير المتناسلة ، والجنود .

R

radula **سفن – مفتات** (من .L : مبشرة ، مكشط)

لسان مسنن فى معظم الرخويات .

redia

ريديا (نسبة إلى **Redi** ، وهو عالم الأحياء الإيطالى)
طور يرق فى دورة حياة الوشائع ؛ ينشأ من يرقة الكيس الجرثومى sporocyst ، وبدوره ينتج عددًا كبيرًا من السركاريات .

rhabdite

عصا – قضيب (من .Gr **rhabdos:** = قضيب)
تراكيب عصوية فى خلايا البشرة ، أو البرانشيما التى تقع تحتها ، فى بعض الدوامات **Turbellaria** ، وتطلق ضمن إفرازات مخاطية .

rhopalium

عصاة حسية – حويصلة لامسية (**من** .L : من .Gr **rhopalon:** = عصا صولجانية)
أحد أعضاء الحس التى توجد على حافة بعض قناديل البحر ؛ حويصلة لامسية **tentaculocyst** .

rhoptries

عصى قمية (من .Gr **rhopalon:** = عصاة غليظة النهاية + **trys** = يحك ، يبلى)
أجسام توجد فى التركيب القمى للبوغيات ؛ وهى مفتوحة الطرف الأمامى ، ويبدو أنها تخترق خلايا العائل .

rhynchocoel

تجويف الخرطوم (من .Gr **rhynchos:** = بوز + **koilos** = أجوف)
التجويف الأنبوبى الظهرى ، فى الديدان الخرطومية **nemerteans** ، الذى يحتوى على الخرطوم المقلوب وليس له فتحة إلى الخارج .

rostellum

منقار – بوز (**من** .L : منقار صغير)
تركيب بارز على رأس الدودة الشريطية ، وغالبًا ما يحمل خطاطيف .

rostrum

بوز (من .L : بوز السفينة)
بروز يشبه البوز على الرأس .

S

Schizocoel

سيلوم انشقاق (من .Gr **schizo:** من **schizein** = ينشق + **koiloma** = تجويف)
سيلوم ينشأ بانشقاق الميزودرم الجنينى ؛ الاسم • schizocoelomate ، يطلق على الحيوانات ذات السيلوم الانشقاقى ؛ مثل : مفصليات الأرجل ، والرخويات .

schizocoelous mesoderm formation

تكوين ميزودرم بالانشقاق السيلومى
تكوين جنينى للميزودرم ، كحبال من الخلايا بين الإكتودرم والإندروم ، ويؤدى انشقاق تلك الحبال إلى تكوين التجويف السيلومى .

schizogony

انشقاق (من .Gr **schizein:** = ينشق + **gonos** = بذرة)
انقسام لاجنسى متعدد .

sclerite

صفيحة صلبة (هيكلية) (من .Gr **skleros:** = صلب)
صفيحة أو شوكة كيتينية ، أو كلسية صلبة ؛ إحدى الصفائح التى تكون الهيكل الخارجى لمفصليات الأرجل خاصة الحشرات .

scleroblast

خلية هيكلية (من .Gr **skleros:** = صلب + **blastos** = جرثومة)
خلية أميبية متخصصة لإفراز شوكة ، وتوجد فى الإسفنجيات .

scolex

رأس صغير – رؤيس (من .Gr **skolex:** = دودة ، يرقة دودية)
عضو التثبيت ، أو مايسمى بالرأس ، فى الديدان الشريطية ؛ يحمل ممصات وفى البعض خطاطيف ، وإلى الخلف منه ، تتميز الأسلات الجديدة .

scyphistoma **الفنجالة – الأنبوبة الهدرية** (من .skyphos: Gr = فنجان + stoma = فم)

طور فى تكوين قناديل البحر الفنجانية ، يتكون مباشرة بعد أن تصير اليرقة مثبتة ، وهى الشكل البوليبى فى قنديل البحر .

serial homology **المضاهاة المتسلسلة أو المتتابعة**

(انظر homology = مضاهاة)

seta (pl. setae) **شوكة** (من .L = إبرة – شوكة)

تركيب كيتينى إبرى الشكل ، ويوجد على جلد الحلقيات ، ومفصليات الأرجل ، وغيرها .

sinistral **يسارى** (من .sinister: L = يسار)

يتعلق باليسار ؛ فى بطنية القدم تكون القوقعة يسارية إذا كانت تفتح إلى يسار العُميد columella عندما تمسك فى مواجهة المشاهد ، وقمة الحلزون إلى أعلى .

المشاهد ، وقمة الحلزون إلى أعلى .

siphonoglyph **الميزاب المهدب – المجرى المريئى** (من .siphon: Gr = قصبة ، أنبوبة + glyphe = نحت)

ميزاب مهدب فى بلعوم شقائق النعمان sea anemones .

siphuncle **أنبوب صغير** (من .siphunculus: Gr = أنبوب صغير)

حبل من النسيج ، يخترق صدفة نوتيلس وأشباهها ، حيث تصل كل الغرف بجسم الحيوان .

solenocyte **خلية أنبوبية** (من .Solen: Gr = أنبوبة + kytos = وعاء أجوف)

طراز خاص من البصيلات اللهبية تحمل فيه البصيلة سوطًا بدلاً من خصلة الأهداب . انظر البصيلة اللهبية flame bulb ، النفريدة الأولية protonephridium .

somatocoel **السيلوم الجسمى** (من .soma: Gr = جسم + koilos = جسم)

