Zoology Department

General Zoology 2

(Zoo 102)

Theoretical Part

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Icons

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 **Text**

Contents

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 millions of animals which exist. He must of necessity arrange them into groups. This arrangement is created the origin of **classification** or **taxonomy** or **systematic**. In such a system animals with several similar characters are placed together in the same group. 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) 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.

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

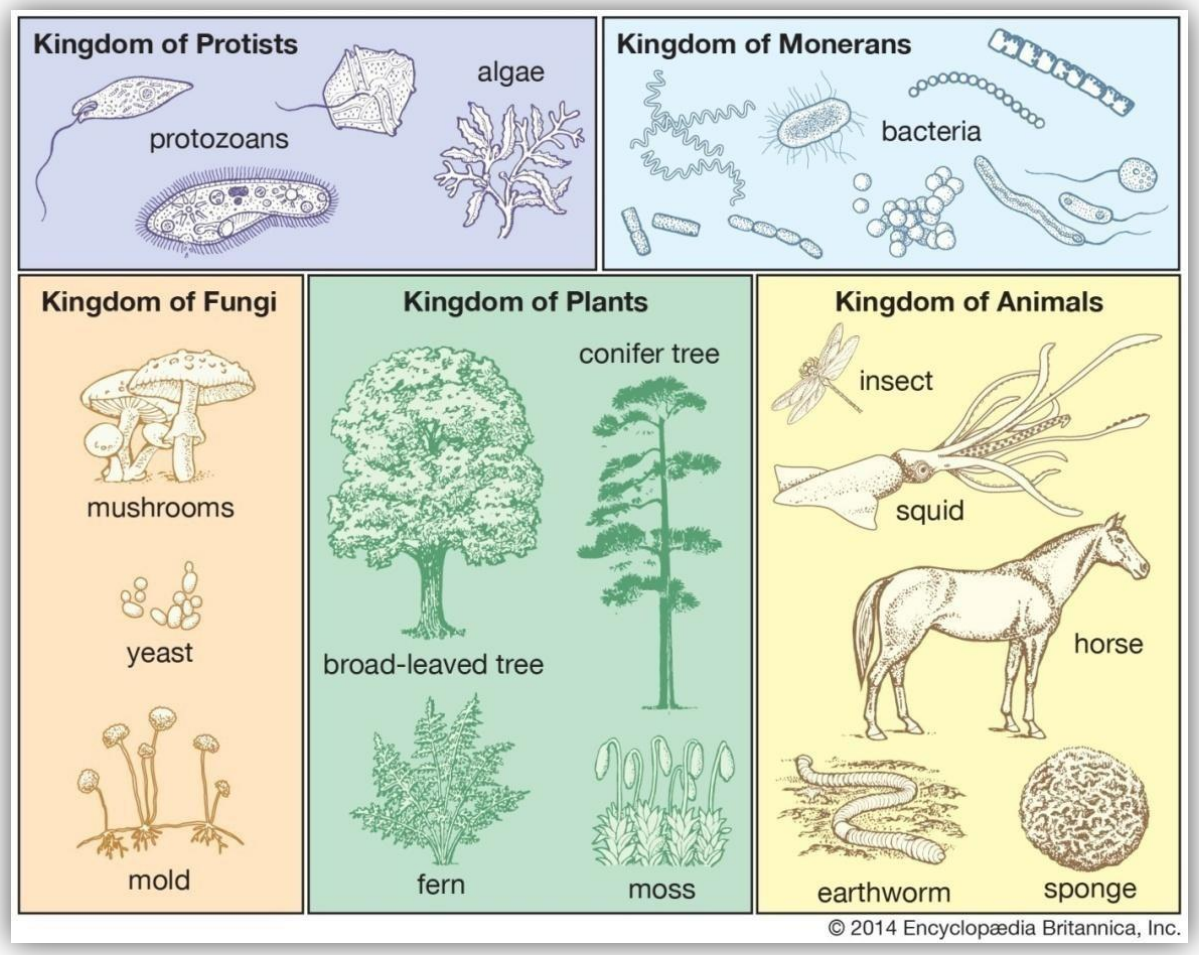

Figure 1: Animal kingdoms

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.

Kingdom: **Protista** (protists)

Subkingdom : Protozoa

General characters:

 1- Very small in size, can only be seen by the light microscope and live in all environments.

2- Many species live as solitary individuals, while a few live in colonies.

3- In majority of cases there is only one nucleus in the cytoplasm with distinct (endosome). Cytoplasm is usually differentiated in to outer clear ectoplasm and inner granular endoplasm.

4- The cell is covered by a plasma membrane or by a pellicle.

5- They move either by pseudopodia, flagella, cilia and some have no locomotory organelles.

6- Nutrition: some are heterotrophic: feeds on other organisms (bacteria, algae, smaller protozoa, …) and some are autotrophic).

7- Osmoregulatory organelles, in the form of contractile vacuoles present in freshwater forms.

8- Respiration by simple diffusion through the body surface.

9- Excretion takes place by simple diffusion through the body surface.

10- All protozoans can reproduce asexually, either by binary fission or by multiple fission. But some protozoans can reproduce sexually by forming male and female gametes.

11- Encystement is common in protozoa under unfavorable conditions.

Taxonomy of Protozoa

Phylum: Sarcomastigophora

- **Subphylum: Sarcodina**

  Includes protozoans which move by pseudopodia

  ex.: *Amoeba*.

- **Subphylum: Mastigophora**

  Includes protozoans which move by one or more flagella,

  ex.: *Trypanosoma* and *Euglena*

- **Subphylum: Opalinata**

  Includes protozoans which move by cilia other than ciliophora

  Ex: *Opalina*

Phylum: Ciliophora

Includes protozoa which move by cilia,

ex.: *Paramecium*

Phylum: Apicomplexa

Includes protozoa which have no distinct locomotory organelles,

ex.: *Plasmodium*

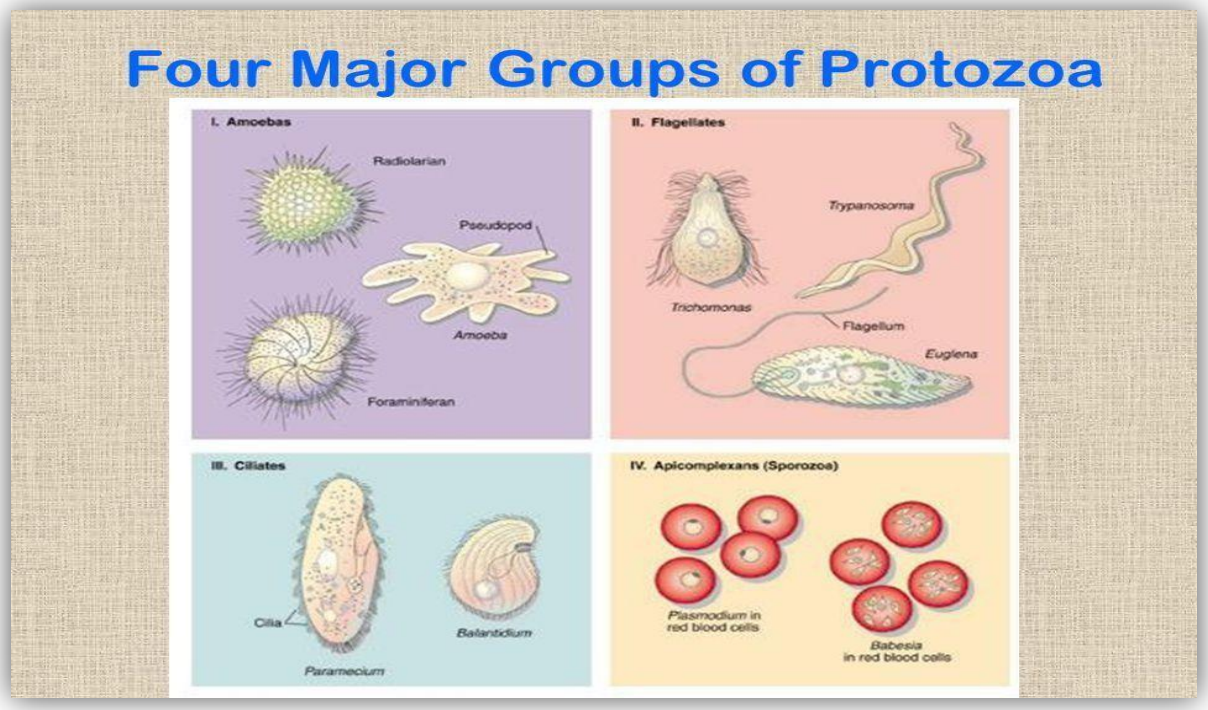

Figure 2: Groups of Protozoans

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.

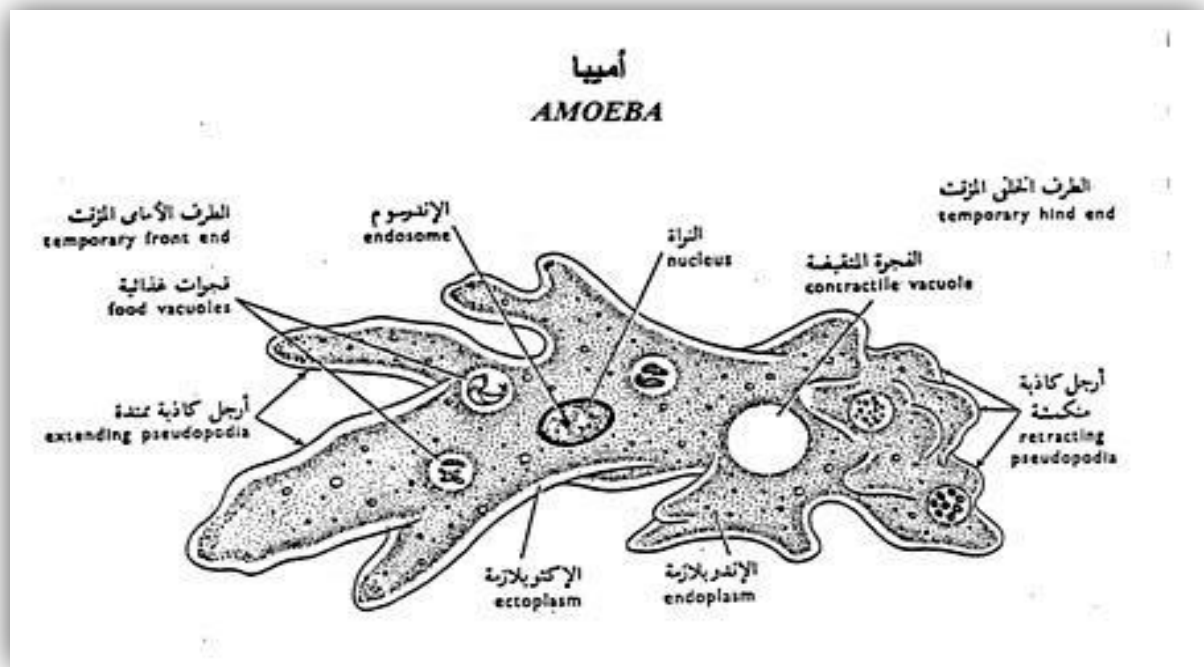

Figure 3: Amoeba

- 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 multiple fission during encystment under unfavorable conditions.

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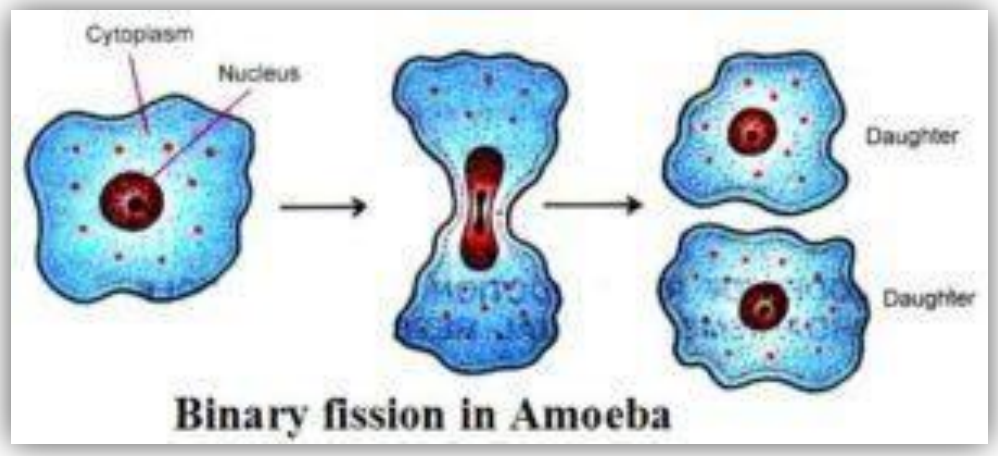

Figure 4: Binary fission in Amoeba

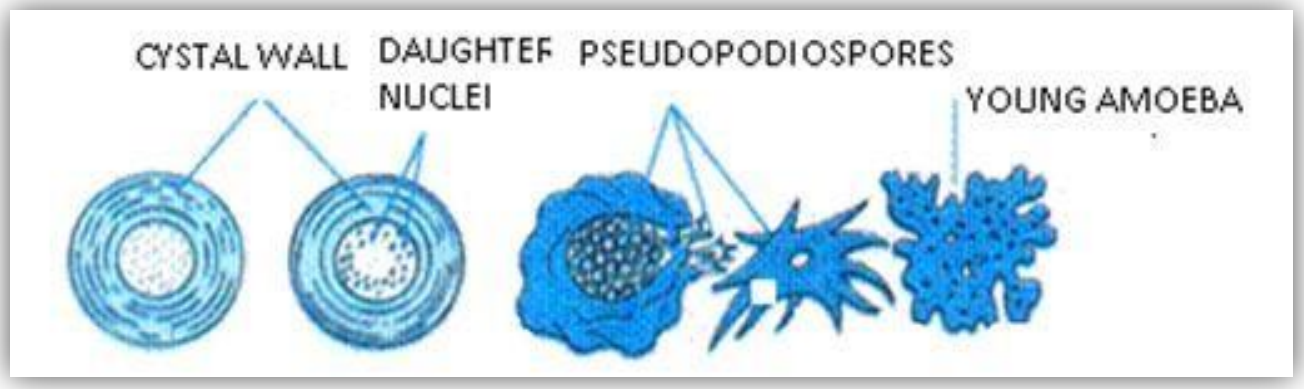

Figure 5: Encystement in Amoeba

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Subphylum: Mastigophora

e.g.: *Trypanosoma*

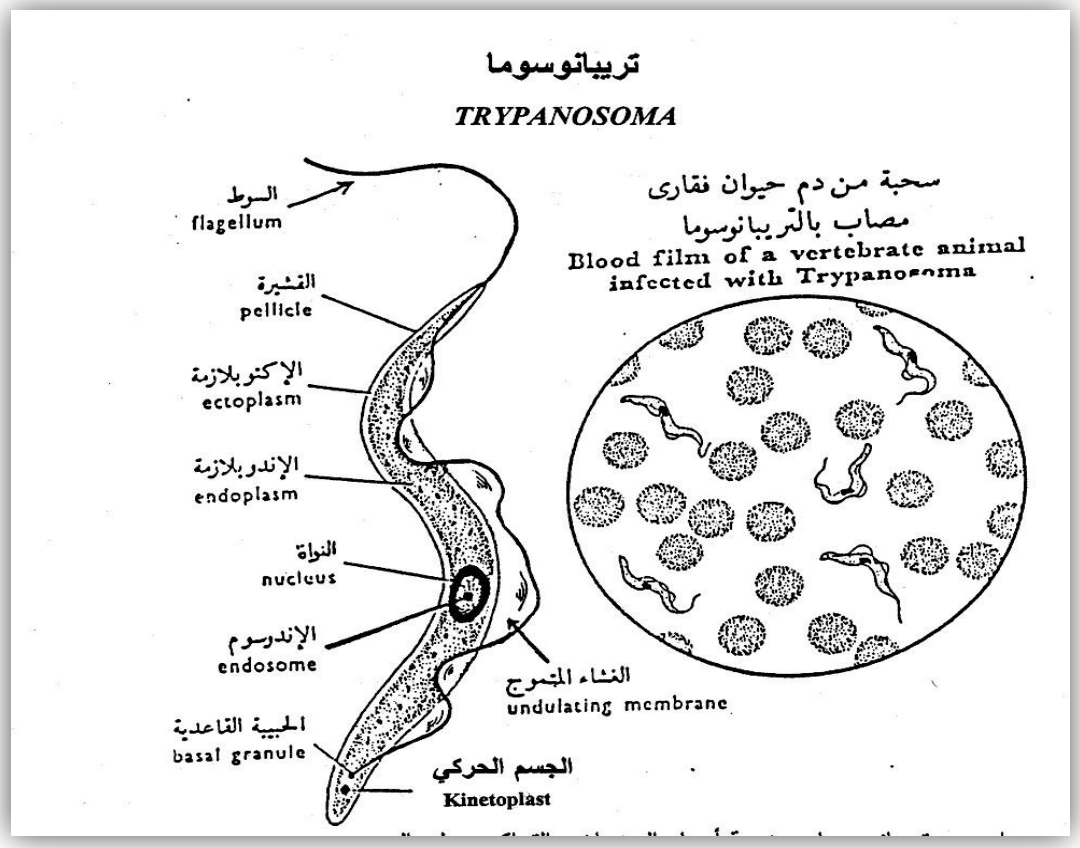

Figure 6: *Trypanosoma*

- *Trypanosoma* is a flagellate parasite, live in two hosts: invertebrate and vertebrate hosts. In the former they usually infest the alimentary canal while in the latter they live in the blood.
- Trypanosomes infect a variety of hosts and cause various diseases, including the fatal human diseases sleeping sickness.
- It has a long slender undulating body with a flagellum at the anterior end. The flagellum connected to the body by a thin membrane called: the undulating membrane. The

flagellum arises from the basal granule situated near the posterior end of the body.

- Reproduction asexually by longitudinal binary fission.

