ZOOLOGY DEPARTMENT

Invertebrates I

Second year students/ Chemistry & Zoology

By/ Dr. Heba M. Fangary

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FACULTY OF SCIENCE

Zoology Department

Invertebrates I

Theoretical Part

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(The Second Year Students)

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The Second Year Students

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Icons

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Contents

Figures Table

Introduction

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 million 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. So, the branch of zoology for grouping or classification of animals on scientific bases is called taxonomy systematic zoology.

Taxonomy is the science of defining and naming groups of biological organisms on the basis of shared characteristics.

History of scientific taxonomy:

One of the first persons collected and organized animals classification system was the Greek philosopher Aristotle (384-322 BC). He classified beings by their parts, such as having four legs, laying eggs, having cold blood, or being warm-bodied, carnivorus or herbivorus. He classified about 500 types of animals in 11 categories according to their structure from and their degree of development at birth.

In the 17th century John Ray (England, 1627–1705) wrote many important taxonomic works and he defined the species.

A species is often defined as the largest group of organisms in which any two individuals of the appropriate sexes or mating types can produce fertile offspring, typically by sexual reproduction.

The Swedish botanist Carl Linnaeus (1707–1778) suggested the 2-kingdom classification of organisms: Kingdoms: Plantae and Animalia. Also formalised the modern system of naming organisms called binomial nomenclature. **Binomial nomenclature** ("two-term naming system") is a formal system of naming species of living things by giving each a name composed of two parts, both of which use Latin grammatical forms. The first part of the name – the *generic name* – identifies the genus to which the species belongs, while the second part – the **specific name** identifies the species within the genus.

But Bacteria, Fungi, Slime moulds (Mycetozoa), Phytoflagellates (Euglena), Cryptomonadina (Cryptomonas, Chilomonas), Dinoflagellates and diatoms could not be definetly placed into any of the two kingdoms. And hence this posed objections to two-kingdom classification.

In view of these objections, Ernst Haeckel proposed a third kingdom Protista for all non-multicellular animals.

These three kingdoms were,

1. Kingdom Plantae

2. Kingdom Animalia and

3. Kingdom Protista (Non multicellular animals)

But still bacteria, ray fungi, multicellular fungi and PPLO were still difficult to be classified in the above categories.

Kingdoms of the living world

Robert Harding Whittaker (1920 – 1980) was an American plant ecologist, He was the first to propose the five-kingdom taxonomic classification of the world's biota into the Animalia, Plantae, Fungi, Protista, and Monera in 1969.

Kingdom: Monera

- 1 cell, no true nucleus - prokaryote (genetic material scattered and not enclosed by a membrane).
- Examples - bacteria, blue-green bacteria.

Kingdom: Protista

- 1 cell, have a true nucleus – eukaryote
- Examples - *Amoeba*, Diatom, *Euglena*, *Paramecium*, some algae (unicellular), etc….

Kingdom: Fungi

Kingdom: Plantae

Kingdom: Animalia (animals)

- multicellular
- have nuclei
- do move
- Examples - sponge, jellyfish, insect, fish, frog, bird, man.

Kingdom: Protista

Thus the kingdom Protista now includes species of single-celled organisms that have the genetic material enclosed in a nucleus and have membrane bound organelles like Golgi body, mitochondria, lysosomes, centrosome etc.

The kingdom Protista includes both plant Protista (=Protophyta) and animal Protista (=Protozoa). Protists are the most nutritionally diverse of all eukaryotes. They use mitochondria for cellular respiration. Some which do not possess mitochondria either live anaerobically or contain mutualistic bacteria. Protists move by use of flagella or cilia during some part of their lives. They may reproduce sexually or asexually, sometimes both during certain stages of life. Some protists are involved in symbiotic relationships, living in body fluids, tissues or cells of hosts. These relationships may be mutualistic or parasitic.

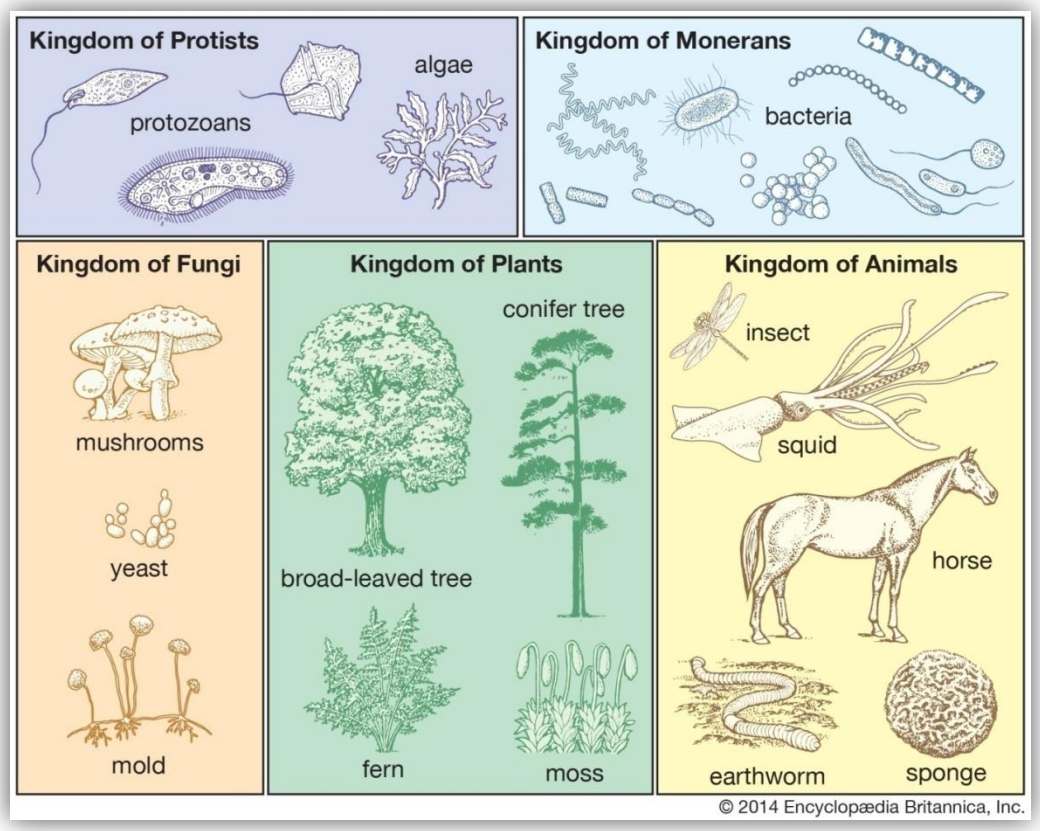

Fig. 1: Kingdoms of living world

Kingdom: **Protista** (protists)

Subkingdom: **Protozoa**

Phylum: Protozoa

General characters:

Habitat- Protozoa are found in the aquatic environment. They live in freshwater or oceans. Some are free-living and some are parasitic in plants and animals. Mostly they are aerobic but some are anaerobic and present in the rumen or human intestine.

Some of the species are found in extreme environments like hot springs. Some of them form resting cyst to overcome dry environments.

Size and Shape- The size and shape of Protozoa vary greatly, from microbial (1µm) to large enough and can be seen by the naked eye. The shell of unicellular foraminifera can have a diameter of 20 cm.

They lack a rigid cell wall, so they are flexible and found in various shapes. Cells are enclosed in a thin plasma membrane. Some of the species have a hard shell on the outer surface. In some of the protozoans especially in ciliates, the cell is supported by **Pellicle,** which may be flexible or rigid and give organisms the definite shape and help in locomotion.

Cellular Structure- They are unicellular having a eukaryotic cell. The metabolic functions are performed by some specialised internal structures.

- They mostly have one membrane-bound nucleus in the cell
- The nucleus has diffused appearance due to scattered chromatin, the vesicular nucleus contains a central body called endosome or nucleoli. Nucleoli of apicomplexans have DNA, whereas amoeboids lack DNA in their endosome
- Ciliates have micronucleus and macronucleus
- The plasma membrane encloses the cytoplasm and other locomotory projections like flagella, pseudopodia and cilia
- Some of the genera have a membranous envelope called pellicle, which gives a definite shape to the cell. In some of the protozoans, epibiotic bacteria attach to the pellicle by their fimbriae
- The cytoplasm is differentiated into outer ectoplasm and inner endoplasm, ectoplasm is transparent and endoplasm contains cell organelles
- Some of the protozoa have cytostome for ingesting food. Food vacuoles are present, where ingested food comes. Ciliates have a gullet, a body cavity which opens outside
- The central vacuole is present for osmoregulation, that removes excess water

- Membrane-bound cell organelles, like mitochondria, Golgi bodies, lysosomes and other specialised structures are present

Nutrition- Protozoa are heterotrophic and have holozoic nutrition. They ingest their food by phagocytosis. Some of the protozoan groups have a specialised structure called **cytostome** for phagocytosis.

The pseudopodia of amoeboids help in catching the prey. Thousands of cilia present in ciliates drive the food-laden water into the gullet.

The ingested food comes to the food vacuole and gets acted on by lysosomal enzymes. The digested food gets distributed throughout the cell.

Locomotion- Most of the protozoa species have flagella, cilia or pseudopodia. Sporozoa, which don't have any locomotory structure, have subpellicular microtubules, which help in the slow movement.

Life Cycle- The life cycle of most of the protozoa alternates between dormant cyst stage and proliferating vegetative stage, e.g. trophozoites.

The cyst stage can survive harsh conditions without water and nutrients. It can remain outside the host for a longer duration and get transmitted.

The trophozoite stage is infectious, and they feed and multiply during this stage.

Reproduction- Mostly they reproduce by asexual means. They multiply by binary fission, longitudinal fission, transverse fission or budding.

In some of the species, sexual reproduction is present. The sexual reproduction is by conjugation, syngamy or by gametocytes formation.

Classification of Protozoa:

- Phylum protozoa is classified into four classes on the basis of locomotary organs

Class 1 Rhizopoda

- **Locomotary organ:** Pseudopodia
- Mostly free living, some are parasitic
- **Reproduction:** asexually by binary fission and sexually by syngamy.
- No conjugation.
- Examples: *Amoeba, Entamoeba*

Class 2 Mastigophora/ Flagellata

- Locomotory organ: Flagella
- Free living or parasite.
- Body covered with cellulose, chitin or silica.
- Reproduction: A sexual reproduction by longitudinal fission.
- No conjugation.
- Examples: *Giardia, Euglena, Trypanosoma*

Class 3 Sporozoa

- Locomotory organ: Absent
- Exclusively endoparasites
- Contractile vacuoles is absent
- Body covered with pellicle.
- Reproduction: Asexual reproduction by fission and Sexual reproduction by spores
- Examples: *Plasmodium, Monocystis*

Class 4 Ciliata

- locomotary organ: Cillia
- Body covered by pellicle.
- Reproduction: Asexual reproduction by binary fission. Sexual reproduction by conjugation.
- Nuclei two types i.e. macronucleus and micronucleus.
- Examples: *Paramecium*, *Voricella, Blantidium*

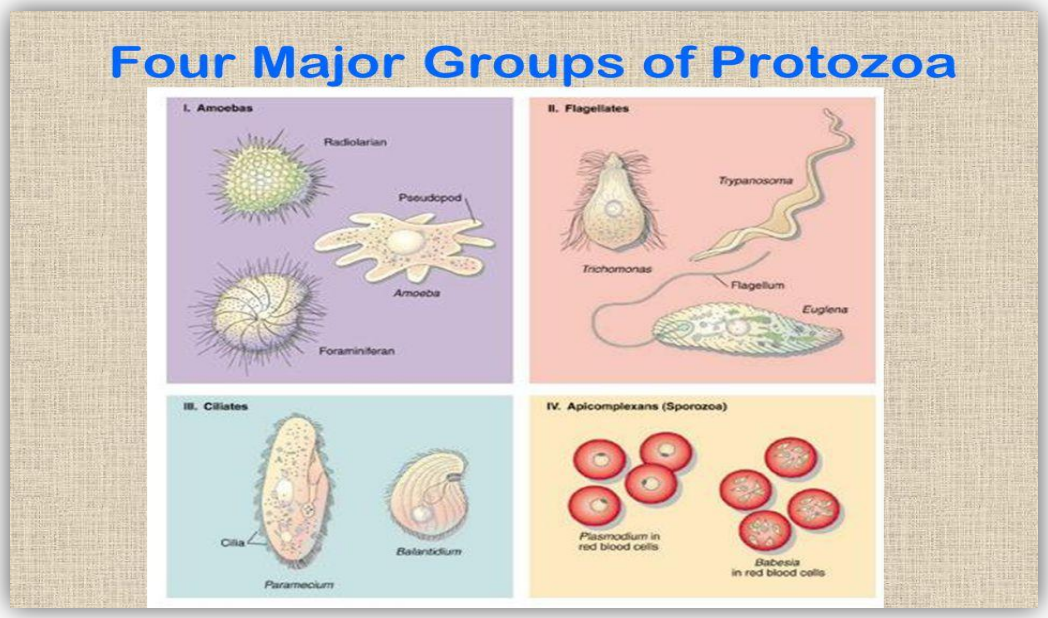

Fig. 2: Classification of Protozoa

Amoeba

- **Shape***:* *Amoeba* has the ability to alter its shape, primarily by extending and retracting pseudopods.

- ***Amoeba*** moves and feeds by using pseudopods, which are bulges of cytoplasm. The appearance and internal structure of pseudopods are used to distinguish groups of *Amoeba* from one another. The food sources of amoebae vary. Some amoebae are predatory and live by consuming bacteria and other protists. Some are detritivores and eat dead organic material.

- ***Amoeba*** contains an endoplasm that is granular in nature. This granular endoplasm contains the nucleus and various food vacuoles.

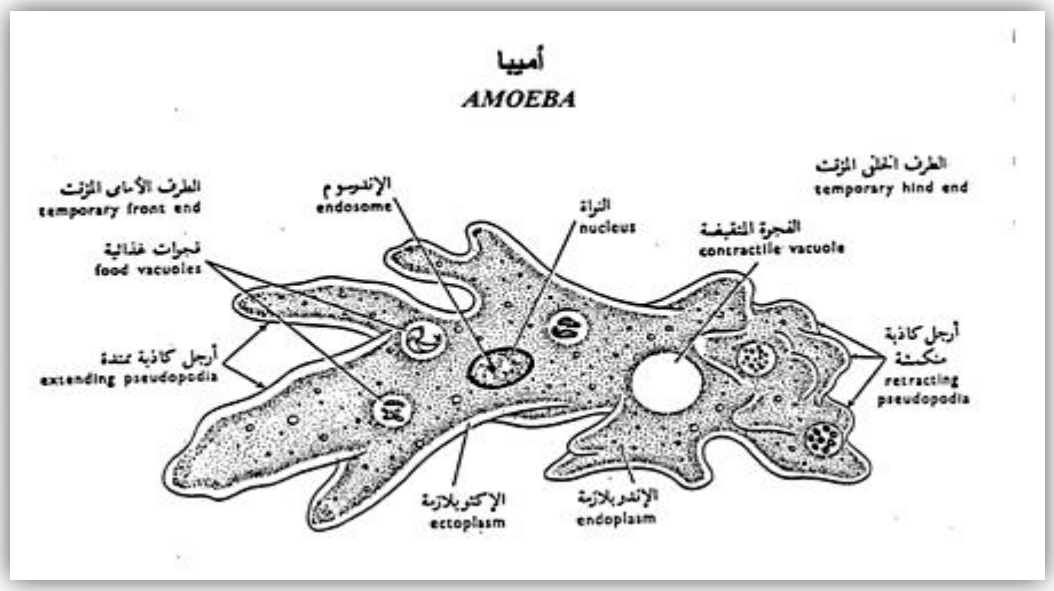

Fig. 3: *Amoeba*

- To regulate osmotic pressure, most freshwater *Amoeba* have a contractile vacuole which expels excess water from the cell. This organelle is necessary because freshwater has a lower concentration of solutes (such as salt) than the amoebas own internal fluids. Marine amoebae do not usually possess a contractile vacuole, because the concentration of solutes within the cell is in balance with the tonicity of the surrounding water.

- Reproduction by binary fission, and by multiple fission (during encystment) under unfavorable conditions.

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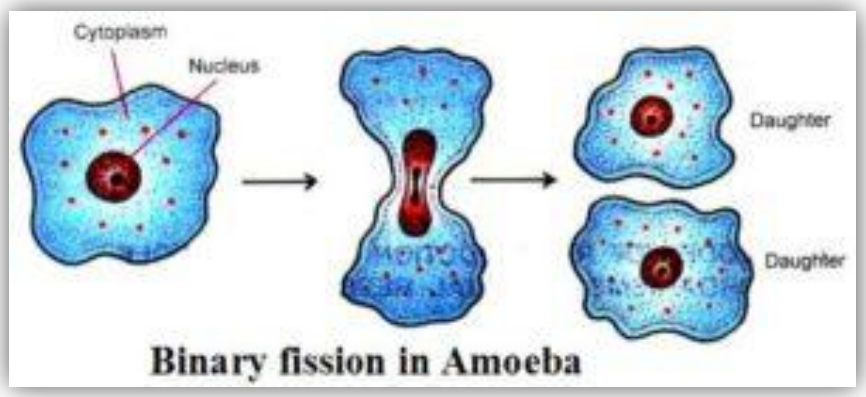

Fig. 4: Binary fission in *Amoeba*

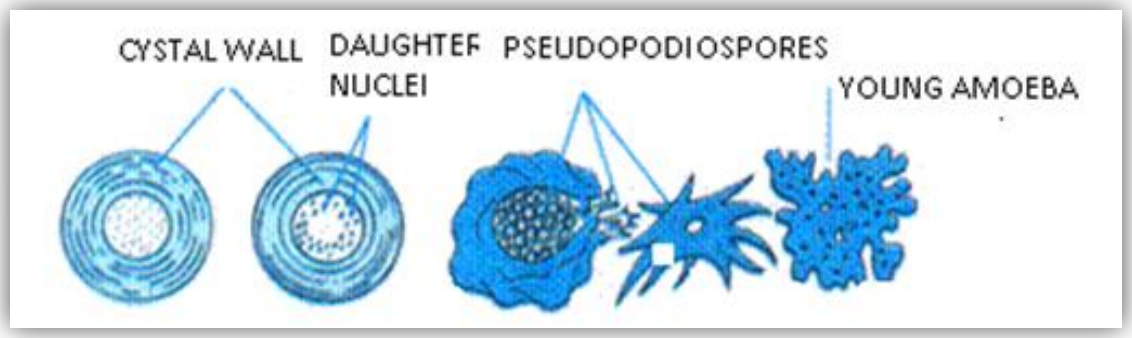

Fig. 5: Encystement in Amoeba

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Class: Mastigophora

e.g.: *Euglena*

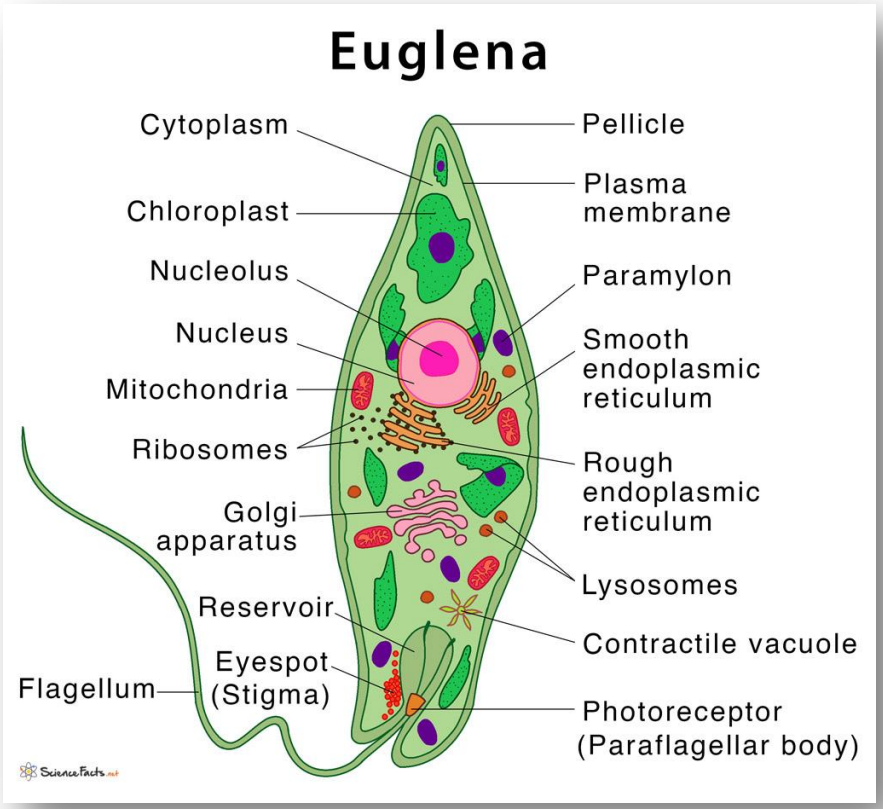


Fig. 6: *Euglena*

- Euglena are microorganisms that feature both plant and animal characteristics. Found worldwide, live in fresh and brackish water rich in organic matter and can also be found in moist soils.

Structures found in a typical photosynthetic *Euglena* cell include:

- Pellicle: a flexible membrane that supports the plasma membrane.
- Plasma membrane: a thin, semi-permeable membrane that surrounds the cytoplasm of a cell, enclosing its contents.
- Cytoplasm: gel-like, aqueous substance within the cell.
- Chloroplasts: chlorophyll containing plastids that absorbs light energy for photosynthesis.
- Contractile Vacuole: a structure that removes excess water from the cell.
- Flagellum: cellular protrusion formed from specialized groupings of microtubules that aid in cell movement.
- Eyespot: This area (typically red) contains pigmented granules that aid in the detection of light. It is sometimes called a stigma.
- Photoreceptor or Paraflagellar Body: This light-sensitive region detects light and is located near the flagellum. It assists in phototaxis (movement toward or away from light).
- Paramylon: This starch-like carbohydrate is composed of glucose produced during photosynthesis. It serves as a food reserve when photosynthesis is not possible.
- Nucleus: a membrane-bound structure that contains DNA
    - Nucleolus: structure within the nucleus that contains RNA and produces ribosomal RNA for the synthesis of ribosomes

- Mitochondria: organelles that generate energy for the cell
- Ribosomes: Consisting of RNA and proteins, ribosomes are responsible for protein assembly.
- Reservoir: inward pocket near the anterior of the cell where flagella arise and excess water is dispelled by the contractile vacuole
- Some species of *Euglena* possess organelles that can be found in both plant and animal cells. *Euglena viridis* and *Euglena gracilis* are examples of *Euglena* that contain chloroplasts as do plants. They also have flagella and do not have a cell wall, which are typical characteristics of animal cells. Most species of *Euglena* have no chloroplasts and must ingest food by phagocytosis. These organisms engulf and feed on other unicellular organisms in their surroundings such as bacteria and algae.
- Most *Euglena* have a life cycle consisting of a free-swimming stage and a non-motile stage. In the free-swimming stage, *Euglena* reproduce rapidly by a type of asexual reproduction method known as binary fission. The euglenoid cell reproduces its organelles by mitosis and then splits longitudinally into two daughter cells. When environmental conditions become unfavorable and too difficult for *Euglena* to survive, they can enclose themselves within a thick-walled protective cyst. Protective cyst formation is characteristic of the non-motile stage.

- In unfavorable conditions, some euglenids can also form reproductive cysts in what is known as the palmelloid stage of their life cycle. In the palmelloid stage, Euglena gather together (discarding their flagella) and become enveloped in a gelatinous, gummy substance. Individual euglenids form reproductive cysts in which binary fission occurs producing many (32 or more) daughter cells. When environmental conditions once again become favorable, these new daughter cells become flagellated and are released from the gelatinous mass.