أحد أزواج الكيسين اللذين يكونا السيلوم الرئيسى لجسم الجلد شوكيات .

spermatheca **مستودع منوى** (من .sperma: Gr = بذرة + theke = محفظة)

كيس يوجد فى الأعضاء التناسلية الأنثوية لاستقبال وخزن الحيوانات المنوية .

spermatophore **حزمة منوية – حامل المنى** (من .spermatos, sperma: Gr = بذرة + pherein = يحمل)

محفظة أو لفافة تحتوى على الحيوانات المنوية التى تكونها الذكور فى عديد من المجموعات اللافقارية وقليل من الفقاريات .

spicule **شوكة** (من .L : تصغير spica = قمة ، نقطة)

أحد الأجسام الهيكلية الكلسية ، أو الرملية الدقيقة التى توجد فى الإسفنجيات ، والأوليات الشعاعية ، والمراجين اللينة ، وخيار البحر .

spiracle **ثقب تنفسى** (من .spiraculum: L من spirare = يتنفس)

الفتحة الخارجية للقصبية الهوائية فى مفصليات الأرجل ؛ أحد أزواج الفتحات التى توجد على رأس الأسماك الغضروفية الصلبة الخياشيم (elasmobranchs) لمرور الماء . الفتحة الزفيرية للغرفة الخيشومية لأبى ذنيبة .

spiral cleavage **التفلج الحلزونى**

طراز من التفلج الجنينى المبكر ، حيث تكون فيه مستويات الانقسام مائلة بالنسبة للمحور القطبى ، وتنتج خلايا غير متساوية بالتفلج اليمينى واليسارى المتبادل حول المحور القطبى ؛ التفلج المحدد determinate .

spongin **إسفنجين**

* مادة ليفية كولاجينية تكون الشبكة الهيكلية فى الإسفنجيات القرنية ؛

spongioblast **خلية أسفنجية** (من .spongos: Gr = إسفنج + blastos = برعم)

خلية فى الإسفنج تفرز الإسفنجين ، وهى مادة بروتينية .

spongocoel **تجويف إسفنجى** (من .spongos: Gr = إسفنج + koilos = أجوف)

التجويف المركزى فى الإسفنجيات .

sporocyst **كيس بوغى أو جرثومى** (من .sporos: Gr = بذرة + kystis = كيس)

طور يرقى فى دورة حياة الوشائع ؛ وينشأ من الميراسيديم .

sporogony **تكوين الأبواغ أو الجراثيم** (من .sporos: Gr = بذرة + gonos = ميلاد)

انقسام عديد لإنتاج الحوينات الجرثومية بعد تكوين الزيجوت .

sporozoite **حوين بوغى أو جرثومى – سبوروزويت** (من .sporos: Gr = بذرة + zoon = حيوان)

طور فى دورة حياة كثير من الحيوانات الأولية الجرثومية ، ويخرج من الأكياس البيضية (أوسيست oocyst)

statoblast **حويصلة جنينية** (من .statos: Gr = قائم ، مثبت + blastos = جرثومة)

محفظة محدبة الوجهين ، تحتوى على خلايا جنينية ، تنتجها معظم خارجيات الشرج ectoprocts التى تعيش فى المياه العذبة بالتبرعم اللاجنسى ، وهى تكون الأفراد الجديدة بحلول الظروف الملائمة .

statocyst **حوصلة التوازن** (من .statos: Gr = قائم + kystis = مثانة)

عضو حسى للتوازن ؛ حوصلة خلوية ممتلئة بسائل يحتوى على واحدة أو أكثر من الحبيبات (حصى التوازن statoliths) تستخدم فى تحديد اتجاه الجاذبية .

statolith حُصية أو حصاة (حجر) اتزان (من .statos: Gr = قائم + lithos = حصاة)

جسم كلسى صغير يستند على خصلات من الأهداب فى حوصلة التوازن .

stereogastrula **جاسترولة مصمتة** (من .stereos: Gr = مصمت + gaster = معدة + .ula: L = للتصغير)

طراز مصمت من الجاسترولة مثل بلانيولا اللاسعات .

sternum **قص – سترنة** (من .L : عظمة الصدر)

الصفيحة البطنية لعقلة الجسم فى مفصليات الأرجل ؛ عظمة الصدر فى الفقاريات .

stigma **بقعة عينية** (من L = علامة أو وشم)

بقعة عينية فى بعض الأوليات . الثقب التنفسى فى بعض مفصليات الأرجل الأرضية .

stolon **جذر أو ساق زاحفة** (من .stolo: L = ساق أو ممص نبات)

امتداد يشبه الجذر فى جدار الجسم ، يعطى براعم يمكن أن تنمو إلى أفراد جديدة ، وبالتالى يكون حيوانًا مركبًا ، تبقى فيه الحوينات متحدة بواسطة الجذر ؛ يوجد فى بعض اللاسعات الزهرية والهدرية ، وخارجيات الشرج ectoprocts ، (الزقيات) ascidians .

strobila **المتخرطة** (من .strobile: Gr = سدادة من النسيج تشبه مخروط الصنوبر)

طور فى تكوين قنديل البحر الفنجانى ؛ أيضًا ، سلسلة الأسلات فى الدودة الشريطية .

sycon **سيكونى** (من .sykon: Gr = تينة)

طراز من جهاز القنوات فى بعض الإسفنجيات ، ويطلق عليه أحيانًا syconoid .

مدمج خلوى (من .syn: Gr = مع + kytos = وعاء أجوف) **syncytium**

كتلة بروتوبلازمية تحتوى على أنوية عديدة ، غير مقسمة إلى خلايا .