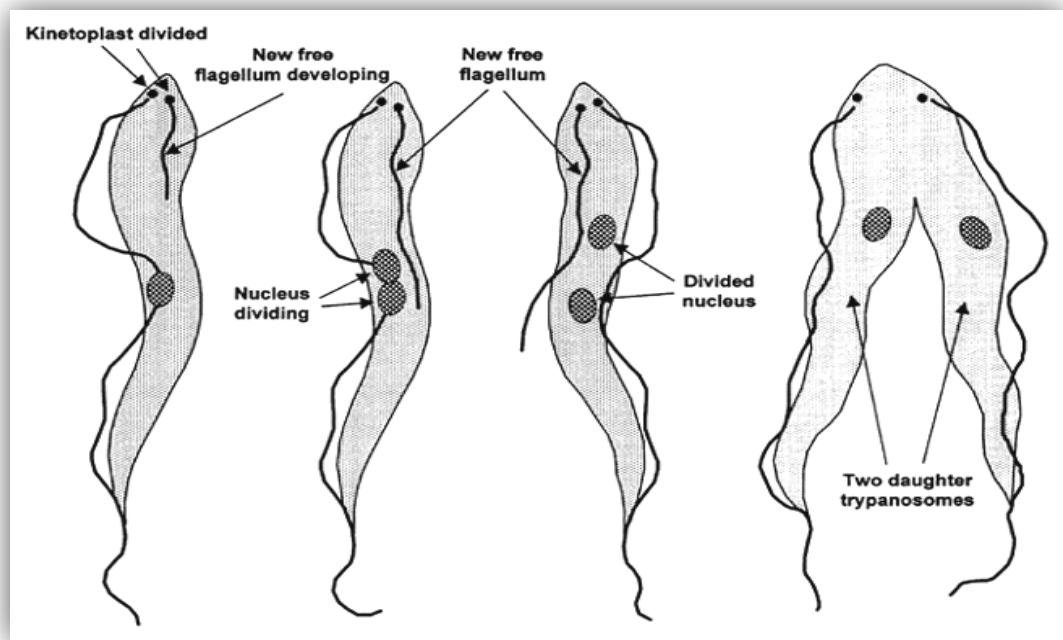

Figure 7: Binary fission in *Trypanosoma*

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

Phylum: Porifera

General characters:

- Sponges are sessile and mostly marine animals 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 or 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: (ascon, sycon and leucon).

The Ascon type (*Leucosolenia)*

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

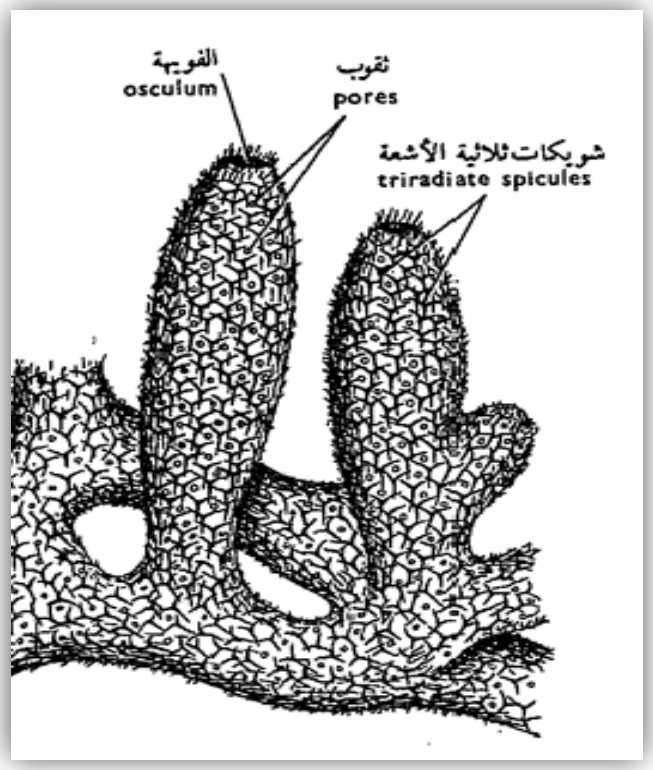

Figure 8: ***Leucosolenia***

- 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.

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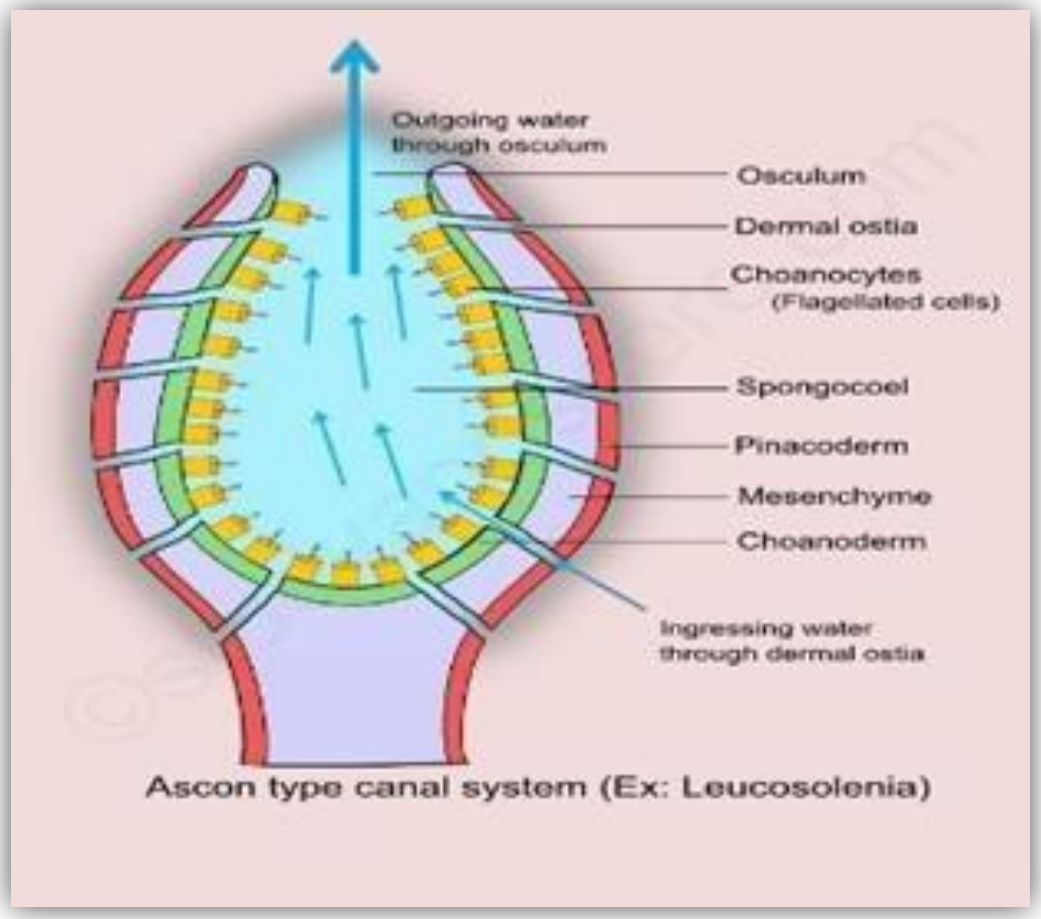


Figure 9: Internal structure of *Leucosolenia*

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 **porocytes** acts as a pore**.**

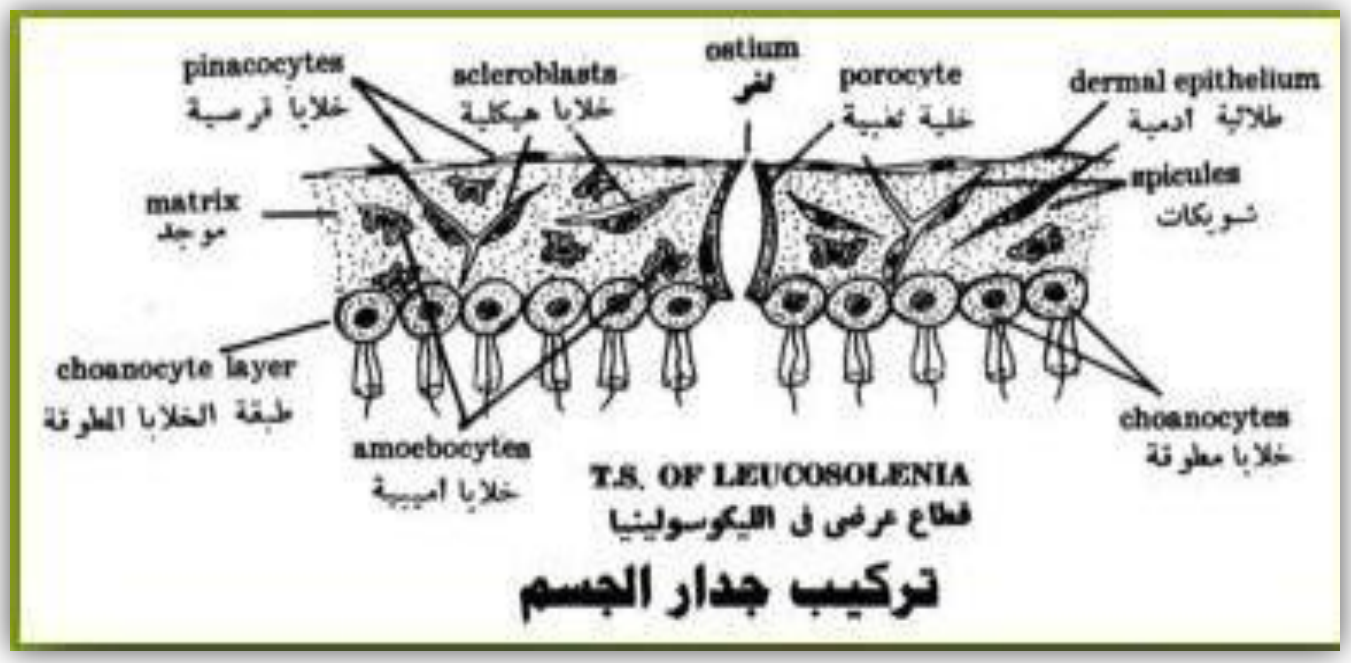


Figure 10: Body wall of *Leucosolenia*

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.

figure 11: The sycon type

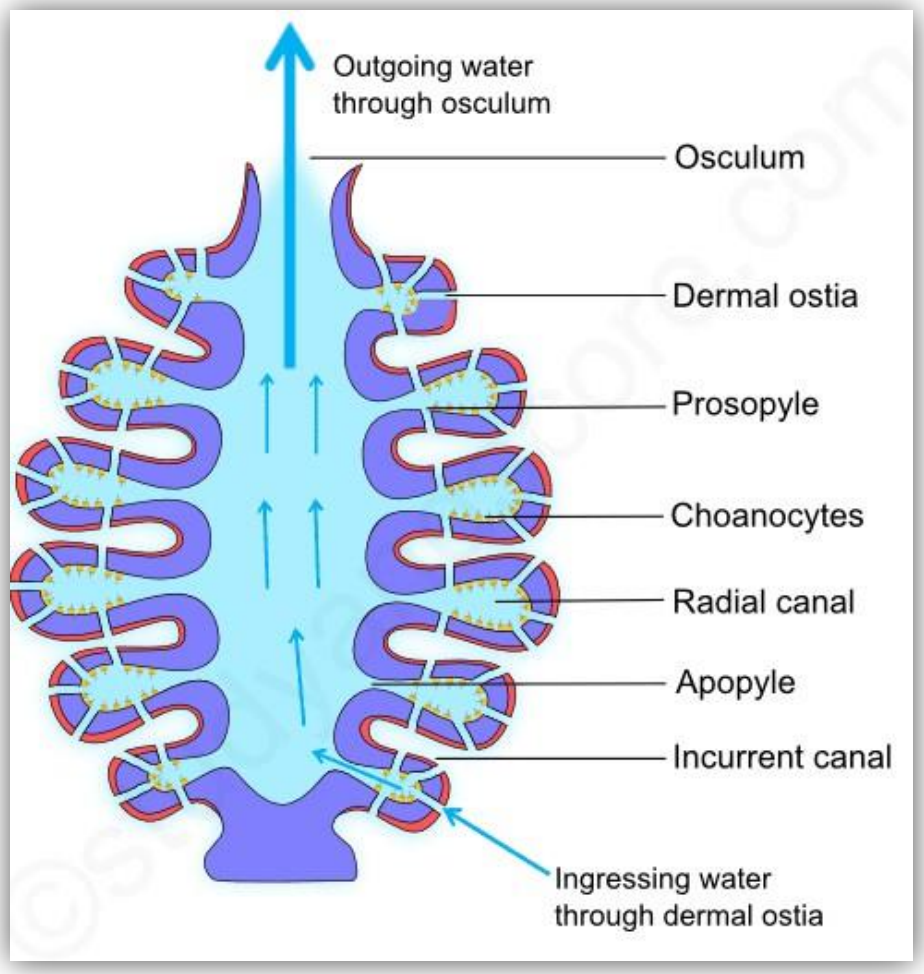


Figure 12: Sycon type canal system

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.

Figure 13: ***Euspongia***

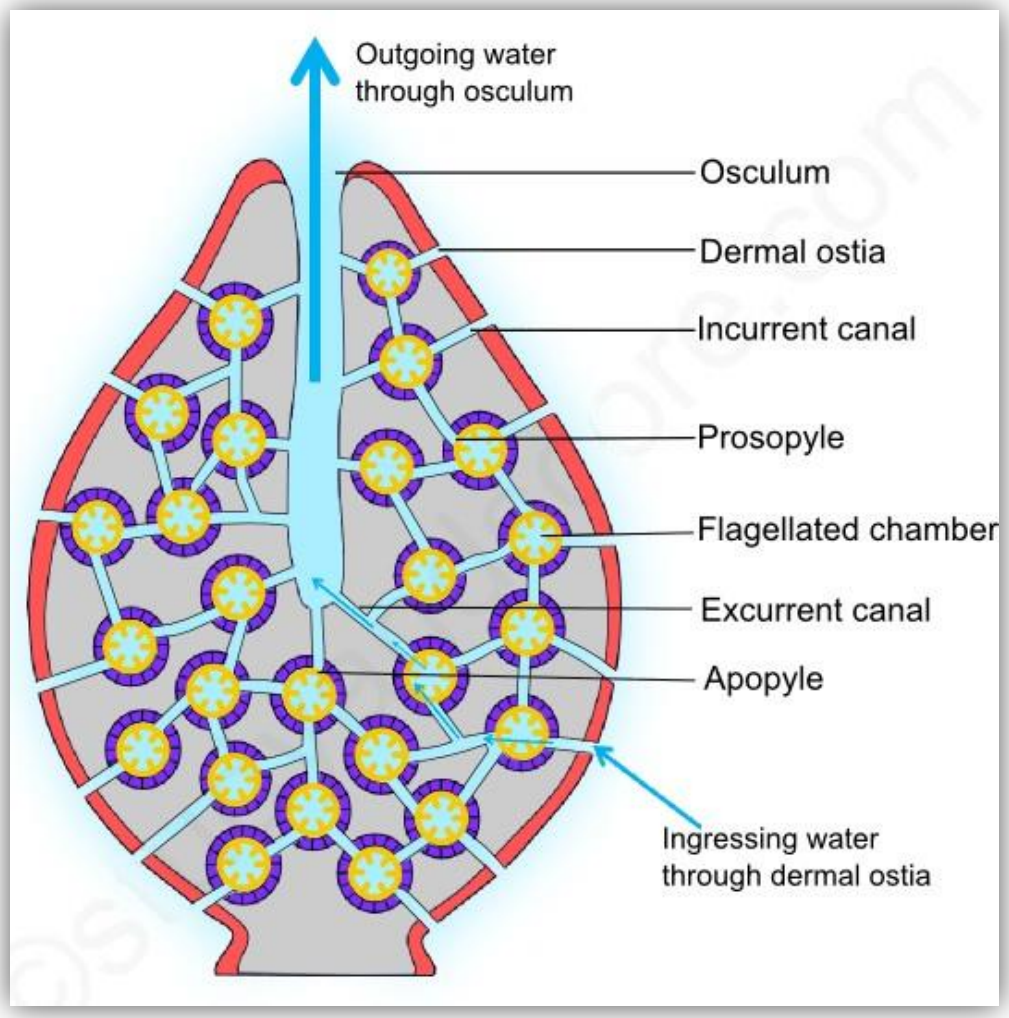


Figure 14: Leucon type canal system

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: Coelenterata

1- Simple aquatic metazoa, mostly marine and sessile.

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 (stinging structures), not found in any other phylum.

5. There is a single cavity (the gastrovascular cavity or coelenteron cavity).
6. Respiration and excretion by simple diffusion.
7. They have a simple diffuse nervous tissue in the form of a nerve net.
8. They reproduce asexually by budding, and sexually by gametes.
9. Most have two forms during the life cycle (hydroid form or polyp), and free swimming jelly-fish like form (medusa).
10. Some forms with external calcareous skeleton.

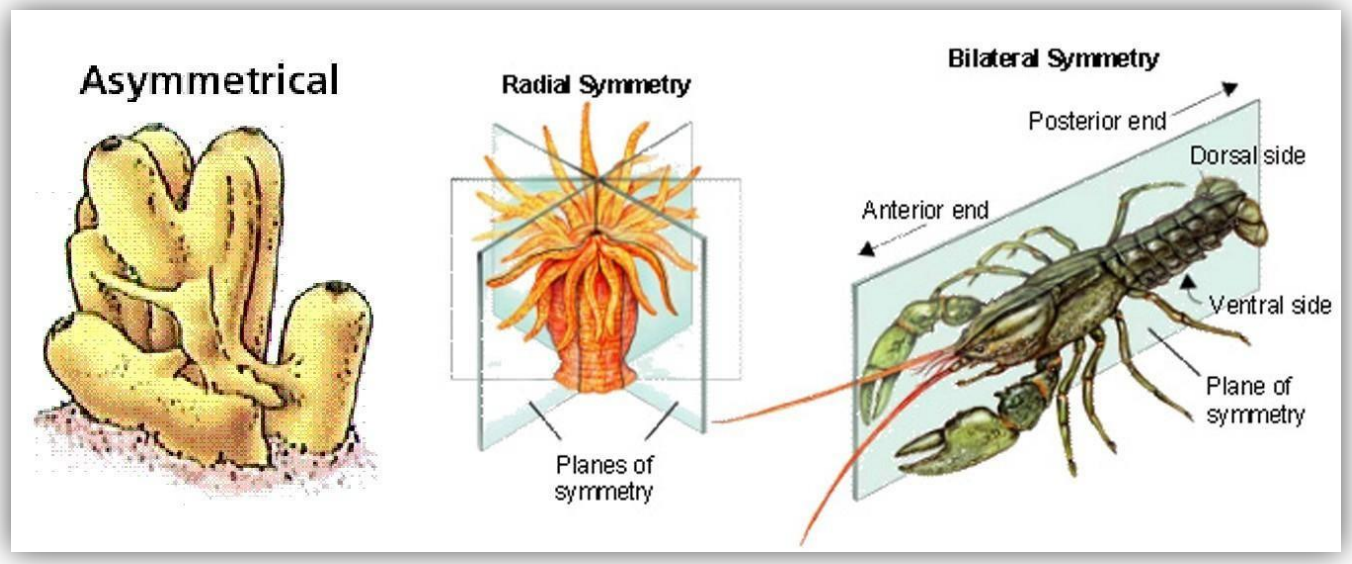


Figure 15: Types of Symmetry

Radial symmetry generates identical body halves around the central axis whereas bilateral symmetry generates only two sides as left and right.