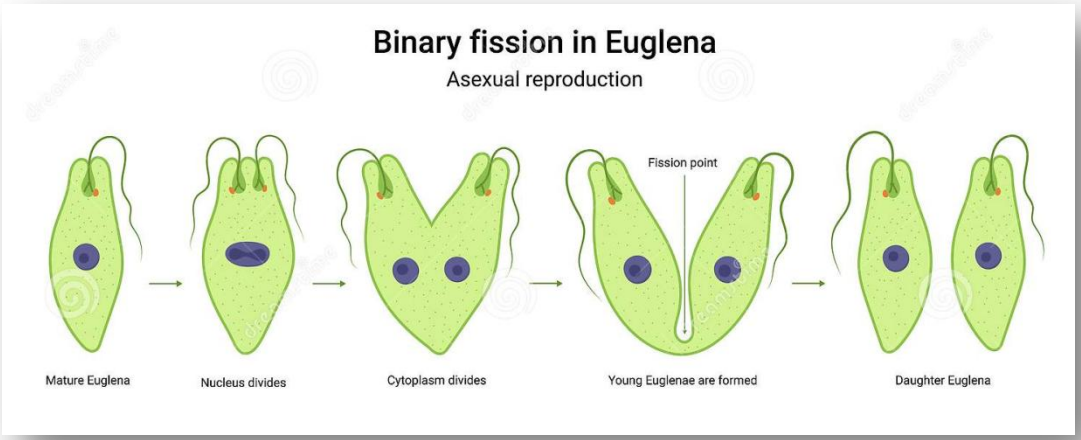


Fig. 7: Binary fission in *Euglena*

Class: Ciliata

e. g.: *Paramecium*

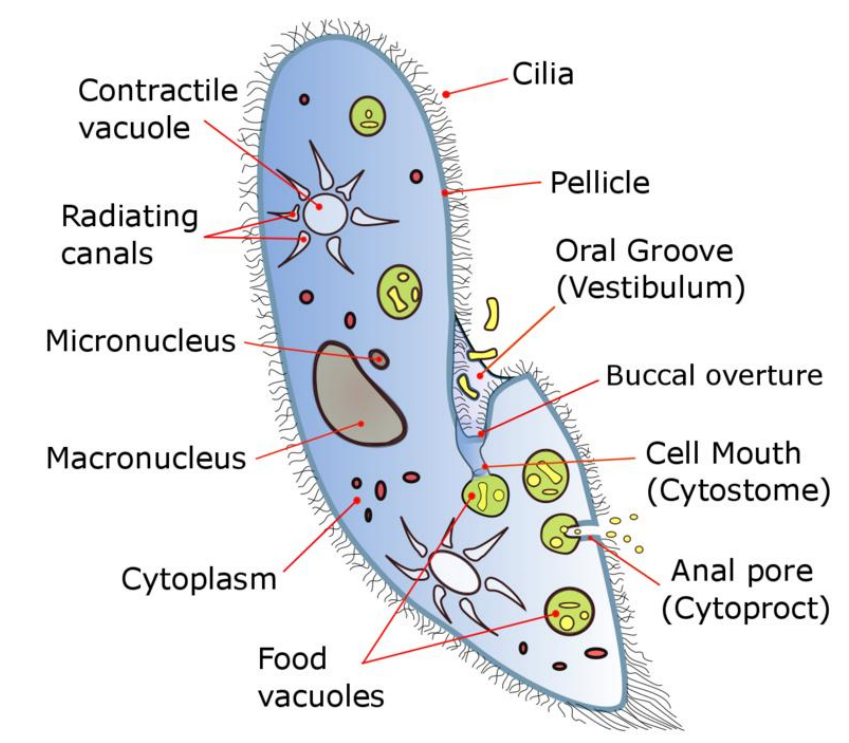


Fig. 8: *Paramecium*

1- Species of *Paramecium* range in size from 50 to 330 micrometres in length. Cells are typically ovoid, elongate, foot- or cigar-shaped. It is mostly found in freshwater environments.

2- **Shape**: The body is elongated, blunt and rounded at the anterior end and somewhat pointed of the posterior end. The body is distinguished into an oral or ventral surface and an aboral or dorsal surface.

3- **Oral groove**: The ventral surface of body bears a prominent, oblique and shallow depression is called oral groove, it arise from the middle of body and extends to the left side of anterior end. Posteriorly the oral groove leads into a deeper conical vestibule which is communicates with a buccal cavity having a basal mouth or cytostom.

4- **Pellicle**: The body of paramecium externally covered by living, thin, clear, firm and elastic cuticular membrane called the pellicle or periplast. It gives a definite body form to the organism. It bears a hexagonal depressions from each comes out a cilium. Below it lie the basal granules or kinetosomes of the cilia. Also there are spindle- shaped trichocysts arranged perpendicular to the surface for defense and adhesive.

5- **Cilia**: The entire body surface is covered by a uniform covering of numerous, hair like protoplasmic fine projections called cilia. These emerge out from the centre of each polygonal depression (circumelliary space) of pellicles. Functions of cilia are locomotion and capturing the food partic**les.**

6- **Macronucleus**: The macronucleus is roughly kidney shaped and with in conspicuous nuclear membrane, posses many nucleus and much more chromatin material (DNA). Macronulear is the somatic or vegetative nucleus and contr**ol** metabolic activities of the cell. It is derived from micronucleus during reproductive processes. It is situated near the cytostome.

7- **Micronucleus**: A small rounded micronucleus is lodged in a depression on the surface of the macronucleus. It has a nuclear membrane and with diploid number of chrosomes. It controls the reproductive activities of the orga**nism.**

8- Contractile Vacuoles: In paramecium, unlike amoeba, there are two large liquid filled contractile vacuoles occurring somewhat fixed position in endoplasm of one either end of body close to the dorsal surface. The contractile vacuole opens to the outside through a district discharge canal in the pellicle of dorsal side. Each contractile vacuole is surrounded by six to ten elongated radiating canals, which are also known as feeding canals or radiating canals**.**

Importance of Protozoa

Useful Protozoa

 Protozoa are found almost everywhere, in water, in moist surface of the soil, in air and even within the bodies of other animals and plants. They exert far more influence on the worldly affairs. They are harmful as well as useful species.

Helpful in sanitation: Numerous biologic protozoa help indirectly in purification of water by feeding on putrefying bacteria in various water bodies. These Protozoa play an important role

in the sanitary betterment, improvement of water and keeping water safe for drinking purposes.

Planktonic Protozoa as food: Protozoa floating on the plankton of sea provide directly or indirectly the source of food supplies to man, fish and other animals. They form one of the first links in the numerous and complicated food chains that exist in the oceans of the world. Clams and young fish feed extensively on aquatic larvae, small crustaceans, worms, etc. all of which take Protozoa as food. Thus Protozoa indirectly form food of fish, clams and other animals, which in their turn are consumed by man.

Symbiotic Protozoa: Some Protozoans are found in symbiotic relationship with other organisms. This association is beneficial to both the partners. The two partners become so dependent on each other and their separation results in the death of both. Several intestinal Protozoan flagellates of termites and woodroaches are extremely vital for the very existence of their hosts. They digest cellulose into soluble glycogen substance for their hosts as well as for themselves.

Oceanic ooze and fossil Protozoa: the tiny skeletons of dead pelagic Foraminiferida, Radiolaria and Heliozoa sink to the sea bottom forming the soft mud or oceanic ooze. These tiny skeletons are made up of silica or calcium carbonate and over the years, deposited on the floor of the ocean, became solid and

fossilized and converted into some important sedimentary rock strata found all over the world. These have been put to various commercial uses such as filtering agents, abrasives, chalk, building stones etc.

Protozoa in study: They are studied in the laboratories for the comprehension and application of biological principles. Due to their minute size and quick reproduction, they are studied by geneticists for heredity and variations. They are progenitors of metazoans so their study helps in understanding the probable beginning of organic matter and the origin and evolution of life. The study of physiology of Protozoa also contributed to know about the physiology of cell.

Harmful Protozoa

Protozoa are found almost everywhere, in water, in moist surface of the soil, in air and even within the bodies of other animals and plants. They exert far more influence on the worldly affairs. They are harmful as well as useful species.

Soil Protozoa: several species of Protozoa, present in large numbers in soil feed upon the nitrifying bacteria and thus decline their activity and consequently tend to decrease the amount of nitrogen given to the soil by the nitrifying bacteria.

Water pollution: The Protozoa of faecal origin are responsible for water contamination or pollution. Some free living Protozoa

also pollute water by producing aromatic and oily secretions with objectionable odors which render water unfit for human consumption. Some bioluminescent dinoflagellates living in sea multiply extensively to turn the water red with their bodies.

The phenomenon is known as blooming and is the cause of 'red tides' experienced in the sea. The red water often gives afoul and disagreeable small to the ocean water. Large concentrations of these flagellate Protozoans may even lead to destruction of fish and poisoning of edible mollusks such as clam, oysters, mussels etc. making them unfit for human consumption.

Pathogenic Protozoa: Protozoa causing diseases are called pathogenic Protozoa. They occur in all classes of Protozoa.

*** Pathogenic Sarcodines:** There are two common genera which live in the intestine of man and other animals. Two species of Entamoeba cause serious dysentery in man and in reptiles.

*** Pathogenic flagellates:** The parasitic flagellates include Leishmania, Trypanosoma, Histomonas, Trichomonas, and Giardia. Three different species of Leishmania severe disease in man. These are transmitted by sandflies of the genus phlebotomus. The parasitic species of Trypanosoma in mammals causes serious diseases.

Different Trichomonas species cause vaginal Trichomoniasis in humans, cattle, doves, pigeon, turkeys and chickens. Giardia intestinalis causes Giardiasis in humans.

*** Pathogenic Sporozoans:** This super class is exclusively of parasitic forms. Some genera like Plasmodium, Eimeria, Isospora and Babesia include pathogenic species. Four species of Plasmodium cause malaria in man. Different species of Plasmodium cause malaria in monkeys tree rats and jungle fowl.

Pathogenic species of Eimeria causes coccidiosis in chickens, rabbits, dogs, cats, cattle, sheep and goats. One parasitic species of Isospora infect intestine of man, others infect cats and dogs. Babesia is intra-erythrocytic parasite of various vertebrates and causes lethal fevers, malignant jaundice and anaemia in horses, rodents, cat's goats etc.

*** Pathogenic Ciliates:** Balantidium coli are the only important intestinal parasites in man and also often found in frogs.

Basis of classification of the Animal Kingdom

Classification of Animal Kingdom is based on various fundamental features like –

1. **Levels of Organisation,**
2. **Symmetry,**
3. **Diploblastic and Triploblastic Organisation,**
4. **Coelom development,**
5. **Segmentation of the body and**
6. **Presense or absence of Notochord.**

Levels of Organisation

- Though all members of Animalia are multicellular, all of them do not exhibit the same pattern of organisation of cells.
- For example, in sponges, the cells are arranged as loose cell aggregates, i.e., they exhibit **cellular level of organisation**. Some division of labour (activities) occur among the cells.
- In coelenterates, the arrangement of cells is more complex. Here the cells performing the same function are arranged into tissues, hence is called **tissue level of organisation**.
- A still higher level of organisation, i.e., organ level [**organ level of organisation**] is exhibited by members of

Platyhelminthes and other higher phyla where tissues are grouped together to form organs, each specialised for a particular function.

- In animals like Annelids, Arthropods, Molluscs, Echinoderms and Chordates, organs have associated to form functional systems, each system concerned with a specific physiological function. This pattern is called **organ system level of organisation**.
- Organ systems in different groups of animals exhibit various patterns of complexities.
- For example, the digestive system in **Platyhelminthes (incomplete digestive system)** has only a single opening to the outside of the body that serves as both mouth and anus, and is hence called incomplete. A **complete digestive system** has two openings, mouth and anus.
- Similarly, the circulatory system may be of two types: **open type** in which the blood is pumped out of the heart and the cells and tissues are directly bathed in it and **closed type** in which the blood is circulated through a series of vessels of varying diameters (arteries, veins and capillaries).

Symmetry

- Symmetry is the arrangement of shapes or body parts so that they are equal on each side of a dividing line.
- Animals can be categorised on the basis of their symmetry.

- Sponges are mostly asymmetrical, i.e., any plane that passes through the centre does not divide them into equal halves.
- When any plane passing through the central axis of the body divides the organism into two identical halves, it is called **radial symmetry**. Coelenterates, Ctenophores and Echinoderms have this kind of body plan.
- Animals like Annelids, Arthropods, etc., where the body can be divided into identical left and right halves in only one plane, exhibit **bilateral symmetry**.

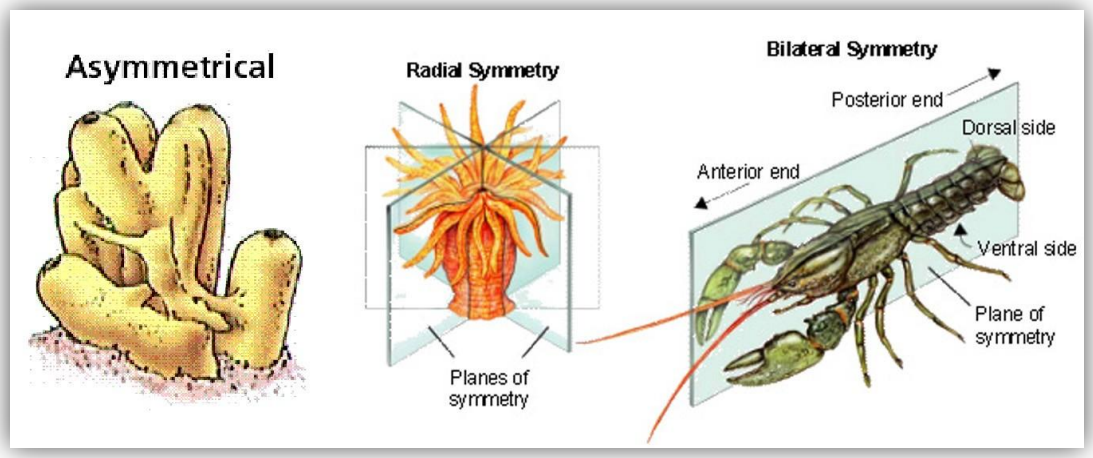


Fig. 9: Symmetry

Diploblastic and Triploblastic Organisation

- Animals in which the cells are arranged in two embryonic layers, an **external ectoderm** and an **internal endoderm**, are called **diploblastic animals**, e.g., Coelenterates. An

undifferentiated layer, **mesoglea**, is present in between the ectoderm and the endoderm.

- Those animals in which the developing embryo has a third germinal layer, **mesoderm**, in between the ectoderm and endoderm, are called **triploblastic animals** (platyhelminthes to chordates). Mesoderm allows development of muscle layers in body wall, allows more elaborate organs, more specialization and greater division of labor.

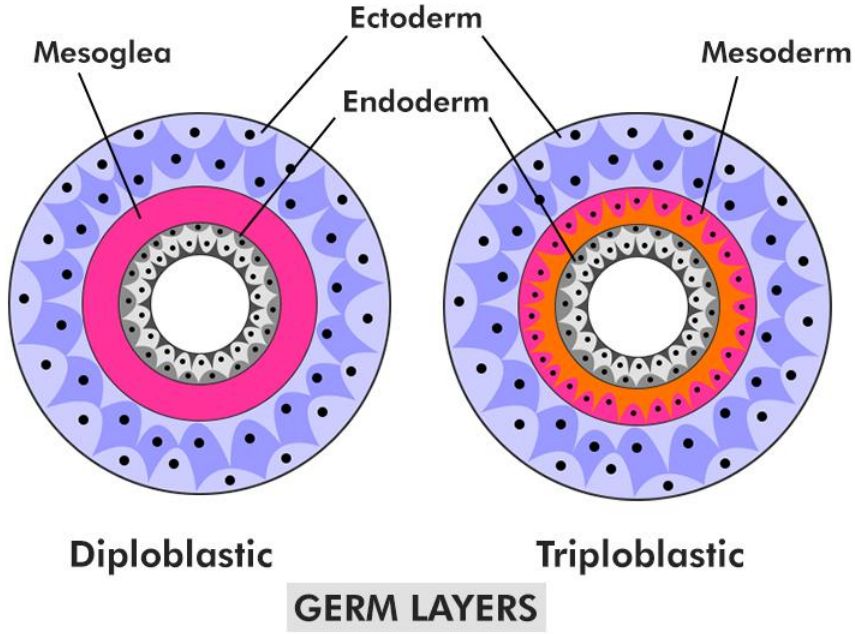


Fig. 10: Diploblastic and triploblastic animals

Coelom

- Presence or absence of a cavity between the body wall and the gut wall is very important in classification.
- The true coelom is a fluid-filled body cavity, which is completely lined by the tissues derived from the mesoderm.
- Animals possessing coelom are called **coelomates**, e.g., Annelids, Molluscs, Arthropods, Echinoderms, Hemichordates & Chordates.
- In some animals, the body cavity is not lined by mesoderm, instead, the mesoderm is present as scattered pouches in between the ectoderm and endoderm. Such a body cavity is called **pseudocoelom** and the animals possessing them are called pseudocoelomates, e.g., Aschelminthes.
- The animals in which the body cavity is absent are called **acoelomates**, e.g., Platyhelminthes.

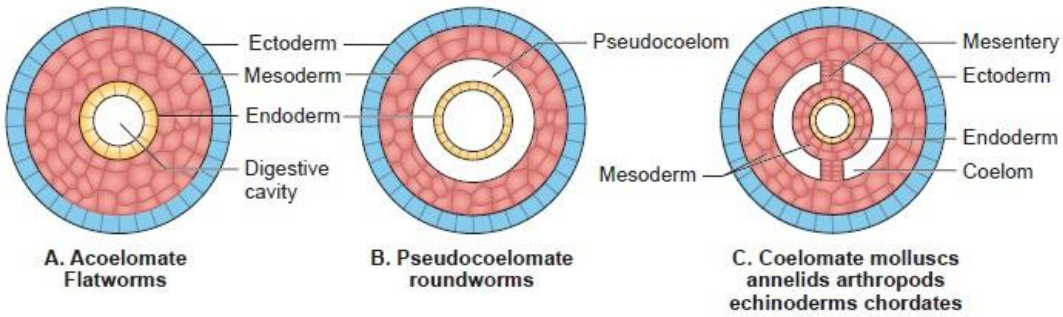


Fig. 11: Coelom

Coelom Function

- Coelom works as a shock absorber and protects from any kind of mechanical shock. It gives more flexibility to the body organs to move and protects from any damage on minor bends by cushioning the internal organs
- The coelomic fluid acts as a hydrostatic skeleton, which helps in the locomotion of soft-bodied animals and gives the body a definite shape. Contracting muscles can push against the coelomic fluid because of the fluid pressure.
- The coelomocyte cells, that either float freely in the coelom or attached to the wall, support the immune system. They support the immune system by initiating humoral immune response and phagocytosis
- The coelomic fluid also helps in gaseous transport and transport of nutrients and waste products
- Coelom gives the extra space required by organs to develop and function. E.g. pumping action of the heart, carrying a child in the womb, etc. is possible due to coelom

Segmentation and Metamerism

In animals, zoologists define metamery as a mesodermal event resulting in serial repetition of unit subdivisions of ectoderm and mesoderm products. Endoderm is not involved in metamery. Segmentation is not the same concept as metamerism:

segmentation can be confined only to ectodermally derived tissue, e.g., in the Cestoda tapeworms. Metamerism is far more important biologically since it results in metameres - also called somites - that play a critical role in advanced locomotion.

One can divide metamerism into two main categories:

- **homonomous metamery** is a strict serial succession of metameres. It can be grouped into two more classifications known as pseudometamerism and true metamerism. An example of **pseudometamerism** is in the class Cestoda. The tapeworm is composed of many repeating segments - primarily for reproduction and basic nutrient exchange. Each segment acts independently from the others, which is why it is not considered true metamerism. Another worm, the earthworm in phylum Annelida, can exemplify true metamerism. In each segment of the worm, a repetition of organs and muscle tissue can be found. What differentiates the Annelids from Cestoda is that the segments in the earthworm all work together for the whole organism. It is believed that segmentation evolved for many reasons, including a higher degree of motion. Taking the earthworm, for example: the segmentation of the muscular tissue allows the worm to move in an inching pattern. The circular muscles work to allow the segments to elongate one by one, and the longitudinal muscles then

work to shorten the elongated segments. This pattern continues down the entirety of the worm, allowing it to inch along a surface. Each segment is allowed to work independently, but towards the movement of the whole worm.

- **heteronomous metamery** is the condition where metameres have grouped together to perform similar tasks. The extreme example of this is the insect head (5 metameres), thorax (3 metameres), and abdomen (11 metameres, not all discernible in all insects). The process that results in the grouping of metameres is called "tagmatization", and each grouping is called a tagma (plural: tagmata). In organisms with highly derived tagmata, such as the insects, much of the metamerism within a tagma may not be trivially distinguishable. It may have to be sought in structures that do not necessarily reflect the grouped metameric function (eg. the ladder nerve system or somites do not reflect the unitary structure of a thorax).

Notochord

- Notochord is a mesodermally [the middle layer of cells or tissues of an embryo, or the parts derived from this (e.g. cartilage, muscles, and bone)] derived rod-like structure

formed on the dorsal side [posterior] during embryonic development in some animals.

- Animals with notochord are called **chordates** and those animals which do not form this structure are called non-chordates, e.g., Porifera to Echinoderms.

Kingdom: **Animalia** (animals)
Subkingdom: **Parazoa**

Phylum: Porifera

General characters:

- Sponges are sessile or sedentary and mostly marine animals (a few are freshwater forms) which show little or no detectable movement.
- They are primitive multicellular animals.
- They are thin flattened or have irregular shapes.
- The body has numerous pores (ostia) and canals.
- Inside the body there is a single cavity lined by flagellated cells.
- The body cells are less specialized, they do not form proper tissues or organs.

- They have a skeleton of calcareous spicules or organic spongin fibres.
- They are holozoic, digestion is entirely intracellular. They generally feed on bacteria and other food particles that are present in the water
- They respire and excrete by simple diffusion.
- They have no sensory or nerve cells.
- They reproduce asexually by budding, gemmule formation or by regeneration, they also reproduce sexually by gametes (most sponges are hermaphrodite).
- There are three types of sponges: ascon, sycon and leucon.

Classification of Porifera

Porifera is divided into three classes based on the skeleton they possess.

1. **Calcarea**

• Skeleton consists mainly of calcareous spicules

Examples: *Sycon*, *Leucosolenia*

- 2. **Hexactinellida** (Hyalospongiae)

• Skeleton consists mainly of siliceous spicules

Examples: *Euplectella*, *Hyalonema*

3. **Demospongiae**

• Skeleton consists mainly of spongin fibres which may be in combination with spicules

Example: *Euspongia*

The Ascon type (*Leucosolenia)*

- This is the simplest type of sponges.
- The body is tube in shape, live in colonies. It has triradiate spicules.

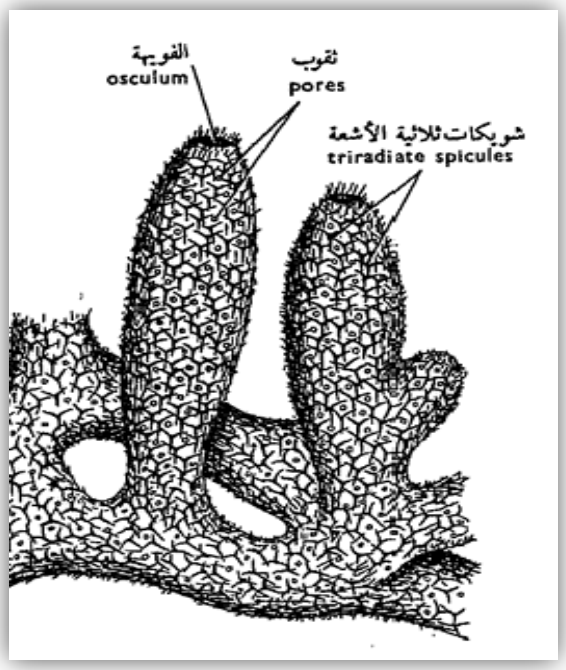


Fig. 12: *Leucosolenia*

- The body wall surrounds a central cavity known as paragastric cavity lined with flagellated cells.

- The wall is thin, contains many openings (ostia) which lead directly to the paragastric cavity which open outside through osculum.