التزاوج باتحاد الأمشاج (من .syn: Gr مع +gamos = زواج) **syngamy**

تلقيح مشيجة بمشيجة فرد آخر لتكون زيجوتًا ، يوجد فى معظم الحيوانات ذوات التكاثر الجنسى .

النواة الزيجوتية (من .syn: Gr = مع + karyon = نواة) **synkaryon**

نواة الزيجوت الناتجة من اندماج الأنوية الأولية .

علم التصنيف التطورى **systematics**

علم التقسيم والبيولوجيا التطورية .

T

ترتيب – تصنيف **tagma pl. tagmata)**

أحد قطاعات الجسم المركبة فى أحد الحيوانات القشرية ، التى تنشأ من الاتحاد الجنينى لعقلتين أو أكثر ؛ مثل : الرأس ، والصدر ، والجسم .

علم التصنيف (من .taxis: Gr = ترتيب + nomos = قانون) **taxonomy**

دراسة مبادئ التقسيم العلمى ؛ الترتيب التصنيفى وتسمية الكائنات .

غلاف سقفى **tectum**

تركيب يشبه السقف مثل الجزء الظهرى للرؤيس فى الفاش والقراد .

جلد – إهاب – غطاء (من .tentaculum: L من tegere = يغطى) **tegument**

جلد ، وبالتحديد الغطاء الخارجى فى الديدان الشريطية ، والتريماتودا ، والذى كان يعتقد – سابقًا – أنه جليد cuticle .

ذويل (من .L : طرف – نهاية) **telson**

بروز فى نهاية حلقات الجسم فى كثير من القشريات .

حويصلة لامسية (من .tentaculum: L = لامسة + .kystis: Gr = كيس) **tentaculocyst**

أحد الأعضاء الحسية التى تنتشر على حافة الميدوسات ؛ عصاة حسية rhopalium .

صفيحة ظهرية – ترجة (من .L : ظهر) **tergum**

الجزء الظهرى من عقلة الجسم فى مفصليات الأرجل .

أجسام تيدمان (نسبة إلى عالم التشريح الألمانى) **Tiedemann's bodies**

أربعة أو خمسة أزواج من الأجسام الكيسية الشكل الملحقة بالقناة الدائرية فى نجوم البحر ، ووظيفتها كما يبدو هى إنتاج الخلايا السيلومية .

ظاهرة الالتواء (الالتفاف) (من .L : يلوى ، يلتف) **torsion**

ظاهرة تحدث فى تكوين بطنية الأقدام التى تغير وضع الأعضاء الحشوية والبرنسية ١٨٠ درجة .

حويصلة سمية (من .toxikon: Gr = سم + kystis = مثانة) **toxicyst**

تراكيب فى الأوليات الهدبية المفترسة ، تطلق عند استثارتها سمًّا لإخضاع الفريسة .

القصبة التنفسية **trachea**

القصبة الهوائية فى الفقاريات العليا ؛ وأيضًا ، أى من الأنابيب الهوائية للحشرات .

vector **حامل أو ناقل الطفيل** (من .L : حامل ، ناقل ؛ vectem = يحمل)

أى عامل وسيط يحمل وينقل الأطوار المسببة للمرض من عائل إلى آخر .

veliger **المرقعة** (من .velum: L = برقع)

الطور اليرق لبعض الرخويات ، ينشأ من يرقة مطوقة ، ويحمل بدايات القدم ، والبرنس ، والقشرة ، وهكذا .

velum **برقع** (من .veil: L = غطاء)

غشاء يوجد على باطن المظلة فى ميدوسة الهدريات ؛ أيضًا ، عضو السباحة المهدب فى اليرقة المبرقعة .

vitellaria **الغدد المحية** (من .vitellus: L = مح البيضة)

تراكيب توجد فى عديد من الديدان المفلطحة ، وتنتج الخلايا المحية ، وهى توفر المادة التى تتكون منها قشرة البيضة ، والمواد الغذائية اللازمة للجنين .

X

X- organ **عضو إكس**

عضو عصبى إفرازى فى عنق عين القشريات ، يفرز هرمونًا مثبطًا للانسلاخ .

Y

Y-organ **عضو واى**

غدة فى العقلة القرنية ، أو الفكية ، فى بعض القشريات ، تفرز هرمون الانسلاخ .

Z

zoecium, zooecium **مسكن الحيوان** (من .zoon: Gr = حيوان + oikos = مسكن)

الغلاف أو القشرة الجُليدية فى خارجيات الشرج .

zoochlorella **طحلب زوكلوريللا** (من .zoon: Gr = حيوان ، حياة + chlorella)

أحد الطحالب الخضراء الدقيقة (عادة كلوريللا Chlorella) التى تعيش تكافليًا فى بعض الأوليات ، واللافقاريات الأخرى .

zooid **حوين** (من .zoon: Gr = حياة)

أحد الأفراد فى مستعمرة حيوانية ، مثل : مستعمرات اللاسعات ، وخارجيات الشرج .

zygote **لاقحة – زيجوت** (من .zygotos: Gr = مقترن)

البيضة الملقحة .