Classification of Coelenterata

- **Class: Hydrozoa**
- Most have the polyp and medusa forms during the life cycle.
- **Order: Hydroidea**
- Have the polyp form only: ex.:*Hydra*
- **Order: Calyptoblastea**
- Have the two forms (polyp and medusa) ex.: *Obelia*
- **Class: Scyphozoa**
- Contains the jelly-fishes, have only the medusa form.
- **Class: 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.

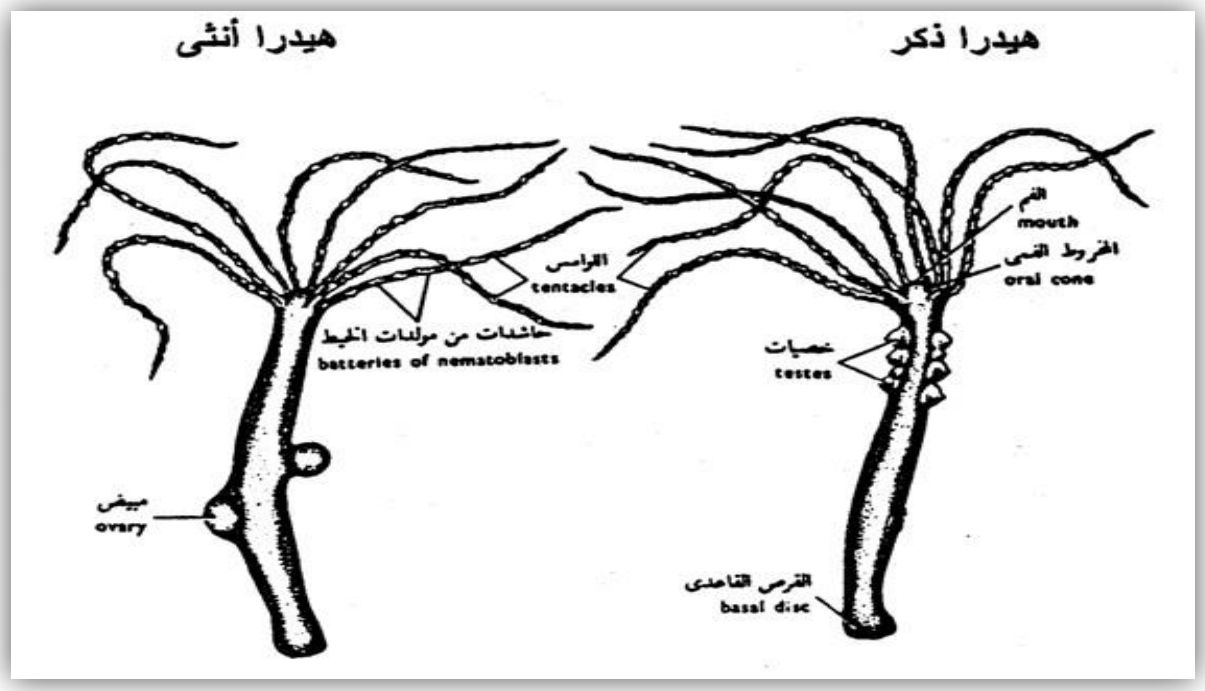


Figure 16: *Hydra*

- *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.

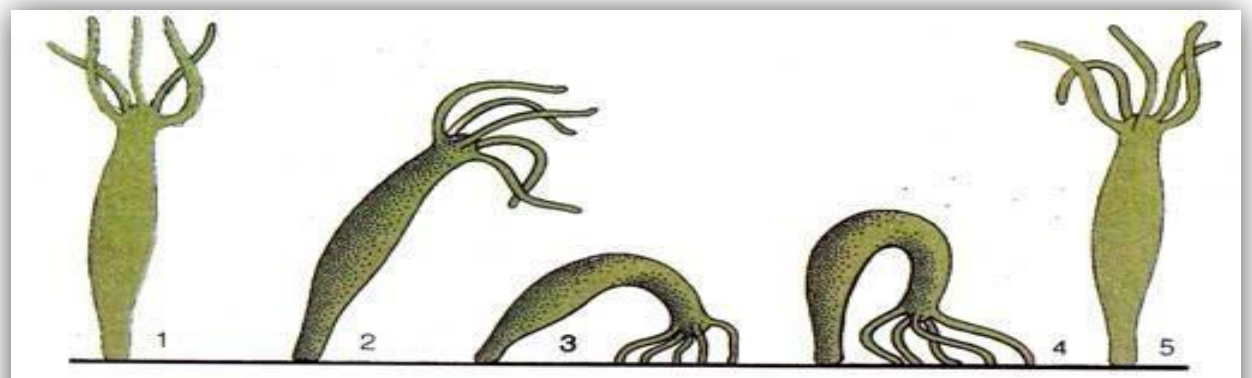
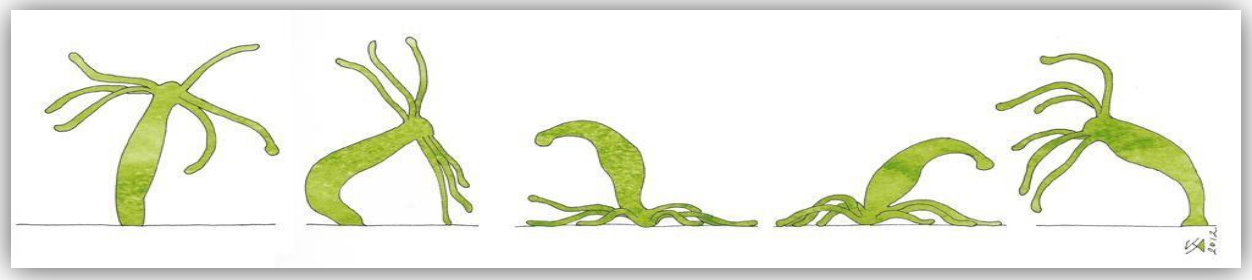


Fig. 31.15. *Hydra* showing looping movements.

- **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



- **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.

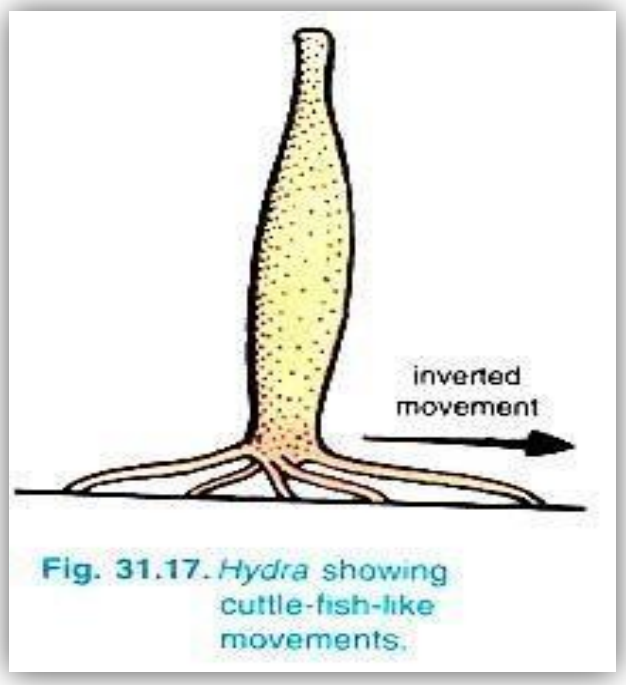


Fig. 31.17. *Hydra* showing cuttle-fish-like movements.

- **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

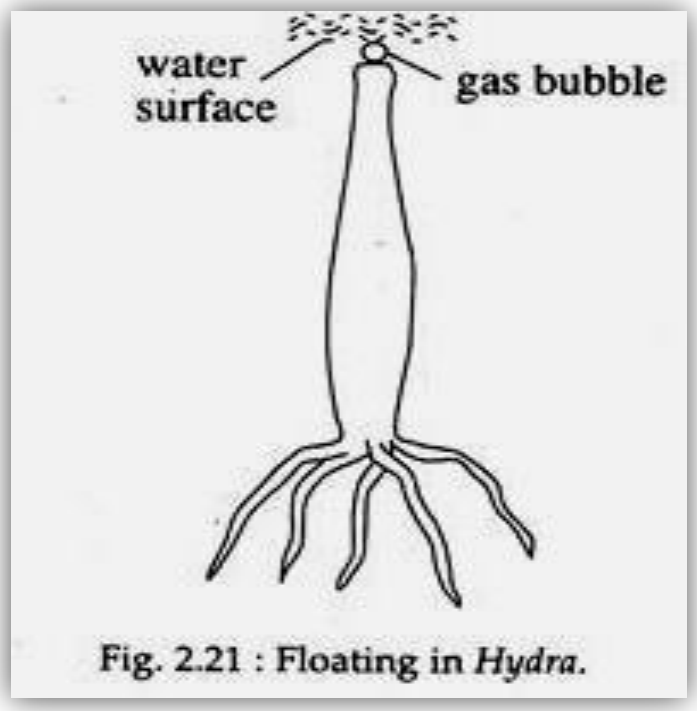


Fig. 2.21 : Floating in *Hydra*.

- **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.

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.

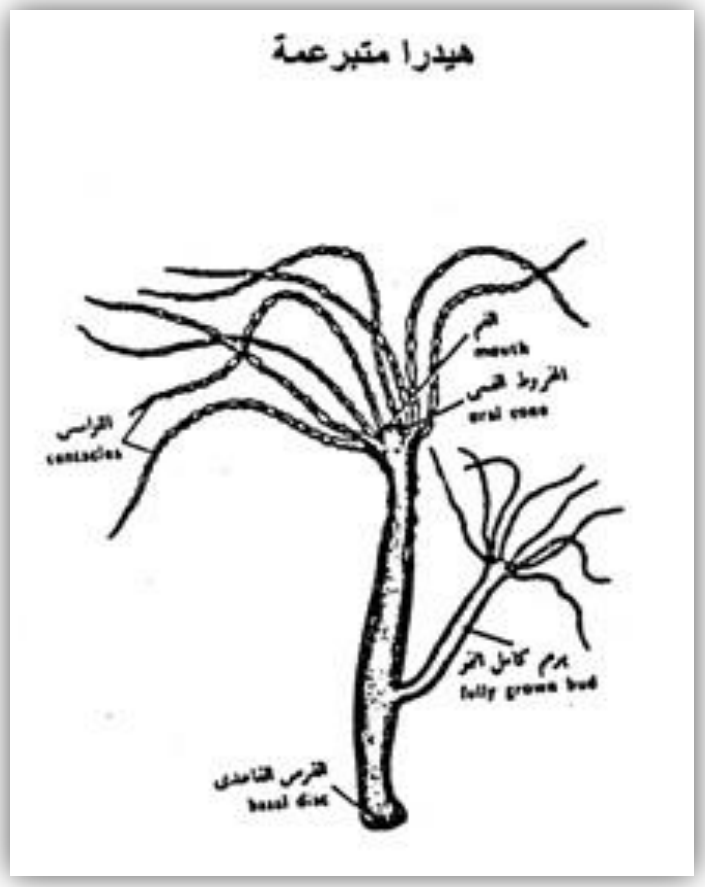


Figure 17: Budding in Hydra

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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.

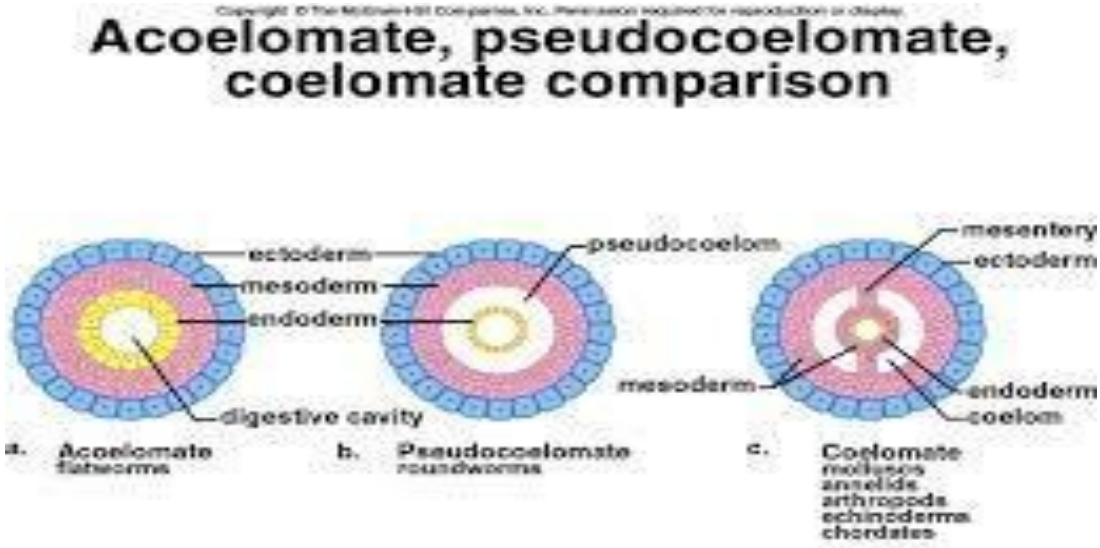
Taking this into account, we must note that during the last decades a lot of interesting bioactive substances have been isolated from Cnidarians and those substances have been demonstrated for having cytotoxic, hemolytic, anti-inflammatory, antitumoral, anti-infective, anti-parasitic, as well as other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

Subkingdom: Eumetazoa

●Triploblastica

Triploblastic animals have three germ layers: ectoderm, mesoderm and endoderm. Mesoderm allows development of muscle layers in body wall, allows more elaborate organs, more specialization and greater division of labor.

- They are classified into three groups according to the presence of the true coelom, Acoelomata, Pseudocoelomata and coelomata.
- The true coelom is a fluid-filled body cavity, which is completely lined by the tissues derived from the mesoderm.



Acoelomata: (Animals without body cavity)

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)

Schistosoma haematobium

- ***Schistosoma*** is a genus belongs to Class: Trematoda, Order: Digenea, commonly known as **blood flukes**. They are parasitic flatworms responsible for a highly significant group of infections in humans termed *schistosomiasis.*

- Two species infect man in Egypt. *S. haematobium* which lives in venous vesical plexus and drops the eggs in the venules of the urinary bladder to pass out with the urine. The other species is *S. mansoni* which lives in the mesentric veins and drops the eggs in the venules of the rectum to pass out with the faeces.