Watch video

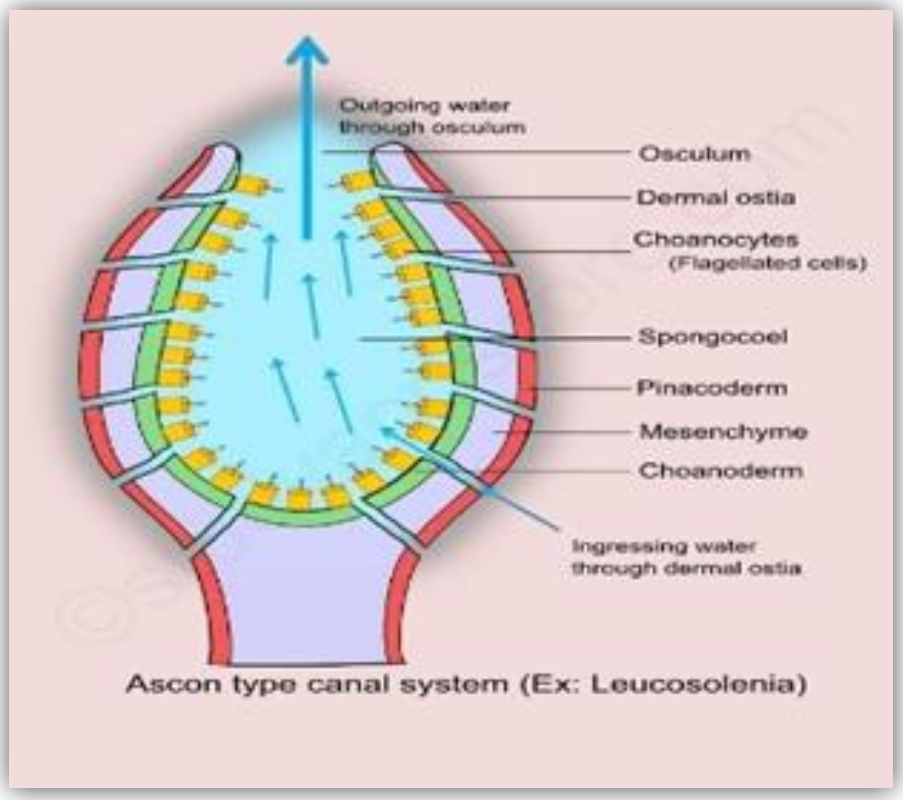


Fig. 13: Internal structure of *Leucosolenia*

The body wall of *Leucosolenia* consists of two cellular layers:

1- The dermal layer: the outer layer formed of thin flattened cells: **pinacocytes.**

2- The gastral layer: contains choanocytes with flagellates extend to the paragastric cavity.

The gastral layer: contains choanocytes with flagellates extend to the paragastric cavity, and between the two layers there is a jelly substance contains three types of cells (**scleroblasts**, **amoebocytes** and **porocytes**). **Scleroblasts** secrete calcareous spicules**, amoebocytes** can develop into any other cell in the body and form the games in the sexual reproduction and **porocytes** act as pores**.**

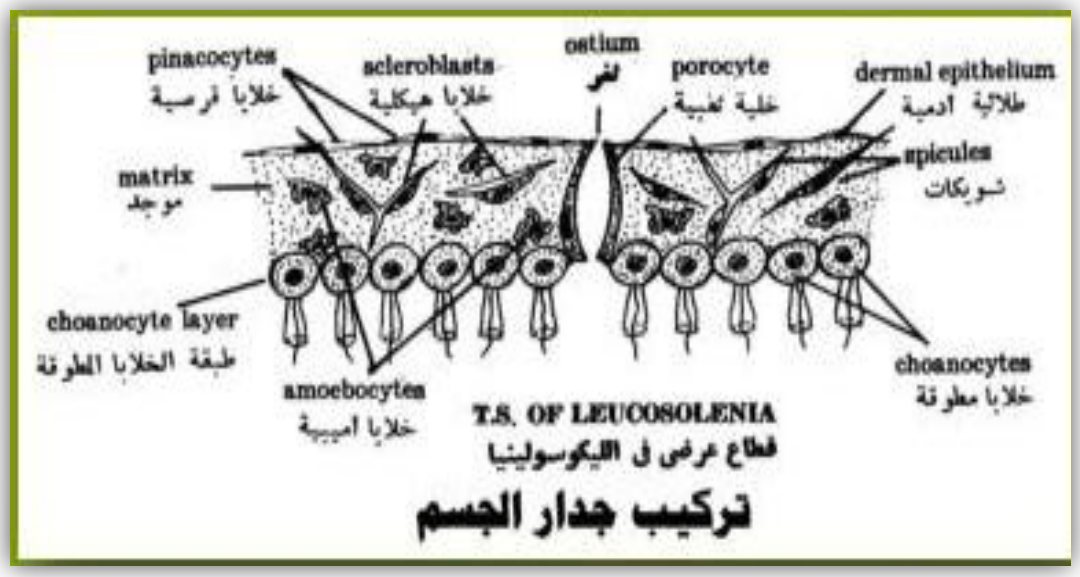


Fig. 14: Body wall of *Leucosolenia*

The Sycon type: *Sycon*

This is a solitary marine sponge, live attached to rocks in shallow waters, it has a vase shaped body with a single large osculum at the free end.

The body wall is relatively thick, folded forming many horizontal flagellated chambers

The flagellated chambers are lined with choanocytes

Water is drawn through the ostia into the inhalant canals, then pass to the flagellated chambers then to the paragastric cavity, and finally to the outside through the osculum.

Fig. 15: *Sycon*

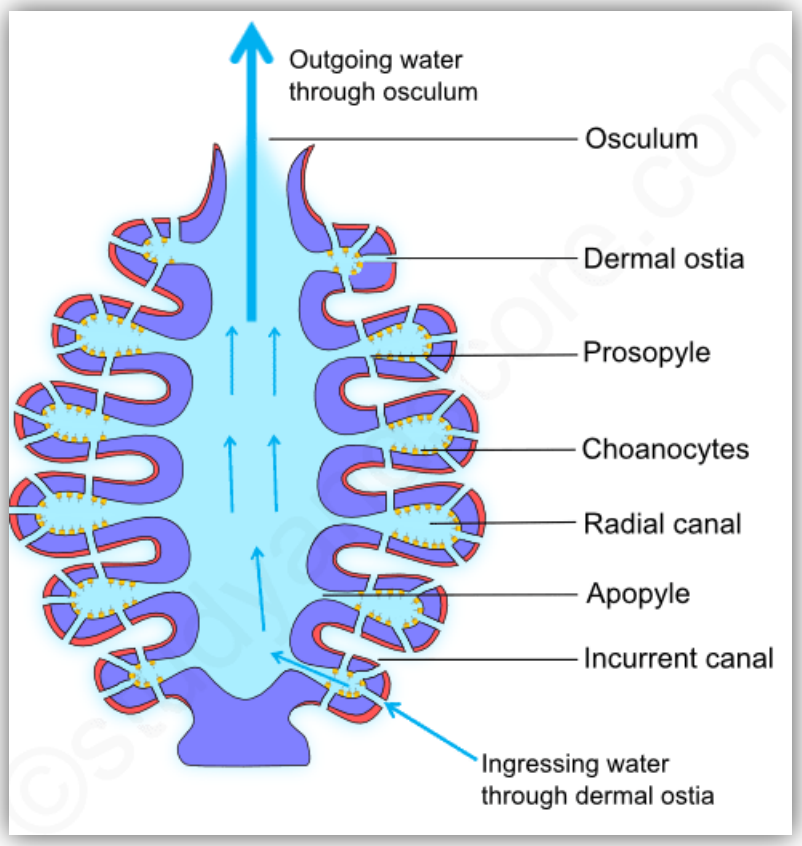


Fig. 16: Internal structure of *Sycon*

The Leucon type: *Euspongia*

- Spherical, irregular or cup shape.
- They live on the sea bottom attached to rocks.
- The body surface contains minute ostia, in between there are several larger oscula with more complex structure.
- It contains a complex network of branching spongin fibres extends within the jelly and gives the animal the characteristic spongy texture.

- The layer of choanocytes is highly folded and the paragastric cavity is reduced.
- The ostia found on the outer surface lead into large subdermal cavities, from which some inhalant canals extend to the flagellated chambers.

Fig. 17: *Euspongia*

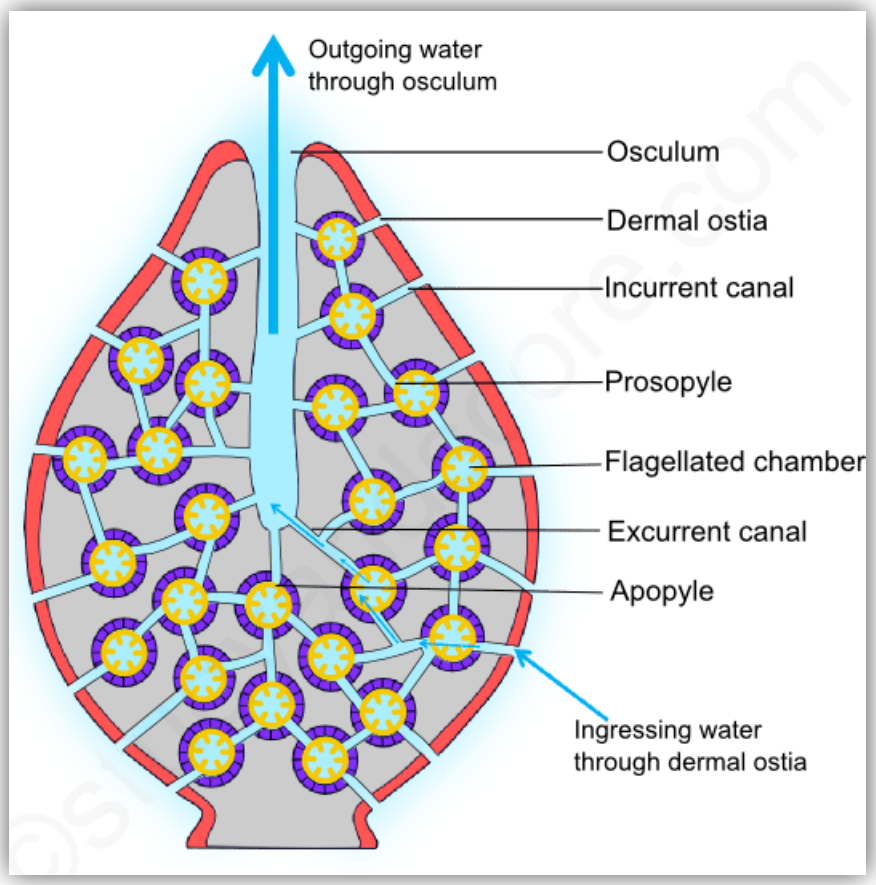


Fig. 18: Internal structure of *Euspongia*

Gemmules of Sponges

- Gemmules are asexual reproductive bodies of most of the freshwater and a few marine sponges.
- These are internal buds and are response to the hostile environment.These are small, hard, ball-like structure consisting of an outer capsule and an inner mass of amoebocytes.
- These are resistant to desiccation (drying out), freezing, and

anoxia (lack of oxygen) and can lie around for long periods of time. Under favourable conditions, the mass of amoebocytes come out in water and develops into a young sponge.

Economics Importance of Phylum Porifera (Sponges)

 Sponges play a vital role in the economic and commercial growth of our society. Some sponges are used in the bath because of their skeleton. The followings are the uses of sponges.

1. Man uses the skeleton of sponges for washing and bathing. Many artificial sponges have been made from synthetic material. But still, there is much demand for the natural sponge. It is an important industry in any part of the world. The best commercial sponges are found in the warm water of the Mediterranean Sea.
2. Sponges have a great capacity to absorb water. So they are used in surgical operations for absorbing fluid and blood.
3. Sponges are also used for sound absorption in buildings.
4. during the cultivation of radish and other fast-growing seeds and food items, sponges are used to maintain agriculture on a large scale.

5. for the quick sprouting out of seeds in agriculture, sponges are used as a moistened. it creates a container around the seed.
6. to avoid cracks, it is also used as a box with fragile things to protect them from having cracks on them. which provides softness and safety against being breakable.
7. sponges play an important role in catching the oil leaks. they are wrapped up with some tools to hold them safely so that they don’t slip into your hands.
8. They are also used to try the inside of the vase by putting it in a stick.
9. by mixing it in soaps and detergents, it saves soaps from melting fast, more ever, putting sponges on the soaps, it can suck extra water which caused the melting down of the soap.
10. It can be used to eliminate stink odor from the refrigerator by sprinkling it a small amount.
11. By putting some sponges on the base of wares, it can avoid wares from scratches.
12. It is also used to remove sticking wallpapers from the walls just because of soaking the sponges into the water and vaping it over the wall with the help of stubborn left paper.
13. used as a scrub while taking bath.

Subkingdom: Eumetazoa

- **……..Diploblastica**

Phylum: Cnidaria (Coelenterata)

1- Simple sessile aquatic metazoans, mostly marine and a few live in freshwater.

2- Many are colonial (ex.: Corals). Some are solitary (ex: sea anemone).

2- They are radially symmetrical (the body is divided into two symmetrical halves if cut in any direction pass in through the axis).

3- There are two layers in the body (ectoderm, endoderm) separated by a jelly – like mesogloea.

4- They have nematocysts or cnidocytes, hence the name cnidaria. They are stinging structures not found in any other phylum.

5- There is a single cavity (the gastrovascular cavity or coelenteron cavity).

5. Respiration and excretion by simple diffusion.
6. They have a simple diffuse nervous tissue in the form of a nerve net.

7. They reproduce asexually by budding, and sexually by gametes.
8. Polyp and medusa are the two different forms of cnidarians. Polyp is hydroid form which is sessile with mouth-up orientation. Medusa is umbrella or bell shaped with mouth down orientation. It swims by constricting the
9. Some forms with external calcareous skeleton.

Classification of Coelenterata

- **Class 1: Hydrozoa**

Most have the polyp and medusa forms during the life cycle.

- **Order 1: Hydroidea**

Have the polyp form only: ex.:*Hydra*

- **Order 2: Calyptoblastea**

Have the two forms (polyp and medusa) ex.: *Obelia*

- **Class 2: Scyphozoa**

Contains the jelly-fishes, have only the medusa form.

- **Class 3: Actinozoa**

Contains the sea anemones (the sea flowers) and the stony corals, have only the polyp form.

Hydra

- ***Hydra*** is a genus of small, fresh-water organisms. It measures from 2 to 20 mm in length.
- ***Hydra*** has a tubular, radially symmetric body, secured by a simple adhesive foot called the basal disc.
- At the free end of the body (the oral cone), there is a mouth opening surrounded by 6 to 8 thin, mobile tentacles. Each tentacle is clothed with highly specialised stinging structures called nematocysts.
- If *Hydra* attacked, the tentacles can be retracted to small buds, and the body column itself can be retracted to a small gelatinous sphere.

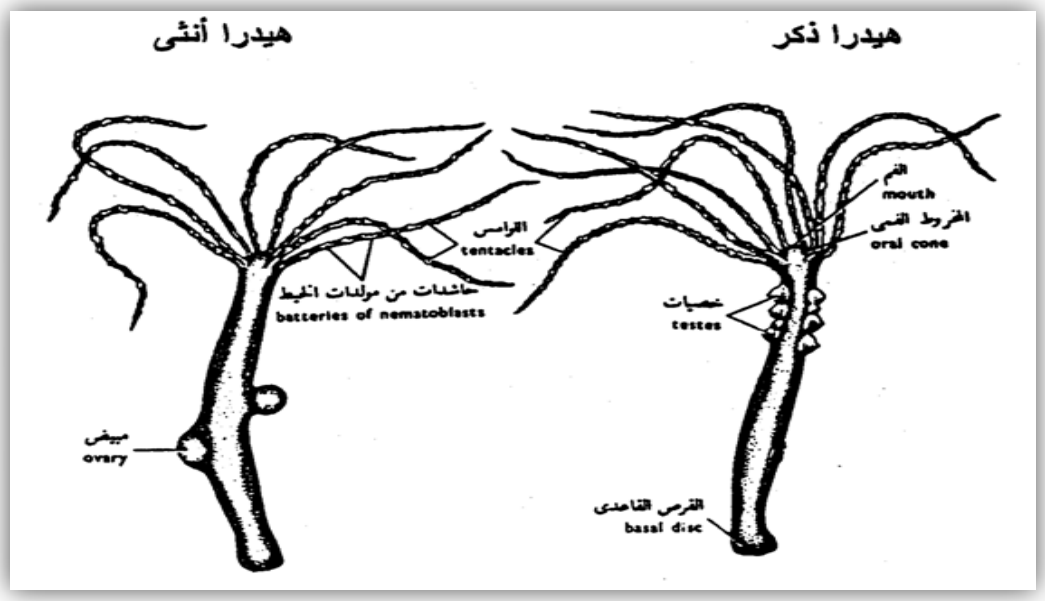


Fig. 19: Hydra

- *Hydra* is generally sedentary or sessile, but do move, especially when hunting. They have different distinct methods for moving: 'looping', 'somersaulting', floating, swimming,…….

- *Hydra* mainly feeds on aquatic invertebrates such as *Daphnia* and *Cyclops*.

- Locomotion in *Hydra*

- **1- Looping = walking:** the body at first extends and then bends and fixes the tentacles to the substratum. It then releases the attachment of the basal disc, reattaches the basal disc near the tentacles and again take an upright position by releasing its tentacles.

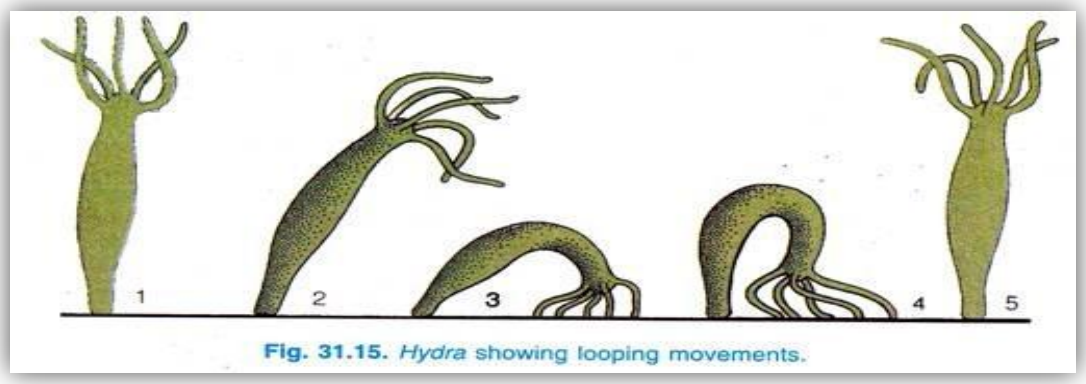


Fig. 31.15. *Hydra* showing looping movements.

Fig. 20: Looping in *Hydra*

- **2- Somersaulting:** *Hydra* extends its body and is bent to one side to place the tentacles on the substratum. The basal disc is freed from its attachment, and the animal stands on its tentacles.
- The body is then extended and bent to place the basal disc on the substratum, the tentacles loosen their hold and the animal regains an upright position

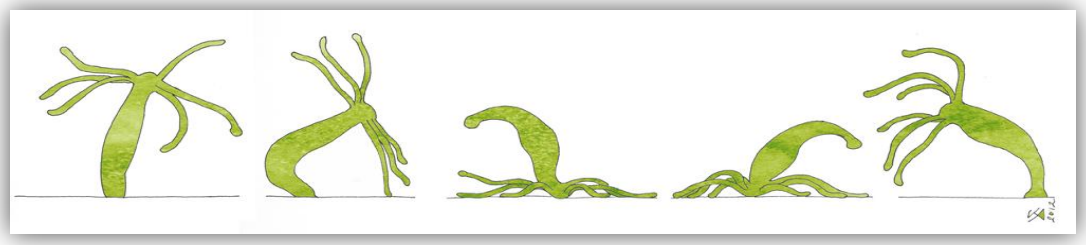


Fig. 21: Somersaulting in *Hydra*

- **3- Gliding:** *Hydra* can glide slowly along its attachment by pseudopodia from the basal disc.

- **4- Cuttlefish-like movement:** The tentacles are fixed to the substratum and with the pedal disc up, *Hydra* moves over the substratum by pulling its tentacles along.

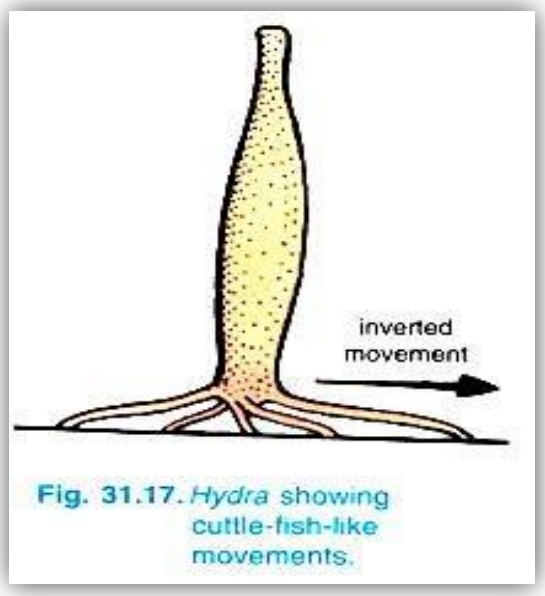


Fig. 31.17. *Hydra* showing cuttle-fish-like movements.

Fig. 22: Cuttlefish -like movement

- **5- Floating:** *Hydra* can produce a bubble of gas secreted by some ectodermal cells of the basal disc which helps the animal to float on the surface of the water and is passively carried from one place to another by water current.
- **6- Swimming:** By freeing itself from the substratum and with the help of wave-like
- movements of the tentacles,

Hydra swims in water

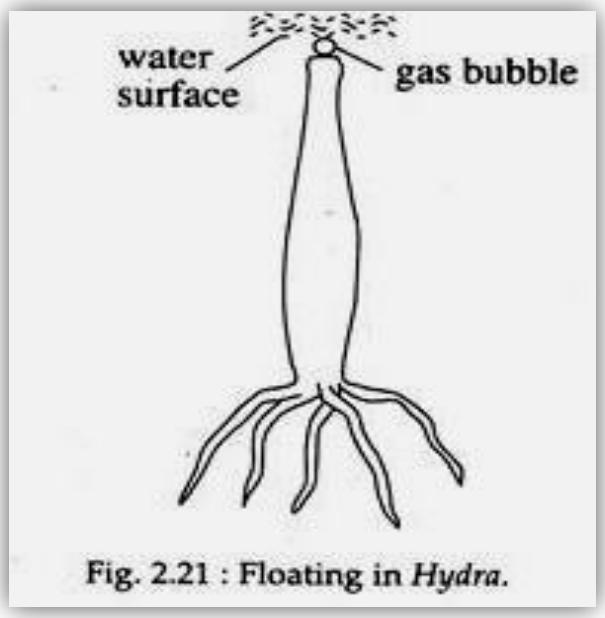


Fig. 2.21 : Floating in *Hydra*.

Fig. 23: Floating

- **7- Climbing**
- *Hydra* can climb by attaching its tentacles to some distant objects and then releasing the basal disc and by contracting the tentacles the body is drawn up to a new position.

Watch video

Fig. 31.19. *Hydra* showing climbing.

Fig. 24: Climbing

Reproduction

- When food is plentiful, many *Hydra* reproduce asexually by producing buds in the body wall, which grow to be miniature adults and break away when they are mature.
- When *Hydra* is well fed, a new bud can form every two days. When conditions are harsh, often before winter or in poor feeding conditions, sexual reproduction occurs in some *Hydra*. Swellings in the body wall develop into either ovaries or testes. The testes release free-swimming gametes into the water, and these can fertilize the egg in the ovary of another individual. The fertilized eggs secrete

a tough outer coating, and, as the adult dies (due to starvation and/or cold), these resting eggs fall to the bottom of the lake or pond to await better conditions. Some *Hydra* species are hermaphrodite.