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QUESTIONS

<u>Question 1</u>: Choose the correct answer from (A) or (B) or (C) or (D)

Total degree of this part 81 degree (3 degrees / each one)

1- Body wall a syncytial epidermis, adhesive glands usually present, no cilia, Secretes tough, flexible cuticle containing collagen; protects worms from abrasion in soil and sediment, protects parasites from digestive enzymes. Some have an elaborately sculpted cuticle probably helps them move through soil or sediment. cuticle is sometimes molted as animal grows

cuticle sometimes shows superficial segmentation their cuticle is highly resistant to fairly extreme environments and conditions, some can survive pH's from 1.5-11.5, some can survive mercuric chloride solutions that would kill most other animals. Only living organisms to survive a space shuttle explosion; eg. 6 canisters of *C. elegans* survived the Columbia disaster, allows them to survive in many unusual habitats including:

(A) - Phylum : Nematoda **(B) -** Phylum : Protozoa **(C) -** Class: Trematoda (D) – Class: cephalopoda

2 - Ascaridida belongs to:

(A) - Class: Polychaeta **(B) -** Order: Oxyurida **(C) -** Class: Bivalvia (D - Superfamily : Ascaridoidea

3- Body Form: Most are long and wormlike with head-body-pygidium. some with bizzare forms. Head (prostomium & peristomium); most annelids show some degree of cephalization with a distinct head (=prostomium). tentacles, palps and sensory structures. peristomium behind prostomium contains the mouth with pharynx and chitinous jaws. body with well developed metamerism (=segmentation). most prominent distinguishing feature seen in just a few other phyla: eg arthropods, chordates. segments are separated by tissue = septae. allows more efficient hydrostatic skeleton offers a way to achieve greater size: rather than increasing size of each organ. each organ is repeated in each segment. the segmentation is both external and internal essential features of segmentation: several systems (eg. nervous, excretory) show serial repetition. segmentation is produced during embryonic development. NOTE: the same as asexual budding as in tapeworms. most of them have paired appendages on most segments = parapodia used for locomotion.

(A) - Phylum : Platyhelminthes **(B) -** Phylum : Annelida **(C) -** Superfamily : Spiruroidea **(D) -** Class : Nuda

4 - A group of species which are closely related forms

(A) - Order **(B) -** Species **(C) -** Superfamily (D) - Genus

5 - Myriopods are:

(A) - Class **(B) -** Family **(C) -** Subphylum **(D)** - Superclass

6 - Most with pentamerous (= pentaradial) radial symmetry. No distinct head or brain (no cephalization). Most have endoskeleton of calcium plates. unique water vascular system for feeding and movement. Dermal branchiae for gas exchange. No real circulatory system. No excretory system. Sense organs poorly developed. Pedicellariae for protection

(A) - Class : Sporozoa **(B) -** Phylum : Protozoa **(C) -** Class : Rotifera **(D) -** Phylum: Echinodermata

7 - Refers to the arrangement of parts in relation to planes and centralized axes, the regularity of the form. In a symmetrical animal one or several planes will divide the organism into parts with essentially equivalent geometrical designs.

(A) - Symmetry **(B) -** analogy **(C) -** Homology **(D) -** Phylogeny

8 - do not have internal body cavity other than the lumen of the digestive canal; the space between their body wall and visceral organs is filled with mesenchymal tissues a type of undifferenryiated tissue consisting of scattered cells and extra cellular material.

(A) - Acoelomates **(B):** Pseudocoelomates **(C) -** Phylogeny (D) - Radial symmetry

9 - Choanocytes (= collar cells) are found in:
(A) - Class : Sporozoa **(B) -** Phylum : Porifera **(C) -** Phylum: Echinodermata **(D) -** *Hydra* sp

10 - Body Wall consists of :
<u>A. Epidermis:</u> free living forms have single layer of ciliated cells. parasitic forms have syncytial layer that lacks cilia.
<u>B. Muscle Layers:</u> two layers around body wall: circular muscle, longitudinal muscle, no rigid skeleton for muscles to act on. Thick muscle layers in pharynx (=feeding tube) make it “prehensile”. in some primitive species these muscle cells resemble the epitheliomuscular cells of cnidarians
(A) - Class : Mastigophora **(B) -** Phylum: Nematoda **(C) -** Phylum: Echinodermata

(D) - Phylum: Platyhelminthes

11 - Mouth opening and the muscular pharynx lying in the midventral side of the animal

(A) - Class : Sporozoa **(B) -** CLass : Arachinida **(C) -** Phylum: Echinodermata **(D) -** Class : Turbellaria

12 - No digestive system is found

(A) - Class :Cestoda **(B) -** Class : Trematoda **(C) -** Phylum: Echinodermata (D) - Order : Oxyurida

13 - Is the application of distinctive to each of the groups recognized in any given Zoological classification.

Thus nomenclature is an essential or secondary outcome of classification.

(A) – Taxonomy **(B) -** Cell number **(C) -** Systematics (D) - Zoological nomenclature

14 - Is the scientific study of the kinds and diversity of organisms on of any and all relationships among them.

(A) - Zoolological nomenclature **(B)** – Symmetry **(C)** – Species **(D)** - Systematic

15 - It is cylindrical in form and may be divided into number of similar parts, only around a central longitudinal axis. A longitudinal axis is defined as line segment extending from one pole of an organism to another pole on the opposite end. e.g. Hydra, Jelly fishes, Sea Anemones and adult Echinoderms as star fish and sea urichin etc.

(A) - Radial symmetry **(B)** – Symmetry **(C)** – Genus **(D)** - Bilateral symmetry

16 - have bodies composed of more on less similar parts or they have organs in a similar series along the main axis. Each part is called metamere, somite or segment.