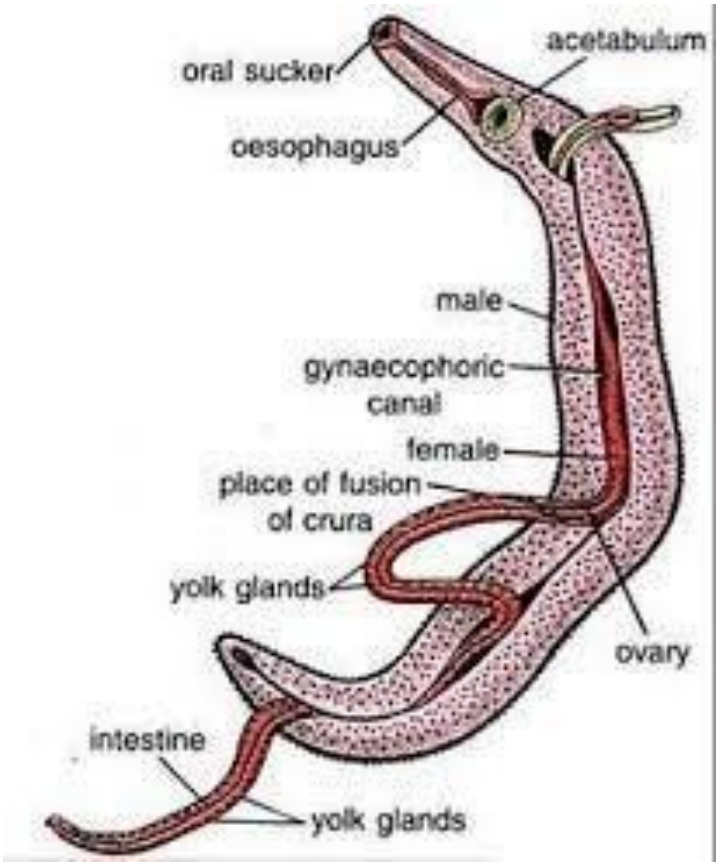


Figure 18: Male embracing female

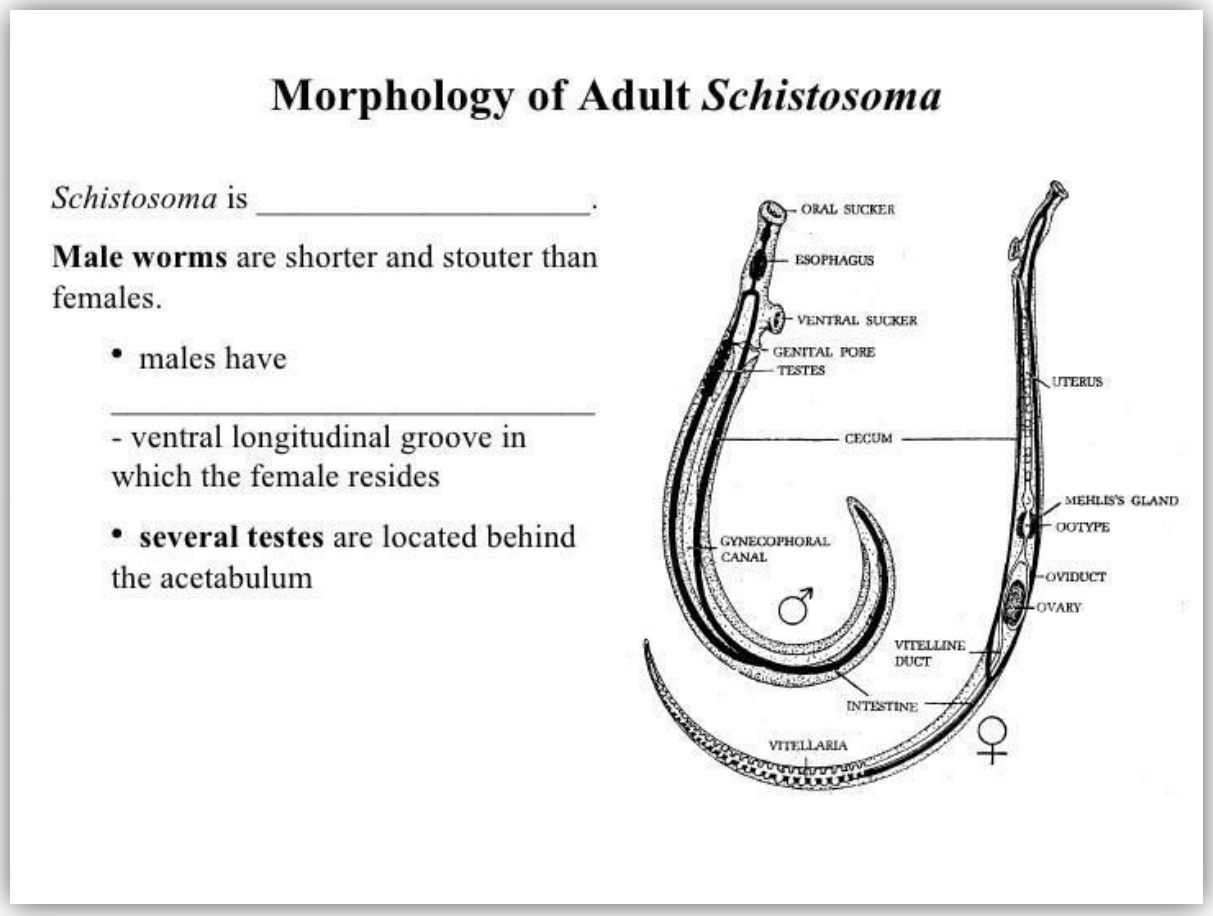


Figure 19: Morphology of *Schistosoma*

- ***S. haematobium***: the sexes are separate but usually found in pairing condition. The male (10-15 mm long) broader and shorter than female (16-20 mm) and has a cylindrical appearance but is actually flat with the sides rolled ventrally to form the gynaecophoric groove in which the narrower female is partly lodged. The body of male covered with tubercles for clinging to the walls of the venules while moving against the blood stream. The female body is cylindrical and smooth to pass easily through the small blood vessels for laying the eggs.

Life cycle

- Eggs are eliminated with faeces or urine to the water. Under optimal conditions the egg hatch and release

miracidium , which swim and penetrate specific snail intermediate host (*Bulinus truncatus* snail for *S. haematobium* and *Biomphalaria alexandrina* snail for *S. mansoni*). The stages in the snail include 2 generations to produce the infective stage (cercariae). Upon release from the snail, the (cercariae) swim, penetrate the skin of the human host, and migrate through several tissues to their residence in the veins.

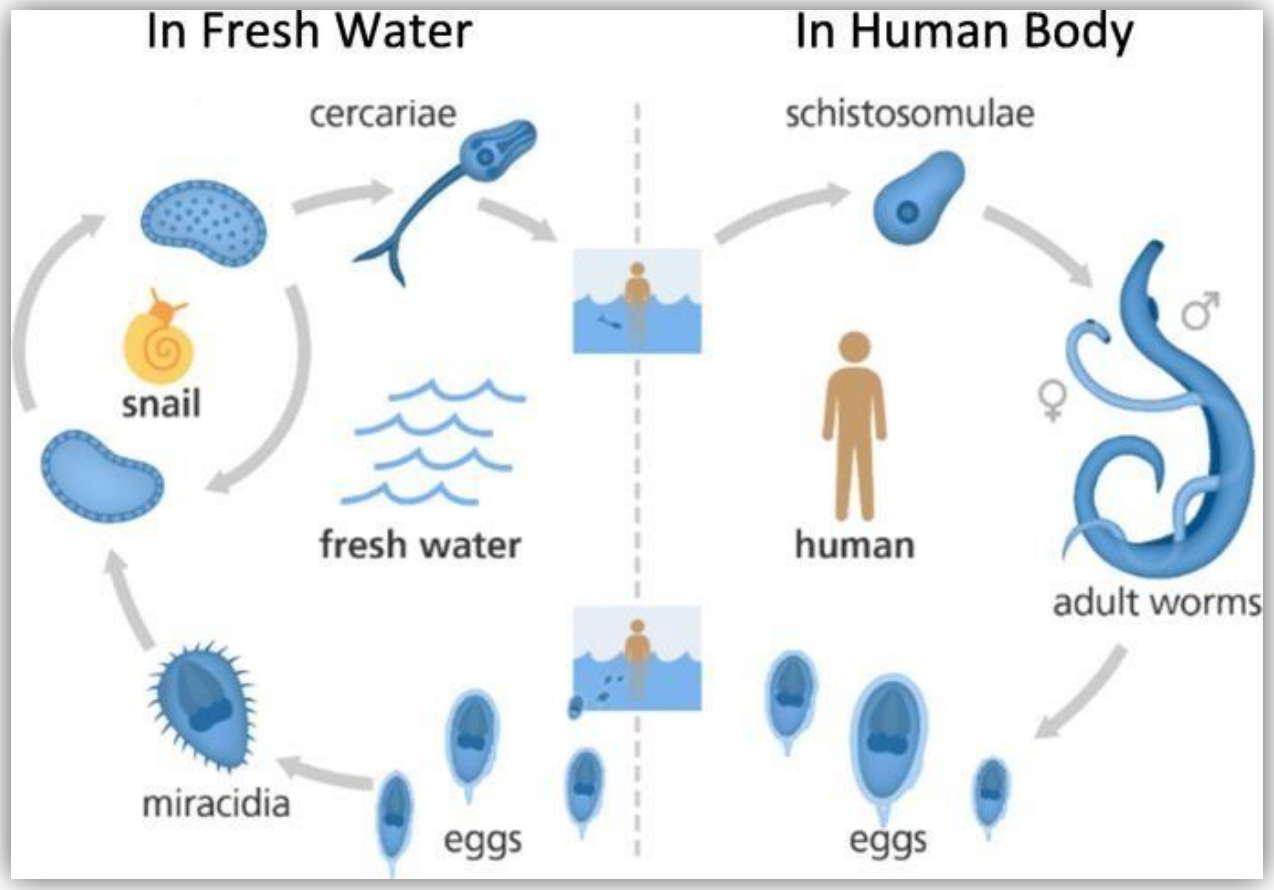


Figure 20: Life cycle of *Schistosoma*

Watch video

Figure 21: ***Biomphalaria alexandrina***

Figure 22: ***Bulinus truncatus***

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

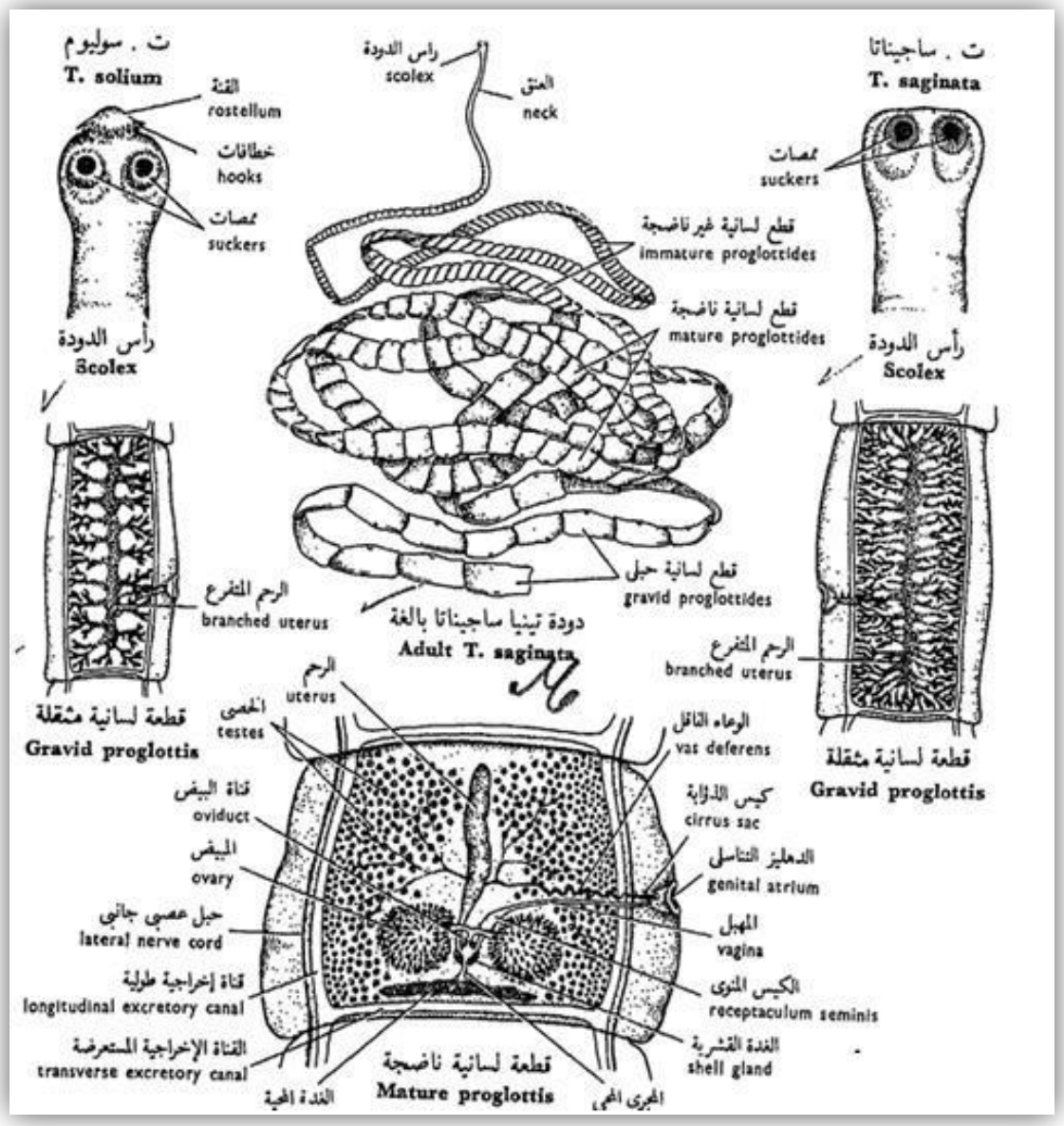


Figure 23: *Taenia*

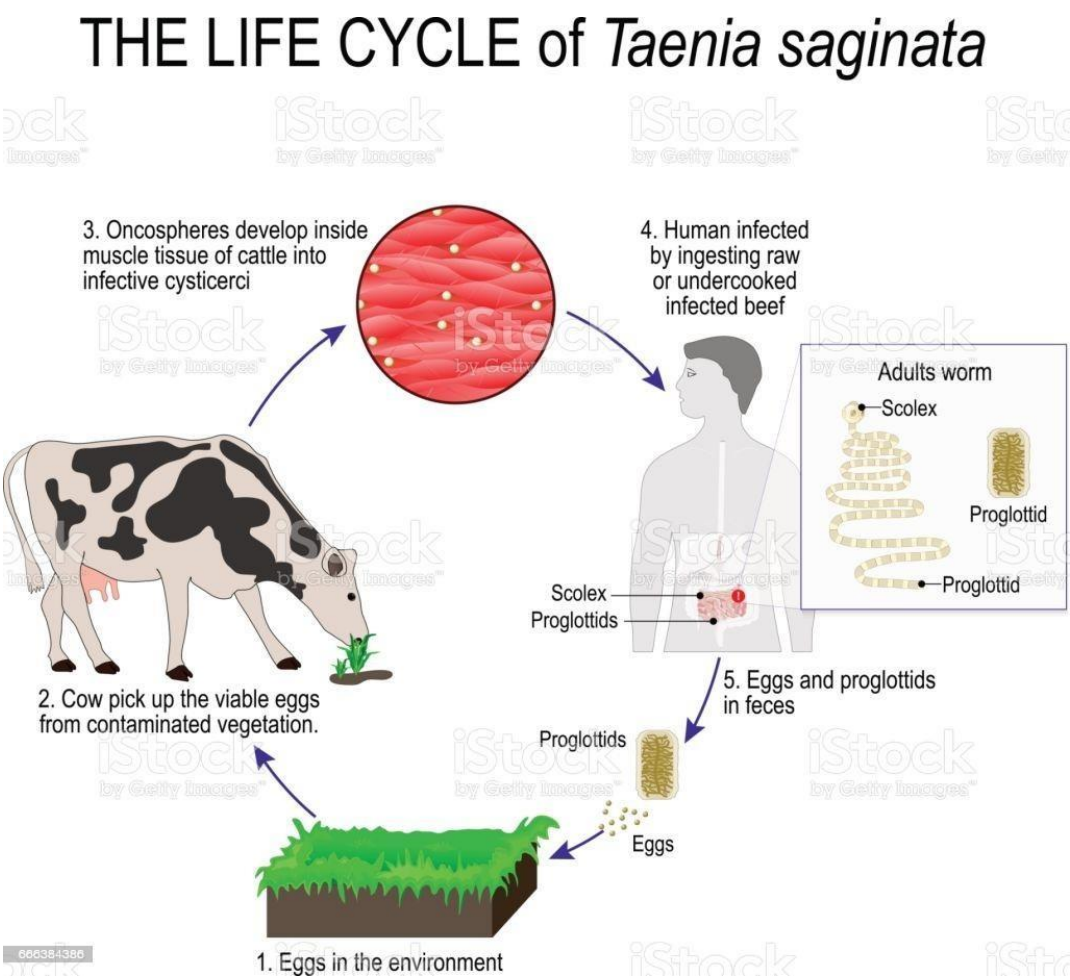


Figure24 : Life cycle of *Taenia*

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

A pseudocoelomate is an organism with body cavity that is not derived from the mesoderm, as in a true *coelom*, or body cavity

Phylum: Aschelminthes (Nematods)

(the round worms)

- They may be free living (aquatic and terrestrial) or parasitic on plants and animals.
- They are bilaterally symmetrical, triploblastic and pseudocoelomate animals.
- The body is cylindrical. unsegmented with smooth cuticle and well developed muscle fibers.
- The alimentary canal is complete with a mouth, a well-developed muscular pharynx and anus.
- Two lateral excretory tubes removes body wastes from the body cavity through one excretory pore.
- No respiratory or circulatory systems.
- Nervous system with circumenteric ring, 6 anterior and 6 posterior nerves.
- Sexes are separated. Often females are longer than males.

Order: Ascaridata
Genus: *Ascaris*

- Some species of this genus 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 others closely and differ in few details.

- The body form is cylindrical, Long and the length in male about 15-26 cm and in female about 22-30 cm. The two ends are tapring. The female is the larger and has a straight posterior end, while the male is slender and has a sharply curved posterior end.

- There are 4 longitudinal streaks run the entire length of the body, 2 thin dorsal and ventral lines (contain two nerve cords) and 2 broader lateral lines (contain two execretory canals).

- The mouth lies at the anterior end of the body and the execretory pore lies on the ventral side, 2 mm behind the mouth. The female genital opening lies on the ventral side near the anterior end. The cloaca (the genital duct joins the hind gut) in male opens near the posterior end and two copulatory spicules project from the cloaca.

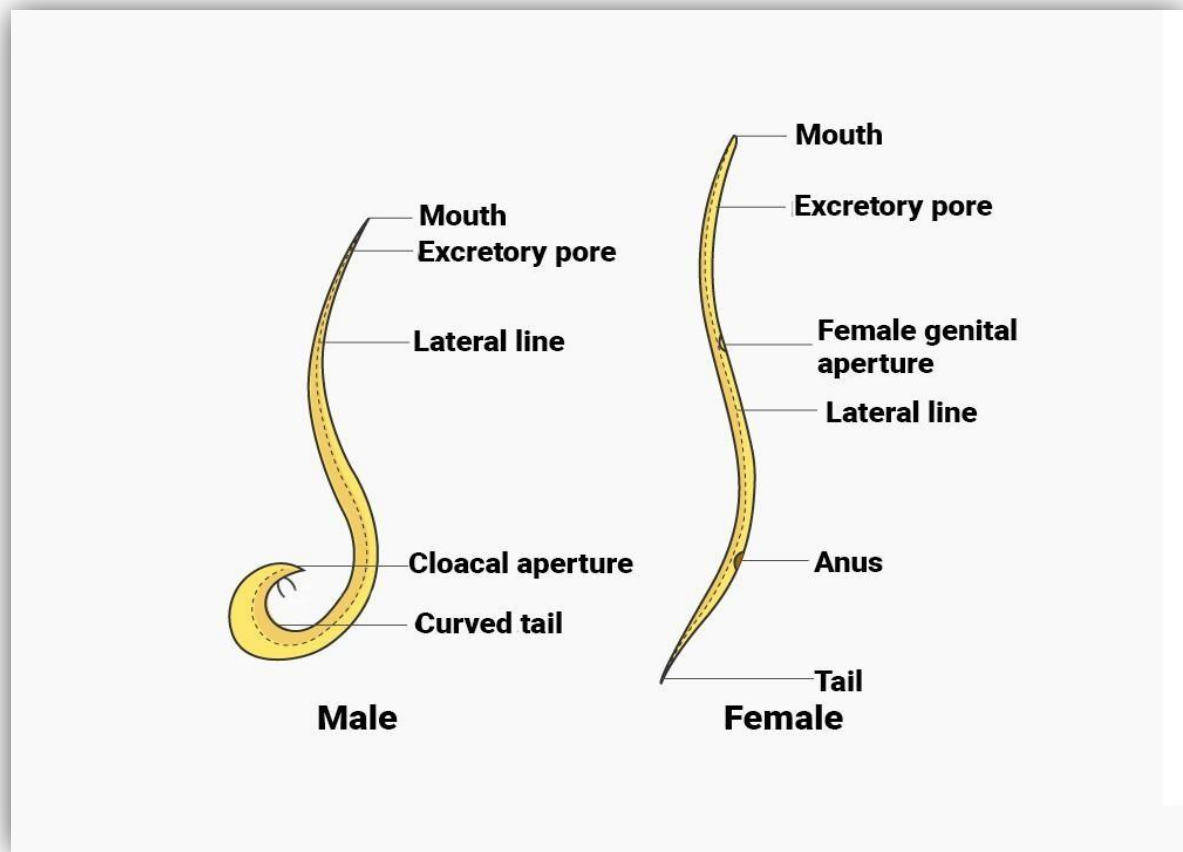


Figure 25: ***Ascaris***

- The female lays about 200,000 eggs daily which pass out with the faeces.
- The infective stage is the egg 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.