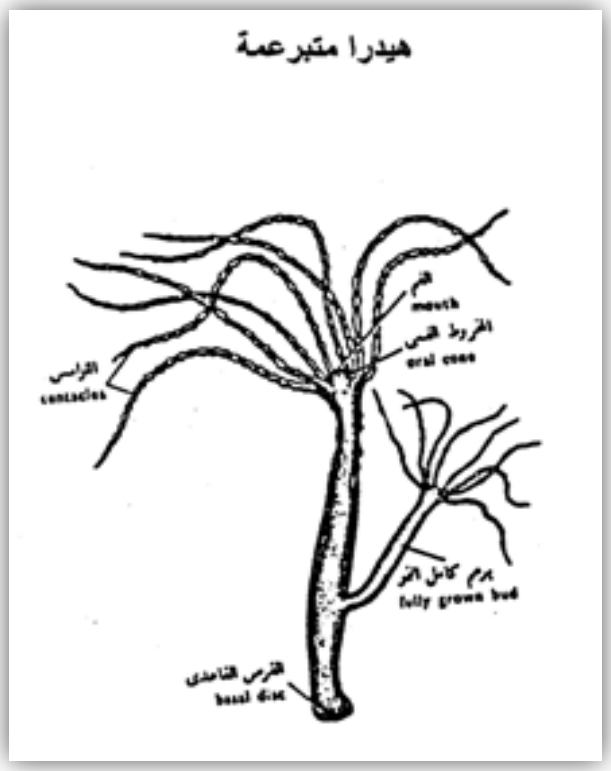


Fig. 25: Budding in *Hydra*

Watch video

Obelia

Habit and Habitat: *Obelia* is sedentary, marine colonial form found attached on the surface of sea weeds, molluscan shells, rocks and wooden piles in shallow water up to 80 metres in

depth. *Obelia* is cosmopolitan in distribution, forming a whitish or light-brown plant-like fur in the sea; hence, the common name sea-fur is assigned to it.

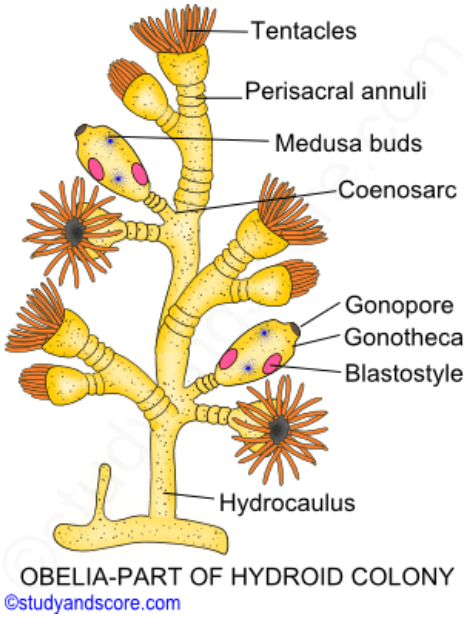


Fig. 26: *Obelia*

The polyp colony reproduces asexually. During this stage of life, *Obelia* are confined to substrate surfaces. On mature colonies there are individual hydranths called gastrozooids, which can be found expanded or contracted, to aid in the growth of this organism by feeding; the reproductive polyp gonozooids have medusa buds. Other hydranths are specialized for defence. The main stalky body of the colony is composed of a *coenosarc*, which is covered by a protective *perisarc*.

The next generation of the life cycle begins when the medusae are released from the gonozooids, producing free swimming only male medusae velum with gonads, a mouth, and tentacles. The physical appearance of the male and female medusae velum, including their gonads, are indistinguishable, and the sex can only be determined by observing the inside of the gonads, which will either contain sperm or eggs. The medusae reproduce sexually, releasing sperm and eggs that fertilize to form a zygote, which later morphs into a blastula, then a ciliated swimming larva called a planula.

The planulae are free-swimming for a while but eventually attach themselves to some solid surface, where they begin their reproductive phase of life. Once attached to a substrate, a planula quickly develops into one feeding polyp. As the polyp grows, it begins developing branches of other feeding individuals, thus forming a new generation of polyps by asexual budding.

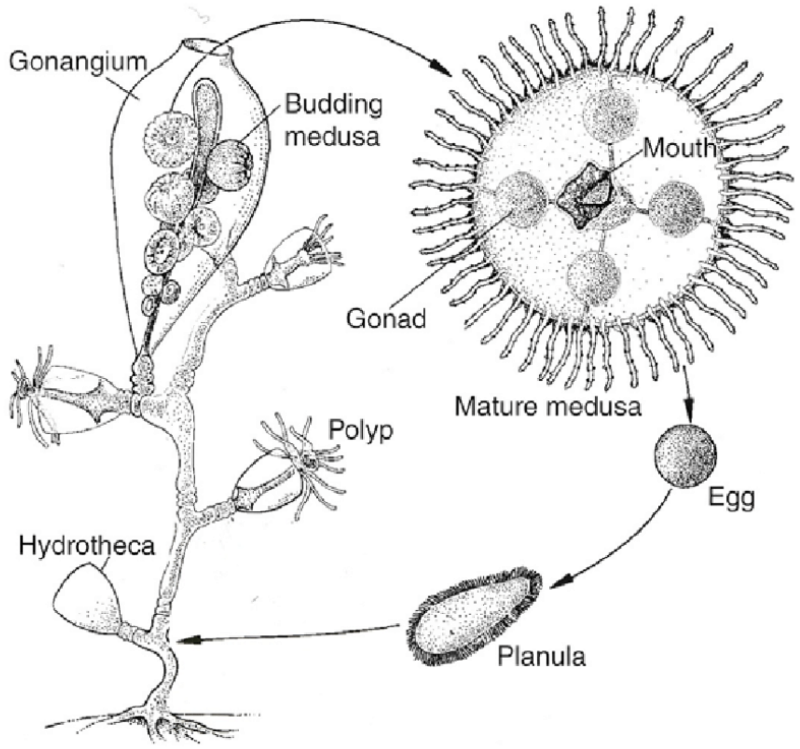


Fig. 27: lifecycle of *Obelia*

Importance of Coelenterata

Coelenterata also called Cnidraians

1. Cnidarians are a major contributor to the aquarium trade industry

Yes, the aquarium industry has flourished a lot due to the presence of various cnidarians like Jellyfishes, corals, etc. Amongst the other cnidarians, the Moon Jellyfish is the most famous one.

Moon Jellyfish is often cultured around the world and it finds its application in various household aquariums. Their sting is not powerful and venomous because they are planktivores.

Another very important one is the Colt Coral species that is highly found in Indo-Pacific coral reefs. They do not have the calcium carbonate skeleton of the reef-building corals. It is a hardy aquarium species and is commonly well-cultured.

2. Their ecosystems are a source of food for millions

The cnidarians like those in the Coral Reefs provide an ecosystem surrounding their existence where various other food resources can thrive. Thus, Coral reefs provide food to millions of humans.

Corals, like trees, provide a three-dimensional structure and substrate to house and feed fish and other marine animals that humans eat.

People living in the coastal regions highly depend on marine animals to cope up with their feeding needs.

Reef animals are an important source of protein. There you can find tons of fishes, crustaceans, molluscs, and other invertebrates as food for humans.

Cnidarians like some edible species of jellyfish are suitable for human consumption and are used as a source of food and as an

ingredient in various dishes. These are cultured and harvested on a large scale to serve as a source of food for millions.

Sea Anemones are also a very famous delicacy. Anemones are eaten like deep-fried fish chips, and also as diced in the soup.

3. Coral Reefs protect coastlines from storms and erosion

It's a very important point to note that Coral reefs are important to protect the sea coastlines from the damaging effects of wave action and tropical storms while providing great comfortable habitats and shelter for many marine organisms.

The Coral Reef and its ecosystem run along more than 150,000 km of coastline in more than 100 countries and territories.

These reefs stretch about hundreds of meters deep underwater and maybe kilometers far from seashores.

4. Coral Reefs also provide habitat, spawning, and nursery grounds for economically important fish species

Yes, it has been already mentioned above in the post that the Coral Reefs provide habitats and shelter for many marine organisms. In doing so, they do create the most diverse ecosystems on the planet.

They do serve as good nursery grounds for commercially important fishes, The Reef fish varieties are the more colourful ones than the others.

They provide the best habitat for fish breeding and the protection of the eggs and the larvae of the various marine animals. The ecosystem makes it happen in a far better way.

The fishing industry depends on coral reefs because many fish spawn there and juvenile fish spend time there before making their way to the open sea. And this is actually very much important for a good cause.

These coral reef habitats are particularly very much important and beneficial when determining the component habitat structures in marine protected areas and fish breeding and spawning grounds.

5. Coral Reefs are the hotspots of marine biodiversity

Yes! Too much biodiversity of the oceans thrives there. You can’t just imagine, it’s that too much.

These Coral Reefs are the hotspots of marine biodiversity. It’s so much so that it occupies less than 1% of the ocean floor but, is home to more than 25% of marine life.

Do you know? Coral reefs are believed by many to have the highest biodiversity of any ecosystem on the planet earth. Yes, it’s even more than a tropical rainforest like the Amazon.

The presence of the Coral Reefs has helped a lot in the existence of various animals and in the development and

diversification of new ones from the ancestors over the extreme course of evolution.

6. It boosts the fishing, recreational, and tourism industry a lot

The fishing industry in recent years has been boosted a lot in finding out the proper harvesting and cultural techniques in close relation to the coral reefs and the other cnidarians.

The fish that grow and live on coral reefs are a significant food source for over a billion people worldwide, and also for many of whom live far from the reefs.

7. They are a source of new medicines

Cnidarians are the new source of drugs, medicines, and biomedical research.

With the development of biotechnology and the advancement of science-technology, they are highly used as a new source for synthesizing Marine Bioactive Compounds.

Taking this into account, we must note that during the last decades a lot of interesting bioactive substances have been isolated from Cnidarians and those substances have been demonstrated for having cytotoxic, hemolytic, anti-inflammatory, antitumoral, anti-infective, anti-parasitic, as well as other interesting properties for medical use.

Subkingdom: Eumetazoa

- **……..Triploblastica**

Phylum: Platyhelminthes

General characters:

- They are the first animals which illustrate the development of organ system.
- May be free living or parasites.
- They are soft bodied, unsegmented worms.
- They are bilateral symmetry and dorsoventrally flat worms.
- They show three germinal layers i.e. ectoderm, mesoderm and endoderm.
- A true body cavity or coelom is absent, and the space between the body organs is filled with loose parenchyma.
- Muscular system is well developed.
- The alimentary canal is either absent or highly branched. Anus is absent.
- Excretory system consists of flame bulbs or flame cells or protonephridia connected to the excretory ducts.
- Circulatory and respiratory systems are absent.

- Nervous system and sense organs are poorly developed, consists of a pair of ganglia connected to 3 pairs of nerve cords.
- Usually hermaphrodite animals.
- Fertilization is internal and development may be direct or indirect
- Direct development: It is a type of development in which an embryo develops into a mature individual without involving a larval stage.
- Indirect development: It is a type of development that involves a sexually-immature larval stage, having different food requirement than adults.

Classification of Platyhelminthes

Class 1 Turbellaria

- Mostly Free-living fresh water organism
- Body: dorso-ventrally flattened
- Hooks and sucker usually absent
- Examples: *Planaria*

Class 2 Trematoda

- Mostly parasitic
- Body: dorso-ventrally flattened leaf like
- Hooks and sucker are present

- Examples; *Fasciola hepatica* (Liver fluke) *Schistosoma* (blood fluke)

Class 3 Cestoda

- Exclusive parasitic
- Body: dorso-ventrally flattened tape like
- Hooks and sucker are present
- Digestive system-absent
- Excretion: Protonephridia with flame cell
- Examples: *Taenia* (tapeworm)

The Liver Fluke (*Fasciola hepatica)*

- *Fasciola hepatica* is an endoparasite with a leaf-like, dorsoventrally flattened body. It is commonly known as liver-fluke.
- It lives inside the bile-duct of liver in sheep, goats and cattle. It causes a disease called liver-rot in sheep.
- It is conical in shape, about 25 mm long and about 15mm in breadth. It is narrow at the anterior end, broad in the middle and tapers towards the posterior end.
- At the anterior end there is a triangular projection, the head-lobe. It has two suckers, an oral sucker or anterior sucker at the tip of the head lobe and a ventral sucker or acetabulum behind the head lobe, on the ventral side.

- The oral sucker encloses the mouth and the ventral sucker has no aperture. The suckers help in the attachment of the parasite to the host.
- Between the two suckers there is or genital opening or gonopore. An excretory pore is present at the hind end.

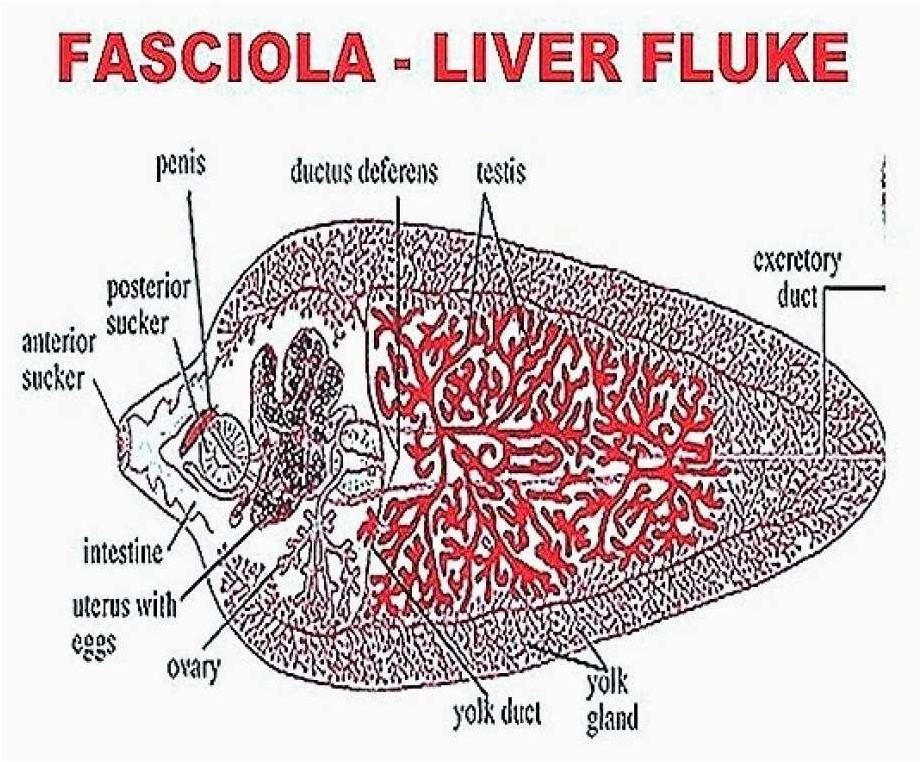


Fig. 28: *Fasciola*

Digestive System

- The digestive system is very simple. It is formed of a mouth, the pharynx, oesophagus and the intestine.
- The mouth is sub-ventral in position. It is surrounded by the oral sucker. It leads into a funnel-shaped muscular pharynx.

- The pharynx is surrounded with pharyngeal glands. The lumen of the pharynx is very narrow, which leads into a short, narrow oesophagus.
- The oesophagus is followed by the intestine. The intestine soon after its origin divides into two branches called caeca. Each caecum runs up to the posterior end where it ends blindly. Each caecum is divided into a number of branching diverticula. The anus is absent.
- The liver fluke feeds on the blood and bile of the host. It sucks the liquid food by the muscular pharynx. As the food is already in the digested state and fit for absorption, the digestive glands are completely absent. The food is absorbed in intestine. The branches of diverticula transport the digested food to the different parts of the body along the parenchyma.

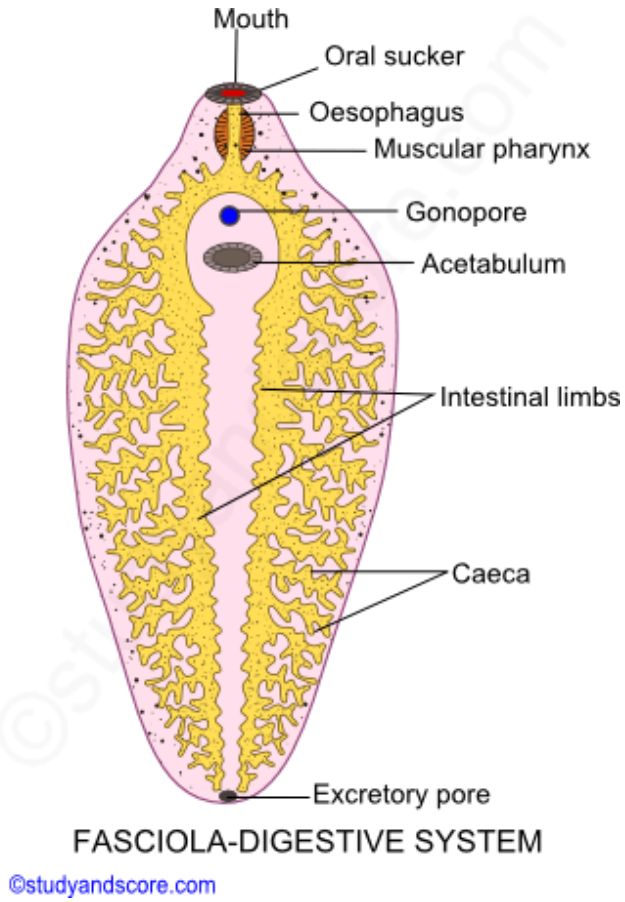


Fig. 29: Digestive system in *Fasciola*

Excretory System

- The excretory system in liver fluke is formed of protonephridia. It has no internal opening. It consists of a median longitudinal excretory canal.
- The canal opens to the outside at the posterior end of the animal by an excretory pore. The excretory canal gives out many branches. Each branch ends in a cell called flame cell.

- Each flame cell is formed of a single cell It has an elastic thin wall with a nucleus and a cavity. The cavity contains a bundle of cilia. The cilia show flickering movement like a flame; hence the name flame cell.
- The surface is produced into pseudopodia. The liquid wastes are absorbed from the surrounding tissues by the flame cells. By the movement of cilia, the wastes are sent out through the excretory pore.

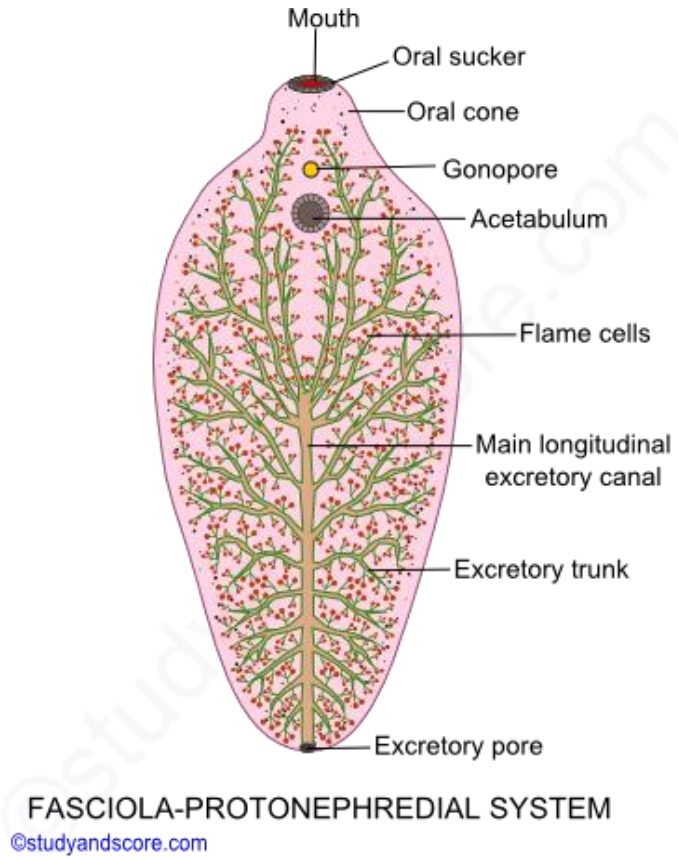


Fig. 30: Excretory system in *Fasciola*

Reproductive System

- Liver fluke is hermaphrodite. Both male and female reproductive organs are present in the same animal. It contains complicated reproductive organs.
- The male and female genital ducts open into a common chamber, the genital atrium. The genital atrium opens outside through the common genital aperture

Male Reproductive System

- It consists of two testes. They are tubular and highly branched. A vas deferens arises from each testis. The two vasa deferentia run forward and join to form a median bag-like structure the seminal vesicle.
- The sperms produced by the testes are stored in the seminal vesicle. The seminal vesicle leads into a narrow tube, the ejaculatory duct. The ejaculatory duct opens into a muscular tube called penis. It opens into the genital atrium by the male genital aperture

Female Reproductive System

- The female reproductive system is formed of a single ovary. It is tubular and branched. It lies in the middle of the body in front of the testes. An oviduct arises from the ovary. It runs forward and joins the vitelline duct.
- There are numerous small rounded yolk glands or vitellaria on the sides of the body. These glands secrete yolk and the shell. A minute duct known as yolk duct arises from each yolk gland. All yolk ducts unite into an anterior

longitudinal vitelline duct and a posterior longitudinal vitelline duct on each side.

- The two longitudinal ducts join to form a transverse vitelline duct. The transverse vitelline ducts of the two sides run inward and join to form a median vitelline duct which runs forward and joins the oviduct.
- The junction of median vitelline duct and the oviduct is slightly dilated to form an ootype. Around the ootype there is a mass of unicellular Mehli's glands or shell glands. The secretion of Mehli's glands lubricates the passage of eggs in the uterus. It also activates the sperm and hardens the egg shell.
- From the ootype arises a large duct called ovo-vitelline duct or uterus. The uterus runs forwards as a coiled tube and opens to the exterior through the female genital pore close to the male genital pore.
- From the ootype arises another canal known as Laurer's canal. It runs vertically upwards and opens on the mid-dorsal surface. During copulation, the sperms are received from the other fluke through this canal. So it is also termed copulation canal.

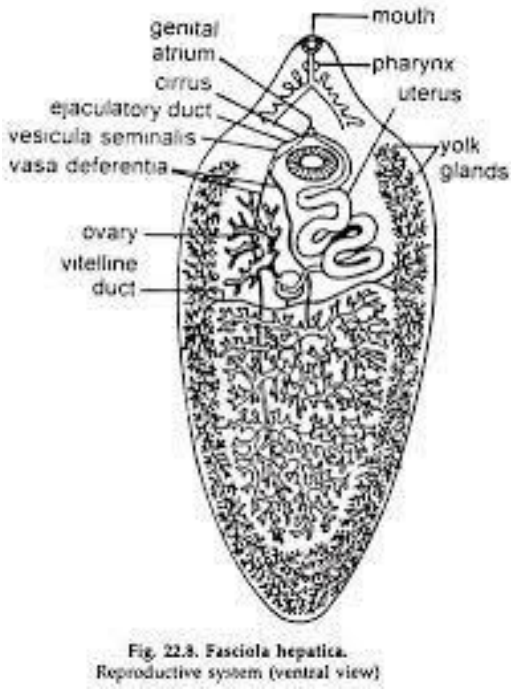


Fig. 22.8. Fasciola hepatica.
Reproductive system (ventral view)

Fig. 31: Reproductive system in *Fasciola*

Life Cycle

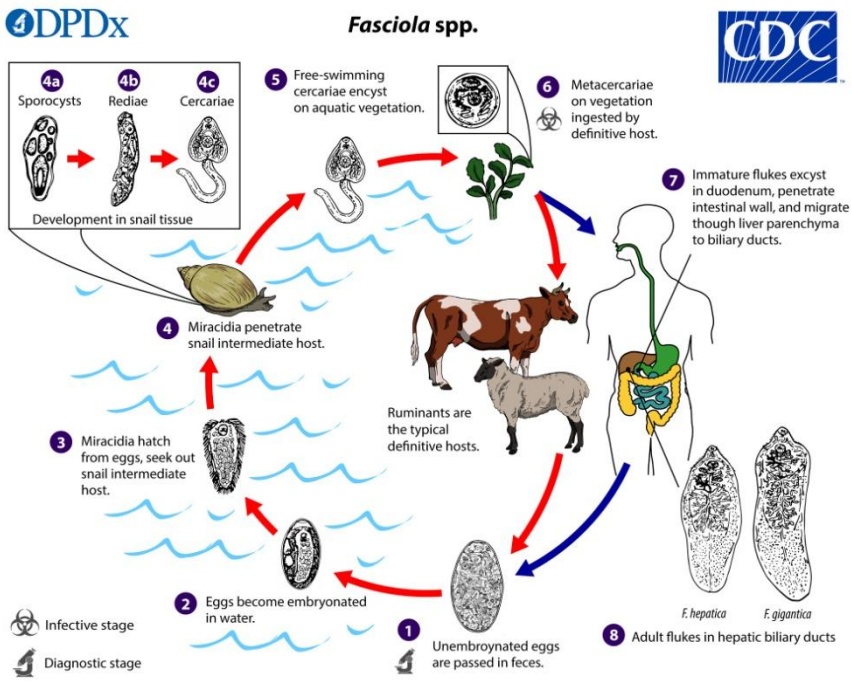


Fig. 32: Lifecycle of *Fasciola*

Immature eggs are discharged in the biliary ducts and passed in the stool. Eggs become embryonated in freshwater over ~2 weeks; embryonated eggs release miracidia, which invade a suitable snail intermediate host (*Lymnaea caillaudi* for *f. gigantic* and *Lymnaea truncatula* for *f. hepatica*. In the snail, the parasites undergo several developmental stages (sporocysts, rediae, and cercariae). The cercariae are released from the snail and encyst as metacercariae on aquatic vegetation or other substrates. Humans and other mammals become infected by ingesting metacercariae-contaminated vegetation (e.g., watercress). After ingestion, the metacercariae excyst in the duodenum and

penetrate through the intestinal wall into the peritoneal cavity. The immature flukes then migrate through the liver parenchyma into biliary ducts, where they mature into adult flukes and produce eggs. In humans, maturation from metacercariae into adult flukes usually takes about 3–4 months; development of *F. gigantica* may take somewhat longer than *F. hepatica*.