(A) - A symmetry **(B)** - Spherical symmetry **(C)** – Metamerism **(D)** - Bilateral symmetry

17 - Animals have an internal cavity originated from blastocoels of blastula. e.g. Nematodes and Rotifera.

(A) - A type **(B)** - Spherical symmetry **(C)** – Pseudocoelomates **D)** - Bilateral symmetry

18 - are those have two germ layers; ectoderm and endoderm

(A) - A poriferan animals **(B)** - Diploplastic animals **(C)** - A coelomates **D)** - Bilateral symmetry

19 - is a supporting frame work of organisms. There is two type of which; endoskeleton and exoskeleton. Endo are found in sponges echinoderms, chordata while exo is found in mollusca, arthropoda

(A) - Embryonic layers **(B)** - Diploplastic animals **(C)** - Coelomates animals **(D)** - Skeletal system

20 - Are those animals which their mouth is formed from the blastopore (Mollusoa, Annelida, Arthropoda).

(A) - Protostome animals **(B)** - Diploplastic animals **(C)** - Triploplastic animals **(D)** - Digestive system

21 - are those which have a new mouth are formed elsewhere other than from blastopore. e.g.

Echinodermata, Hemichordate and Chordata.

(A) - Coelomates animals **(B)** - Deuterstome animals **(C)** - Triploplastic animals **(D)** - Digestive system

22 - Animals consisting of a single cell, (occasionall) colonies of single cell. But never organized into tissues usually microscopic in size

(A) - Phylum Porifera **(B)** - Phylum Cinideria **(C)** - Class : Anthozoa **(D)** - Phylum : Protozoa

23 - Body not distinctly separated from arms; arms (usually 5 but up to 50 in number) broad and not jointed

(A) - Phylum : Mollusca **(B)** - Class : Cestoda **(C)** - Class : Asteroidea **(D)** - Subphylum : Sarcomastigophora

24 - No antennae; head and thorax fused; abdomen distinct; four pairs of leg; no wings

(A) - Phylum : Echinodermata **(B)** - Class : Arachinida **(C)** - Class : Oligochaeta **(D)** - Class: Hydrozoa

25 - layers of mesoderm on the inside of the body wall and the outside of the digestive tract, muscle layers in both places, digestive system much better developed.
(A) – Metamerism **(B)** – Eucoelomates **(C)** - Class : Cephalopoda **(D)** - *Sepia* sp

26 - Bilharzias caused by :

(A) – Sponges **(B)** - *Taenia* sp **(C)** - *Schistosoma* sp **(D)** - *Octopus* sp

27 - Cnidocytes (stinging cells) are found in

(A) - *Hydra* sp **(B)** - *Fasciola* sp **(C)** - *Ascaris* sp **(D)** - *Planaria* sp

QUESTION (1) –GIVE THE SCIENTIFIC TERM FOR THE FOLLOWING:

1 - Bilaterally symmetrical invertebrates with jointed exoskeleton covering body and appendages; cilia absent; body segmented, though segmentation commonly reduced as a result of fusion; appendages typically specialized for different functions; coelom greatly reduced; nervous system consists of dorsal brain and a double or single (fused) ventral nerve cord; eggs typically rich in yolk; development highly modified.

2 - Extinct; head (or cephalon) composed of 5 segments bearing a pair of antennae and compound eyes; oval, flattened body composed of cephalon, thorax, and pygidium, each segmented; dorsal surface molded longitudinally into 3 lobes; each segment bears a pair of similar, branched appendages; marine; Cambrian Period to the end of the Paleozoic Era; more than 4,000 fossil species known.

3 - Body divided into prosoma (cephalothorax) and opisthosoma (abdomen); no antennae; first pair of appendages consists of chelicerae flanking the mouth; in most chelicerates the other prosomal appendages are a pair of pedipalps and four pairs of legs.

4 - Large marine chelicerates with book gills on the underside of the opisthosoma; prosoma covered by a dorsal carapace; opisthosoma bears a long terminal spine; 2 orders, Xiphosura (horseshoe crabs, 4 species) and Eurypterida (Gigantostraca), which is extinct and includes 200 fossil species from the Paleozoic Era.

5 - Chiefly terrestrial; segmental appendages primitively unbranched; head appendages comprise a pair of antennae, a pair of mandibles, and 1 or 2 pairs of maxillae; trunk and appendages variable; respiratory organs are tracheae.

- 6 - Elongate; many trunk segments, each with 1 pair of legs; 2 pairs of maxillae covered by a large pair of poison claws representing the first pair of trunk appendages; eyes, if present, are simple ocelli; gonopore on last segment; 5 mm to almost 30 cm; about 3,000 living species.
- 7 - Mouthparts consist of a pair of mandibles and 2 pairs of maxillae; 12 leg-bearing trunk segments; terminal segment carries a pair of spinnerets; gonopore on fourth segment; l–8 mm; about 160 living species.
- 8 - Elongate; trunk containing many diplosegments, each bearing 2 pairs of legs and spiracles; single pair of maxillae fused to form a flattened plate (gnathochilarium); first 4 trunk segments not

diplosegments, and third bears the gonopores; simple eyes (ocelli) present or absent; 2 mm–28 cm; about 10,000 living species.

- 9 - Antennae branched; a pair of maxillae; 9–11 trunk segments bearing legs; gonopores on third trunk segment as in diplopods; 0.5–1.5 mm; about 500 described species.

10 - among the most numerous of any phylum. About 15,000 species of nematodes are known at present. Due to much diversity in form and structures difficult to classify. Chitwood (1933) divided them into 2 classes phasmidia and Aphasmidia on the basis of presence and absence of phasmids.

