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المرحلة الرابعة ـ الدراستين الصباحية والمسائية
الفصل الدراسي الاول

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LEC 1

Invertebrates

Introduction:

The invertebrates include those animals which are without backbone as opposed to vertebrates in which a series of vertebrates constitute backbone. The invertebrate constitutes about 97% of the known animals which number over a million. There is not even positive character which is common to all invertebrates, and the differences between the groups are very large, each group of invertebrates has certain structural peculiarities, a special terminology, and distinct classification.

Vertebrates	Invertebrates
1. They have an internal skeleton.	1. They have no internal skeleton.
2. A backbone is present.	2. Backbone is not present.
3. Nerve cord is dorsal and hollow.	3. Nerve cord is ventral and solid.
4. Heart is on the ventral side of the body.	4. Heart when present is on the dorsal side of the body.
5. Hemoglobin is present is Red blood cells.	5. Hemoglobin if present is dissolved in plasma.

Animal Classification:

There are more than one million species of animals. A way of sorting through all those species is to organize them by similar properties, or characteristics. There are three different system of classification:

1-Artificial Classification: The ordering of organisms into groups based on non-evolutionary features. It is a system of classification based on one or two easily recognizable characters.

2-Natural Classification: The natural classification may be defined as "Classification based on characters which indicate natural relationships". The natural system of classification is based on similarity.

3. Phylogenetic Classification: The phylogenetic system is based on the evolutionary and genetic relationship of the organisms. It enables us to find out the ancestors or derivatives of any taxon.

Taxon and Category:

The taxa are the groups of animals generally groups of species. Any such group of such population is called taxon.

Taxonomic Categories:

Kingdom

a taxonomic category of the highest rank, grouping together all forms of life having certain fundamental characteristics in common.eg Animalia,plantae,etc

Phylum

Phylum is second highest unit of classification after Kingdom. It includes one or more related classes of animals. In plants, instead of phylum, the term 'division' is used.

Class

Class is a taxonomic group consisting of one or more related orders.

Order

Order is a taxonomic group containing one or more families.

Family

Family is a taxonomic group containing one or more related genus.

Genus

Genus is a taxonomic group including closely related species.

Species

A group of closely related organisms that are very similar to each other and are usually capable of interbreeding and producing fertile offspring. The species is the fundamental category of taxonomic classification, ranking below a genus or subgenus.

The Importance of Invertebrates:

Some Invertebrates Benefits:

1- **Pollinators,** Example honey bees
2- **Recyclers** :recycling and processing of waste in the environment. Example (Dung Beetles).
3- **Play a large role in Food webs** it is shown that while different species of invertebrates can play the role of herbivores and carnivores in a food web, there are also many species of decomposer invertebrates that help to break down animal wastes and bodies of dead plants and animals.

4- **Biological Control Agents:** Uses invertebrate predators and parasitoids, so called natural enemies, for the sustainable reduction of pest populations, including other invertebrates and invasive plant species.

5- **Soil Ecosystem Engineer and Regulators**

6- **Provider of Goods:** Sponges for bathing, Corals, Oysters and others for jewelry, Cloth production (silk).

7- **Use as Food**

8- **Medicinal benefits.** Hirudin is a naturally occurring peptide in the salivary glands of blood-sucking leeches that has a blood anticoagulant property.

9- **Invertebrates as model organisms for research**. Example : *Drosophila melanogaster* (fruit fly).This fruit fly has approximately 15,500 genes on its four chromosomes, whereas humans have about 22,000 genes among their 23 chromosomes. Low and manageable number of chromosomes make *Drosophila* species easier to study. Another example is *Caenorhabditis elegan*s which is used in biological research. Because it has , short lifespan, and small genome.

10- **Invertebrates as Bioindicators:** Some invertebrate communities are often used as indicators of ecosystem health because many species are sensitive to pollution.

Some Harms of Invertebrates

1- Many invertebrates affected the agriculture production in field and stores.

2- Some invertebrates transmit and cause variable diseases to man and animals.

Some examples:

Disease	Vector	Causative agent
Leishmaniasis	Sand fly	*Leishmania tropica, Leishmania donovani Leishmania major*
Chagas disease (American trypanosomiasis)	Various assassin bugs of subfamily Triatominae	*Trypanosoma cruzi*
Malaria	Mosquito	*Plasmodium*

3- Some group of marine invertebrates cause **biofouling** (the accumulation of invertebrates such as cnidarians, protozon and sponges on ships cause reduction of their efficiency.

LEC 2

Phylum: Protozoa

Introduction:

The organisms referred to as protozoa are united only on the basis of a single characteristic: they **are not multicellular**. Protozoan phyla do demonstrate a basic body plan or grade—a **single eukaryotic cell**—and they amply demonstrate the enormous adaptive potential of that grade.

Characteristics of Protozoan Phyla

1. Unicellular; some colonial, and some with multicellular stages in their life cycles. Mostly microscopic.

3. All symmetries represented in the group.

4. No germ layer present.No organs or tissues, but specialized organelles are found; nucleus single or multiple.

6. Free-living, mutualism, commensalism, parasitism all represented in the groups.

7. Locomotion by pseudopodia, flagella, cilia, and direct cell movements; some sessile.

8. Some provided with a simple endoskeleton or exoskeleton, but most are naked.

9. Nutrition of all types: autotrophic, heterotrophic and saprozoic.

10. Aquatic or terrestrial habitat; free-living or symbiotic mode of life.

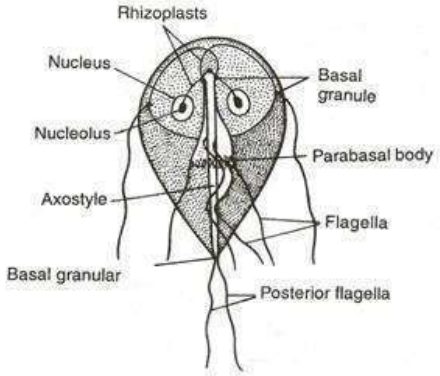
11. Reproduction asexually by fission, budding, and cysts and sexually by conjugation or by syngamy.

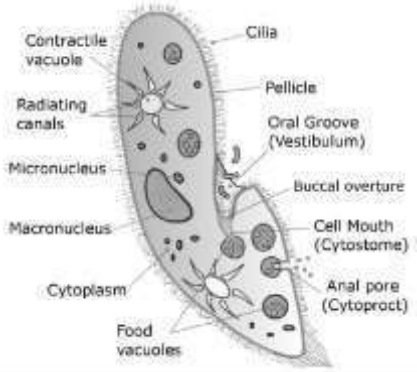
Form and Function

Structures and physiology of protozoan cells are largely the same as those of cells of multicellular organisms.

Nucleus

The form, structure and size of Protozoan nucleus are extremely variable . Most Protozoa contain a single nucleus and in many there are two or more. *Giardia* and *Protoopalina* contain two similar and identical nuclei while *Paramecium* has dissimilar nuclei, i.e., **micronucleus** and **macronucleus**. The macronucleus is considered as '**somatic or vegetative**' nucleus performing general metabolic activities while the small one is considered as '**generative**' which looks after the reproductive part. The macronucleus offers variation in its form and structure. It is compact, spherical or ellipsoidal in most cases. In *Vorticella* it is much elongated. In *Spirostomum* and *Stentor,* it is like a chain of nodes joined to one another by filaments.





Giardia Trophozoit *Paramecium*

Protozoan nucleus may be **vesicular** or **compact**. **Vesicular** nucleus consists of a nuclear membrane which is very thin and delicate but nucleoplasm is distinct and chromatin content is less. The **compact** nuclei are always massive as they contain large amount of chromatin substance and a comparatively small amount of nucleoplasm.

Cytoplasm

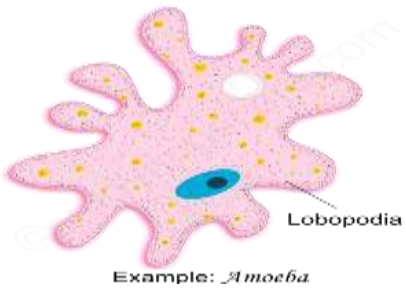
Cellular organelles like those in cells of multicellular animals can be distinguished in the cytoplasm of many protozoa. These organelles include mitochondria, endoplasmic reticulum, Golgi apparatus, and various vesicles. Chloroplasts, the membrane-bound organelles in which photosynthesis takes place, are found in most phytoflagellates . Sometimes peripheral and central areas of cytoplasm can be distinguished as **ectoplasm** and **endoplasm.**

Endoplasm appears more granular and contains the nucleus and cytoplasmic organelles. **Ectoplasm** appears more transparent by light microscopy, and it bears the bases of the cilia or flagella. Ectoplasm is often more rigid and is in the gel state of a colloid, whereas the more fluid endoplasm is in the sol state.