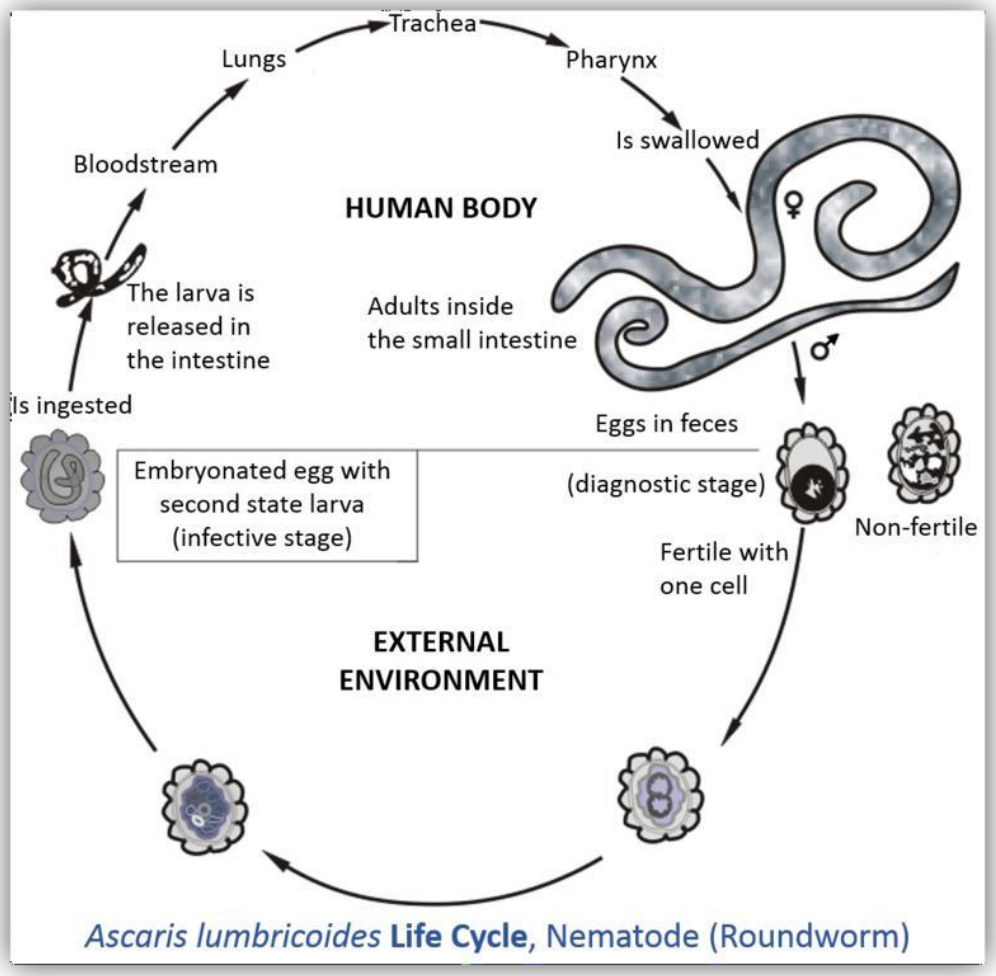


figure 26: Life cycle of *Ascaris lumbricoides*

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.
- They have an elongated and metamerically segmented body.
- The body covered with a thin non- chitinous cuticle and the body wall is muscular with circular and longitudinal muscles.
- They possess chaetae on the segments, some forms with 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.
- 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

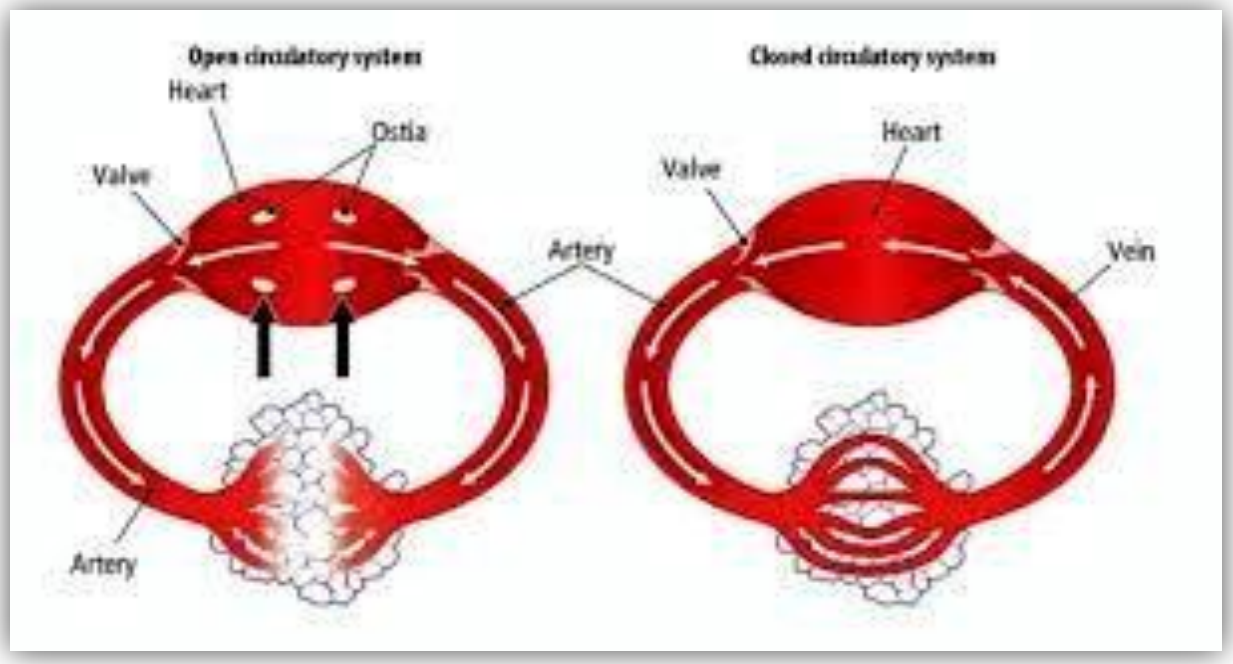


Figure 27: Opened and closed circulatory system

Classification of Annelida

Class: Oligochaeta

Includes the earthworms, live in moist soil or in freshwater. They are hermaphrodite and without parapodia. 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.
- Everybody segment, except the first and the last, bears 4 pairs of chaetae, two ventral pairs and one pair on each lateral side.

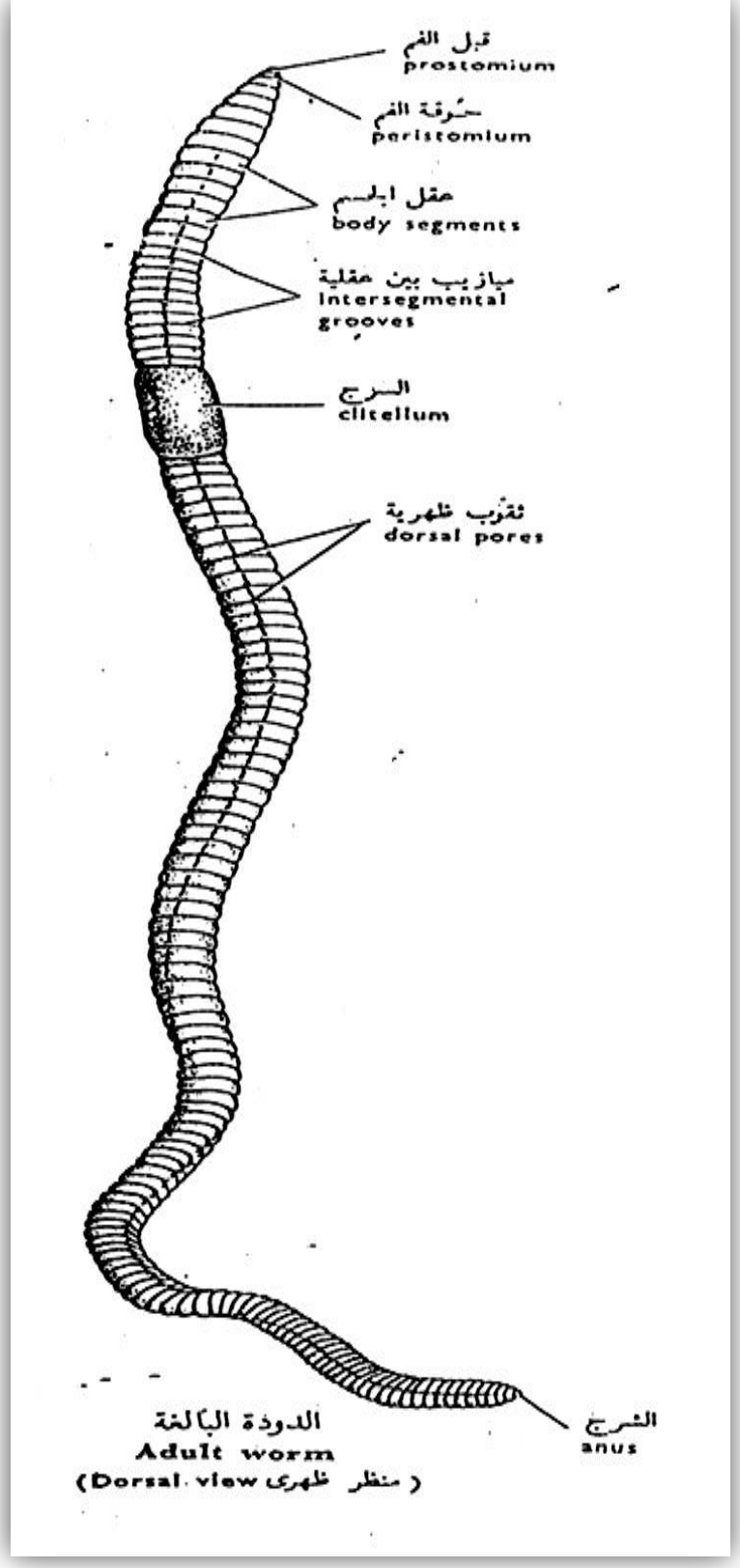


Figure 28: ***Allolobophora caliginosa***

- **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.

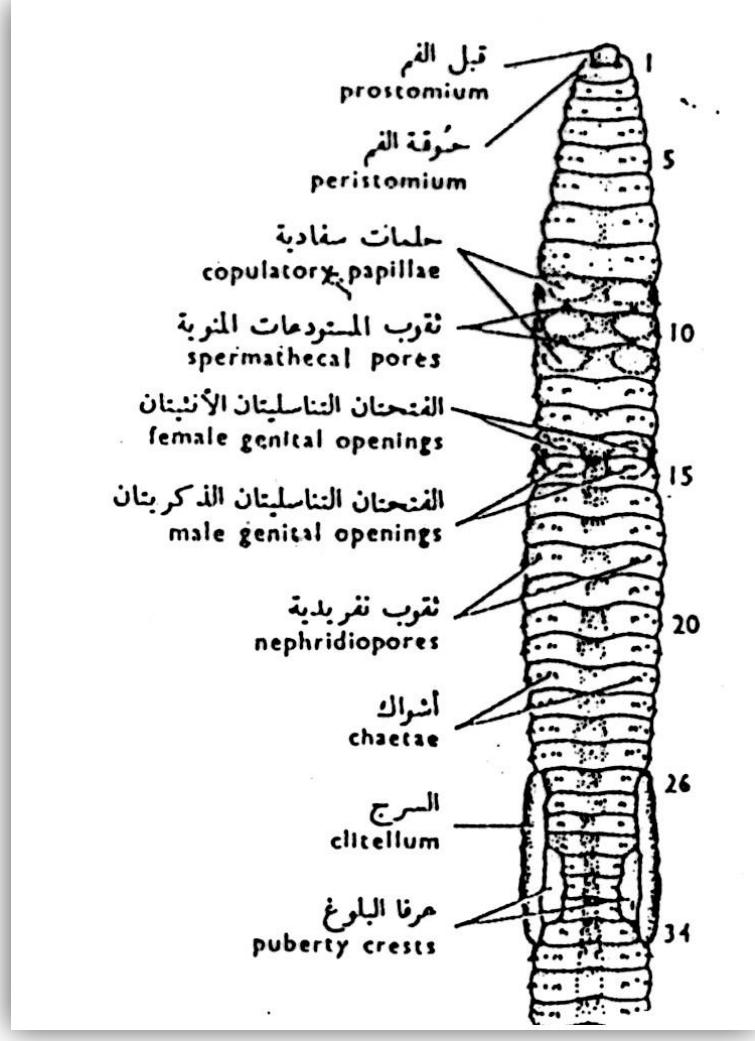


Figure 29: Ventral view of *Allolobophora*

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.

Phylum: Arthropoda

- The largest phylum in the Animal kingdom.

General characters

- Cosmopolitan in distribution, found as aquatic, terrestrial and aerial forms. Some are ectoparasites and vectors of disease.
- Body is triploblastic and bilaterally symmetrical.
- Body is segmented. Number of segments is less than this in Annelida and forms certain regions. It is divisible into head, thorax and abdomen.
  NOTE: In some forms, body is divisible into cephalothorax (head and thorax are fused) and abdomen, or head and trunk
- Body has jointed appendages or legs (which modified to different structures to perform different functions like jaws, walking legs, paddles).
- Body is covered with chitinous exoskeleton formed by epidermis. The exoskeleton forms internal projections useful for muscle attachment. The exoskeleton is casts off periodically and a new one is secreted. That is called molting or ecdysis.
- True coelom is greatly reduced. It is represented only by the cavities of the reproductive and excretory organs. The general body cavity (haemocoel) is filled with blood.
- Digestive system is complete, straight and well developed. The mouth bears mouth parts for ingestion of food.
- Respiration takes place by general body surface or gills, trachea, booklungs or bookgills.

- Circulatory system is of opened type i.e. do not have blood vessels and the blood enters directly into the body chambers or (haemocoel), and returns back to the heart through ostia.
- Excretion takes place through Malphigian tubules (in terrestrial form) or green glands (in aquatic forms).
- Nervous system is of annelidian type, which consists of a brain and a ventral nerve cord.
- Sensory organs include antennae, sensory hairs for touch and chemoreceptor, simple and compound eyes, auditory organs (in insects) and statocysts (in crustacean).
- Striated muscles are presented segmentary.
- Unisexual i.e. sexes are separated. Fertilization is internal or external. They are either oviparous or ovoviviparous. Development may be direct or indirect.
- Oviparous: lying leggs hatch out of the female body.
- Ovoviviparous: form eggs but still inside the female till hatching.
- 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.

 **Watch video**

Classification of phylum Arthropoda

Subphylum: Mandibulata

Class: Crustacea

General characters:

- Mainly aquatic, few live in moist places. Few are parasitic forms.
- The body is divided into 3 regions: head, thorax (usually fused in one part : cephalothorax) and abodomen.
- The head contains 6 segments :
- The first segment disappears in adult.
- The second bears the first anntennae or (antennules)
- The third bears the secont antennae or (Antennae)
- The fourth bears the Mandibles
- The fifth bears the first maxillae or (Maxillules)
- The sixth bears the second maxillae or (Maxillae)
- The thoracic and abdominal segments differ from one crustacean animal to another, but generally each segment with a pair of appendages and sometimes disappear from abdomen.
- The digestive tract is almost straight. It consists of an anterior foregut and a posterior hind gut, both lined by chitin and separated by the unchitinised midgut which often give rise to digestive glands.
- The opened circulatory system includes a contractile heart enclosed in pericardial cavity.
- Respiration takes place by general body surface or gills.
- Excretion takes place through coxal or anntennal glands (green glands).

- The sexes are usually separated. Development usually indirect forming (Nauplius larva).

The Prawn

- Class: Crustacea
- Subcalss: Malacostraca
- Order: Eucarida
- Suborder: Decapoda
- Family: Macrura
- e. g.: *Penaeus japonicus*
- It is a prominent member of our marine fauna.
- The body is divided into an anterior cephalothorax and a posterior abdomen.
- The cephalothorax (6 cephalic (5 in adult)+ 8 thoracic segments) is covered on all sides except ventrally by carapace which extended anteriorly into a long serrated pointed rostrum.
- No external signs of segmentation on head and thorax.
- On each side of the carapace, a V-shaped cervical groove that demark between head and thorax. Also note 3 dorsal grooves two of these are branchiocardiac grooves and the third is the rostral groove.
- The dorsal part of carapace is called cardiostegite and the sides are called branchiostegite.

- On both sides of rostrum two compound eyes are present carried on long stalks. Each eye made up of a large number of structural & functional units called ommatidia
- The abdomen with (6) segments ended with a small telson and the anus opens on its ventral surface.
- The segments of abdomen can be moved upon one another according to the presence of the peg and socket hinges on each side.
- A pair of appendages arises on each segment of the body. So 19 pair of appendages are present in adult animal.