11 - Anterior end with six labial papillae and 10-12 sensory bristles. cuticle usually with bristles. Cyanthiform amphids. Chiefly marine, free-living.

12 - Anterior end with 6-10 papillae. cuticle smooth, no bristles. Cyanthiform amphids. Buccal cavity with the protrusible spear. Free-living in soil and fresh-water.

13 - Size large. Anterior end with 16 labial papillae and no sensory. bristles. Cuticle smooth, no bristles. Cyanthiform or reduced amphids. Oesophagus long leading into the blind intestine. Larva parasitic in invertebrates. Adult free-living.

14 - Size small. Cuticle smooth or ringed; with heavy bristles. Spiral amphids. Buccal cavity with teeth. Pharynx with posterior bulb. Mostly marine; free-living.

15 - Size small. Circular amphids. Cuticle smooth or slightly ringed, often with bristles. Anterior end with 4,6,8, or many sensory bristles. Free-living; mostly marine, some fresh-water, some terrestrial.

16 - Size small. Cresent-shaped or pump-shaped amphids. The heavily ringed cuticle. Anterior end with 4 sensory bristles, head armored. Marine; free-living.

17 - basis of presence and absence of parapodia, setae, metameres, and other morphological features.

18 - Burrowing and tube-dwelling form. Body made of 2 or more regions, with unlike segments and parapodia. Head is small or much modified without eyes and tentacles, prostomium small. No acicula and compound setae. Pharynx non-protrusible without jaws and teeth. Gills, when present, localized to the anterior segments.Feeding on plankton or organic detritus.

19 - Mostly ectoparasitic, blood-sucking or carnivorous. Few are marine, freshwater or terrestrial. The body is elongated and usually flattened and dorso-ventrally or cylindrical. The body consists of a fixed number of segments (33). Each segment breaks up into 2 to 4 rings or annuli. Segmentation external without internal septa. Par podia and setae are absent. Both anterior and posterior ends of the body with ventrally situated suckers. The mouth opens on the ventral surface on anterior suckers, while anus opens dorsal to the posterior suckers. Coelom much reduced due to filling by botryoidal tissues, and form haemocoelomic sinuses. Hermaphrodite with one male and one female gonopore.

Fertilization internal. Asexual reproduction is not known. Eggs are always laid in cocoons. Development is direct without a free-swimming larval stage.

20 - Mostly parasitic on the fins of salmon fishes. The body comprises 30 segments only. They are primitive, without anterior suckers, proboscis, and jaws. Double rows of setae are present in 5 anterior segments. The body cavity is spacious and incompletely divided by septa. The vascular system consists of the dorsal and ventral vessels. Nephridial opening situated on the surface between the segments. Examples: a single genus and species (*Acanthobdella*) parasitic on salmon.

21 - Parasites on snails, frogs and fishes, marine and freshwater form. Each typical body segment consists of 3,6 or 12 rings. The mouth is a small median aperture situated in the anterior suckers. A protrusible proboscis with no jaws. Coelom without compartments. Blood vascular system separated from coelomic sinuses. Blood is colorless.

22 - Freshwater and terrestrial form. Ectoparasitic blood-sucking leeches. Each typical body segment consists of 5 rings or annuli. Anterior suckers with 3 jaws, 1 median dorsal and 2 ventrolateral. The proboscis is absent. Blood is red-colored. Botryoidal tissues present.

23 - Terrestrial and aquatic. Some predaceous. Pharynx non- protrusible. No teeth but one or two styles may be present.

24 - Exclusively marine form. Body elongated and worm-like. Setae and parapodia are usually absent. External segmentation is slightly marked by faint, while internal segmentation is marked by coelomic septa. Prostomium bears 2 or 3 tentacles. Sexes usually separate, hermaphrodite. Usually trochophore larva.

25 - are pseudocoelomate, bilaterally symmetrical, triploblastic, unsegmented, vermiform, organ-system grade of construction with complete digestive tubes.

26 - Found in freshwater. One genus (*Nectonema*) marine. Body very long, thin, slender and cylindrical. Body wall with thick cuticle bearing small papillae. Epidermis cellular, single-layered. The digestive system is complete in larva but degenerates in non-feeding adults. Cloaca present. Pseudocoel mostly filled with parenchyma. No circulatory, respiratory and excretory system. Nervous system with a circumenteric nerve ring and midventral nerve cord. Gonad and gonoducts paired. Oviducts also open into the cloaca. Juveniles parasitic in grasshoppers, crickets and other insects.

27 - Microscopic animals found in ponds, lakes, and streams. Rarely in oceans, commonly called wheel bearers**.** Body wall thickened into stiff plates or **lorica** into which head may. Anterior end with ciliated **corona (wheel organ)** used for feeding and locomotion. Post- anal foot with toes and adhesive glands for attachments. Body musculature includes longitudinal and transverse muscle bands and strands. The digestive system with a grinding organ, **mastax**, lined internally by a strong cuticle. The excretory system with two rotonephridia and two Protonephridial tubes which empty into bladders. The nervous system of 3 major ganglia and nerves. Sensory organs antennae and eyespots. Male smaller than females. Parthenogenesis common. Female oviparous, no larval stages.

28 - Body elongated with a long neck. Corona is small. Paired gonads. Found as commensals on crustaceans.

29 - Corona usually with 2 trochal discs. Pedal glands more than two. Male degenerate; female with paired germovitellaria. Swimming or creeping form.