Locomotion in Protozoa

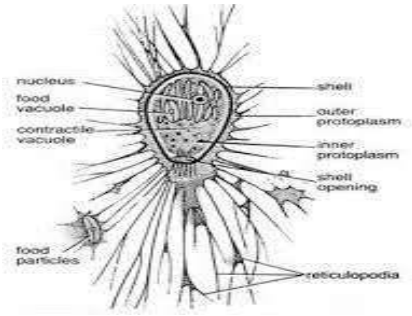
1- **Pseudopodia**: Pseudopodia are blunt, fingerlike temporary protrusions of the cytoplasm. Used for locomotion, food capture, and endocytosis. In the protozoa, pseudopodia exist in several forms.

- **Lobopodia** which are rather large, blunt extensions of the cell body containing both endoplasm and ectoplasm. They are found in *Amoeba.*



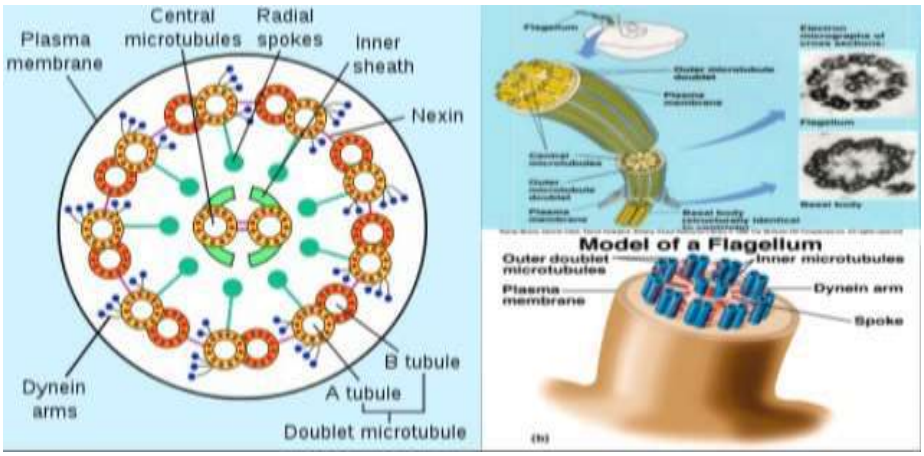
- **Filopodia** are thin extensions, usually branching, and containing only ectoplasm. They are found in members of the sarcodine

- **Reticulopodia** are distinguished from filipodia in that reticulopodia repeatedly rejoin to form a netlike mesh. They are found in *Allogromia*.



2- **Cilia**: Cilia are small hair-like structures, present usually in large numbers on the body surface. In some cases (*Vorticella*), the cilia are restricted only in a concentric circle at the distal end of the body.

3- **Flagella:** Flagella are whip-like structures in the formation of which cytoplasm takes part. These are usually 2-4 in number. A flagellum has an inner stiff structure, known as **axoneme**, which is surrounded by a protoplasmic sheath. Both cilia and flagella are organized from centriole that constitutes basal bodies. **These basal bodies** control the movement. The movement of cilia and flagella is due to the presence of microtubules within it, these are called **axonemes**.



These microtubules are present in doublet. In this doublet structure, one microtubule is incomplete and the other is complete and hence this way there are total of nine doublets that surrounds the middle doublet thus creating 9+2 arrangement. The doublet structure that is present in between has both the complete microtubules. Protein present in between the doublet joins them all and this protein is called

dynein. This dynein protein has ATPase activity and hence helps the tubulin slide one over the other, assisting them to bend properly.

Nutrition

Protozoa can be categorized broadly into:

Autotrophs (which synthesize their own organic constituents from inorganic substrates).

Heterotrophs (which must obtain organic molecules synthesized by other organisms.

Another kind of classification, usually applied to heterotrophs:

Phagotrophs, or Holozoic feeders, involves those that ingest visible particles of food.

Osmotrophs, or Saprozoic feeders, involves those that ingest food in a soluble form.

Osmoregulation and Excretion:

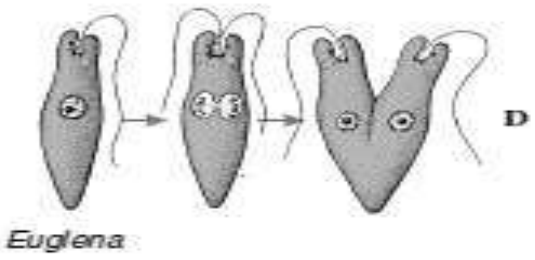
Waste products are water, carbon dioxide and nitrogenous compounds and remain in soluble forms. Waste materials are passed out of the body by diffusion or by the contractile vacuoles. Surrounding water is hypertonic to freshwater amoeba.

So, water constantly enters inside the body of amoeba through the cell surface. This excess water interferes with the body functions and is eliminated by the discharge of contractile vacuole. Marine or parasitic protozoa live in isotonic media and do not have contractile vacuoles. Some amount of carbon dioxide is diffused out through the cell surface. Rest of the carbon dioxide and ammonia which remain in soluble state are thrown out of the body by the contractile vacuoles.

Reproduction:

1- **Asexual reproduction** Can be divided in to four types:

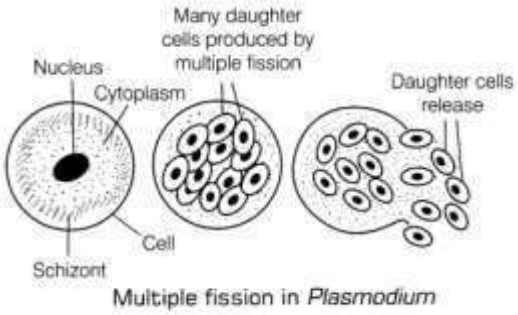
- **Binary fission:** in which the animal splits into two approximately equal offspring. This kind of reproduction is found in *Euglena*.



Euglena

- **Budding**: Reproduction in which the offspring arises as an outgrowth from the parent and is initially smaller than the parent. Budding is rare in protozoa except **Order: Suctoria**.

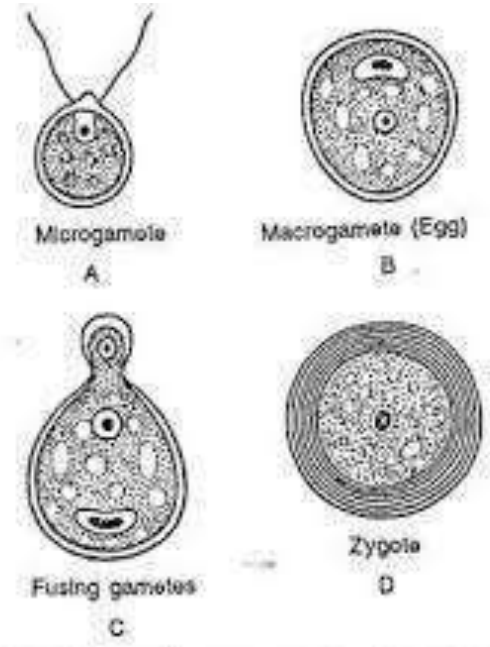
- **Multiple fission**: A mode of asexual reproduction in which the nuclei divide more than once before cytokinesis occurs. Multiple fission, or **schizogony**, is common among the Sporozoea and some Sarcodina. If the multiple fission is preceded by or associated with union of gametes, it is referred to as **sporogony**.



Multiple fission in *Plasmodium*

2- Sexual reproduction:

- **Syngamy**: Fertilization of one gamete with another individual gamete to form a zygote. When gametes all look alike, they are called **isogametes**, but most species have two dissimilar types, or **anisogametes**. **Conjugation**: Temporary union of two ciliate protozoa while they are exchanging chromatin material and undergoing nuclear phenomena resulting in binary fission.This type of reproduction is found in *Paramecium.*



Encystment and Excystment

- Survival under harsh conditions surely is related to the ability to form cysts in some protozoa: dormant forms marked by the possession of resistant external coverings and a more or less complete shutdown of metabolic machinery. Cyst formation is also important to many parasitic forms that must survive a harsh environment between hosts. However, some parasites do not form cysts, apparently depending on direct transfer from one host to another. Reproductive phases such as fission, budding, and syngamy may occur in cysts of some species. Benefits of encystment are

Protect against environmental changes and Serve as means of host to host transfer for parasitic species.

Classification of Protozoa:

1- Class Flagellata:

-Body covered by thin pellicle. -One to many flagella. -Autotrophic or heterotrophic.