Taenia saginata

T. saginata is the largest of species in the genus *Taenia*. An adult worm is normally 4 to 10 m in length, but can become very large; specimens over 22 m long are reported. Typical of cestodes, its body is flattened dorsoventrally and heavily segmented. It is entirely covered by a tegument. The body is white in colour and consists of three portions: scolex, neck, and strobila. The scolex has four suckers, but they have no hooks. Lack of hooks and a rostellum is an identifying feature from other *Taenia* species. The rest of the body proper, the strobila, is basically a chain of numerous body segments called proglottids. The neck is the shortest part of the body, and consists of immature proglottids. The midstrobila is made of mature proglottids that eventually lead to the gravid proglottids, which are at the posterior end. An individual can have as many as 1000 to 2000 proglottids.

T. saginata does not have a digestive system, mouth, anus, or digestive tract. It derives nutrients from the host through its tegument, as the tegument is completely covered with absorptive hair-like microtriches. It is also an acoelomate, having no body cavity. The inside of each mature proglottid is filled with muscular layers and complete male and female reproductive systems, including the tubular unbranched uterus, ovary, genital pore, testes, and vitelline gland. In the gravid proglottid, the uterus contains up to 15 side branches filled with eggs

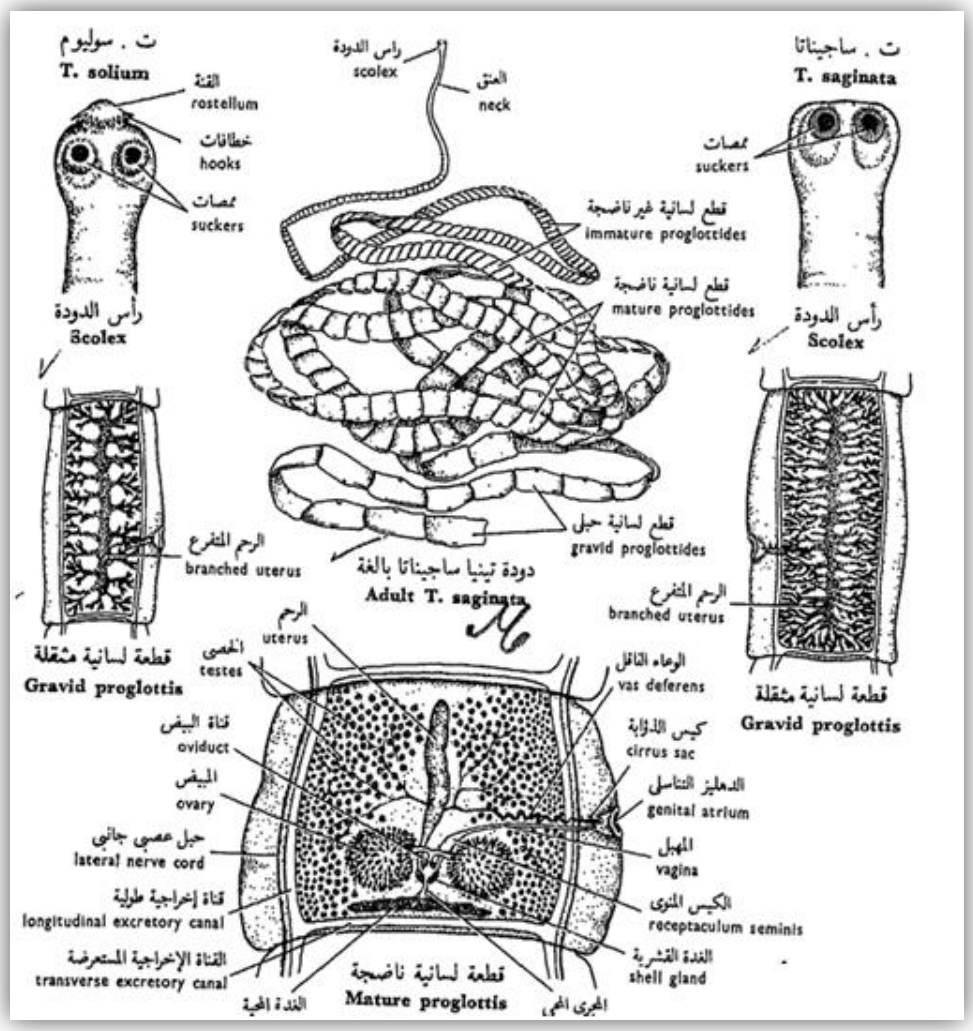


Fig. 33: *Taenia*

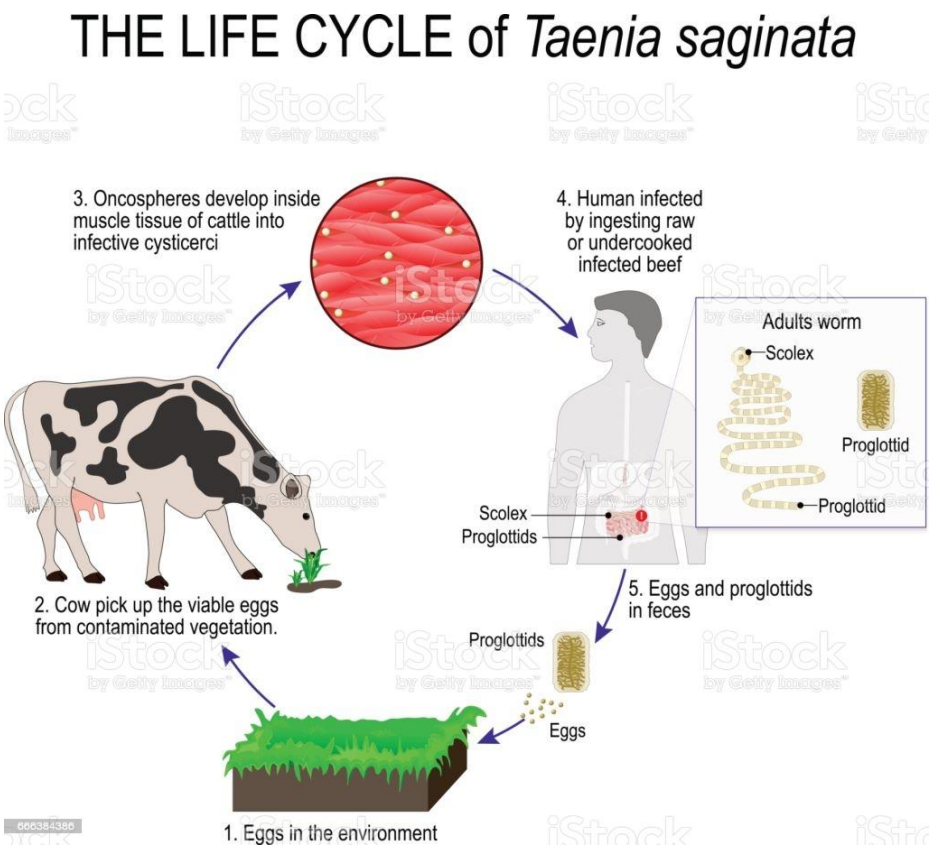


Fig. 34: Life cycle of *Taenia*

The eggs are released when a proglottid detaches from the tapeworm in the intestinal lumen or when a segment disintegrates outside the host. The eggs are small diameter 30–40 µm) and round. *The eggs are highly resistant and can remain infective in a moist environment for weeks or months.

Carried by feces of humans infected with Taenia, they contaminate pastures or feed either directly or via sewage. When the cattle ingest the eggs, the oncospheres hatch in the small intestine, migrate into the intestinal wall, and are

transported with the bloodstream into the striated musculature of the cattle.

Economic Importance of Phylum Platyhelminthes

The economic importance of Phylum Platyhelminthes are as follows:

i. Flatworms play a significant role in biological communities – marine, freshwater and terrestrial ecosystems.

ii. Flatworms absorb all oxygen via diffusion from the surrounding air.

iii. Most Turbellarians are carnivorous predators and scavengers and play a role in the food chain.

iv. *Fasciola* causes fascioliasis or liver rot, characterised as hepatitis.

v. *Echinococcus* causes hydatid disease, characterised by enlargement of the liver.

Pseudocoelomata

Phylum: Aschelminthes (Nematods)

(the round worms)

General characters:

1-The body of the Phylum Aschelminthes is circular in cross-section, hence, the name roundworms.

2-They may be free living, aquatic and terrestrial or parasitic in plants and animals.

3- Roundworms have organ-system level of body organization.

4-They are bilaterally symmetrical, triploblastic and pseudo coelomate animals.

5-Digestive System: Alimentary canal is complete with a well-developed muscular pharynx.

6- An excretory tube removes body wastes from the body cavity through the excretory pore.

7- Sexes are separating (dioecious), i.e., males and females are distinct.

8- Fertilization is internal and development may be direct (the young ones resemble the adult) or indirect.

9- Body wall with thick resistant, cuticle, cellular or syncytial epidermis, and only longitudinal muscle fibers in four bands.

10- Cuticle is made up of sceleroprotein, which is resistant to digestive enzyme of fibers in four bands..

11- Excretory system or glandular organs (Renette gland cells) or canals or both. Excretory canal formed by a huge excretory renette call at the juvenile stage.

12- Nervous system with circumenteric ring and anterior and posterior nerves.

Order: Ascaridata

- Some species of genus: *Ascaris* are the largest round worms. There are 3 species: *A. lumbricoides* which lives in the small intestine of man, *A. megalocephala* lives in the small intestine of the horse and *A. vitulorum* in that of the cow. They resemble each other closely and differ in few details.

Ascaris lumbricoides

Size: is characterized by its great size. Males are 15–31 cm long. Females are 20–49 cm long.

Shape: The body is long, cylindrical, fusiform (pointed at both the ends), creamy white or pinkish in color. The male's posterior end is curved ventrally and has a bluntly pointed tail and is more slender than female. The vulva is located in the anterior end and accounts for about one-third of its body length. Female is the larger and has a straight posterior end. Uteri may contain up to 27 million eggs at a time, with 200,000 being laid per day. There is four longitudinal streaks run the entire length of the body, two thin white dorsal and ventral lines, and two broader and darker

lateral lines, these four lines mark the internal division of the muscles in the body.

Ascaris lumbricoides is the "giant roundworm" of humans, growing to a length of up to 35 cm (14 in). It is one of several species of Ascaris. An ascarid nematode of the phylum Nematoda, it is the most common parasitic worm in humans. This organism is responsible for the disease **ascariasis**, a type of helminthiasis and one of the groups of neglected tropical diseases. An estimated one-sixth of the human population is infected by A. lumbricoides or another roundworm. Ascariasis is prevalent worldwide, especially in tropical and subtropical countries.

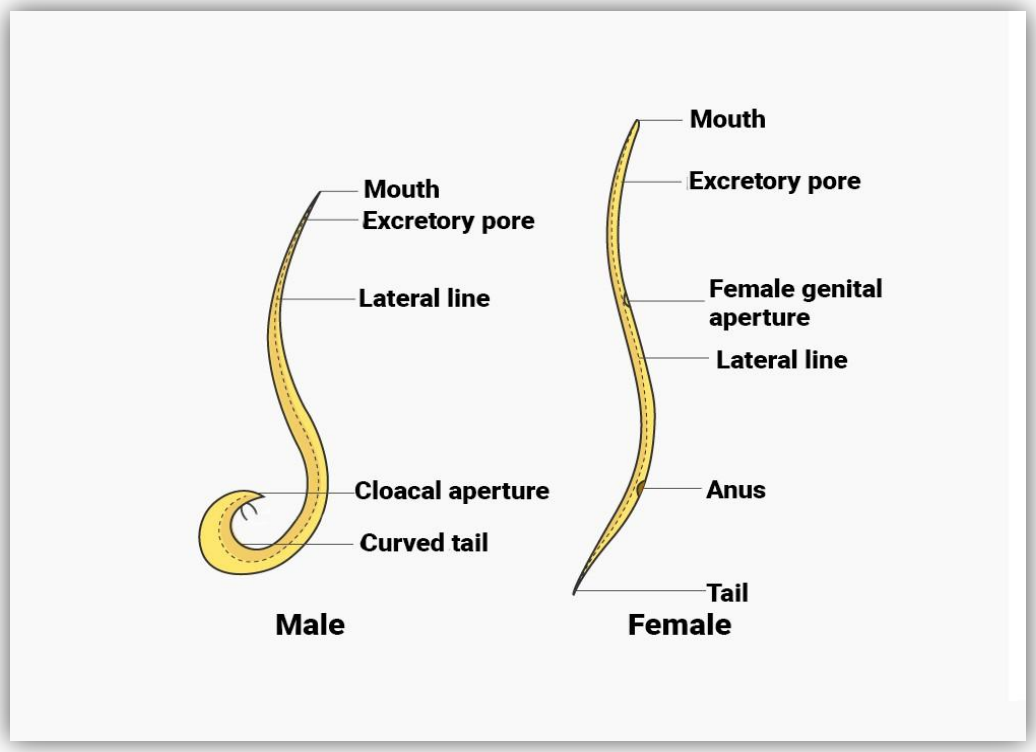


Fig. 35: *Ascaris*

Internal structure:

Digestive system

Alimentary canal starts with the mouth at the anterior end and ends with the anus at the posterior end. and consists of three parts : a short stomodaeum, long midgut, short posterior proctodaeum. **Mouth**: It is a triradiate aperture located at the anterior end of the body. Mouth is guarded by three lips or labia, one dorsal and two ventrolateral. **Stomodaeum: ectodermal** in origin, and differentiated into a short buccal cavity followed by a short muscular oesphageal swelling (called pharynx). **Midgut: endodermal** in origin, long tube called intestine, . At the junction of the pharynx and the intestine a small valve is present which stops the food from going back into the pharynx. Intestine consists of single layer of columnar epithelial cells lined externally by basement membrane. **Proctodaeum :** ectodermal in origin, short, and called **Rectum**, In males the rectum opens into cloaca which also receives ejaculatory duct. Whereas in females, rectum opens out through anus. The food of Ascaris consists of blood and partially digested food occurring in the fluid form in the host's gut.

Respiratory system: Respiration is anaerobic or anoxybiotic as the oxygen content in the host's intestine is usually low. In the process of anaerobic respiration, glycogen undergoes glycolysis to yield carbon dioxide, fatty acids and energy.

Excretory system: The excretory system of Ascaris is simple as there are no flame cells. The excretory system consists of two longitudinal excretory canals one through each lateral line, The two canals unite with each other at the anterior end and open to the

outside through the single excretory aperture situated on the ventral side behind the mouth. The excretory product of Ascaris is mainly urea and so it is also known as ureotelic animal. The excretory canals collect the excretory products from different parts of the body and these excretory products are eliminated through the excretory pore. The pressure of the pseudocoleomic fluid helps in ultrafiltration process. Some ammonia and urea are also passed out through the anus.

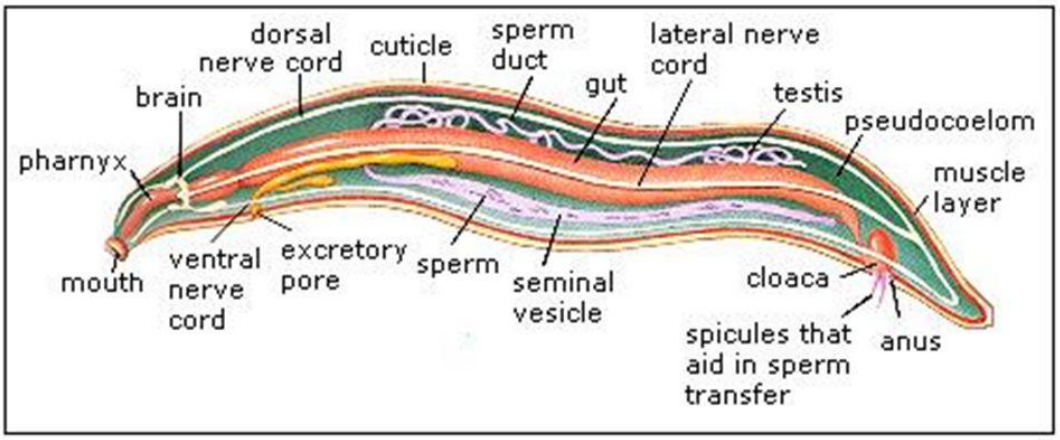
Circulatory system: There is no circulatory system.

Nervous System: The nervous system consists of a ring of nervous matter round the pharynx. The ring is swollen at the ventral side and is ganglion-like. The ring gives off six nerves to the anterior and six nerves to the posterior side. Of the posterior nerves, two are of considerable thickness and run along the dorsal and ventral lines up to the posterior end of the body.

Reproductive system: Male and female sexes are separate in Ascaris and these roundworms also show sexual dimorphism. Males are smaller than the females and they also have a curved tail with pre and post anal papillae, cloaca and a pair of spicules. The gonads are long, tubular and coiled. Gonads are attached at

the genital pore in females and at the cloaca in the male worms. **The male reproductive system :** Consists of: Testes, Vas deferens, Seminal vesicles, Ejaculatory duct *Testis*: A single testis is present in the roundworms which extend to the middle of the body. The testis is in the form of long- thread like highly twisted tube. The wall of testis is made up of single layer of cuboidal cells covered by basement membrane. *Vas deferens*: The distal part of the testis continues as a short, thick and twisted tube called as vas deferens, which leads to vesicula seminalis *Seminal vesicle:* Seminal vesicle is a thick, wide and muscular continuation of the vas deferens, It lies in the posterior third of the pseudocoel below the intestine, which opens in the ejaculatory duct. *Ejaculatory duct:* The terminal part of the seminal vesicle narrows down to form highly muscular ejaculatory duct. The ejaculatory duct joins to the rectum to form cloaca. This duct contains a number of prostatic glands whose secretions help in copulation. *Penial spicules*: Penial spicules (copulatory spicules) are located in the spicular pouch. Two spicular pouches are situated on the dorsal side of the cloaca. These are basically evaginations of the cloaca. The penial spicules are enclosed in a spicular sheath which protrudes out of the cloaca aperture during copulation. **Female reproductive system:** Female reproductive organs lie in the posterior two third of pseudocoel.

Anatomy of Ascaris



- The female lays about 200,000 eggs daily which pass out with the faeces.
- The infective stage is <u>the egg</u> which contains an embryo, that molts inside the egg ready to infect a new host.
- *Ascaris lumbricoides*, infects humans via the fecal-oral route. Eggs released by adult females are shed in feces. Unfertilized eggs are often observed in fecal samples but never become infective. Fertilized eggs embryonate and become infective after 18 days to several weeks in soil, depending on the environmental conditions (optimum: moist, warm, shaded soil). When an embryonated egg is

ingested, a Rhabditiform larva hatches then penetrates the wall of the gastrointestinal tract and enters the blood stream. From there, it is carried to the liver and heart, and enters pulmonary circulation to break free in the alveoli, A microworm moves through the small intestine and matures into an adult worm until it emerges through the abdominal cavity. Fertilization can now occur and the female produces as many as 200,000 eggs per day for 12–18 months. These fertilized eggs become infectious after two weeks in soil; they can persist in soil for 10 years or more.

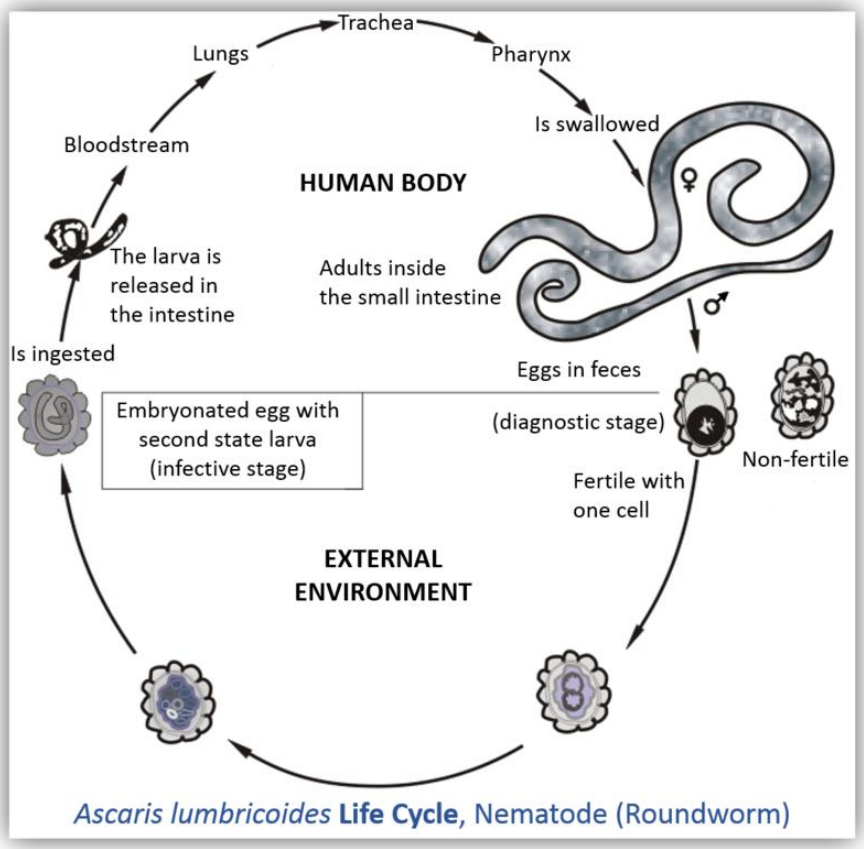


Fig. 36: Lifecycle of *Ascaris*

Importance of Aschelminthes

Aschelminths can be free-living or parasitic. The free-living organisms are extremely abundant in soils and sediments and they feed on bacteria. While some others are plant parasites and can cause disease in crops that are economically important. The others are parasites that can be found in animals and human

beings. Some of the parasitic worms include hookworms, pinworms, Guinea worms, and intestinal roundworms.

Ascaris lumbricoides is the Giant Intestinal Roundworm that is an endoparasite living in the human intestine. They are very common in children. These worms cause a disease called ascariasis. Many adult roundworms live inside the intestine, causing obstruction to the intestinal passage. This causes abdominal discomfort, colic-like pain, impaired digestion, diarrhea, and vomiting. Generally, deworming medicines are given to get rid of these roundworms from the body.

Coelomata

Phylum: Annelida

General characters:

- These animals are found on land, in moist soil, freshwater or in the sea and they are free living or ectoparasites.
- They are triploblastic, coelomate and bilaterally symmetrical animals.
- 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.
- The body covered with a thin non- chitinous cuticle and the body wall is muscular with circular and longitudinal muscles.
- 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 alimentary canal is elongated and a tube like. It extends from the mouth to the anus.
- The respiration takes place through the external surface of the body or through gills of parapodia and head.

- They have closed type of circulatory system, i.e., the blood flows in the blood vessels.
- The excretion by tube- like organs, called nephredia. In each segment a pair or more nephredia are present.
- The nervous system consists of a brain and double nerve cord, with many ganglia in each segment.
- Sexes are separated or occur in the same body. Development may be direct or through a trochophore larva. Regeneration is also common.