30 - Swimming or sessile forms. Male small or degenerate. Male usually with one testis. Female posses single germovitellaria.

31 - Arranging organisms into an ascending series of groups of ever-increasing inclusiveness is a hierarchical system of classification. Major taxa (sing., taxon), into which organisms are grouped were given one of several standard taxonomic ranks to indicate the general degree of inclusiveness of the group.

32 - Linnaeus's system for naming species is known as.

33 - Linnaeus's scheme of arranging organisms into an ascending series of groups of ever-increasing inclusiveness is.

34 - Denotes the construction of classes, groupings of organisms that possess a common feature, called an essence, used to define the class

35 - The taxa are groupings of species related by evolutionary descent with modification, as diagnosed by sharing.

36 - Is known as binomial nomenclature.

37 - Has a latinized name composed of two words (hence binomial) printed in italics (or underlined if handwritten or typed).

38 - The first word names the genus, which is capitalized; the second word is the species epithet, which is peculiar to the species within the genus and is written in lowercase

39 - Is always a noun, and the species epithet is usually an adjective that must agree in gender with the genus.

40 - Is an interbreeding population of individuals having common descent and sharing intergrading characteristics.

41 - Is a technique for identifying organisms to species using sequence information from a standard gene present in all animals

42 - The phylogenetic species concept is defined as an *irreducible (basal) grouping of organisms diagnosably distinct from other such groupings and within which there is a parental pattern of ancestry and descent.*

43 - two types of taxonomy; artificial and natural.

44 - At which animals are grouped according to their place of living (Aquatic or terrestrial). Type of feeding (Rerbovorous, Carnivorous, Omnivorous) and area of living (hot, cold, icy) etc….

45 - At which animals are grouped depending on the degree of relationships among the individuals of each group. These relationships can only be obtained by help of other science branches as Comparative Anatomy, physiology, Cytology, Embryology, Paleontology and ecology etc.

46 - Type of larvae is important in classification. There are several forms of larvae and each of while characterizing a special group of animals e.g., Vileger for,

47 - Noplius larva for,

48 - Planula for

49 - Brachularia for

Species were defined by fixed, essential features (usually morphological) considered as a divinely created pattern or archetype. This practice constitutes the typological (or morphological) species concept. Scientists recognized species formally by designating a type specimen that was labeled and deposited in a museum to represent the ideal form or morphology for the species.

50 - Are too similar in morphology to be diagnosed as separate species by morphological characters alone.

51 - These are the ray footed protozoans. Locomotory structures are axopodia. Skeleton consists of siliceous shell (Radiolaria) or strontium sulphate spines (Acantharea) or siliceous shell or radiating needles (Heliozoa). Silicious shells of radiolarians form ooze Examples: Collozoum (radiolarian) Actinophrys (heliozoan) Acanthometra (acantharean), Actinosphaerium

52 -: Parasitic; no special locomotory structures; pseudopodia, if present, useful only in ingestion, o Sporozoites and merozoites bear anterior apical complex that helps penetrate host cells, No polar filaments

53 -: Sporozoites are long, o Garrtonts are large, extracellular – gregarinids Gamonts are small, intracellular – coccidians. Syngamy is isogamy - Gregarinids Anisogamy – Coccidians

54 -: Body is covered by pellicle; locomotoin organelles are flagella; Asexual reproduction by longitudinal binaiy fission. It includes two classes.

55 -: Some are with chlorophyll bearing chloroplasts. Nutrition is holophytic Reserve food is paramylum or Includes euglenoids and dinoflagllates

56 -: Mostly parasitic; Chloroplasts are absent; nutrition is holozoic, saprobic or parasitic, Reserve food is glycogen or volutin, Examples: Trichomonas, Trichonympht (Mutualistic), Leishmania.

57 -: Commensals or parasites in the gut of anurans

58 - Simplest type. Very small tube shaped sponges. Large central cavity = spongocoel in via small openings called ostia out through single osculum

59 –Derived from asconoid pattern by folding. More branching has incurrent canals and side passages still have main spongocoel single osculum

60 –Most complex, no longer a centrl spongocoel but almost unlimited ability for sponge to grow in size. Generally larger colonial forms. Each mass has its own osculum incurrent and excurrent canals

61 - Most of the larger jellyfish belong to this group. Medusae without velum, cells in mesoglea. All are marine. Solitary polyp stage reduced or completely absent. Thick jelly layer (=mesoglea)

62 - Turbellarians have considerable powers of regeneration; eg. slicing and dicing experiments

63 - Body is bilaterally symmetrical and segmented. Mantle dome-shaped. The shell comprises a single piece or valve. Flattened limpet-shaped shell with spirally coiled Protoconch. Head without eyes and tentacles.Mantle encircles the body as a circular fold of the body. Foot broad and flat, with 8 pairs of pedal retractor muscles. Gills external. 5 pairs of gills in pallial grooves. 6 pairs of nephridia, two of which are gonoducts. Radula in a radular sac; intestine much coiled. Heart of 2 pairs of auricles and a single ventricle. Nervous system with longitudinal pallial and pedal cords. Sexes separate (dioecious

64 - Valves of the shell without insertion plates. Ctenidia a few and posterior.

65 - Valves of the shell with insertion plates. Gills along the whole length of mantle grooves

66 - Body elongated with reduced head. Radula present. Shell as 8 dorsal plates or as spicules. Ventral foot, large, flat and muscular. Non- ganglionated nerve ring around the mouth with 2 pairs of the interconnected nerve cord. External fertilization: trochophore larva.