- Asexual reproduction. -Free living or parasitic.

a- Ordrer Chrysomonadina
- **Small with thin pellicle.**
- **Chromatophore 1 or 2, yellowish or brown.**

b- Order Cryptomonadina
- **Small with rigid pellicle.**
- **Chromatophore 1 or 2 or non, yellowish or brown.**

c-Order Phytomonadina
- **Small with rigid cellulose covering.**
- **Flagella 2 or 4 sometimes more,**

d- Order Euglenodina:
- **Large with rigid cuticle.**
- **Chromatophore green numerous or non.**
- **Flagella 2.**

e- Order Dinoflagellata:
- **Small, naked or with cellulose test.**
- **Chromatophores numerous or non.**
- **Flagella two, in groove.**

f- Order Protomonadina
- **Small, free livening or parasitic.**
- **Flagella 1 or 2.**

g- Order Diplomonadina
- **Small, bilaterally symmetry.**
- **Flagella 4 pairs**

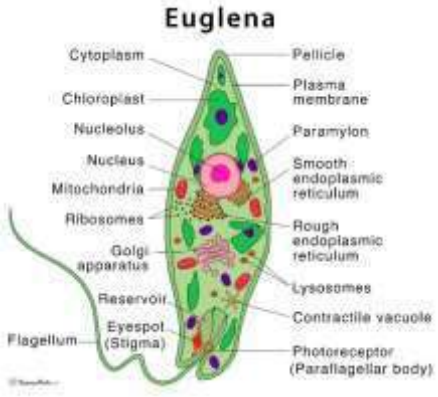
h- Polymastigana
- **Delicate pellicle, parasitic in genital tract.**
- **Flagella 4 to 6, parabasal body 1 and axostyle .**

i- Order Opalinina
- **Covered by cilia-like flagella.**
- **Endopaasites in cold blooded veretebrates.**

Example of Class Flagelata, Order Euglenodina

Euglena:

Is found in freshwater ponds and slow running stream. The animal is large spindle-shaped flagellates with spirally marked pellicle. Body is simple, fusiform elongated or flattened or spindle shaped, measuring 50-100 microns in length. It is usually green or red in colour. From the anterior end arise a whip-like flagellum. The outer covering or plasma membrane is called pellicle which has spiral striations called as myonemes. The cytoplasm below pellicle is differentiated into ectoplasm and endoplasm. The endoplasm contains a single large nucleus, star –shaped central pyrenoid (chloroplast) surrounded by small granules, known as paramylon bodies (are masses of a starch-like food storage material), contractile vacuole and photosensitive stigma (A red eyespot, or stigma, apparently functions in orientation to light). Anterior end contains funnel-like cytopharynx. Nutrition of Euglena is normally autotrophic (holophytic), but if kept in the dark the organism makes use of saprozoic nutrition, absorbing nutrients through its body surface



Example of Class Flagellata, Order Opalinina

Opalina is oval shape with its anterior end slightly narrower than the posterior. The pellicle is uniformly covered by equal sized cilia like flagella. The ectoplasm contains contractile fibrils called myonemes which are responsible for the flexion and extension of the animal. Endoplasm contains many nuclei. Peristome, cytosome, gullet and contractile vacuole are absent. Food materials are absorbed from the body of the host through the surface of the body. Reproduction both sexual and asexual. *Opalina* is found as parasite in the rectum of frogs

Previously *Opalina* was placed in ciliata, then it was placed in flagellata because of the following:

Opalina	**other ciliates**
nuclei are similar or monomorphic	nuclei are dimorphic (macro and micro nucleus).
binary fission the cleavage is longitudinal	binary fission is generally transverse
no conjugation	Conjugation is common

2- Class Sarcodina:

-Body naked or with shell. -With pseudopodia for locomotion and food capture.

-No spore formation no conjugation.

a- Order Amoebina

- **Body amoeboid, naked, no test or shell**
- **Short pseudopodia.**
- **Fresh water, marine or parasitic.**

b-Order Testacea

- **Body enclosed in one chambered shell.**
- **Psudopodia extruded through the shell opening.**
- **Mostly freshwater.**

c-Order Foraminifera

- **Large size with uni or multi-chambered shell.**
- **Pseudopodia are reticulopodia.**
- **Reproduce asexually and sexually.**
- **Mostly marine.**

d- Order Heliozoa

- **Body spherical, naked with siliceous skeleton.**
- **Cytoplasm divided into outer vaculated and inner dense zones.**

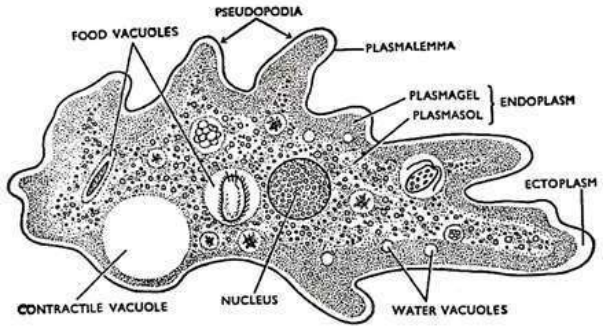
e-Order Radiolaria

- **Body spherical with skeleton of mostly siliceous skeleton.**
- **Central capsule of chitin separating the outer and inner zones of cytoplasm.**

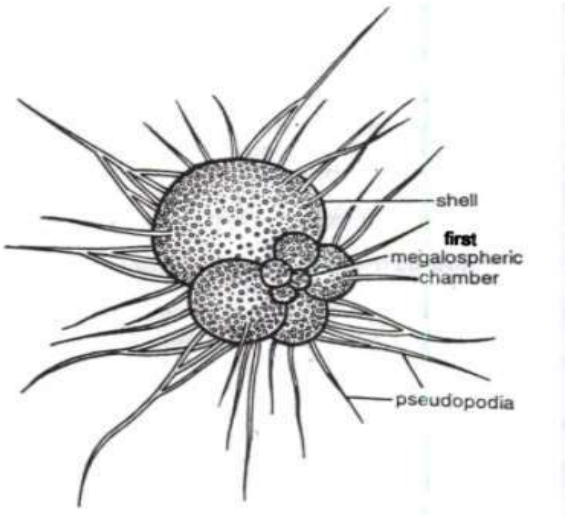
Example of Class: Sarcodina

Amoeba

The animal is of irregular shape with simple or branched pseudopodia and is measuring 250-600 microns in diameter. The body of animal is covered by a thin, delicate and permeable plasma membrane called plasmalemma. Inside the plasmalemma, the cytoplasm is distinguished into outer ectoplasm and inner endoplasm. Various distinct organelles are nucleus (for reproduction and metabolism), contractile vacuole (for osmoregulation) and food vacuole (for nutrition). Nutrition in *Amoeba* is holozoic. Reproduction is by fission and encystment. *Amoeba* move by formation of pseudopodia.



Example of Class Sarcodina, Order Foraminifera*Globigerina* : Is marine animal floating on surface. The animal secretes a calcareous shell of few round chambers. When the living shell chamber becomes small for animal, it secretes a new larger chamber. This many chambered shell is known as multilocular shell. The shell has apertures through which fine. *Globigerina* has a branching pseudopodia called reticulopodia.



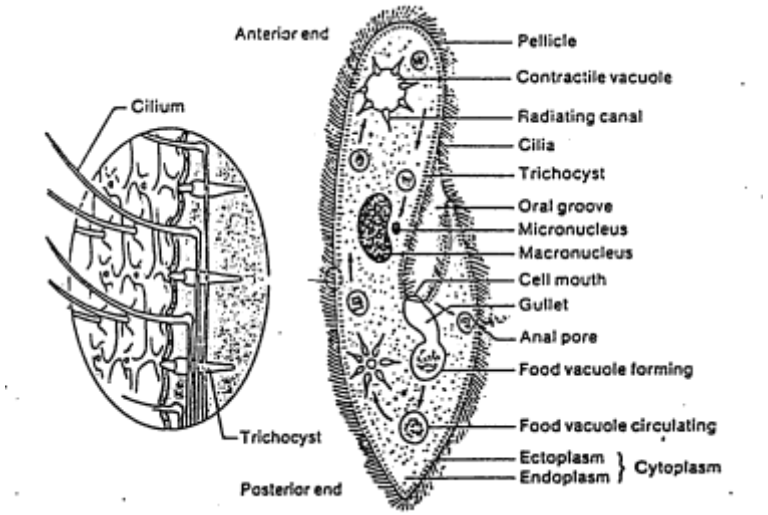
3- Class Ciliata:

-Complex protozoa with firm pellicle. -Locomotion by cilia. -Nuclei of 2 kinds. -Nutrition holozoic. – Asexual reproduction by binary fission. -Sexual reproduction by conjugation and autogmy.