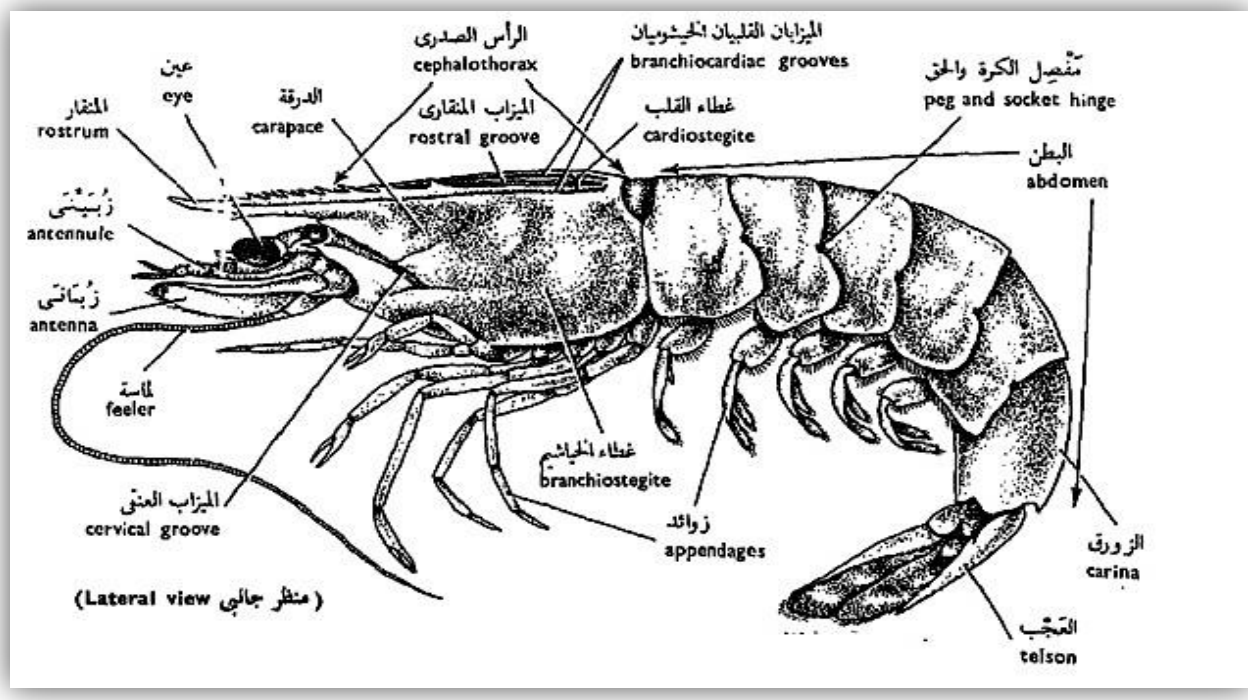


Figure 30: ***Penaeus japonicus***

Watch video

Class: Myriapoda

General features:

1- All are terrestrial.

2- The body is elongated with a consicous head and a trunk consisting of many segments between 11- 177 segment, each one bears one or two pairs of appendages.

3- Each appendage with 7 segments and a claw.

4- The head bears two antennae, two or three pairs of jaws and simple eyes.

5- Respiration through spiracles which connected internally with the tracheal system.

6- Excretion through Malpighian tubules which open in the hind-gut.

7- Sexes are separated. Development usually direct.

Subclass: Chilopoda
e.g.: *Scolopendra morsitans*

- Hides by the day below stones or plant leaves and runs faster at night to prey insects and earthworms.
- The body is elongated, dorsoventrally flattened and divided into head and trunk.

 **Watch video**

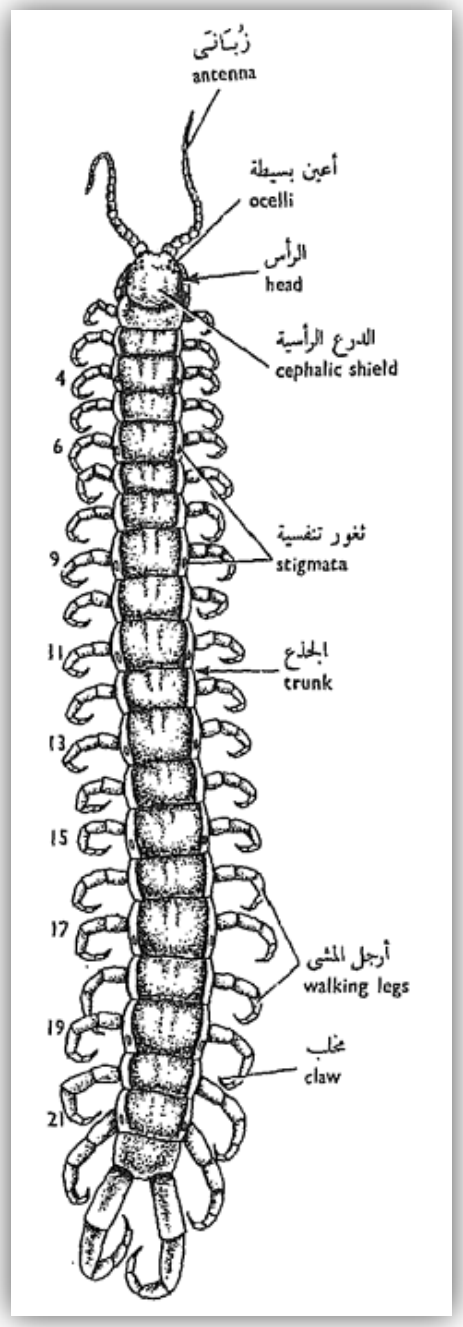


Figure 31: ***Scolopendra morsitans***

- The head consists of 6 segments covered by a cephalic shield. There are two lateral groups of simple eyes (ocelli), each group of 4 ocelli. The head bears two segmented antennae (the main sensory organs).

- The trunk with 22 segments, each segment covered by a dorsal tergum, ventral sternum and 2 lateral pleura. The first segment has no separate tergum (maybe fused with the cephalic shield), this segment bears ventrally the maxillipeds or two poison claws, each ends in a sharp claw on which opens the poison gland.

Figure 32: The poison claws

- Each segment from 2-22 carries one pair of walking legs (which together with the 2 antennae make the 44 appendages). Each leg is built up of 7 segments named from the base: coxa, trochanter, femur, tibia and 3 tarsi ending in a claw.

- Paired respiratory openings or stigmata lie on the pleural shields of the segments 4, 6, 9, 11, 13, 15, 17, 19 and 21. Note that these segments longer than the other segments. The anus opens ventrally on the last segments.

Class: Arachnida

1- Most are terristrial and some are aquatic.

2- The body is divided into two regions: the prosoma and the opisthosoma.

** the prosoma includes head and thorax and in adult consists of 6 segments: the first bears a pair of chelicera, the second bears a pair of pedipalps and the 4 other segments with 4 pairs of walking legs.

** the opisthosoma consists of 13 segments and divided to mesosoma and metasoma (or not divided) and without any appendages.

3- The exoskeleton is strongly chitinized.

4- The eyes are sessile and mostly simple.

5- Respiration by lung-books, tracheae or by gill-books in aquatic forms.

6- Excretion by coxal glands or Malpighian tubules.

7- Sexes are separate and development is usually direct.

 **Watch video**

Order: Scorpionidea

e.g.: *Buthus (Leiurus) quinquestriatus*

It is a dangerous animal, spread in tropical and temperate regions. It is nocturnal (active at night), feeds on juice of insects and spiders.

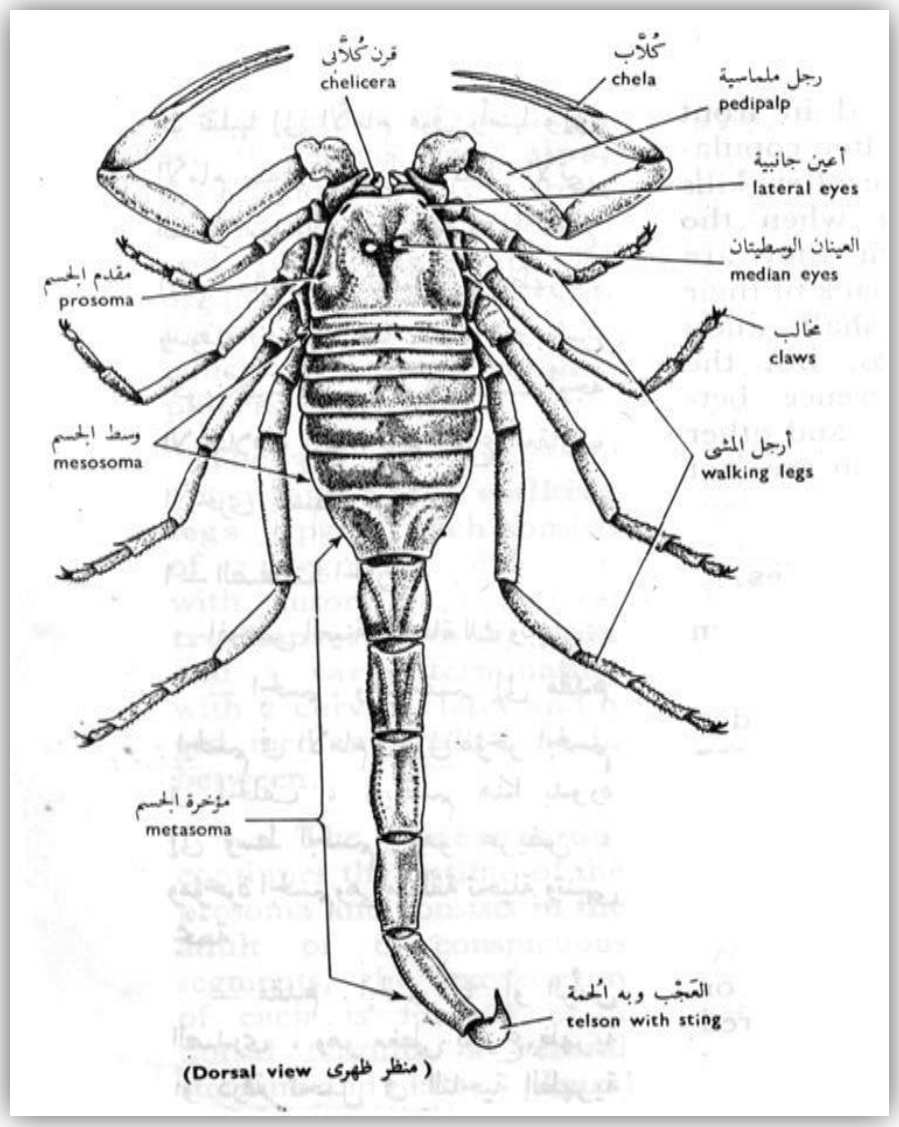


Figure 33: ***Buthus quinquestriatus***

—

— The body is divided into prosoma and opisthosoma which is subdivided to a broad mesosoma and a slender matasoma ends in a sting.

— The prosoma is covered by a dorsal shield (carapace) which carries dorsally a pair of median eyes and two groups each of 5 smaller lateral eyes (all are simple).

— The prosoma carries 6 pairs of appendages: the chelicerae (with a chela), the pedipalps (as feelers and with toothed pincers for offensive action) and 4 pairs of walking legs.

— The mesosoma in adult consists of 6 segments, the first segment carries on its ventral side a divided genital operculum covers the gental opening. The second segment carries a pair of comb-like structures (the pectens) act as tactile organs (longer in the male). The 4 other segments with 4 pairs of stigmata on their ventral side, lead internally into the lung-books.

— The metasoma consists of of 6 narrow cylindrical segments jointed to one another. The last segment terminates with the telson which forms the sting. Two poison glands are found within the sting and open near the spine.

The importance of Arthropods

Pollination

Many plants rely on insect pollinators. Pollination is the process of moving the plants' pollen from the male parts of the plant to the female parts; this process is how the plants reproduce. Plants of economic importance that are pollinated by insects include most vegetables and fruits, along with fiber and hay crops. Without pollinating insects, food would be all but gone, including meat, as livestock feeds on the plants pollinated by these small creatures. Pollinating insects include bees, wasps, butterflies, moths, flies and beetles.

Decomposition

Decomposition may not be the most glorious role of insects and other arthropods, but it's one of the most important. Without decomposers, waste would quickly accumulate into devastating, not to mention foul-smelling, masses. As primary and secondary decomposers, many arthropods help breakdown decomposing matter. Different arthropods are attracted to different types of decomposing matter. Those that feed on dead animals are called carrion feeders and include several species of beetles, flies, ants, mites and wasps. Those that feed on dead plants include many species that live in the soil or in woody plants. When decomposing plant matter is broken down, it forms a rich humus layer for the soil that helps feed the plants. Also in the decomposer group are the arthropods attracted to animal waste, such as dung beetles.

Primary and Secondary Consumers

In the food web, a primary consumer is one that eats plants while a secondary consumer is one that eats plant-eating animals. Both categories contain several arthropods. While some primary consumers become agricultural pests, others help keep weed populations in check. Other arthropods consume the pests that see your vegetable garden as an all-you-can-eat buffet. Secondary consumers include spiders, lady beetles, assassin bugs, ants, centipedes, hunting wasps, mantids and many more.

Other Roles

Insects and other arthropods are the primary food source for many other creatures, including some human populations. Many fish and bird species feed heavily -- or even solely -- on insect and arthropod diets. Crayfish and other crustaceans are a primary food for many humans, as well as other animals. While

tarantulas may be important predators of other invertebrates and some larger creatures, some humans rely heavily on their meat as an abundant source of protein. Other arthropods are heavily consumed by humans, as well, including cicadas, grubs and crickets. Besides pollinating food crops, honeybees also produce honey and beeswax, both of which are of economic importance.

Human Uses

Arthropods are also invaluable to humans, as they are used in many different human-made products. Examples are:

- Bees produce honey and their honeycombs contain beeswax, widely used for making candles, furniture wax and polishes, waxed papers, antiseptics, and fillings for surgical uses.
- The pollens stored in honeycombs were discovered to have a rich mixture of vitamins, enzymes, and amino acids that could provide medical benefits. They were used as ingredients for supplements and medications that could provide relief for colds, asthma, and hay fever.
- Silk produced by arthropods, like those produced by caterpillars to protect their cocoons, is strong enough to use and be woven into fabrics, a discovery first used in ancient China's silk industry.
- The spiders‟ web was discovered as an additional material that could provide strength, and has became essential raw materials for Kevlar vests, fishing nets, surgical sutures, and adhesives, as they contained natural antiseptics.

Arthropods as Food

Many species of crustaceans, especially crabs, lobsters, shrimp, prawns, and crayfish, are consumed by humans, and are now

farmed on a large commercial scale. Nearly 10,000,000 tons of arthropods as food were produced in 2005. Over 70% by weight of all crustaceans caught for consumption are shrimp and prawns. Over 80% is produced in Asia, with China producing nearly half the world‟s total.

Insects and their grubs are at least as nutritious as meat, and are eaten both raw and cooked in many cultures. Beetles, locusts, butterflies, ants, and stinkbugs (which have an apple flavor) are insects that are regularly eaten by people in dozens of countries. In fact, there are more than 1,900 edible insect species on Earth, hundreds of which are already part of the diet of about two billion people worldwide. This is just under one of every three people worldwide, and this number should continue to grow in the future.

The intentional cultivation of arthropods and other small animals for human food, referred to as minilivestock, is now emerging in animal husbandry as an ecologically sound concept. However, the greatest contribution of arthropods to human food supply is by pollination. Three-fourths of the world‟s flowering plants and about 35% of the world‟s food crops depend on animal pollinators to reproduce and increase crop yields. More than 3,500 species of native bees pollinate crops. Some scientists estimate that one out of every three bites of food we eat exists because of animal pollinators, including birds and bats and arthropods like bees, butterflies and moths, and beetles and other insects.

Phylum: Mollusca

General characters:

- Lives in water (freshwater or marine) and some forms are terrestrial. Molluscs come in the second rank after arthropods according to the number of species.
- They are triploblastic, mostly bilaterally symmetrical except **class: Gastropoda**.
- The body is soft, unsegmented without any appendages and divided into: head, a ventral foot and a dorsal visceral hump (no head in **class: Bivalvia).**
- The visceral hump is covered by a thin, fleshy fold called mantle. Mantle secretes a calcareous shell, which may be external or internal or not present at all.
- Mantle also encloses an opened mantle cavity, within lie a pair of gills, the anus and renal openings.
- Coelom is reduced represented by the pericardial cavity, cavities of gonads and kidneys (the excretory organs)
- Respiration by gills in aquatic forms and by lungs in terrestrial forms.
- The circulatory system is opened (except **class: Cephalopoda**) consists of a heart enclosed in a pericardial cavity and extends into a haemocoel.
- The nervous system contains 3 doubled ganglia: the cerebral, pedal and lateral ganglia and maybe visceral ganglion in some forms. Sense organs are eyes, tentacles and statocyst.
- Locomotion takes place by ventral muscular foot.

- The digestive system with salivary and digestive glands. The mouth with a hard chitinous structure, called <u>radula</u> or <u>Odontophore</u> (absent in **<u>class: Bivalvia</u>**).

- Sexes are usually separate and some are hermaphrodite. Development may be direct or indirect forming larvae.