67 - Shell with a short to a very long siphonal canal. Radula consists of rows with 2 or 3 teeth in each row. Nervous system concentrated. Osphradium is large. Free-swimming veliger suppressed.

<u>Question </u>2: Choose the correct answer from (A) or (B) or (C) or (D)

1- Body wall a syncytial epidermis, adhesive glands usually present, no cilia, Secretes tough, flexible cuticle containing collagen; protects worms from abrasion in soil and sediment, protects parasites from digestive enzymes. Some have an elaborately sculpted cuticle probably helps them move through soil or sediment. cuticle is sometimes molted as animal grows
cuticle sometimes shows superficial segmentation their cuticle is highly resistant to fairly extreme environments and conditions, some can survive pH's from 1.5-11.5, some can survive mercuric chloride solutions that would kill most other animals. Only living organisms to survive a space shuttle explosion; eg. 6 canisters of *C. elegans* survived the Columbia disaster, allows them to survive in many unusual habitats including:
(A) - Phylum : Nematoda **(B) -** Phylum : Protozoa **(C) -** Class: Trematoda (D) – Class: cephalopoda

2 - Ascaridida belongs to:

(A) - Class: Polychaeta **(B) -** Order: Oxyurida **(C) -** Class: Bivalvia (D - Superfamily : Ascaridoidea

3- Body Form:_Most are long and wormlike with head-body-pygidium. some with bizzare forms. Head (prostomium & peristomium); most annelids show some degree of cephalization with a distinct head (=prostomium). tentacles, palps and sensory structures. peristomium behind prostomium contains the mouth with pharynx and chitinous jaws. body with well developed metamerism (=segmentation). most prominent distinguishing feature seen in just a few other phyla: eg arthropods, chordates. segments are separated by tissue = septae. allows more efficient hydrostatic skeleton offers a way to achieve greater size: rather than increasing size of each organ. each organ is repeated in each segment. the segmentation is both external and internal essential features of segmentation: several systems (eg. nervous, excretory) show serial repetition. segmentation is produced during embryonic development. NOTE: the same as asexual budding as in tapeworms. most of them have paired appendages on most segments = parapodia used for locomotion.

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35 - Cnidocytes_(stinging cells) are found in

(A) - *Hydra* sp **(B) -** *Fasciola* sp **(C) -** *Ascaris* sp **(D) -** *Planaria* sp

20 - Body Form:_Most are long and wormlike with head-body-pygidium. some with bizzare forms. Head (prostomium & peristomium); most annelids show some degree of cephalization with a distinct head (=prostomium). tentacles, palps and sensory structures. peristomium behind prostomium contains the mouth with pharynx and chitinous jaws. body with well developed metamerism (=segmentation). most prominent distinguishing feature seen in just a few other phyla: eg arthropods, chordates. segments are separated by tissue = septae. allows more efficient hydrostatic skeleton offers a way to achieve greater size: rather than increasing size of each organ. each organ is repeated in each segment. the segmentation is both external and internal essential features of segmentation: several systems (eg. nervous, excretory) show serial repetition. segmentation is produced during embryonic development. NOTE: the same as asexual budding as in tapeworms. most of them have paired appendages on most segments = parapodia used for locomotion.

(A) - Phylum : Platyhelminthes **(B) -** Phylum : Annelida **(C) -** Superfamily : Spiruroidea **(D) -** Class : Nuda

21 - A group of species which are closely related forms

(A) - Genus **(B) -** Species **(C) -** Superfamily (D) - Order

22 - Myriopods are:

(A) - Class **(B) -** Family **(C) -** Subphylum **(D) -** Superclass

23 - Most with pentamerous (= pentaradial) radial symmetry. No distinct head or brain (no cephalization). Most have endoskeleton of calcium plates. unique water vascular system for feeding and movement. Dermal branchiae for gas exchange. No real circulatory system. No excretory system. Sense organs poorly developed. Pedicellariae for protection
(A) - Class : Sporozoa **(B) -** Phylum : Protozoa **(C) -** Class : Rotifera **(D) -** Phylum: Echinodermata

24 - Refers to the arrangement of parts in relation to planes and centralized axes, the regularity of the form. In a symmetrical animal one or several planes will divide the organism into parts with essentially equivalent geometrical designs.

(A) - Symmetry **(B) -** analogy **(C) -** Homology **(D) -** Phylogeny

25 - do not have internal body cavity other than the lumen of the digestive canal; the space between their body wall and visceral organs is filled with mesenchymal tissues a type of undifferenryiated tissue consisting of scattered cells and extra cellular material.

(A) - Acoelomates **(B):** Pseudocoelomates **(C) -** Phylogeny (D) - Radial symmetry

26 - Choanocytes (= collar cells) are found in:

(A) - Class : Sporozoa **(B) -** Phylum : Porifera **(C) -** Phylum: Echinodermata **(D) -** *Hydra* sp

27 - Body Wall consists of :

A. Epidermis: free living forms have single layer of ciliated cells. parasitic forms have syncytial layer that lacks cilia.

B. Muscle Layers: two layers around body wall: circular muscle, longitudinal muscle, no rigid skeleton for muscles to act on. Thick muscle layers in pharynx (=feeding tube) make it "prehensile". in some primitive species these muscle cells resemble the epitheliomuscular cells of cnidarians

(A) - Class : Mastigophora **(B) -** Phylum: Nematoda **(C) -** Phylum: Echinodermata

(D) **-** Phylum: Platyhelminthes