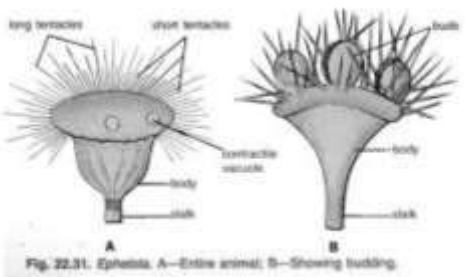
a-Order Holotricha **-Body cilia simple and uniform.** **-Aboral cilia absent**	**b-Order Peritricha** **-Without body cilia.** **-Oral cilia are found clearly.**	**c-Order Spirotricha** **-Body cilia spars and compound.**
d-Order Chonotricha **-Vestibular cilia in aspiraly coiled apical funnel**		**e-Order Suctoria:** **-Cilia are found only in early stages.**

Example of Class: Ciliata

Paramicium: It is a microscopic elongated animal, hving slipper-shaped. The anterior end is bluntly rounded, while posterior end is pointed. Pellicle covers the body. It is clear, firm and elastic cuticular membrane. Cilia cover the entire animal. They are hair-like projections of uniform length, except at posterior end where they are longer and at cytopharynx where they form undulating membrane. The cytostome at the end of the oral groove leads into a tubular cytopharynx, or gullet. Along the gullet an undulating membrane of modified cilia keeps food moving. Cytoplasm contains ectoplasm and endoplasm ectoplasms has myonemes (contain protein filament) and trichocysts (the function of trichocysts is thought to be defensive). Endoplasm contains two nuclei: a large kidney-shaped macronucleus and a smaller micronucleus, food vacuoles, granules, anterior contractile vacuole and posterior contractile vacuole.



Ephelota marine form, found in the sea water. The body is spherical and bearing a stalk. There are two types of tentacles on the body:Long tentacles which are used for piercing and Short tentacles which are used for sucking. The endoplasm contains macro and macronucleus and other granules. Reproduction is by exogenous budding. The bud detaches from parent body and develops to adult.



LEC 3

Phylum: Porifera

Introduction:

The name Porifera (*porus* = pore; *ferro* = to bear). This phylum includes the sponges which are most primitive of multicellular animals. Approximately 10.000 species of sponges are known at present.

Characteristics of Phylum Porifera

1. Multicellular; Body with pores (ostia), canals, and chambers that serve for passage of water.
3. Mostly marine; all aquatic.
4. Radial symmetry or none.
5. Epidermis of flat pinacocytes; most interior surfaces lined with flagellated collar cells (choanocytes) that create water currents; a gelatinous protein matrix called (mesoglea) contains amebocytes of various types and skeletal elements.
6. Skeletal structure of fibrillar collagen (a protein) and calcareous or siliceous crystalline spicules, often combined with variously modified collagen (spongin).
7. No organs or true tissues; digestion intracellular; excretion and respiration by diffusion.
8. All adults sessile and attached to substratum.
9. Asexual reproduction by buds or gemmules and sexual reproduction by eggs and sperm

Types of cells:

The sponges also have specialized cells. Therefore, division of function is present in them. Following types of cells are present in phylum porifera.

1- **Pinacocytes:** Flattened cells composing dermal epithelium in sponges. Pinacocytes are somewhat contractile and help regulate surface area of a sponge.
2- **Porocytes:** Tubular cells that make up the pores of a sponge.
3- **Choanocyte:** Which line flagellated canals and chambers, choanocytes are ovoid cells with one end embedded in mesoglea and the other exposed. The exposed end bears a flagellum surrounded by a collar. Choanocytes not only keep the water moving but also trap and phagocytize food particles that are carried in the water.
4- **Myocytes:** are usually arranged in circular bands around oscula or pores, where they help regulate rate of water flow.

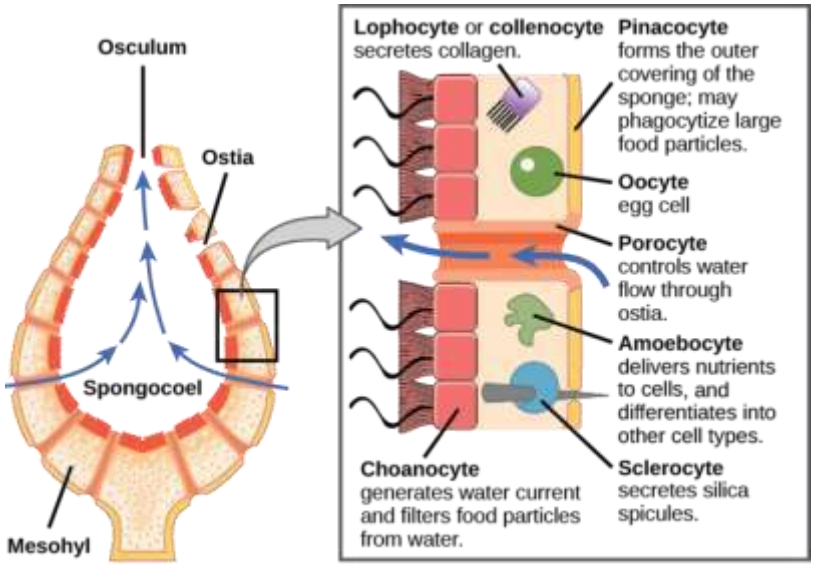
5- **Archaeocytes** Archaeocytes are ameboid cells that move about in the mesoglea and carry out a number of functions. They can **phagocytize** particles at the pinacoderm and receive particles for digestion from choanocytes. Archaeocytes apparently can differentiate into any of the other types of more specialized cells in the sponge.

a- **Sclerocytes**, secrete spicules.

b- **Spongocytes**, secrete the spongin fibers of the skeleton

c- **Collencytes** secrete fibrillar collagen

d- **Lophocytes** secrete large quantities of collagen but are distinguishable morphologically from collencytes.



(a) Basic sponge body plan (b) Some sponge cell types

Types of Skeletons

Its skeleton gives support to a sponge, preventing collapse of canals and chambers. The major structural protein in the animal kingdom is collagen, and fibrils of collagen are found throughout the intercellular matrix of all sponges. In addition, various Demospongiae secrete a form of collagen traditionally known as spongin. Several types of spongin, differing in chemical composition and form (fibers, spicules, filaments, spongin surrounding spicules, and so on) are found in various demosponges. Demospongiae

also secrete siliceous spicules. Calcareous sponges secrete spicules composed mostly of crystalline calcium carbonate and have one, three, or four rays .

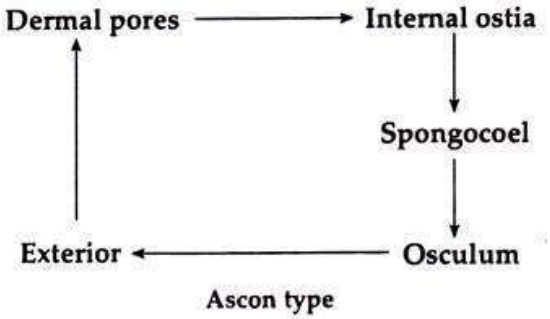
Body opening:

The only body openings of these unusual animals are pores, usually many tiny ones called ostia for incoming water, and a few large ones called oscula (sing., osculum) for water outlet. These openings are connected by a system of canals, some of which are lined with peculiar flagellated collar cells called choanocytes (previously discussed).

Types of Canal Systems

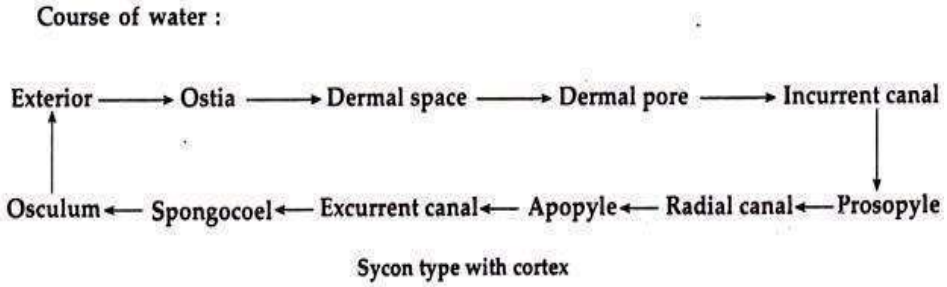
Most sponges have one of three types of canal systems: asconoid, syconoid, or leuconoid .

1-**Asconoids (Flagellated spongocoels):** Asconoid sponges have the simplest organization. They are small and tube shaped. Water enters through microscopic dermal pores into a large cavity called a spongocoel, which is lined with choanocytes. Choanocyte flagella pull water through the pores and expel it through a single large osculum. Asconoids are found only in the Calcarea.