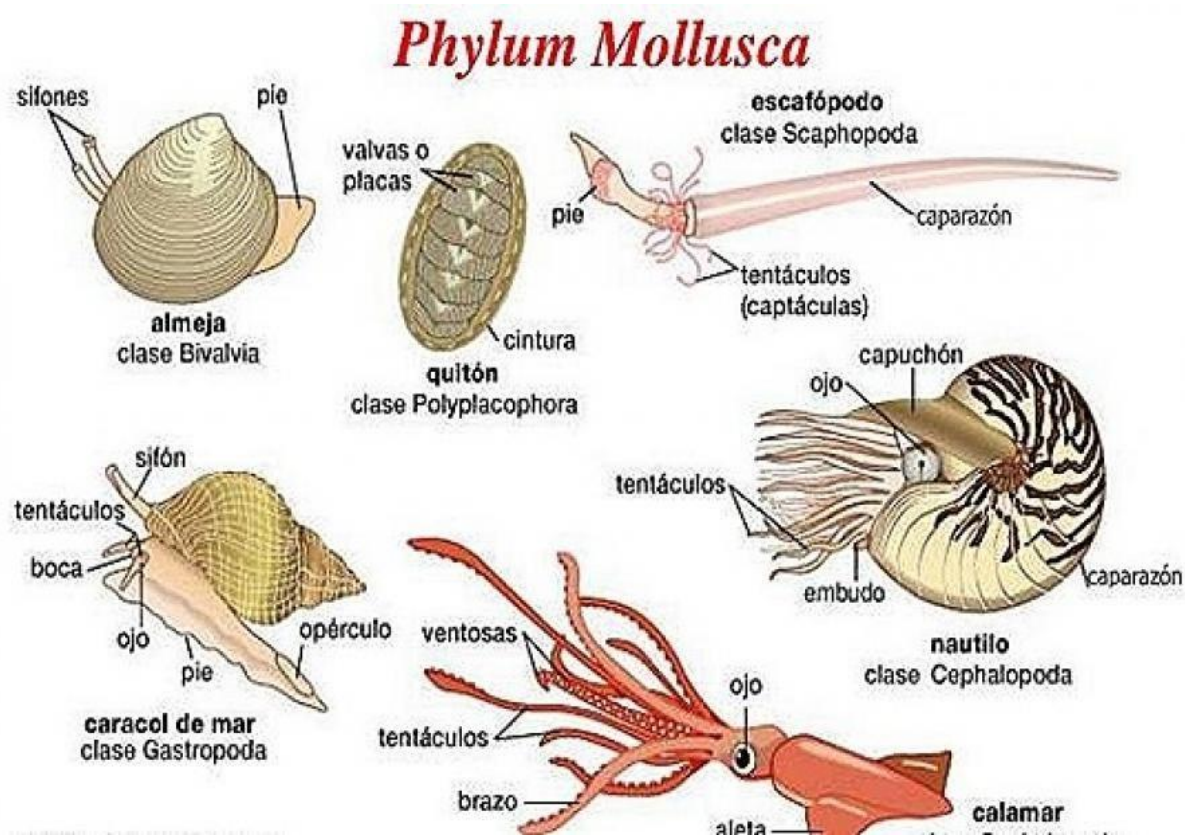


Figure 34: Groups of Mollusca

Class: Placophora

1- All are marine, present in all depths and contains all chitons.

2- Head is poorly developed without eyes or tentacles.

3- Mantle covers all dorsal surface and secrets calcareous spicules and usually also a shell.

4- Foot is flattened and large like a sucker.

5- Feeds on aquatic plants and algae.

6- Development includes a larvae called: trochophore

e.g.: *Acanthochiton spinigera*

- It is common on our sea coasts, adhering to rocks, but when separated strongly from the rock, it rolls itself up to more or less spherical form like a ball.
- The body is elongated and oval in shape. The mantle secrets in the dorsal side a calcareous shell formed of 8 overlapped plates, enabling the animal to roll into a ball. The mantle edge with calcareous spicules.
- In the ventral side, the head is small with only a mouth. The foot is large acts as a creeping organ and as a sucker.
- The mantle cavity is a groove between head-foot and the mantle edge, within found the gills on each side. The anus opens on a papilla projecting behind the foot. In front of anus on each side, an excretory pore and a genital opening.

 **Watch video**

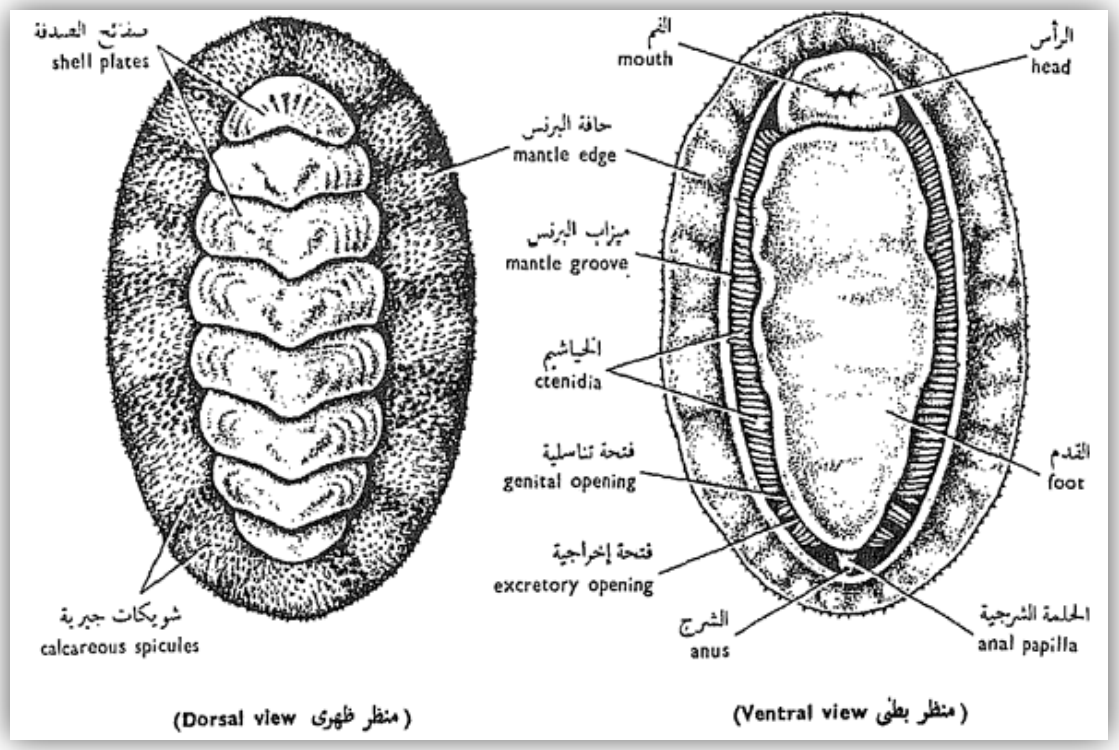


Figure 35: ***Acanthochiton spinigera***

Class: Gastropoda

- Gastropoda is the large class of molluscs, lives in marine water, freshwater and on land.
- The head and foot are fused in one structure (the head-foot), this part is bilaterally symmetrical, but the visceral hump is asymmetrical, due to two processes happened in the embryonic stages called: the torsion and the spiral coiling.
- The mantle form a coiled shell with different colours but sometimes disappear from some forms like slugs.
- Development is direct.

- It is herbivorous, and some species are predators or parasitic.
- Some species acts as intermediate hosts for some parasites like *Fasciola* and *Schistosoma*

Order: Pulmonata

e.g.: *Eremina desertorum*

- Common in the Egyptian desert, feeds on leaves and stems of desert plants. It is nocturnal hides in its shell during the day. It is active in winter.
- The shell with 4 whorls, and it is dextral.
- The headfoot mass bears anteriorly: the mouth, below it an opening of a gland (the pedal gland) produce a slimy secretion. There are 2 pairs of tentacles: the anterior pair is short, but the posterior one is long with two black eyes. A single genital opening found on the right side of head.
- The visceral hump is spirally coiled and occupies the shell whrols. The mantle form a thick ring called the mantle collar, bears on the right side: the pulmonary opening which leads internally to a cavity rich with blood vesels and acts as a lung. Note also the anus and the execretory opening on the mantle collar.

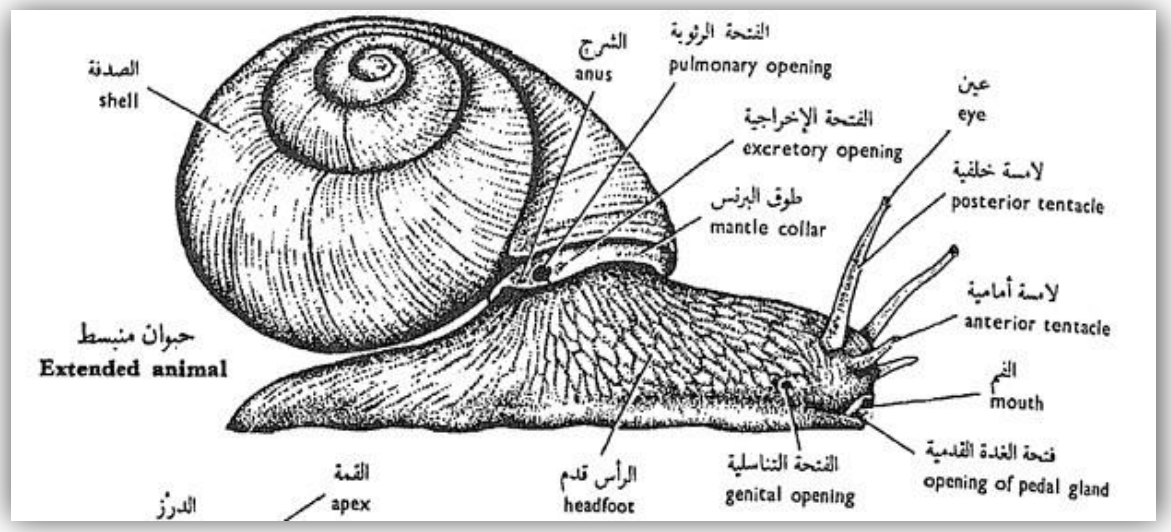


figure 36: ***Eremina desertoum***

Class: Pelecypoda

(Bivalvia) or Lamellibranchiata

- Most are marine and some are freshwater.
- The mantle consists of two lobes (right and left), so the shell is bivalved, the two valves hinged dorsally and jointed by a ligament.
- The head is reduced, only labial palps around the mouth. No radula because they are ciliary feeders.
- Moves very slowly by the foot, but mostly buried in the sand with its front.
- Sexes usually separated, but some are hermaphrodite. Development includes a larva called: veliger larva in marine forms.

e.g.: *Anodonta rubens* (freshwater mussel or clam)

- Lives on the bottom of the river.
- The shell with 2 lateral valves, hinged dorsally. The umbo is a swollen apex found near the anterior part. Note the parallel lines of growth on the outer surface.
- Internally, the mantle consists of 2 lobes, which united together posteriorly to form two tubes: the exhalent siphon (small and smooth-walled) and the inhalent siphon (wider and papillated edges for testing water).
- The visceral hump is the compressed mid-dorsal portion of the body.
- The foot is a large mass, which drags the animal very slowly in the bottom mud.
- The labial palps are 2 pairs around the mouth carry cilia which drive food particles towards the mouth.
- The gills are 2 in number, very large and each one is formed of two plate-like folds.
- The muscles showing on the mantle surface are: the anterior and posterior adductor muscles which controlling the shell valves. The anterior and posterior retractor muscles which withdraw the foot inside the shell. The protractor muscle which forcing the foot outside the shell. Note the insertions of these muscles on the smooth inner surface of each valve.

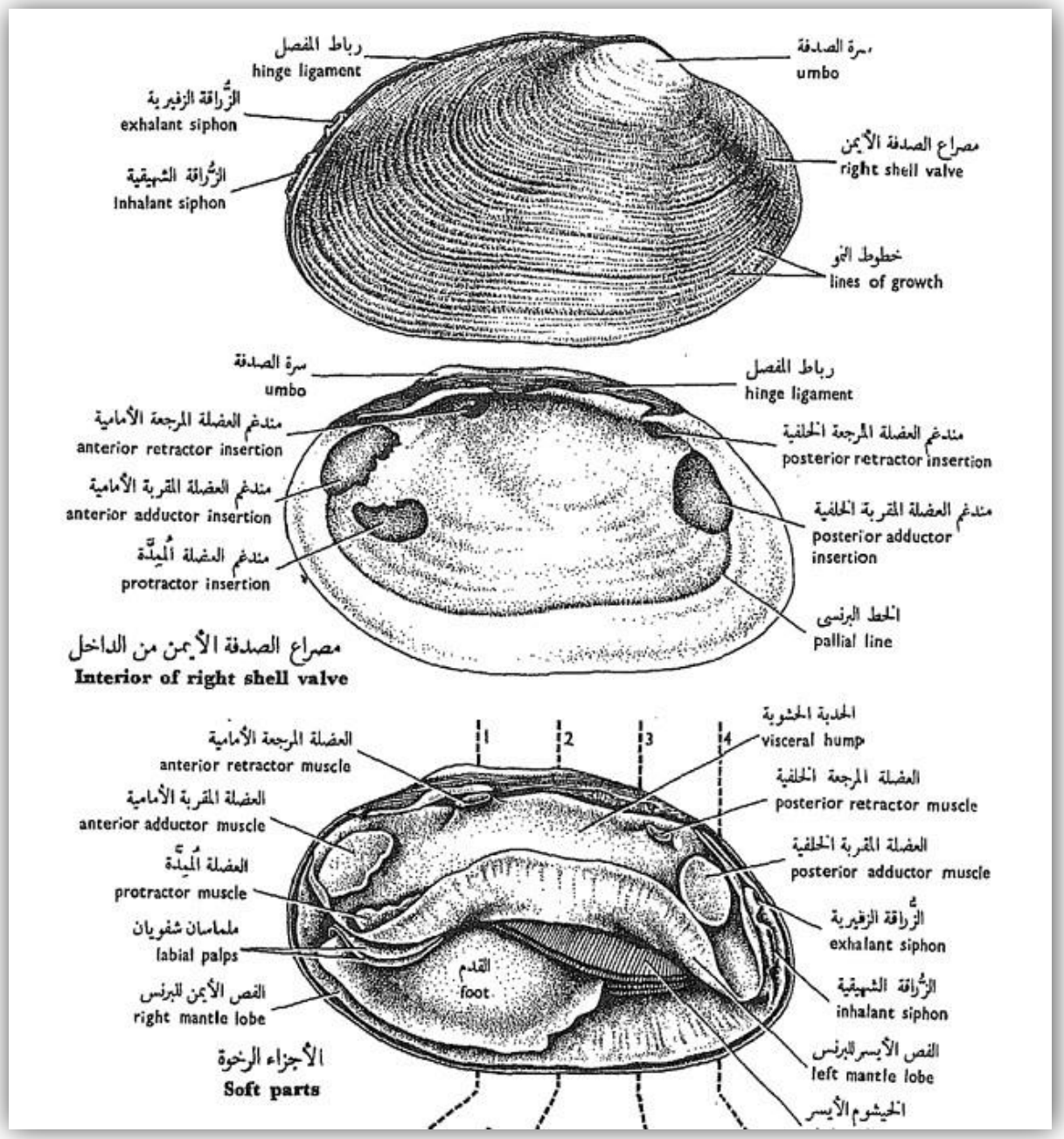


Figure 37: ***Anodonta rubens***

Watch video

Class: Cephalopoda

- All are marine, it is the highest molluscs in development.
- The shell present internally or absent.
- The head is well-developed, with large eyes (as vertebrate eyes). The head bears a number of tentacles and arms (8-10) with strong suckers to capture the prey. These arms maybe are the modified anterior part of foot, thus called: Cephalopoda (head-foot).
- They are predators, so the mouth contains the radula and two sharp horny claws.
- The mantle cavity present in the ventral side contains the gills, anus, execretory and genital openings, also a muscular funnel opens in the cavity (it is the posterior part of foot).
- The circulatory system is closed.
- The nervous system is the highest system in all invertebrates, the ganglia are concentrated and fused together to form a brain enclosed in a cartilaginous capsule which contains statocysts.
- The sexs are separated and the development is direct.
- Cephalopods have several modes of defense. Some species can release light (Bioluminescence). Some species contains Chromatophores in their cells allow them to change colour. Lastly, most species have a sac which contains a black ink-like substance that can envelop and temporarily cloud the enemies' vision.

Order: Dibranchiata
Suborder: Decapoda
e.g.: *Sepia savignyi*

- The body is divided into a head and a visceral hump.
- The head with 2 large eyes similar to those of vertebrates. Also bears the mouth which surrounded by 8 arms (each arm is provided with 4 rows of suckers) and two long tentacles. The tentacles are used in catching the prey and the arms for holding it during eating.
- A muscular funnel found in the ventral side of the head, it opens in the mantle cavity. The water from the mantle cavity is forced out through the funnel opening causing the animal jerk backwards and emits a cloud of ink to escape from enemies.
- The visceral hump with 2 lateral fins, by which the animal swim. An internal shell present in the dorsal side of the visceral hump beneath the integument. Ventrally, occures the mantle cavity with a wide anterior mantle opening.