Watch video

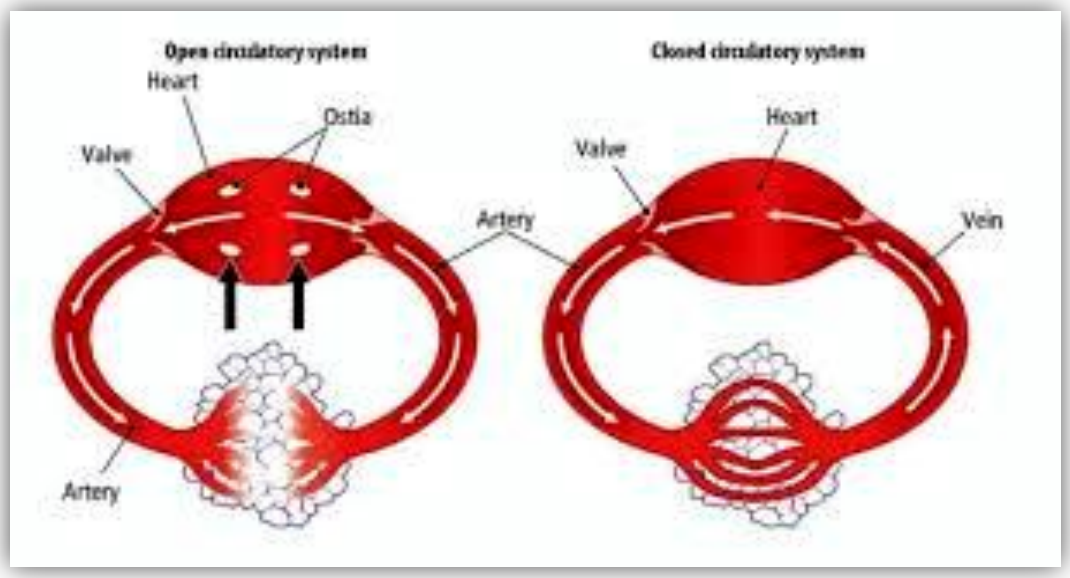


Fig. 37: Types of circulatory system

Classification of Annelida

Class: Oligochaeta

- 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.
- Development is direct. fertilization external (in cocoon); no larval stage.

Ex. *Allolobophora*

Class: Polychaeta

Includes marine forms swim freely in water or live burrowing in the sand and mud near the shore. The sexes are separated and have parapodia. Ex. *Neries*

Class: Hirudinea

Includes the leeches which feed on the blood of vertebrates (parasites). They are hermaphrodite and without parapodia and chaetae. Ex.: *Hirudo*

Allolobophora caliginosa

- Earthworms live in moist soil, build burrows and feed on organic matter.
- The body is cylindrical and divided into great number of segments separated by intersegmental grooves, pointed at the anterior end and flattened at the posterior end.
- The mouth and anus open at the anterior and posterior ends respectively.
- The clitellum (secretes the cocoon) is the thickened skin of segments 26-34 and lies on the dorsal and lateral sides but these segments are distinct on the ventral side. The edges of the clitellum are thickened on segments 31-33 forming the puberty crests.
- Every body segment, except the first and the last, bears 4 pairs of chaetae, two ventral pairs and one pair on each lateral side.

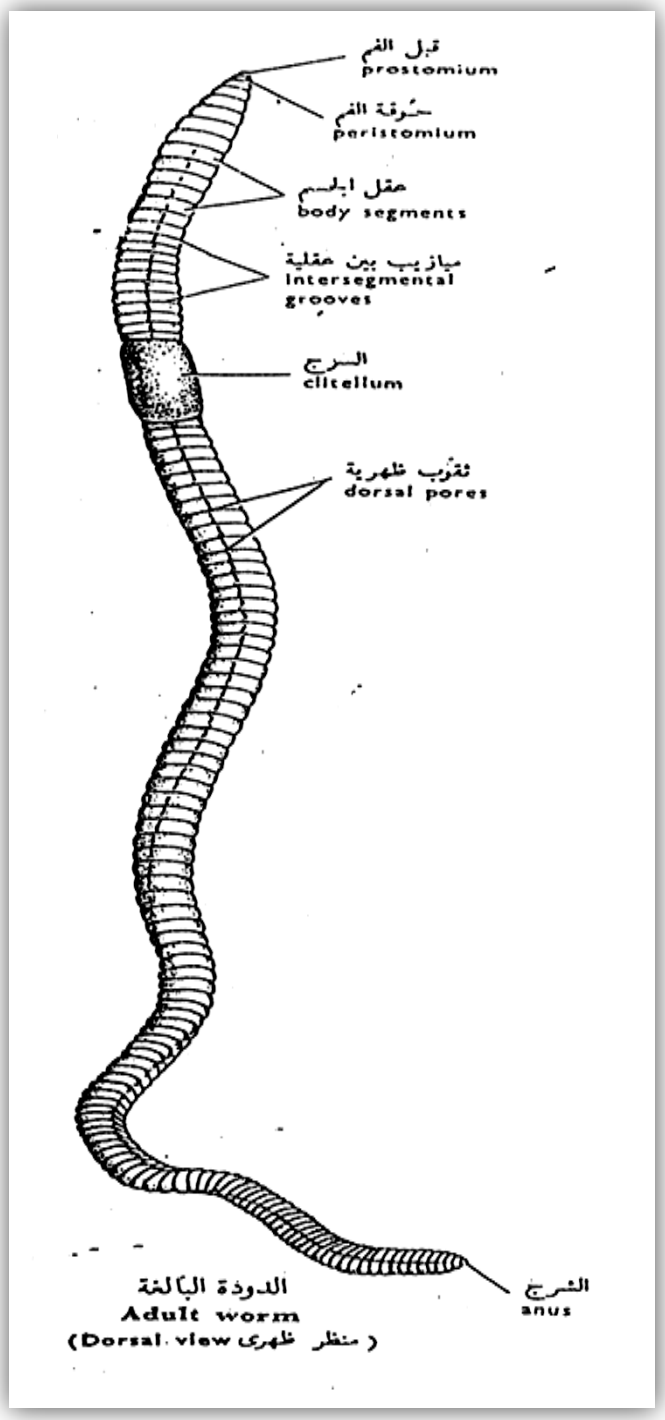


Fig. 38: ***Allolobophora caliginosa***

- **The external body openings:**
- The mouth on the first segment.
- The anus on the last segment.
- The female genital openings (2) on the ventro-lateral sides of segment 14.
- The male genital openings (2) on the ventro-lateral sides of segment 15.
- The spermathecal pores are 2 pairs lies in the intersegmental grooves between segments 9-10 and 10-11 and they are surrounded by three pairs of copulatory papillae on segments 9, 10 , 11
- The dorsal (coelomatic) pores lies mid- dorsally on the grooves from 8-9 to the posterior end, connect the internal coelom with the external environment.
- The excretory pores or nephridiopores lies on the ventral side, a pair on each segment except the first three segments and the last segment.

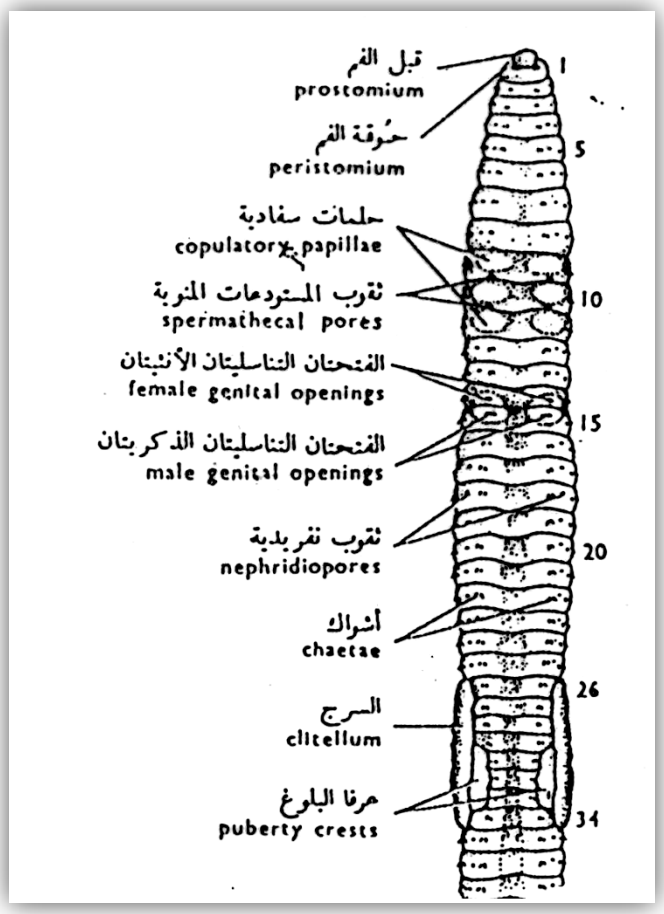


Fig. 39: Ventral view of *Allolobophora*

Economic Importance of Earthworm

Useful Affairs of Earthworms:

The earthworms are better known as the friend of farmers due to the following reasons:

1. The earthworms improve the fertility of soil in different ways and, therefore, they are of utmost importance in agriculture.

Actually, the burrowing and soil feeding habits of earthworms make the soil porous which permit both aeration and quick absorption of water. It also permits easy and deep penetration of the plant roots.

They also bring the fresh subsoil to the surface which is still finer and rich in organic matters. Charles Darwin has estimated that an acre of earth is inhabited by nearly 50,000 earthworms (a recent estimate suggests that their number may reach up to 25, 00,000 per acre) which may bring more than 18 tons of deeper subsoil to the surface in one year.

These are used as bait and food. As bait they are used in fishing. The earthworms were used as food by so many uncivilized people of the world and they are still used as food by Macrea people. The earthworms are eaten upon by frogs, toads, moles, hedgehogs and birds which are of many uses to mankind.

Nereis

Nereis is a typical polychaete genus, living in burrows in sand or mud, often with clams, a reason for which its species are commonly known as clamworms or sandworms.

Neanthes is one of the largest and most common typical marine annelid with most of the characteristics of the phylum. Neanthes is found on the sea-shore in the shallow water in rock crevices, hidden under the stone or sea weeds. Some live in tubular U-shaped burrows lined mucus in sand or mud at tide level. It is carnivorous and nocturnal. At night it keeps its head protruded out of the burrow in search of prey, which is usually a small crustacean, mollusc or annelid. When breeding period approaches it leaves the burrow and comes at the water surface to lend a pelagic life, and then it is called heteronereis.

Shape, size and colour: The body is long, narrow, slender, bilaterally symmetrical, tapering posteriorly and relatively broad anteriorly.It is slightly flattened dorsoventrally, dorsal surface being convex, while ventral surface flat or even somewhat concave. It may range from 30-40 cm in length and 2 to 6 mm in width. Different species are differently coloured. Colour may vary with age and sexual maturity.

Segmentation – Body of Nereis is metamerically divided into a number of metameres or segments arranged in a linear series.

All the metameres are nearly alike except the last one which is rounded. Number of metameres is fairly constant for a species; about 80 in N.cultrifera and N.dumerilli and about 200 in N.virens.

Division of body- Body of Neanthes is divisible into three well marked regions; head, trunk and pygidium.

Head- lies at the anterior end and consists of two main parts- Prostomium and Periosteum. Prostomium is an anterior narrow, nearly triangular fleshy outgrowth, situated mid-dorsally in front of the mouth. Peristomium is a large ring-like structure carrying ventrally the transverse mouth.

Trunk: Posterior to the head, the rest of the body which is metamerically segmented (having 80-120 segments) is called trunk. The segments are known as metameres or somites which bear a pair of parapodia. (c)Pygidium: The last segment of the body called variously as tail, anal segment or pyridium, is elongated, swollen and bears a terminal anus. It bears no parapodia but has a pair of elongated anal cirri and several minute sensory papillae.

Parapodia - The Parapodia are primarily the organs of locomotion used both in creeping and in swimming. They are highly muscular, well vascularised and glandular structure.

Structure of the Parapodium: The segments excepting the first and last segment either lateral side fleshly, flat and hollow parapodium. Largest parapodia are encountered in the middle

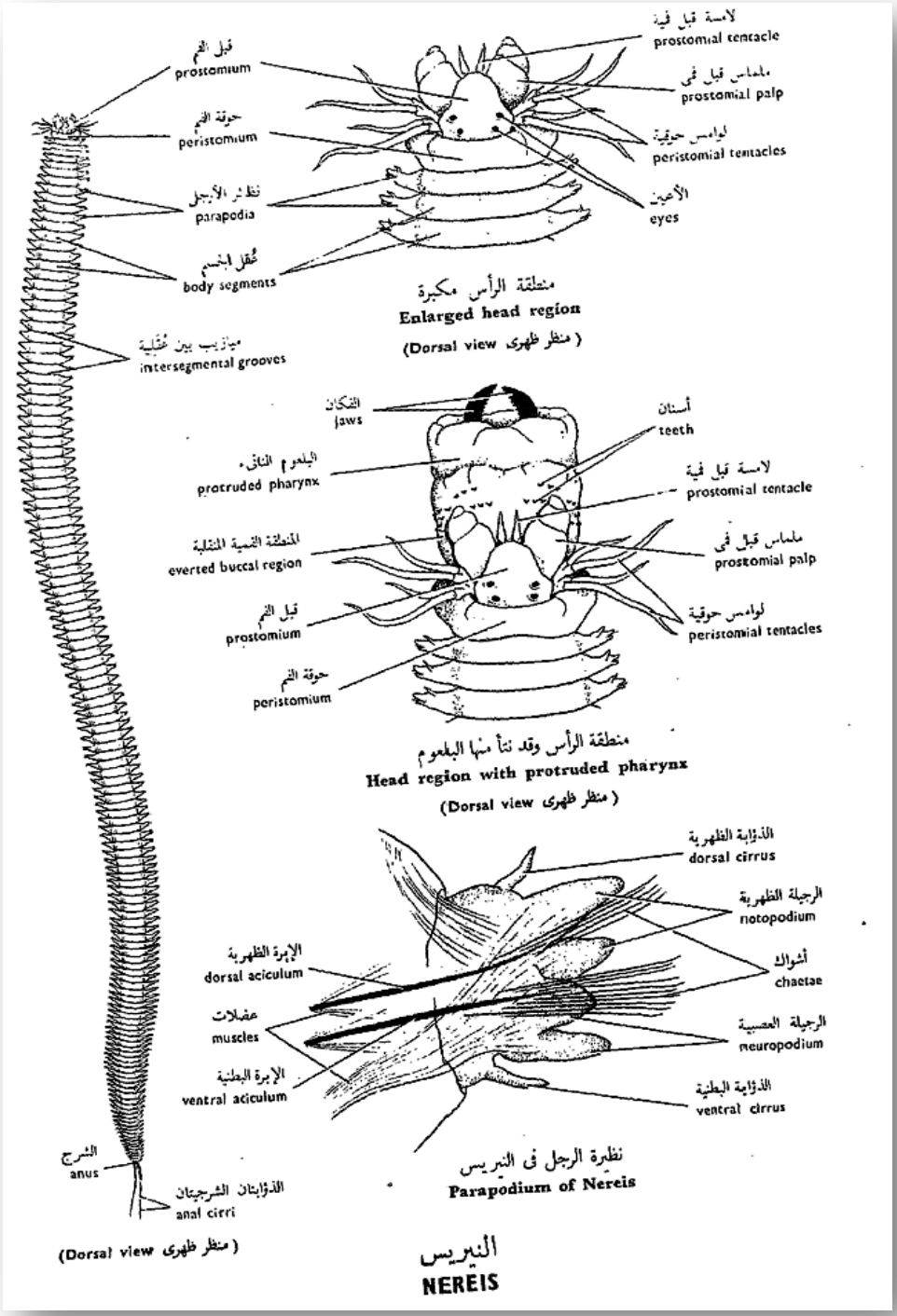


Fig. 40: Nereis

segments of the body, then the size of the parapodia decreases towards the two ends. Each parapodium is biramous in nature. It consists of a basal part and two distal parts. The two distal parts are- (1) dorsally placed notopodium and (2) ventrally placed neuropodium. Both these parts are subdivided into two leaf-like lobes or ligulae, a dorsal superior ligula and a ventral inferior lingula. The dorsal and ventral sides of the parapodium bear small, tentacle-like, cylindrical appendages, called dorsal and ventral cirrus respectively. Each part is supported internally by a chitinous rod, known as aciculum. Each part also bears a bundle of long, fine, stiff, chitinous bristles, the setae or chaetae, which project beyond its margin. Seta: The setae are stiff, needle-like chitinous rods which remain in bundle within a sac in the skin. The sac is known as setigerous sac. The entire bundle may be moved in various directions withthe help of muscles. Each seta consists of a basal shaft with which articulates a terminal blade.

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Zoology Department

Invertebrates I

Practical Part

By/

Dr. Heba M. Fangary

For

(The Second Year Students)

(Chemistry & Zoology)

2022-2023

Kingdom: Protista الطلائعيات

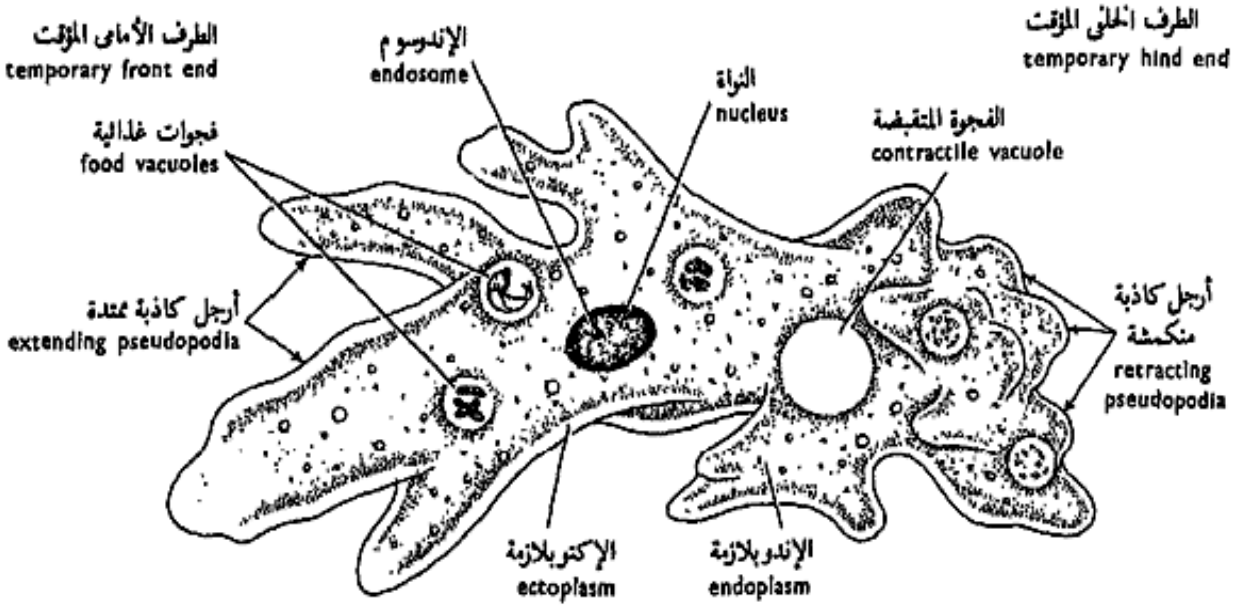
Phylum: Protozoa الأوليات الحيوانية

Class : Sarcodina اللحميات

e. g. : Amoeba الأميبا

ملحوظة:

e. g. = example gratia =for example

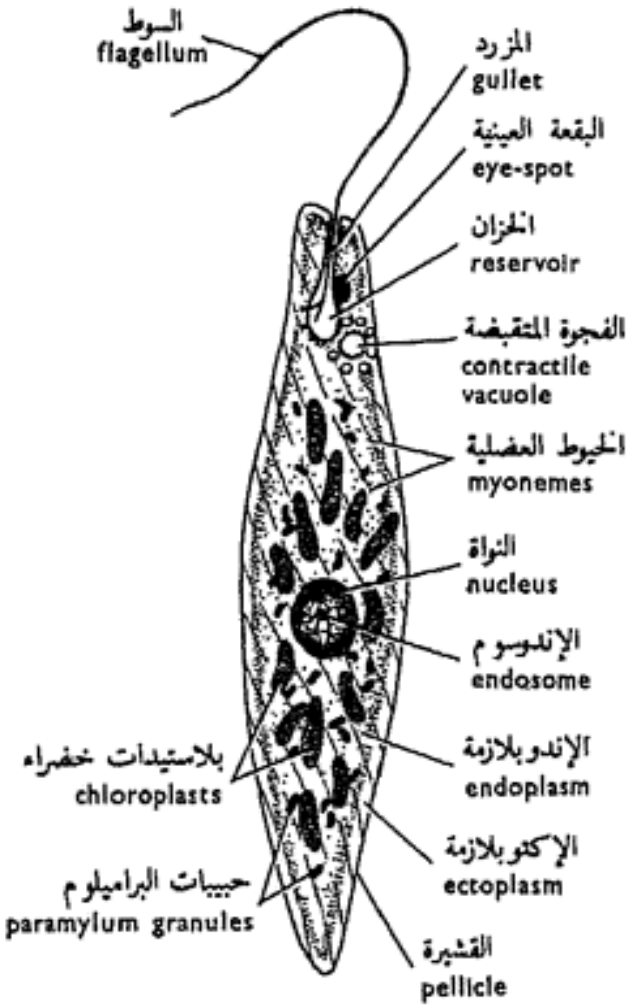


Phylum: Protozoa

Class : Mastigophora السوطيات

Subclass : Phytomastigina السوطيات النباتية

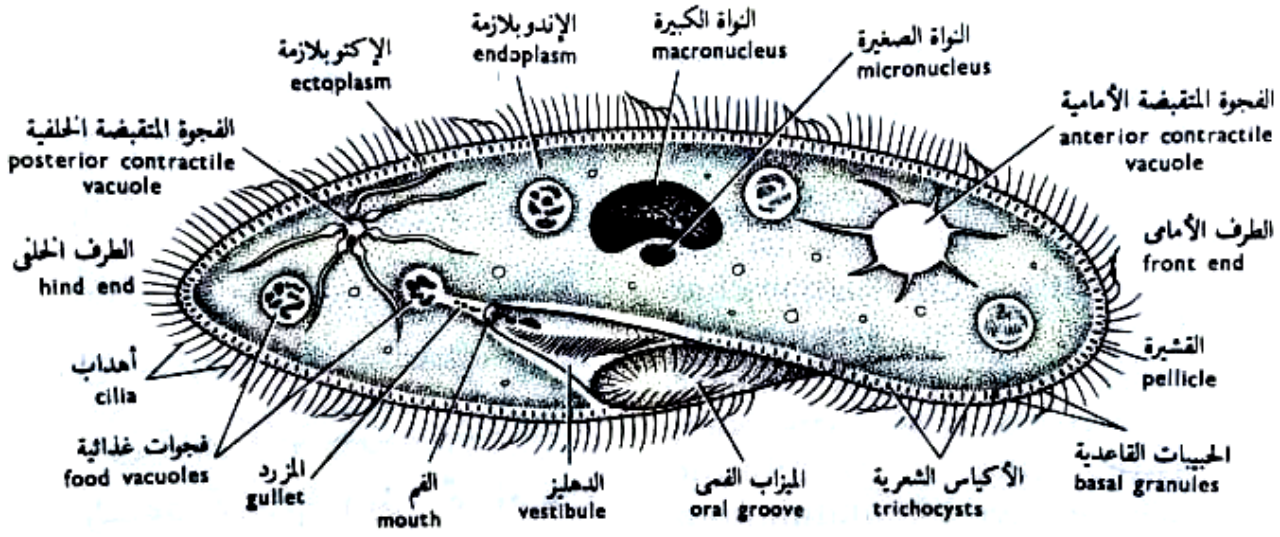
e.g. : *Euglena* اليوجلينا



Phylum : Protozoa

Class : Ciliophora الهدبيات

e.g. : *Paramecium* البرامسيوم



Kingdom: Animalia

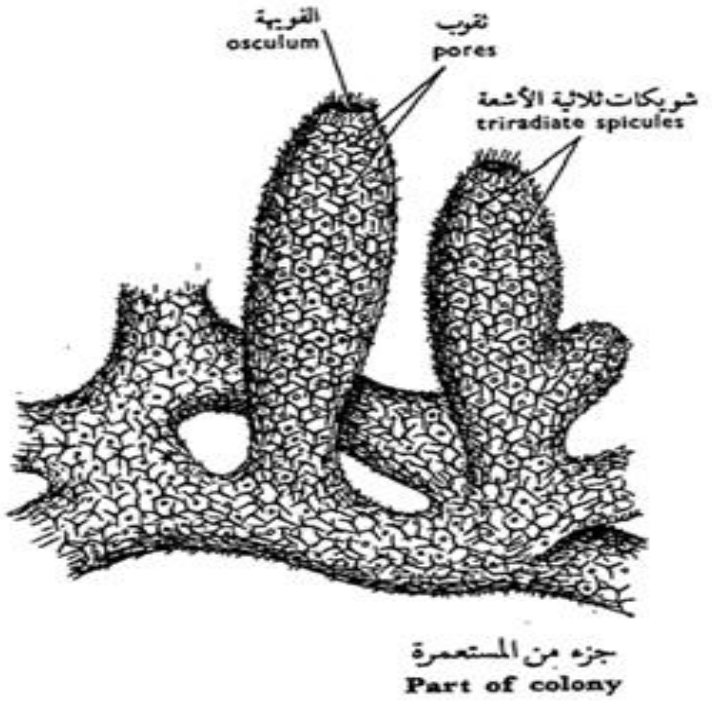
Subkingdom: Parazoa

Phylum : Porifera **الاسفنجيات**

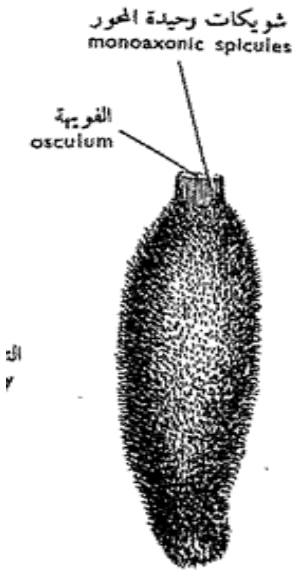
e.g. : *Leucosolenia* (The ascon type) **الليوكوسولينيا (الطراز الأسكوني)**

e. g. : *Sycon* (The sycon type) **السيكون (الطراز السيكوني)**

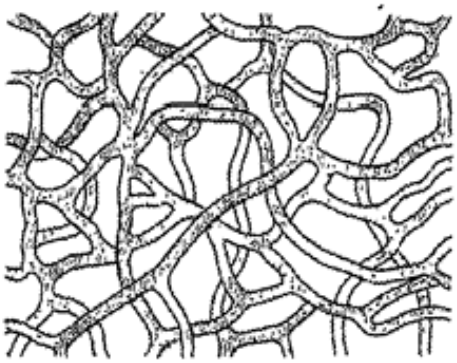
e. g. : *Euspongia* (The leucon type) **أسفنج الحمام (الطراز الليوكوني)**