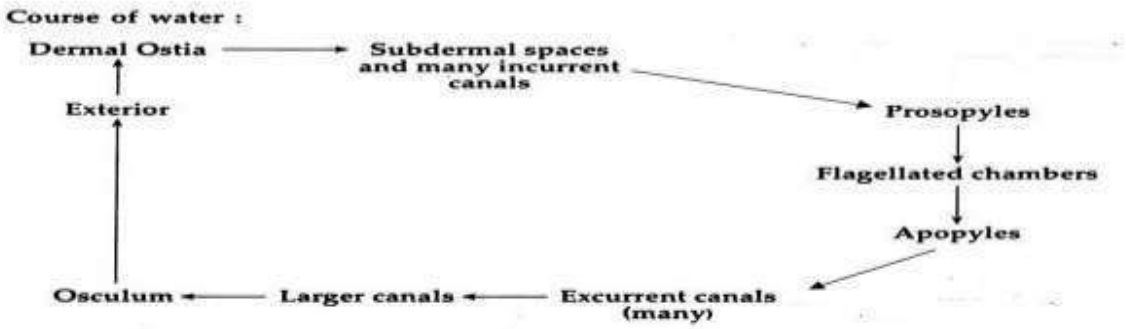
Ascon type

2-**Syconoids: Flagellated Canals** Syconoid sponges look somewhat like larger editions of asconoids, from which they were derived. They have a tubular body and single osculum, but the body wall, which is thicker and more complex than that of asconoids, contains choanocyte-lined **radial canals** that empty into the spongocoel. The spongocoel in syconoids is lined with epithelial-type cells rather than flagellated cells as in asconoids. Water enters through many dermal ostia into incurrent canals and then filters through tiny openings called prosopyles into the radial canals. Food is ingested by the choanocytes, whose flagella force the water through internal pores (apo-pyles) into the spongocoel. From there it emerges through an osculum. Syconoids are found in classes Calcarea and Hexactinellida.



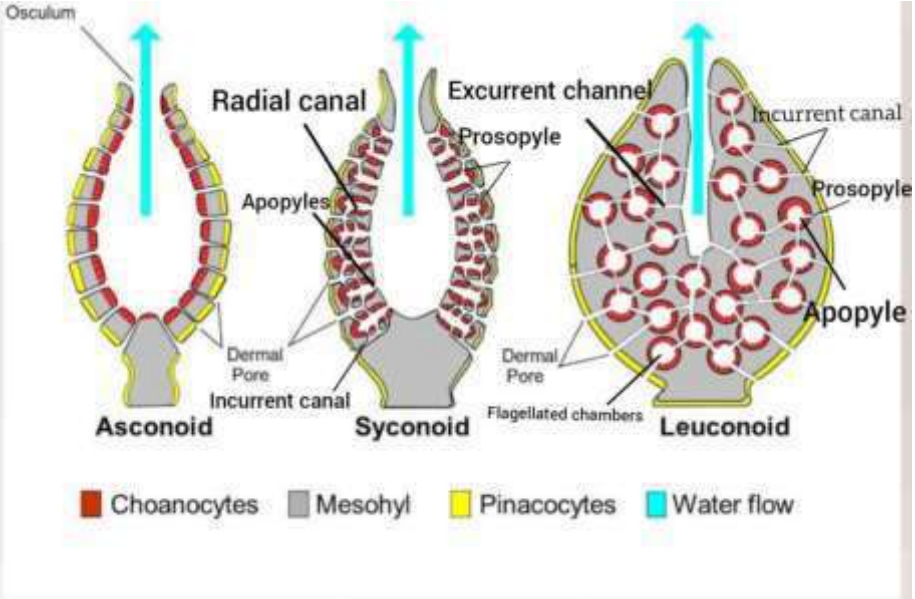
Sycon type with cortex

3-Leuconoids: Flagellated Chambers Leuconoid organization is the most complex of the sponge types and permits an increase in sponge size. As a result of further process of out folding of the choanocyte layer and thickening of body wall, the leuconoid type of canal system develops. The choanocyte layer of the radial canal of the syconoid stage evaginates into many small chambers, and these may repeat the process, so that clusters of small rounded or oval flagellated chambers replace the elongated chambers of the syconoid stage. The choanocytes are limited to these chambers. The interior of the sponge becomes permeated by many incurrent and ex-current canals join to form larger ex-current canals and spaces which lead to the oscula. The surface is covered with epidermal epithelium and is pierced by many dermal pores (ostia) and oscula. The dermal pores lead into incurrent canals that branch irregularly through the mesenchyme. The incurrent canals lead into the small rounded flagellated chambers by opening still termed prosopyles. The flagellated chambers open by apertures called apopyles into ex-current channels, and these unite to form larger and larger tubes, of which the largest lead to the oscula. Most sponges are of the leuconoid type, which occurs in most Calcarea and in all other classes.



Leuconoid type

Example: ***Euspongia***



Sponges Feeding

Sponges feed primarily on particles suspended in the water pumped through their canal systems. Detritus particles, planktonic organisms, and bacteria. Pinacocytes may phagocytize particles at the surface, but most larger particles are consumed in the canals by archaeocytes that move close

to the lining of the canals. Sponges also absorb dissolved nutrients from the water passing through the system. Protein molecules are taken into choanocytes by pinocytosis. Digestion is entirely intracellular (occurs within cells).

Respiratory and Excretory organs

There are no respiratory or excretory organs; both functions apparently occur by diffusion in individual cells. Contractile vacuoles are found in archaeocytes and choanocytes of freshwater sponges.

Reproduction

1-Asexual Reproduction:

a-Reduction bodies: Many fresh water and marine sponges disintegrate in adverse environmental conditions particularly in winter, leaving small rounded balls called reduction bodies. Each body consists of an internal mass of amoebocytes, covered externally by a pinacoderm and spicules. When favorable conditions return, these reduction bodies grow into complete new sponges.

b-Budding: In budding, numerous archaeocytes gather near the surface resulting in a small outgrowth on the pinacoderm. The bud thus formed grows outward to produce a small individual, which either remains attached with the parent individual or gets detached and attached to a nearby rock to grow into an independent colony.

c-Gemmules Production:

Gemmules are formed in freshwater sponges and some marine sponges. Here, archaeocytes collect in the mesohyl and become surrounded by a spongin coat incorporating siliceous spicules. When the parent animal dies, the gemmules survive and remain dormant, preserving the species during periods of freezing or severe drought. Later, cells in the gemmules escape through a special opening, the micropyle, and develop into new sponges.

2-Sexual Reproduction:

Sponges have no organs but amoebocytes form eggs and sperms in the mesenchyme ; first eggs are produced and later the sperms. The amoebocytes get filled with food and become large, they become round to form eggs. Other amoebocytes divide to produce many sperms, a sperm has an oval head and a long tapering tail. Eggs of one sponge are fertilized by sperms from another sponge to form zygotes.

Regeneration

Sponges have the ability to repair injuries and to restore lost parts, a process called regeneration. Regeneration does not imply a reorganization of the entire animal, but only of the wounded portion. The regeneration power is used for cultivation of bath sponge industrially.

Classification of Phylum Porifera

Class Calcarea Have spicules of calcium carbonate that often form a fringe around the osculum (main water outlet); spicules needle shaped or three or four rayed; all three types of canal systems (asconoid, syconoid, leuconoid) represented; all marine. Examples: *Sycon, Leucosolenia*.

Class Hexactinellida Have six-rayed, siliceous spicules extending at right angles from a central point; spicules often united to form network; body often cylindrical or funnel shaped; flagellated chambers in simple syconoid or leuconoid arrangement; habitat mostly deep water; all marine. Examples: Venus' flower basket (*Euplectella*), *Hyalonema*.

Class Demospongiae Have siliceous spicules that are not six rayed, or spongin, or both; leuconoid-type canal systems; one family found in fresh water; all others marine. Examples: *Thenea*, *Cliona*, *Spongilla*, *Myenia*, and all bath sponges.

LEC 4

Phylum: Cnidaria (Coelentrata)

Introduction:

Phylum Cnidaria is an interesting group of more than 9000 species. It takes its name from cells called cnidocytes, which contain the stinging organelles (**nematocysts**) characteristic of the phylum. Nematocysts are formed and used only by cnidarians.

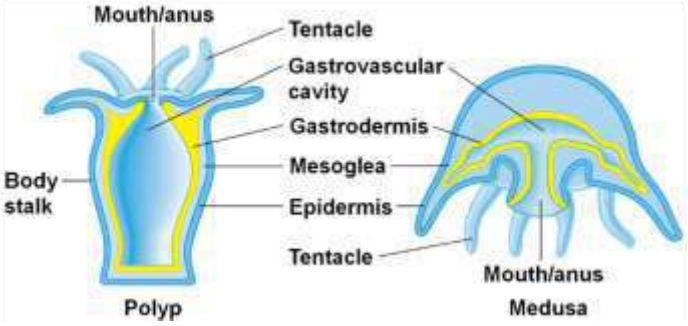
Characteristics of Phylum Cnidaria

1. Entirely aquatic, some in fresh water but mostly marine.
2. Radial symmetry or biradial symmetry
3. Two basic types of individuals: polyps and medusa.
4. Exoskeleton or endoskeleton of chitinous, calcareous, or protein components in some.
5. Body with two layers, epidermis and gastrodermis, with mesoglea (diploblastic).

in some (triploblastic)

6. Gastrovascular cavity with a single opening that serves as both mouth and anus.
7. Special stinging cell organelles called nematocysts
8. Nerve net with symmetrical and asymmetrical synapses; with some sensory organs; diffuse conduction.
9. Muscular system of an outer layer of longitudinal fibers at base of epidermis and an inner one of circular fibers at base of gastrodermis.
10. Asexual reproduction by budding (in polyps) or sexual reproduction by gametes (in all medusae and some polyps)
11. No excretory or respiratory system and no coelomic cavity.