 **Watch video**

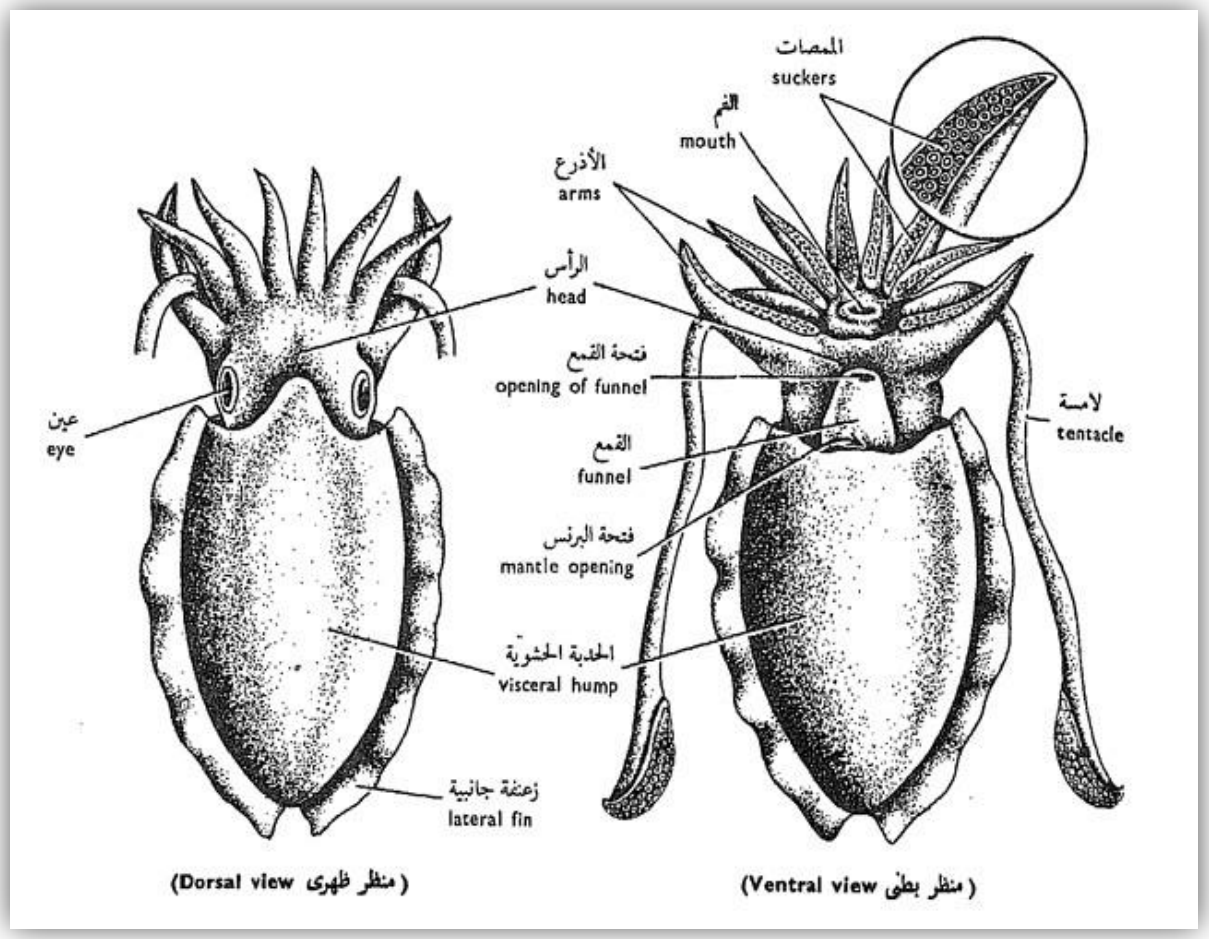


Figure 38: ***Sepia savignyi***

Importance of molluscs

There are some benefits of mollusks which are listed as under:
1. Many molluscs including mussels, oysters, clams and cephalopods are fished for food and support small scale sustenance fisheries in developing countries. Various species in this phylum are very important to the human beings. Clams and Mussels are an important food source in different parts of the world. Octopuses, squids, whelks, oysters and scallops are also eaten by the human beings. They form an important part of the fisheries and agricultural industry.
2. Oysters are nutritious as they contain vitamin A and B,

minerals and appreciable amount of glycogen and protein. 3. Pearl oyster produces pearl, considered a highly valuable jewel, within its shell. Most precious pearls are found in pearl oysters of the genus Pinctada. 4. Chank fishery, a great source of revenue in India is based on a turbinellid gastropod, Xanus pyrum, the shell of which is called the „chank". Chanks are used as trumphet in temples and in the manufacture of bangles. 5. Thick shells having lustrous pearly layer are valued high in the manufacture of buttons, brooches and the like objects. 6. The shells of Cymbium, Dolium, Murex, etc are made into useful articles like lamp stands, lamp shades, etc. 7. Tools, utensils and objects of delight have been formed from gastropodan shells.
8. Nautilus shell is much used for decoration, art and for many other useful purposes.
9. Many shells go into the making of toys, some are polished and sold as curios like the calcareous operculum of turban shells. 10. Dead shells drifted ashore at estuaries by currents, sub-fossil deposits in lakes and broken shells of surf beaten beaches, form the raw material for superior quality lime, which is used in every type of masonry constructions and in whitewashing the buildings. 11. Good quantities of shells are used in carbide and cement manufacture.
12. Many gastropods like squids and small octopus are used as bait for catching fish.
13. Gastropodan shells were used as source of money by various native races as Red Indian tribes of America used the common Dendallium as money.
14. Some gastropods like Nucella and Murex, are sources of Tyrian purple, a dye obtained from their juices. Ink sac of cuttle-fish provides a rich brown pigment called „sepia", used by artists.
15. Fossil cephalopods have a medicinal importance among the red Indians of Montana and Wyoming. They collect the

preserved fossil ammonoids and keep them as „medicine".
16. The credit of "jet propulsion", only recently discovered by man, goes to cephalopods, who have been using it for millions of years.
17. Some gastropods like land slugs and snails cause damage to gardens, orchards, green houses and mushroom beds by feeding upon the succulent parts of seedlings and mature plants.
18. The shipworm, Teredo, a bivalve mollusc bores in wooden boats and ships, causing millions of dollars of damage to wooden structures.
19. Some gastropods cause damage to other molluscs like the marine snail Urossalprinx, causes serious loses to oyster industry by drilling the oyster shells.
20. Some predacious and carnivorous molluscs cause distruction to fishery industry.
21. Snails have importance from a medical point of view as they serve as intermediate host for flatworms, like Fasciola and Schistosoma.

Medicinal Importance

1. The deadly venoms of some Cone Shells (Conidae) are today being used to help victims of strokes and heart disease, and to produce a revolutionary new drug for chronic pain control.
2. An extract from the hard clam or "Quahog" (Mercenaria mercenaria L.) is a strong growth inhibitor of cancers in mice. It is called mercenine, after the clam's scientific name. 3. Paolin, a drug made from abalone juice, is an effective inhibitor of penicillin- resistant strains of bacteria.
4. Ground and processed oyster shells Olympia Oyster (Ostrea conchaphila) are used as a calcium supplements both for humans and animals.

5. Oyster juice has been found to have anti-viral properties, and may be made into a drug eventually.
6. The threads that some mussels (Mytilidae) use to attach themselves to rocks, piers, and other hard surfaces are being tested as possible glue in surgery. These are called "byssal" threads, from the Latin word byssus, which means "fine linen", which is silky, like the fine threads of many mollusks (Mytilus edulis) 7. The cement of the Carrier Shells (Xenophoridae) is being studied for use as a possible cement for bone fractures. The Carrier shells are the camouflage experts of the mollusc world: they attach all kinds of objects - shells, rocks, pieces of coral, sponges, bottle caps. to their shells, so they look like a little pile of trash on the bottom of the sea - a great way to avoid being eaten. 8. In Vietnam, traditional medicine has a wide variety of uses for shells: powdered oyster shell is taken to treat acid indigestion, fatigue and to stop hemorrhage. It is also sprinkled over open wounds and boils. Cuttlefish bones are used as a remedy for rickets (which is caused by lack of vitamin C), a healing agent in the treatment of gastro-intestinal troubles, a local anti-hemorrhagic (i.e., it stops internal bleeding), and as an antiseptic is cases of inflammation of the middle ear. The flat shell of the Abalone, with its iridescent inside, is powdered and taken orally to improve vision, to remove keratoses (cataracts), and to improve such conditions as hemeralopia (where you can see at night well, but hardly at all in the daytime!. Powdered pearls from oysters are used as a topical eye medicine and it has been scientifically proven to have some anti-inflammatory effects on a painful condition called conjunctivitis, where the surface of the eye becomes red and sore.
9. Slugs and snails are terrestrial molluscs which have similar morphology except that slugs, unlike snails, have no obvious shell, although some species possess a partial or internal vestigial shell. Widely distributed around the world, the largest

species of slug in the UK, the Ashy-Grey slug (Limax cinereoniger), can exceed 25 cm in length. For centuries snails, and to a lesser extent slugs, have been used both as a food and as a treatment for a variety of medical conditions. In some part of Italy, the common garden slug, Arion hortensis, is sometimesswallowed whole as a treatment for gastritis or stomach ulcers. In America slugs are not thought to be swallowed live in this way, but a recipe for „Slug Syrup" made up of with sugar be used for the treatment of ulcers, bronchitis and asthma. Snail and slug slime have been used sporadically as skin treatments since the time of the Ancient Greeks. It has recommended that the use of crushed snails to relieve inflamed skin and some 20 years ago, the potential of snail slime was noted by Chilean snail (Elicina) farmers who found that skin lesions healed quickly, with no scars,
when they handled snails for the French food market. Snail Cream with 70% snail extract „soothes regenerates and heals skin". Snail slime based products are claimed to be the new miracle face-fixer in the U.S where they are used to treat acne, reduce pigmentation and scarring, and combat wrinkles. It has also been reported slugs are used in Italy to treat dermatological conditions. Mucus collected from a slug is rubbed onto the skin to treat dermatitis, inflammations, calluses, and acne, and to promote wound healing. In addition, in a special ritual slugs themselves are used for the treatment of warts. Mucus from a live slug is first rubbed onto the wart, and then the slug is hung out in the sunshine to dry out and die. It is believed that once the slug has dried up, the wart should as well. The use of slugs for the treatment of warts is not, however, confined to Italy. Records exist
of the use of slug slime in the US and UK some of which

recommended that the slime be collected at certain phases of the moon to ensure maximum effect.

Phylum: Echinodermata

General characters:

- All are marine, found in the shores to the great depths. Includes forms quite different from the preceding invertebrates.
- Some are free living and some are sessile.
- Adults are radially symmetrical while larvae are bilaterally symmetrical.
- **The body** is not divided, with different shapes (star, rounded or cylindrical).
- They possess a dermal skeleton consists of calcareous ossicles which may develop into short or long spines pushes out on the surface, thus the name: Echinodermata.
- **The coelom** divided into several divisions (perivisceral coelom, perihaemal cavity and a water vascular system characterize this phylum).
- **The water vascular system** is connected to tube feet present on the outer body surface, these feet are the main locomotion organs but can also assist in sensation, respiration and food collecting.
- **Respiration** by dermal gills, tube feet or repiratory tree in class: Holothuroidea .
- **The nervous system** with circumoral nerve ring and radial nerves in all body.

- **The digestive system** is usually complete but in some forms there is no anus.
- **The circulatory system** is very reduced.
- No special execretory organs.
- **The sexes** is usually separated and the development maybe direct or including larva formation.
- Show high power of regeneration.

Class : Asteroidea

e.g.: ***Astropecten relitaris***

- Common in our seas, creeps slowly on the bottom but in rest it lies buried in the sand except the central part.
- **The body** is star-shaped, consisting of a central disc prolonged into 5 arms. The with two surfaces: a lower oral surface and an upper aboral surface.
- **On the aboral surface**, note the pointed spines on the edges of each arm and a blunt spines found in bundles called: the paxillae. Very minute dermal gills arise between the paxillae. Note also a plate with pores in the central disc, opposite to the angle between any two arms. This plate (the madreporite) lead into the water vascular system.

 **Watch video**

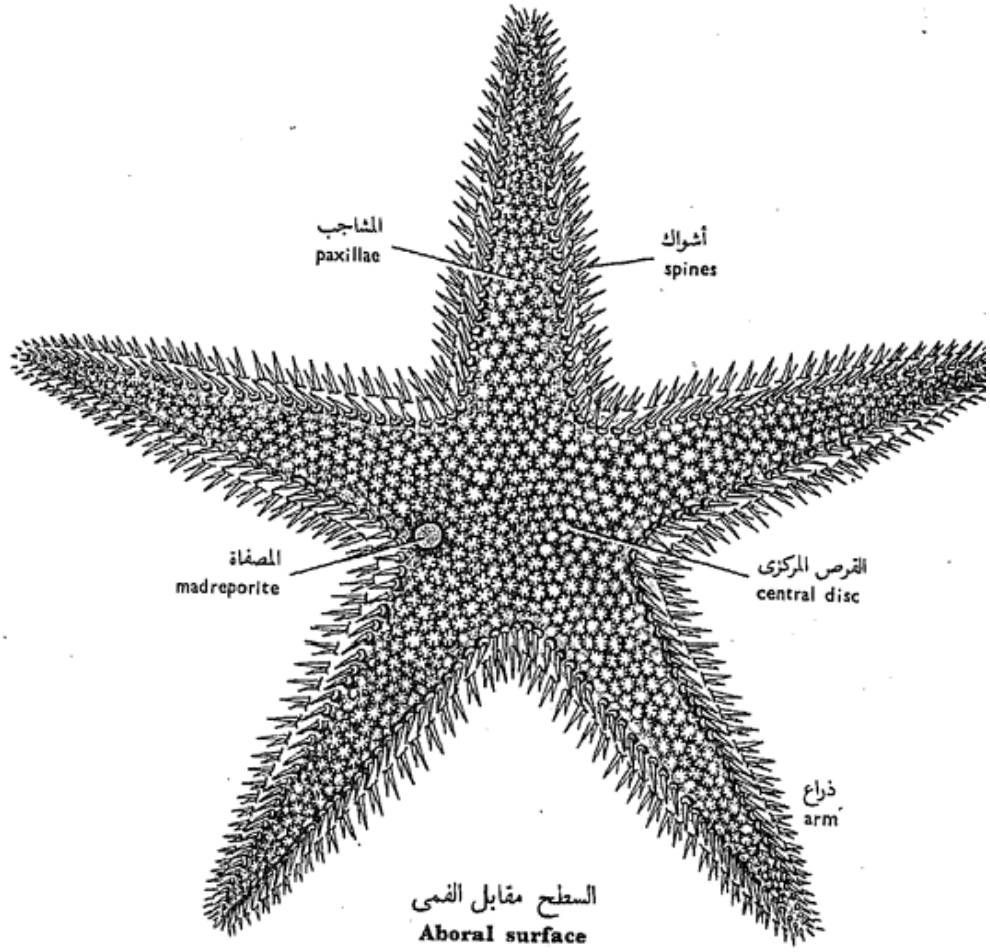


figure 39: ***Astropecten relitaris***

- **On the oral surface**, note the mouth in the centre, surrounded by a soft area (the peristome). Five ambulacral grooves extended out from the mouth along the entire length of each arm. Note, conical structures (the tube feet) project in 2 rows along each ambulacral groove. The terminal tube foot (called: the tentacle) has a pigmented spot (the eye) on its base. Note the different types of spines and the very small modified spines which known as pedicellariae, these small spines clean the body surface and the ambulacral grooves.

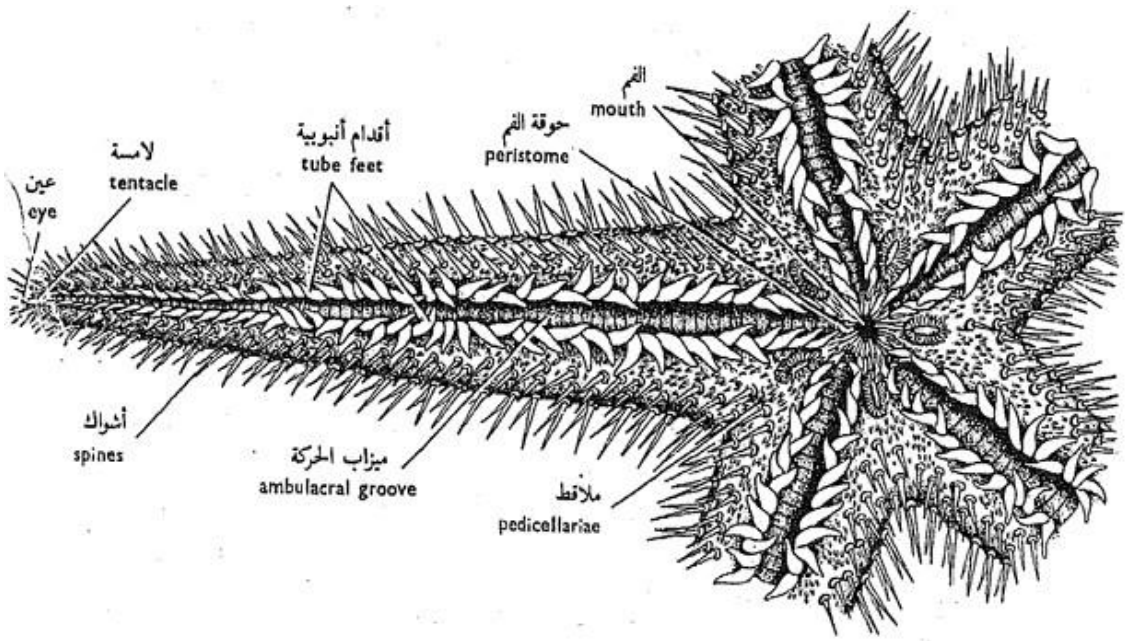


figure 40: Oral surface of *Astropecten*

Importance of Chinoderms

Echinoderms are important for the ecosystem. They are also a source of food and medicine for humans.

Ecological Role

Echinoderms play numerous ecological roles. Sand dollars and sea cucumbers burrow into the sand, providing more oxygen at greater depths of the sea floor. This allows more organisms to live there. In addition, starfish prevent the growth of algae on coral reefs. This allows the coral to filter-feed more easily. And many sea cucumbers provide a habitat for parasites such as crabs, worms, and snails.

Echinoderms are also an important step in the ocean food chain. Echinoderms are the staple diet of many animals, including the sea otter. On the other hand, echinoderms eat seaweed and

keep its growth in check. Recall that the sea urchin is a grazer, mainly feeding on algae on the coral and rocks. Recently, some marine ecosystems have been overrun by seaweed. Excess seaweed can destroy entire reefs. Scientists believe that the extinction of large quantities of echinoderms has caused this destruction

Echinoderms as Food

In some countries, echinoderms are considered delicacies. Around 50,000 tons of sea urchins are captured each year for food. They are consumed mostly in Japan, Peru, Spain and France. Both male and female gonads of sea urchins are also consumed. The taste is described as soft and melting, like a mixture of seafood and fruit. Sea cucumbers are considered a delicacy in some southeastern Asian countries. In China they are used as a basis for gelatinous soups and stews.

Echinoderms as Medicine

Echinoderms are also used as medicine and in scientific research. For example, some sea cucumber toxins slow down the growth rate of tumor cells, so there is an interest in using these in cancer research.

Sea urchins are also model organisms used in developmental biology research. Sea urchins have been used to study the mechanisms of fertilization and egg activation, physiological processes that occur during early development, and the regulation of differentiation in the early embryo. In addition, the molecular basis of early development was studied in sea urchins. Gametes can be obtained easily, sterility is not required, and the eggs and early embryos of many commonly used species are beautifully transparent. In addition, the early

development of sea urchin embryos is a highly conserved process. When a batch of eggs is fertilized, all of the resulting embryos typically develop at the same time. This makes biochemical and molecular studies of early embryos possible in the sea urchin, and has led to a number of major discoveries.

Echinoderms in Farming

The hard skeleton of echinoderms is used as a source of lime by farmers in some areas where limestone is unavailable. **Lime** is added to the soil to allow plants to take up more nutrients. About 4,000 tons of the animals are used each year for this purpose.

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