The Ascon type



The Sycon type



الألياف الإسفنجية من إسفنج الحمام
Spongin fibres from bath sponge

The Leucon type

Kingdom : Animalia

Subkingdom : Eumetazoa

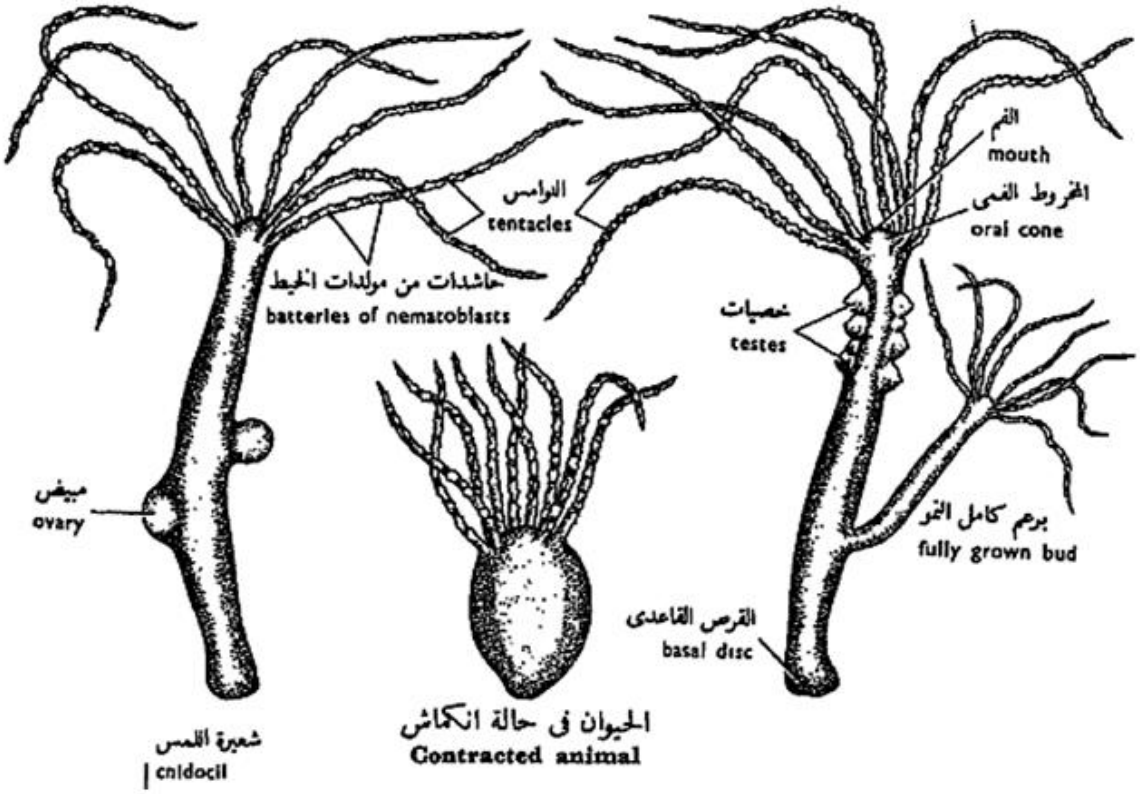
……Diploblastica ثنائية الطبقات

Phylum : Cnidaria (Coelenterata) الجوفمعويات

Class : Hydrozoa

Order : Hydrida

e. g. : *Hydra* الهيدرا

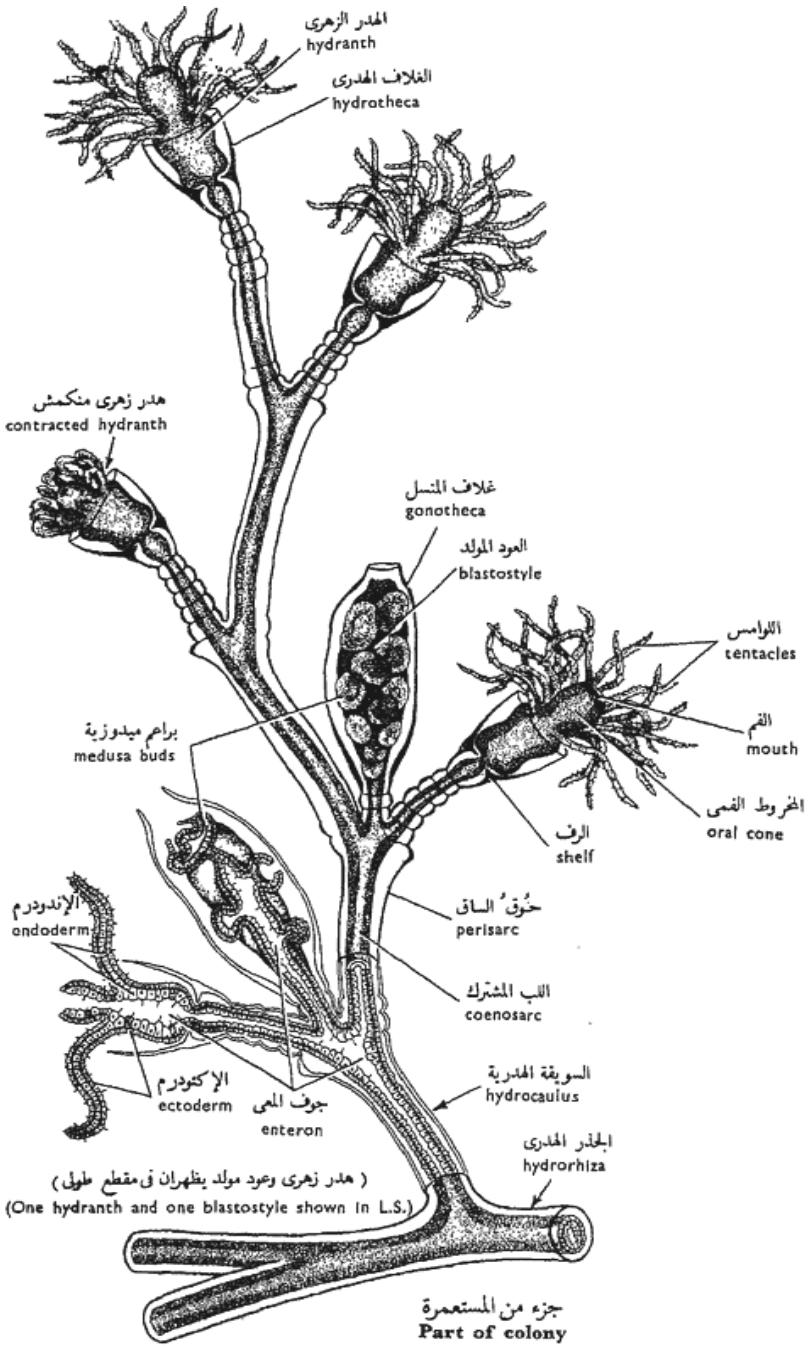


Phylum : Cnidaria (Coelenterata) **الجوفمعويات**

Class : Hydrozoa

Order : Calyptoblastea

e. g. : *Obelia*

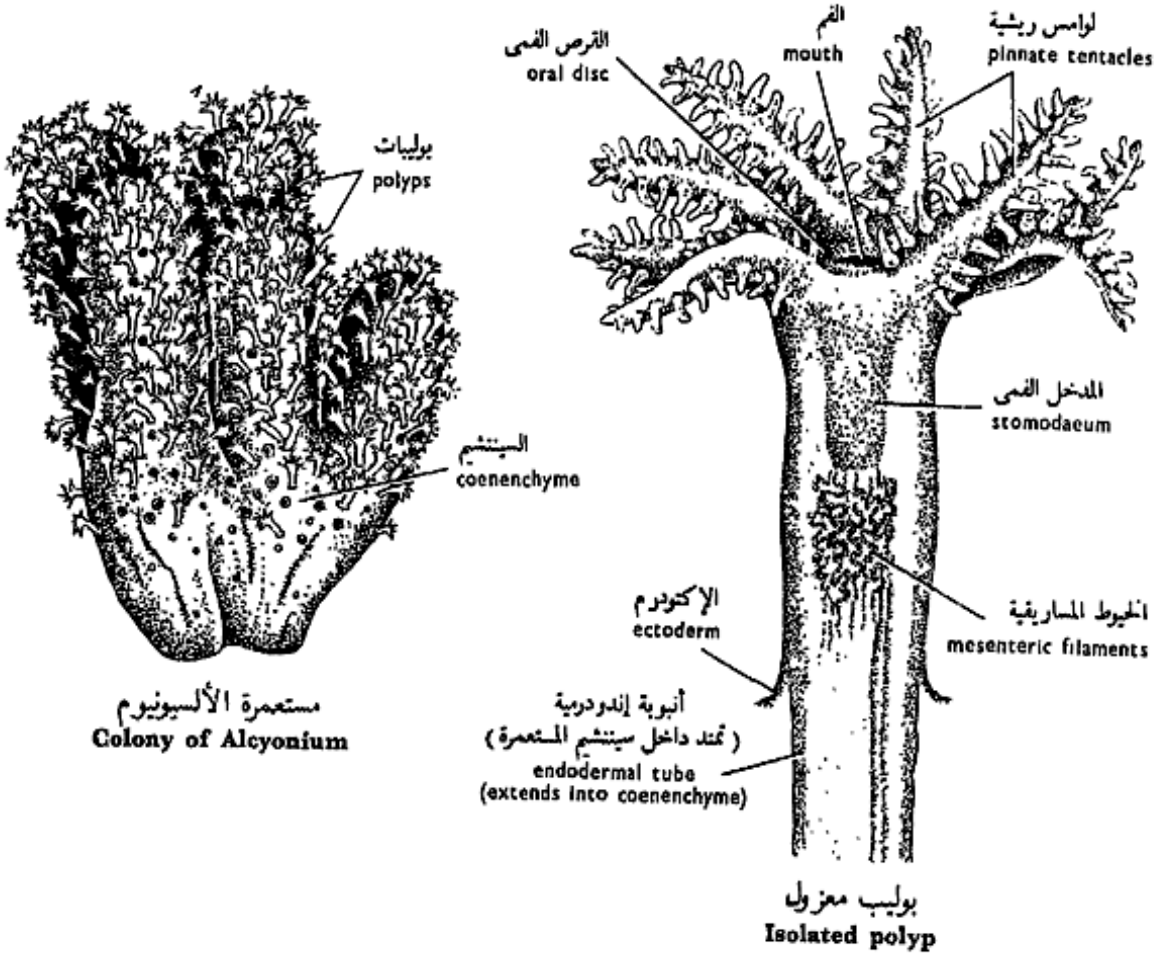


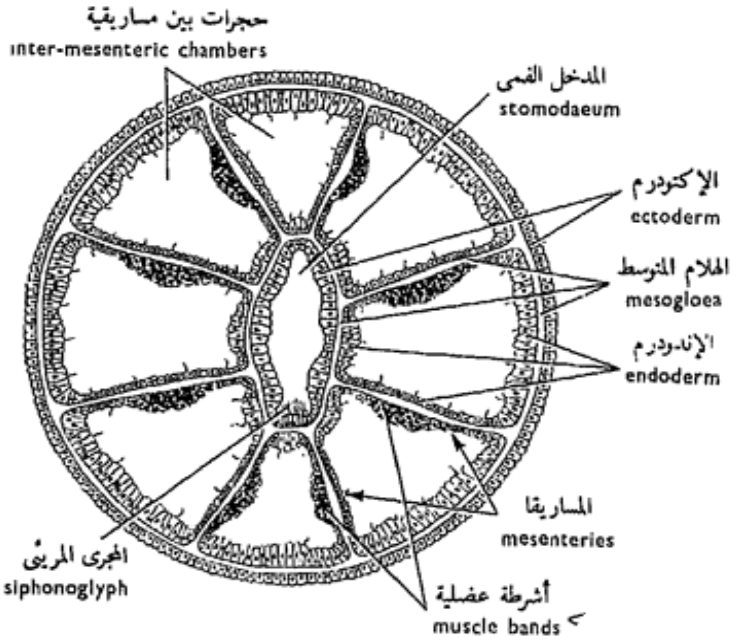
Phylum : Coelenterata **الجوفمعويات**

Class : Actinozoa **الشعاعيات**

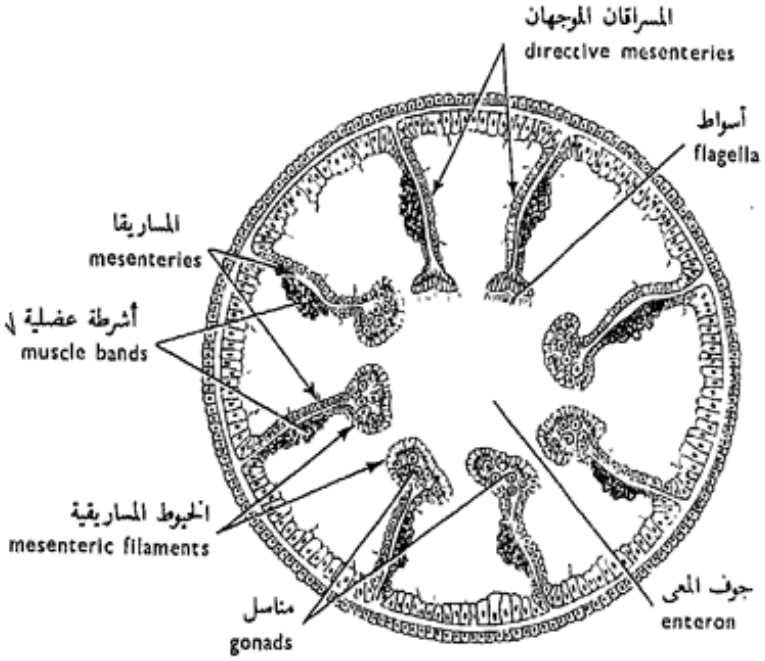
Order : Alcyonaria

e. g. : ***Alcyonium*** **الألسينيوم**





ق . ع . من البوليب فى منطقة المدخل الفمى
T.S. of polyp through stomodaeal region



ق . ع . من البوليب أسفل المدخل الفمى
T.S. of polyp below stomodaeum

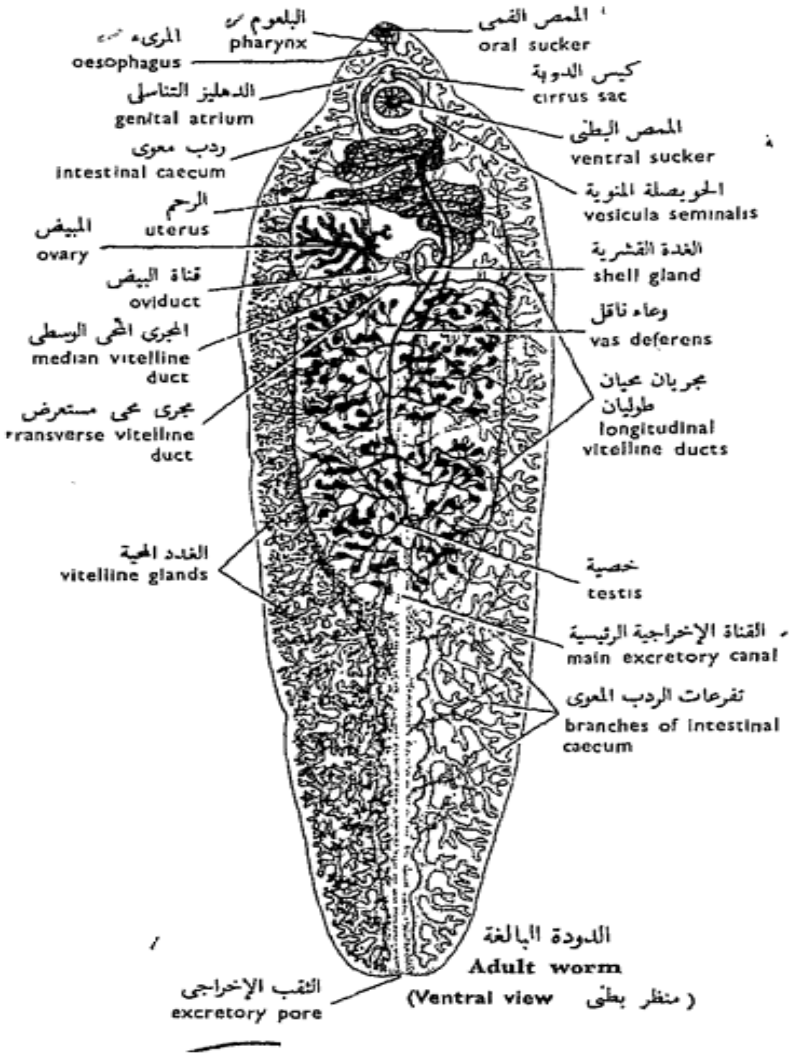
……Triploblastica ثلاثية الطبقات

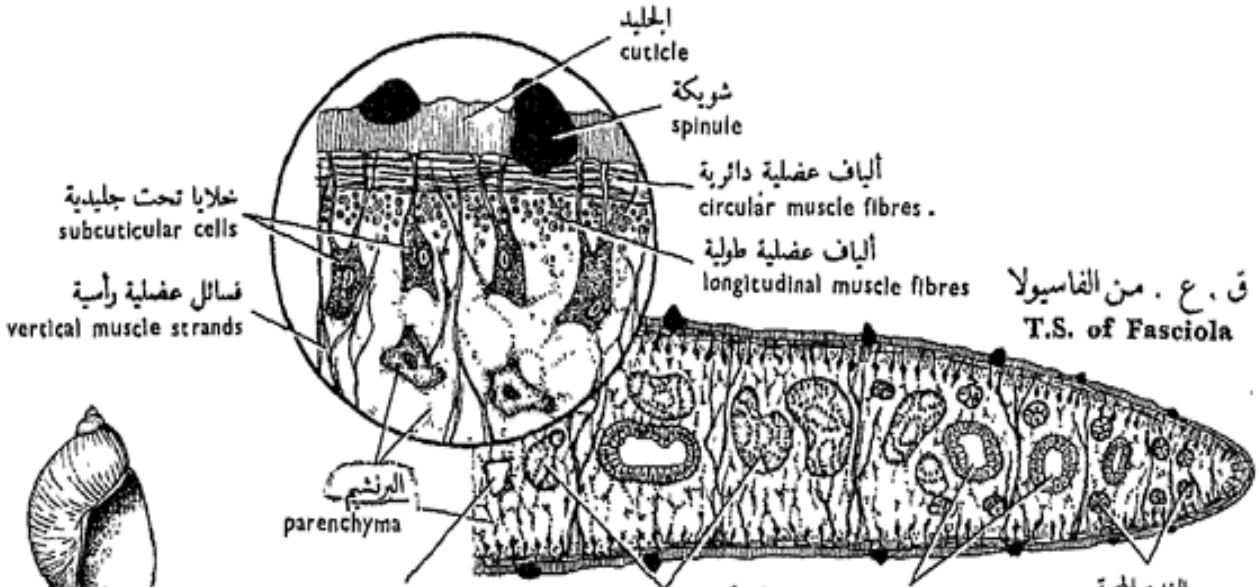
Phylum : Platyhelminthes المفلطحات

Class : Trematoda

Order : Digenea ثنائية العائل

e.g. : *Fasciola gigantic* *الفاشيولا أو الدودة الكبدية*





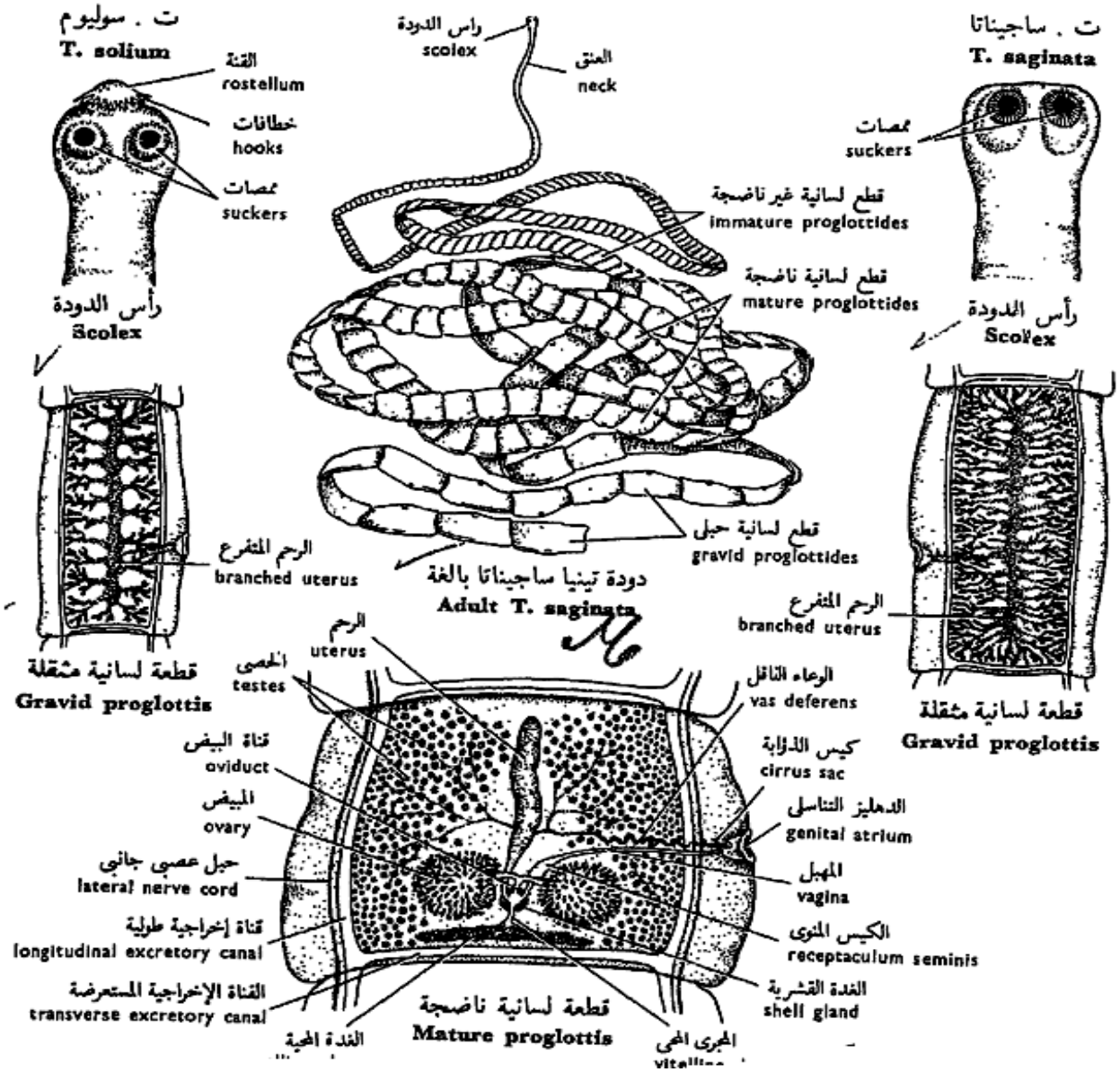
صَدفة ليمنيا كايودى
Shell of
Limnaea caillaudi