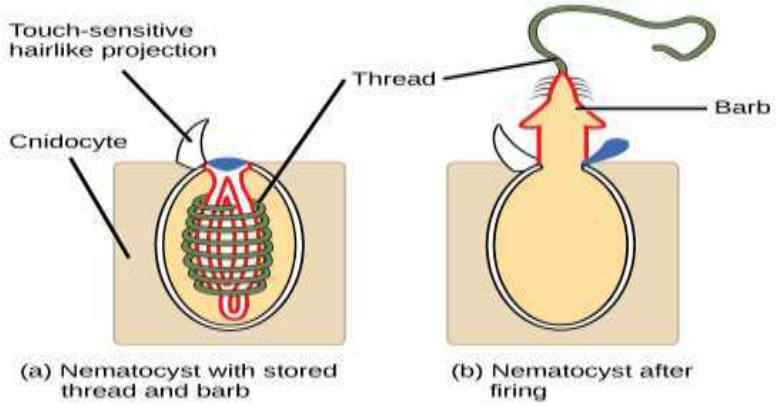
Dimorphism and Polymorphism in Cnidarians One of the most interesting aspects of this phylum is the dimorphism and often polymorphism displayed by many of its members. All cnidarian forms fit into one of two morphological types (dimorphism): a **polyp**, or hydroid form, which is adapted to a sedentary or sessile life, and a **medusa**, or jellyfish form, which is adapted for a floating or free-swimming existence.



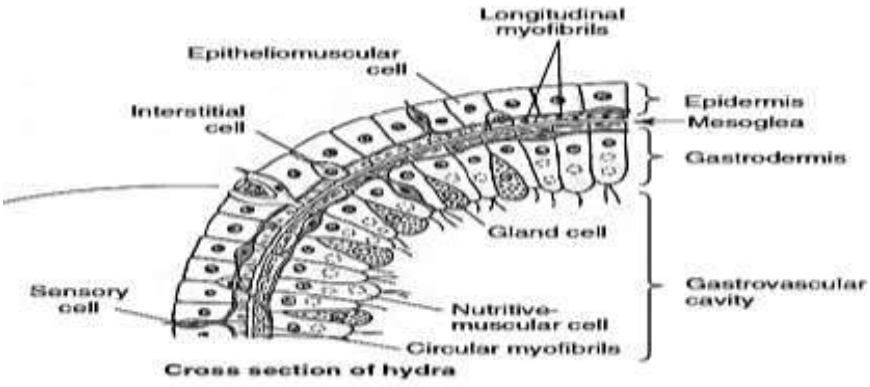
Polyp	Medusa
Fixed	Free swimming
Body cylindrically elongated	Body umbrella-like
Tentacles are usually 24	16 tentacles in young medusa
Mesoglea poorly developed	Mesoglea well developed
Sense organs are absent	Sense organs are present
Mouth circular	Mouth rectangular
Gastro -vascular cavity simple, without radial and circular canal	Gastro -vascular cavity represented by stomach, 4 radial canals and one circular canal
Reproduces asexually	Reproduces sexually

Nematocysts: Stinging Organelles

One of the most characteristic structures in the entire cnidarian group is a stinging organelle called a nematocyst. Nematocysts are tiny capsules composed of material similar to chitin and containing a coiled tubular "thread" or filament, which is a continuation of the narrowed end of the capsule. This end of the capsule is covered by a little lid, or operculum. The inside of the undischarged thread may bear tiny barbs, or spines. A nematocyst is enclosed in the cell that has produced it, the cnidocyte (during its development, a cnidocyte is properly called a cnidoblast).



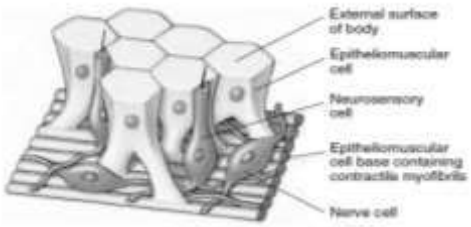
Body Wall The body wall surrounding the gastrovascular cavity consists of an outer epidermis (ectodermal) and an inner gastrodermis (endodermal) with mesoglea between them.



1-Epidermis:

The epidermal layer contains epitheliomuscular, interstitial, gland, cnidocyte, and sensory and nerve cells.

a-Epitheliomuscular cells make up most of the epidermis and serve both for covering and for muscular contraction. Contraction of these fibrils shortens the body or tentacles.



b-Interstitial cells are undifferentiated stem cells found among the bases of the epitheliomuscular cells. Differentiation of interstitial cells produces cnidoblasts, sex cells, buds, nerve cells, and others, but generally not epitheliomuscular cells (which reproduce themselves).

c-Gland cells are tall cells located around the basal disc and mouth, that secrete an adhesive substance for attachment and sometimes a gas bubble for floating.

d-Sensory cells are scattered among the other epidermal cells, especially near the mouth and tentacles and on the basal disc. The free end of each sensory cell bears a flagellum, which is the sensory receptor for chemical and tactile stimuli. The other end branches into fine processes that synapse with nerve cells.

e-Cnidocytes containing nematocysts occur throughout the epidermis

f-Nerve cells of the epidermis are generally multipolar (have many processes), although in more highly organized cnidarians the cells may be bipolar (with two processes). Their processes (axons) form synapses with sensory cells and other nerve cells and junctions with epitheliomuscular cells and cnidocytes.

2-Gastrodermis. The gastrodermis, a layer of cells lining the gastrovascular cavity. The cells of the gastrodermis include nutritive-muscular, interstitial, and gland cells.

a-Nutritive-muscular cells are usually tall columnar cells and have laterally extended bases containing myofibrils. Water is brought in through the mouth by beating of cilia on the nutritive muscular cells. The two cilia on the free end of each cell also serve to circulate food and fluids in the digestive cavity. The cells often contain large numbers of food vacuoles.

b-Interstitial cells are scattered among the bases of the nutritive cells. They transform into other types of cells when the need arises.

c-Gland cells secrete digestive enzymes.

3-Mesoglea. The mesoglea lies between the epidermis and gastrodermis and is attached to both layers. It is gelatinous, and both epidermal and gastrodermal cells send processes into it. The mesoglea helps to support the body and acts as a type of elastic skeleton.

Classification of Cnidaria

1-Class Hydrozoa . Solitary or colonial; asexual polyps and sexual medusae, although one type may be suppressed; hydranths with no mesenteries; medusae (when present) with a velum; both freshwater and marine. Examples: *Hydra, Obelia.*

2-Class Scyphozoa. Solitary; polyp stage reduced or absent; bell shaped medusae without velum; gelatinous mesoglea much enlarged; margin of bell or umbrella typically with eight notches that are provided with sense organs; all marine. Example: *Aurelia*

3-Class Anthozoa All polyps; no medusae; solitary or colonial; gastrovascular cavity subdivided by at least eight mesenteries or septa bearing nematocysts; gonads endodermal; all marine. Example: *Metridium*

Examples: *Hydra*

Is simple, solitary and fresh-water form. It is free living. Hydra has only one form of zooid (the polyp), no polymorphism. *Hydra* is elongated, cylindrical and like an elastic tube measures 1-3 cm in length. Proximal end of the body is known as basal disc or foot, used for attachment with some objects or for locomotion. The free distal end bears the mouth situated on conical elevation called the hypostome. The hypostome is encircled by few (6-10) tentacles. The tentacles are hollow, slenderfinger-like projection provided with nematocyst. Body wall is diploblastic consist of an outer ectoderm and an inner endoderm separated by mesoglea. Body wall encloses a digestive cavity or gastro-vascular cavity which extends to tentacles. Lateral buds may present on the sides of the body which may give rise to new individuals by asexual reproduction. Gonads appear as buds on the sides of the body. Testes lie near the oral end, while the ovaries near the base. Reproduction both asexual and sexual. *Haydra* may be monoecious od dioecious, and it has no free swimming stage.