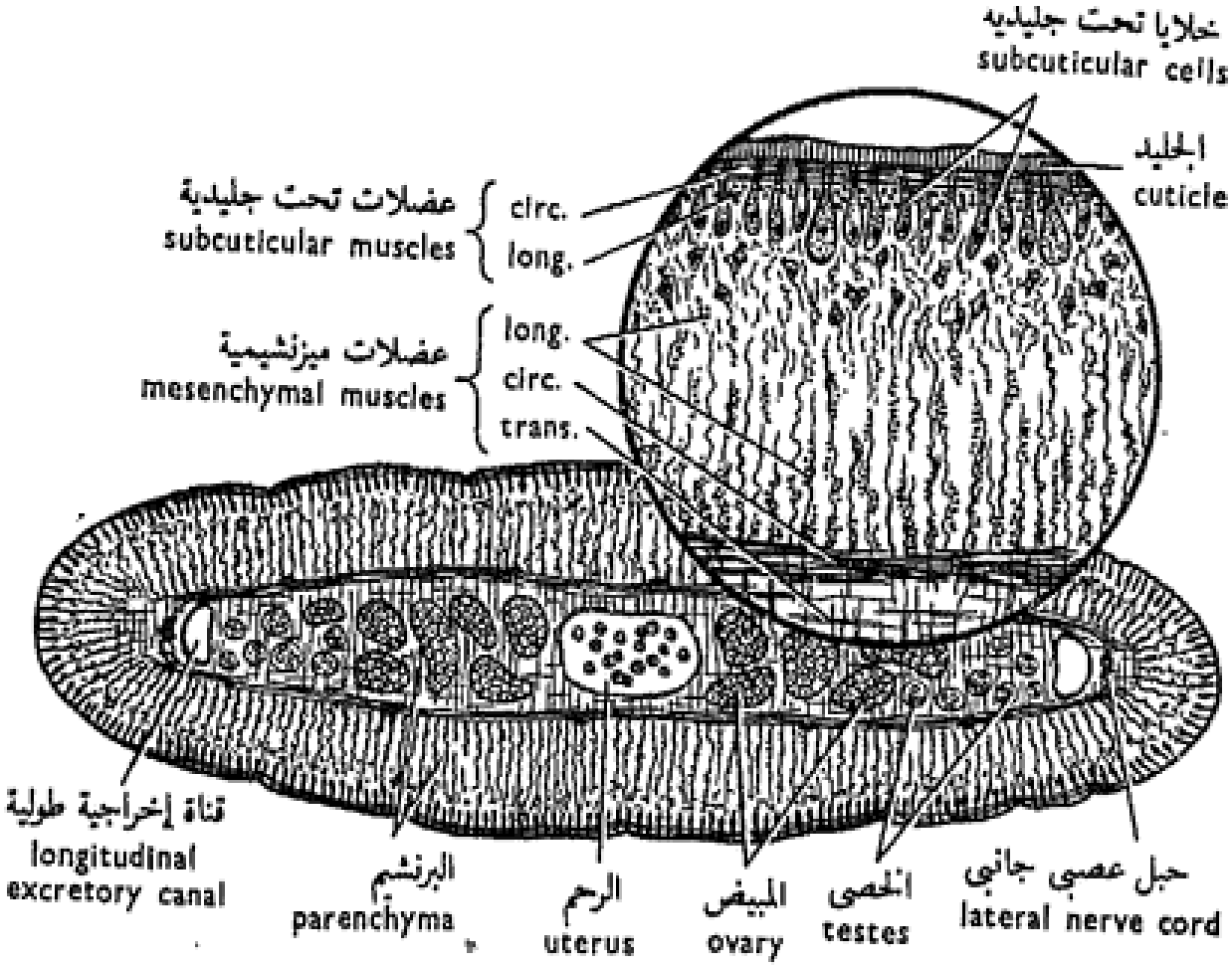
Phylum : Platyhelminthes **المفلطحات**

Class : Cestoda **الديدان الشريطية**

e. g. :*Taenia saginata* ***دودة البقر الشريطية***

e. g. : Taenia solium ***دودة الخنزير الشريطية***



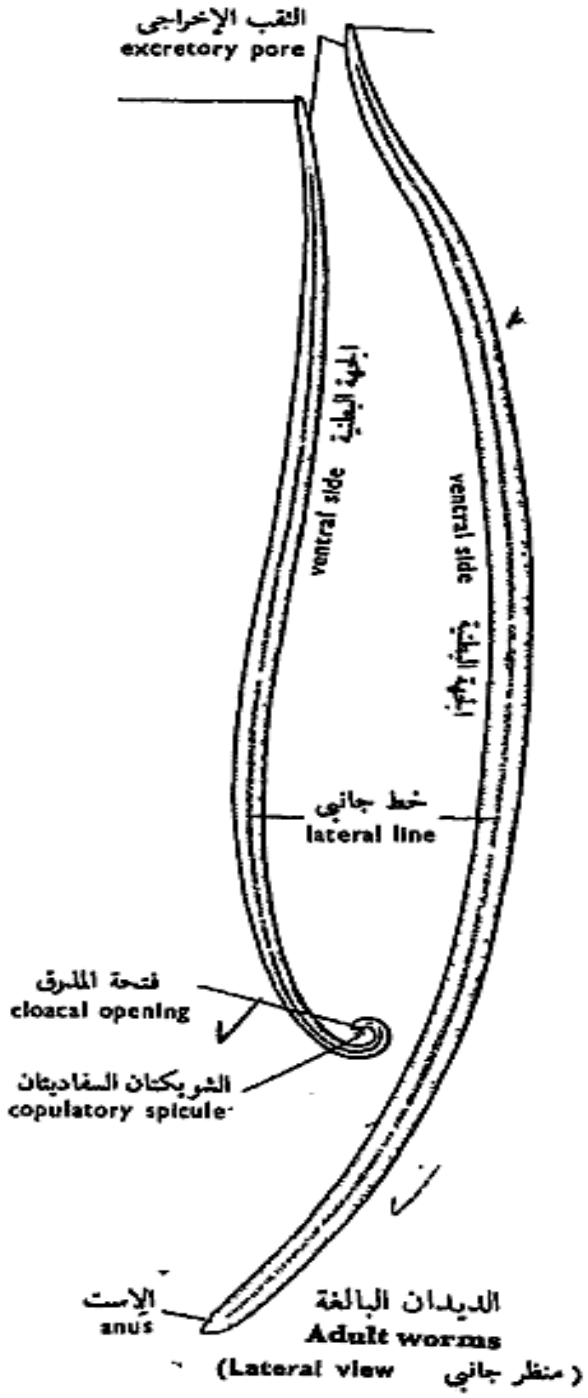


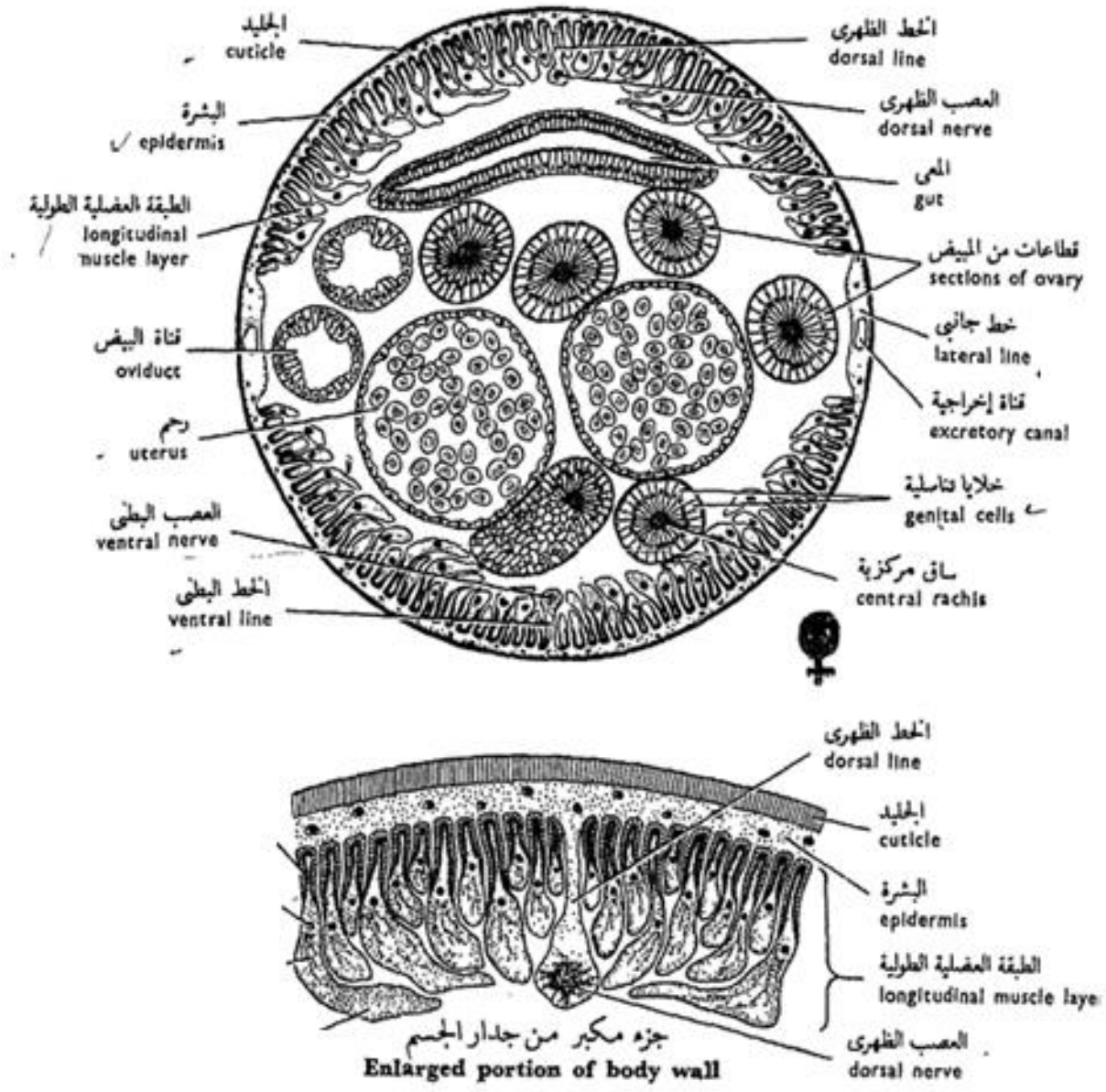
ق . ع . من قطعة لسانية ناضجة -
T.S. of mature proglotti-

Phylum: Aschelminthes الديدان الأسطوانية (المجوفة)

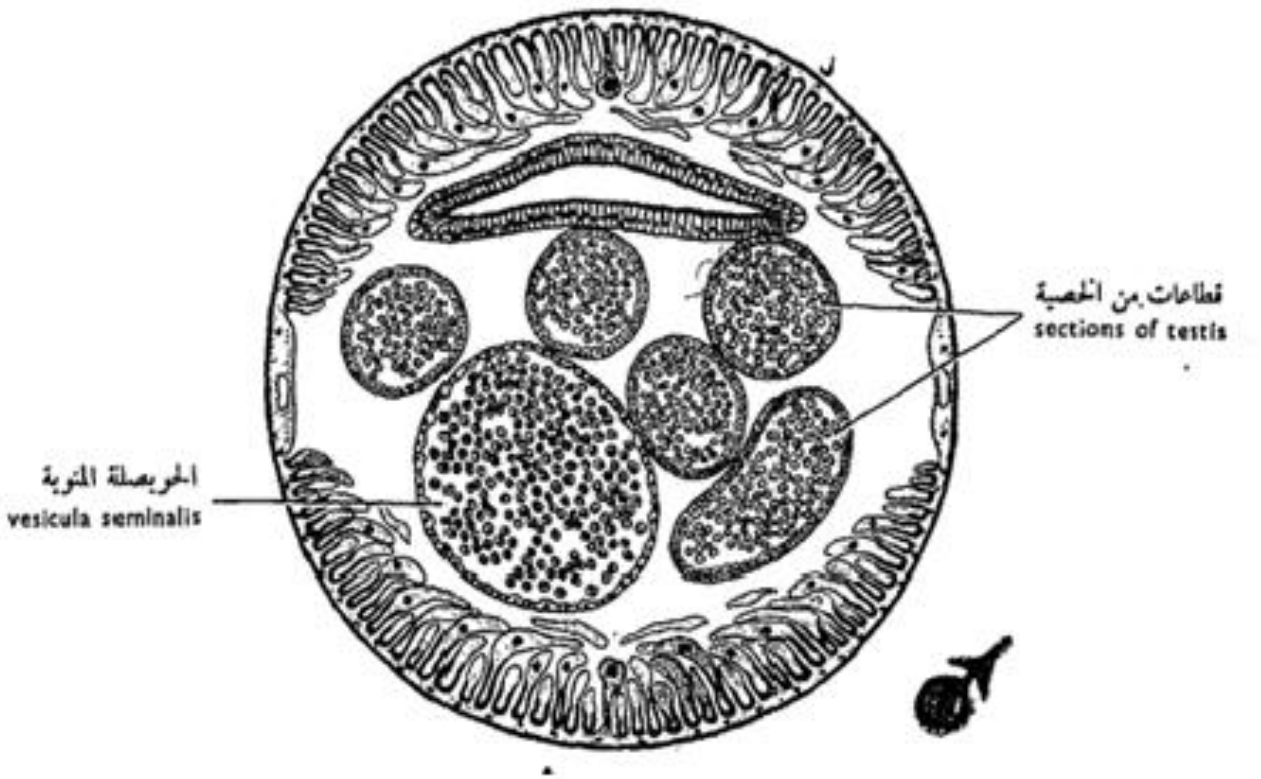
Order : Ascaridata

e.g. : *Ascaris vitulorum* دودة الاسكارس





قطاع عرضي في أنثي الأسكارس

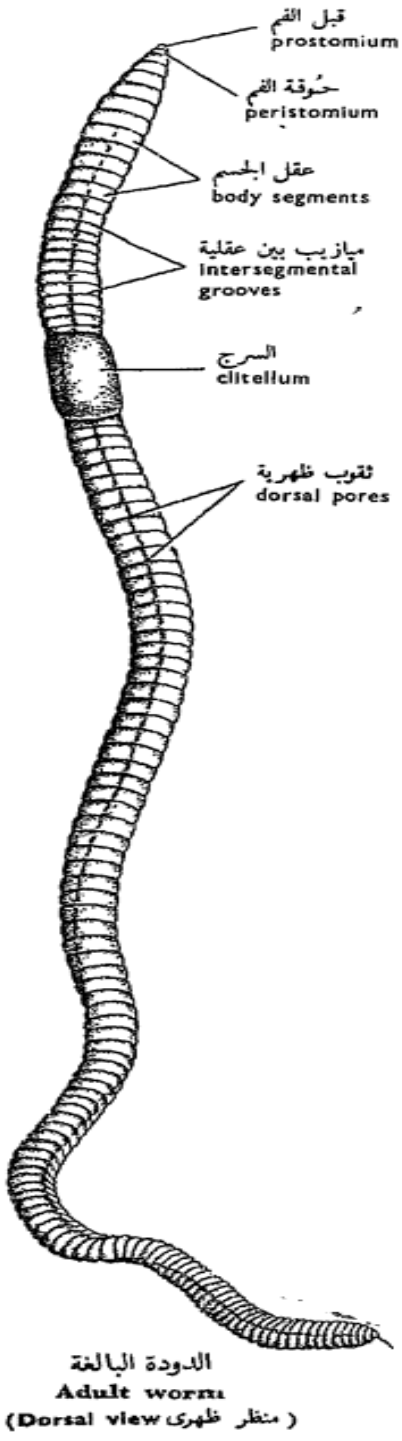


قطاع عرضي في ذكر الأسكارس

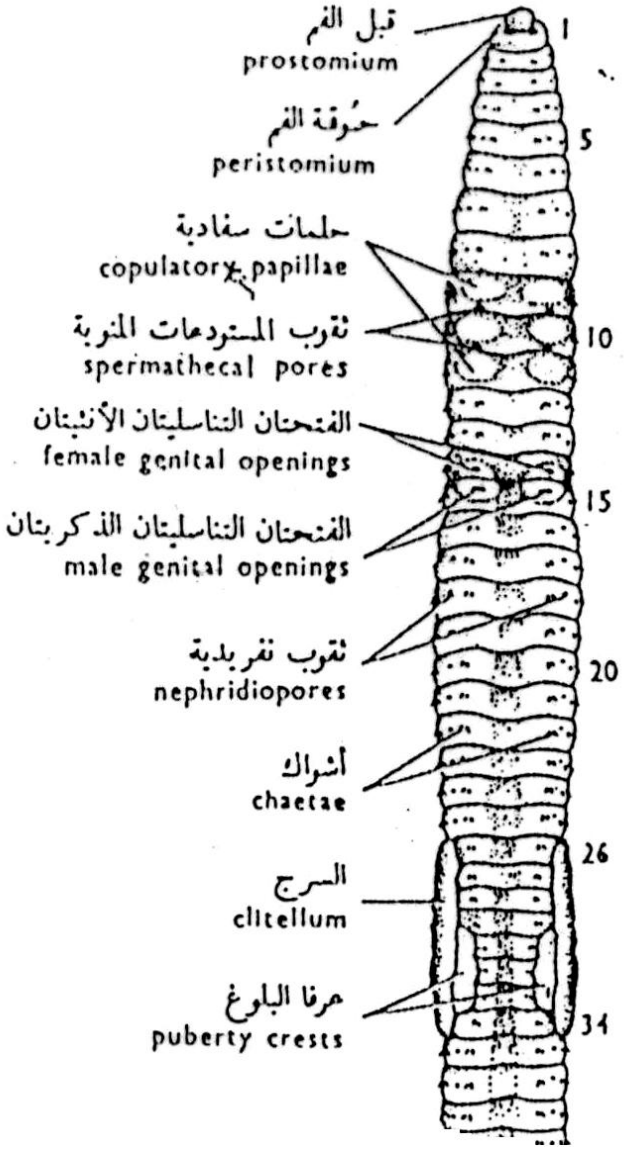
Phylum: Annelida **الحلقيات**

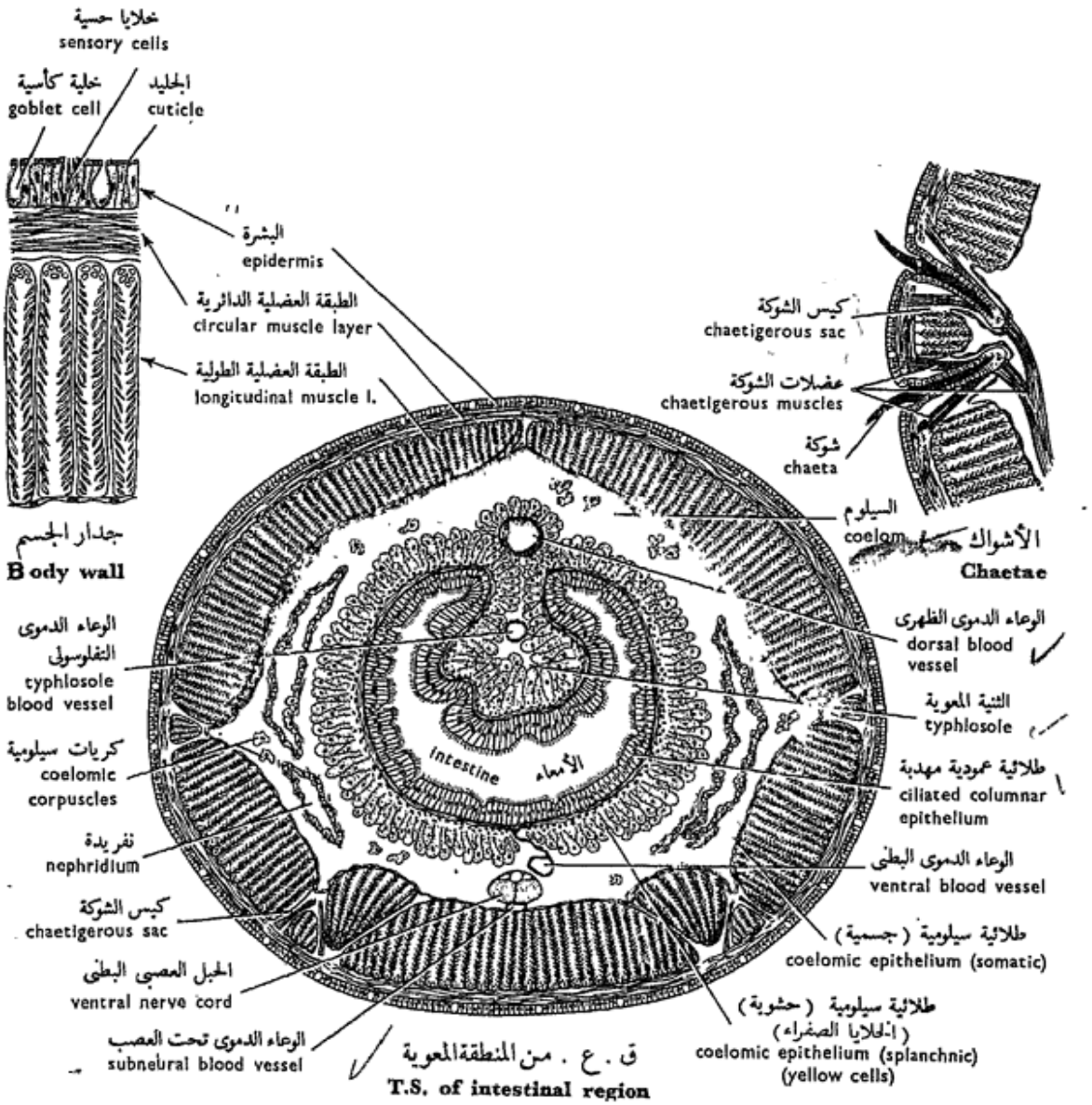
Class : Oligochaeta **قليلات الأشواك**

e.g. : ***Allolobophora caliginosa*** **دودة الأرض**



الدودة البالغة
Adult worm
(Dorsal view منظر ظهرى)





دودة الأرض « ألّولوبوفورا كاليجينوزا »

ALLOLOBOPHORA CALIGINOSA

References

1- أحمد حماد الحسيني واميل دميان (1969): بيولوجية الحيوان العملية (الجزء الثاني)- دار المعارف - مصر