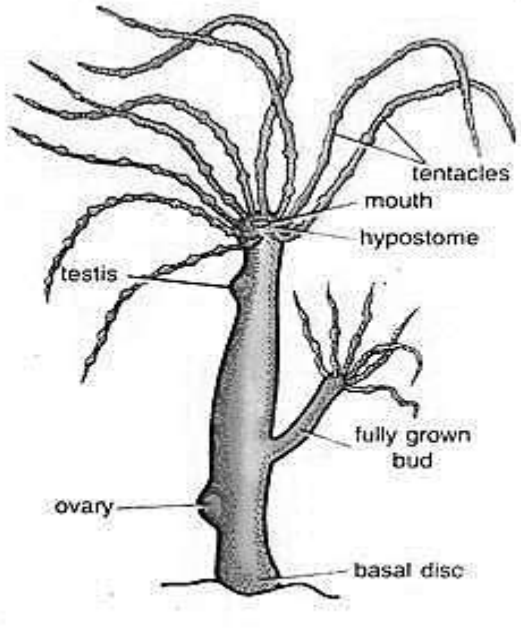


Fig. 31.1. *Hydra.*

Nutrition *Hydra* The food consists of small crustaceans like Cyclops, small annelids and insect larvae. On touching a tentacle by the prey, the stinging apparatus penetrate it and inject a poisonous to paralyze it. The tentacle holding the captured animal contracts and bends over the mouth. The mucous gland cells of the hypostome cover the engulfed food with mucus, then enzymatic gland cells produce a proteolytic enzyme like trypsin which partly digests the proteins this digestion is extracellular. Some endoderm cells form pseudopodia engulf the smaller partly digested particles into food vacuoles. The remaining digestion is completed in the vacuoles, and it is called intracellular digestion. Thus, Hydra combines the intracellular digestion of Protozoa and extracellular digestion of higher animals.

Respiration and Excretion in *Hydra* There are no special organs for respiration and excretion. Gaseous exchange occurs through the general body surface. Nitrogenous wastes are largely in the form of ammonia, which also diffuses through the general body surface. It is also thought that the gastro dermis of basal disc is said to accumulate some excretory matter, which may be discharged through a pore.

Nervous System of *Hydra* There are many nerve cells, each with two to four branching nerve fibers. The nerve fibers are primitive because they do not form axons or dendrites, moreover the nerve fibers form actual contacts with fibers of other nerve cells.

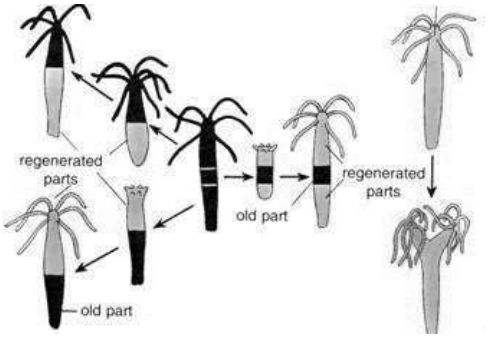
Reproduction in *Hydra*:

(i) Asexual Reproduction of *Hydra*:

Asexual Budding: A bud develops as a simple evagination of the body wall. The ectoderm cells increase in number at one point to form a knob below which the endoderm cells acquire reserve food, then both ectoderm and endoderm are pushed out to form a bud.

(ii)Sexual Reproduction: Most species are dioecious some are monoecious. Eggs in the ovary usually mature one at a time and are fertilized by sperm shed into the water. Zygotes undergo holoblastic cleavage to form a hollow blastula. The inner part of the blastula delaminates to form the endoderm (gastrodermis), and the mesoglea is laid down between ectoderm and endoderm. A cyst forms around the embryo before it breaks loose from the parent, enabling it to survive the winter. No free swimming stage is available in the life history of *Hydra.*

Regeneration in *Haydra* Regeneration may be defined as the ability of certain animals to restore the lost or worn out parts of their bodies. *Hydra* has the considerable power of regeneration.



Example *Obelia*

Is colonial hydroid. It is trimorphic colony having three types of zooids:

1- **Haydranth** or polyp has cylindrical body attached to the axis of the hydrocaulus by its proximal end and free at its distal end. It is covered by cup-shaped hydrotheca. The hypostome is covered by tentacles. It is nutritive zooid of the colony.

2- **Blastostyle or reproductive zooides** is club-shaped without mouth and tentacles. It is enclosed by covering gonotheca. It gives rise to buds which develop into medusa.

3- **Medusa** is bell-shaped reproductive zooid with concave and convex side. It is provided with marginal tentacle, four radial canal, a ring canal, four gonads. From the center of the sub-umbrella arises a short projecting manubrium at its apex is a square mouth surrounded by four oral lobes. Medusa is free swimming zooid.

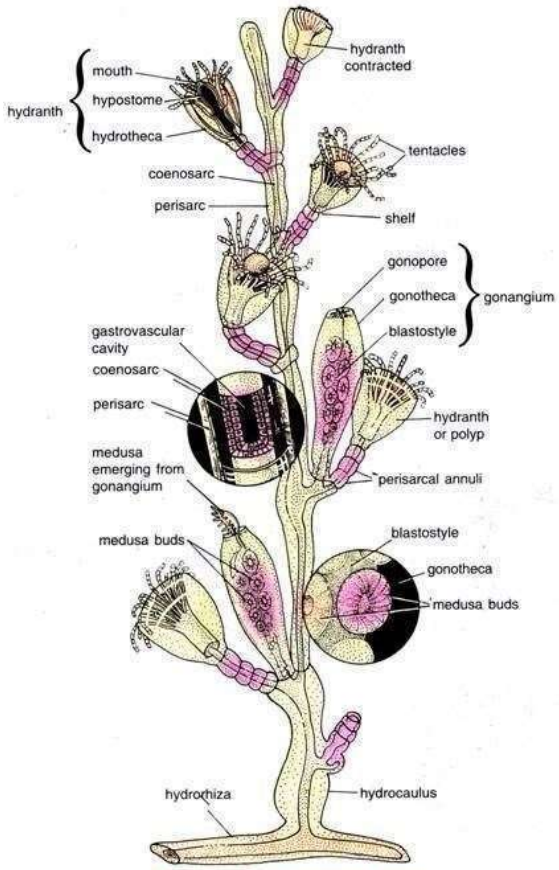


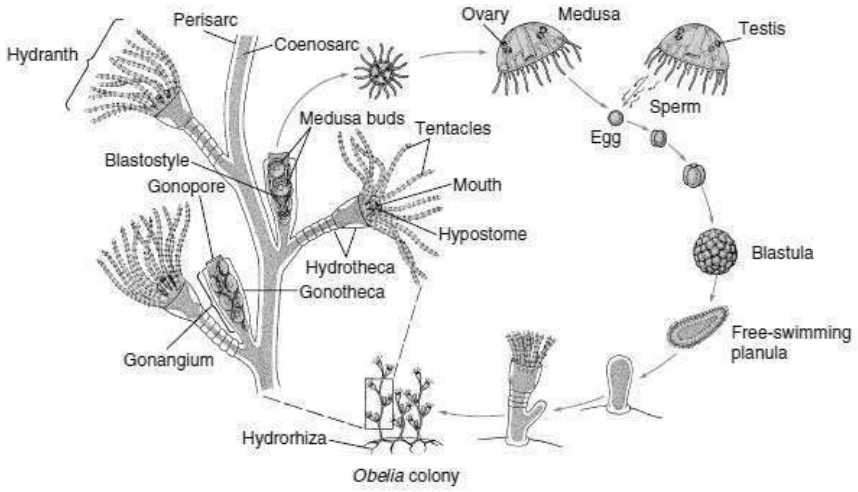
Fig. 32.1. *Obelia*. A portion of colony.

Life cycle

1.**Fertilization**- the fertilization usually take place in open sea water where the gametes are swims freely. Sometime the sperm are carried into female medusa with water current.

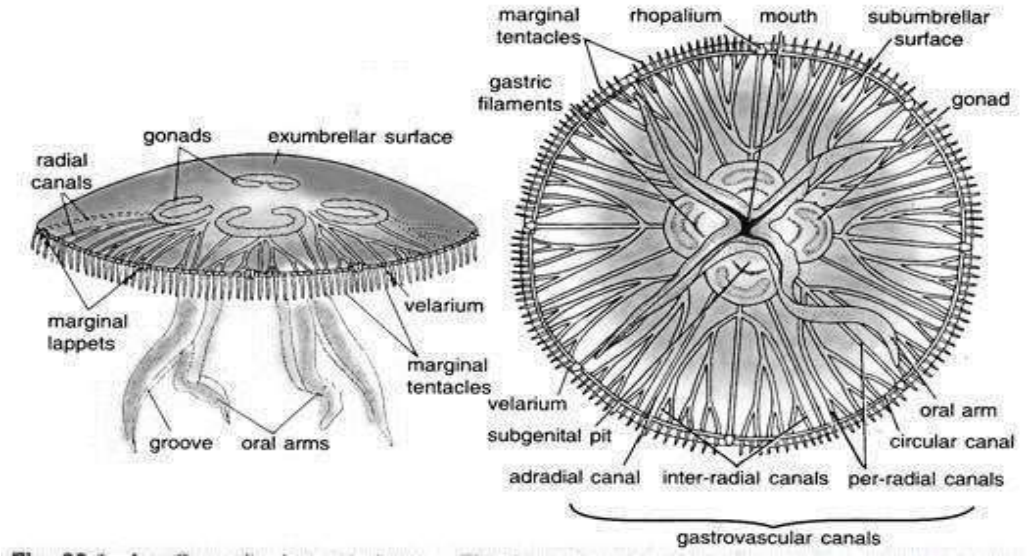
2.**Development**- the development include following :

- **Cleavage**- The zygote undergo holoblastic and equal cleavage to form solid ball of cell called morula. The morula changed into a single layered blastula. Its single layered cell which then then convert into solid gastrula.
- **Planula** is a free-swimming larva but eventually it attached to some solid surface. 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.
- **Hydrula-** a simple polyp or hydrula is formed which grows a hydrorhiza from its base, from which an *Obelia* colony is formed by budding.



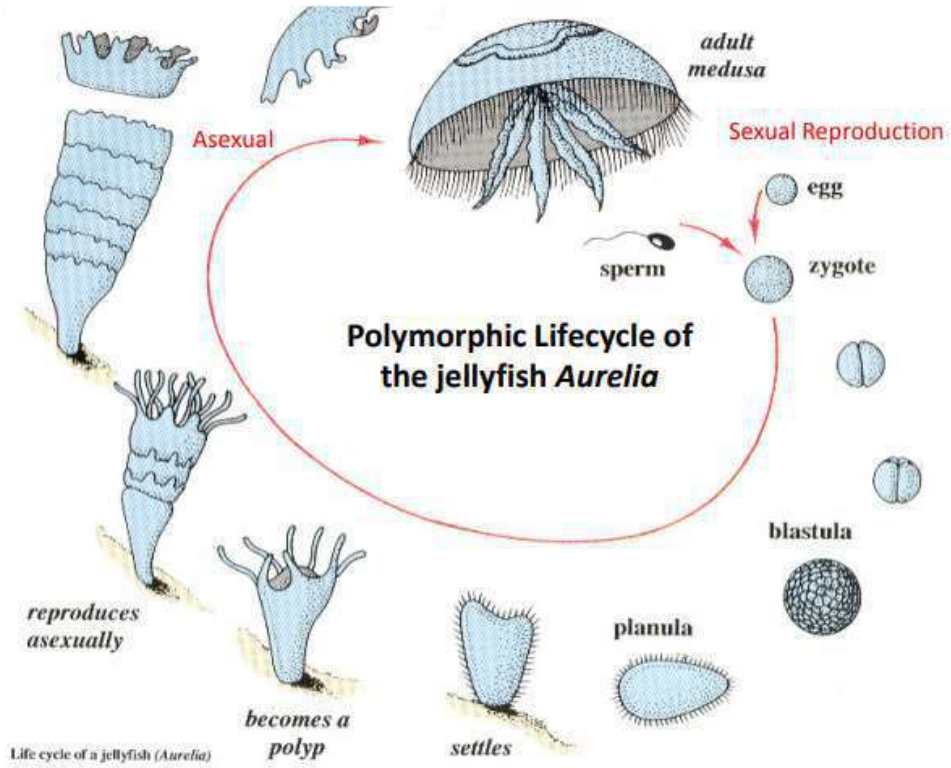
Example *Aurelia*

is a commonest jelly-fish or moon-jelly, occurs in coastal waters of tropical and temperate oceans of the world close to the surface of water. It is cosmopolitan in distribution. Medusa phase is dominant it is called jelly fish. The bell margin of the umbrella-shaped medusa has 8 notches for **tentaculocysts or rhopalium** (which are the sense organs of jelly-fish). As well as the margin equipped with many small hollow tentacles. The true velum is bscent. Long oral arms are present. Canal system complicated, gastric pouch present and the canals are branched. Gastric ridges are present and are bearing gastric filaments. Gonads are exclusively endodermal and four in number.



Life Cycle:

Fertilization is either internal or External. Zygote undergoes to produce a solid ball morula. Morula is transformed into a single layered blastula then two layered gastrula . The embryo now elongates, its outer cells become ciliated, in this way the typical **planula larva** is formed. The ciliated planula attached itself to a stone . Cilia are lost and a mouth opens at its free distal end . The larva now become elongated . Its proximal end is stalklike and is attached to the substratum by an adhesive basel disc. Mouth becomes square in outline. Larva now called as young **Scyphistoma** . **Scyphistoma** survive in this stage to several months. scyphistoma undergoes a remarkable process of budding of oral end called as strobilation. Body develops a series of ring like transverse grooves . Scyphistoma with a segmented body is called a strobili. Each of the segment is called as ephyra larva . About a dozen ephyrae are formed in a single strobilation. **Ephyra** is finally transformed into adult Aurelia



LEC 5

Phylum: Platyhelminthes

Platyhelminthes (from the Greek , platy, meaning "flat" and, helminth-, meaning "worm"). This Phylum includes more than 13,000 species of free-living and parasitic species.

Characteristics of Phylum Platyhelminthes

1. Three germ layers (triploblastic).
2. Bilateral symmetry.
3. Body flattened dorsoventrally.
4. Epidermis may be cellular or syncytial.
5. Muscular system primarily of a sheath form and of mesodermal origin; layers of circular, longitudinal, and sometimes oblique fibers beneath the epidermis.
6. No internal body space other than digestive tube.
7. Digestive system incomplete or absent in some.
8. Nervous system consisting of a pair of anterior ganglia with longitudinal nerve cords connected by transverse nerves .
9. Simple sense organs; eyespots in some.
10. Excretory system of two lateral canals with branches bearing flame cells
11. Respiratory, circulatory, and skeletal systems lacking.
12. Most forms monoecious; reproductive system complex.
13. Class Turbellaria mostly free living; classes Monogenea, Trematoda, and Cestoda entirely parasitic.

Classification:

Platyhelminthes divided in to three classes: Cestoda, Trematoda and Turbellaria

CLASS I: TURBELLARIA :

1. Mostly free - living forms found in fresh or sea waters or on land.

2. Body is unsegmented and is dorsiventrally flattened.

3. Epidermis is cellular or syncytial.

4 Intestine is either absent (Acoela) or simple and sac like (Rhabdocoela) or branched.

Order (1): Acoela: They are marine and small. Mouth and pharynx are simpleor absent. Oviducts 2 yolk glands are absent. Ex : *Convoluta*.

Order (2) : Rhabdocoela : They are small. A digestive bad is present and intestine is sac like. Many are free swimming. Reproductive organs are present.

Ex : *Microstomum, Temnocephala.*

Order 3 : Alloeocoela : Small sized worms are included in this order. Intestine is simple or branched. They are mostly marine.

Ex : Otoplana, Bothnoplana.

Order 4 :Tricladida : Dorsiventrally flat body is seen. Intestine has two lateral limbs and one median limb Genital aperture is single.

Ex: *Planaria.*

CLASS II : TERMATODA :

1.These are commonly known as flukes.

2.These are ectoparasitic or endoparasitic forms.

3. Body is unsegmented and enlongated.

4.Adhesive organs are, one or two suckers without hooks and spines.

4. Digestive tract is bifurcated and highly diverticulated. Anus is absent.

Order 1 : Monogenea : These are ectoparasitic forms. An oral sucker may be" present, or absent or poorly developed. Posterior end with adhesive discs with hooks is common

Ex : *Monocells, Polystomum*.

Order 2 : Aspidobothria : These are endoparasites. Oral sucker is absent. Hooks are absent. Development is direct. Ex . Aspidogaster.

Order 3 : Digenea : Endoparasites are included. Suckers are present without loops. Life cycle is complicated.

Ex : *Fasciola, Opiathorchis*.

CLASSIII:CESTODA:

1.Totally endoparasitic forms.

2. Body covered with thick cuticle.

3.Mouth,digestive tract and sense organs are absent.

4.Fertilization is internal. It is divided into 2 sub-classes.

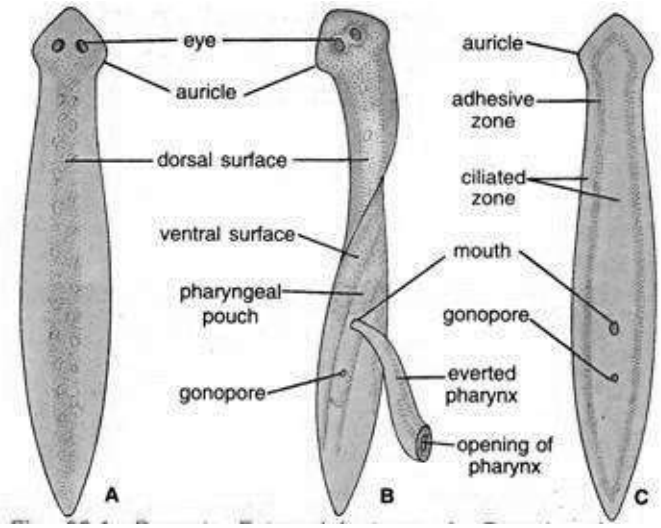
Class I: Cestodaria or Monozoa: These are simple fish parasites. Body without a scolex and strobila.

Ex: *Amphilian*

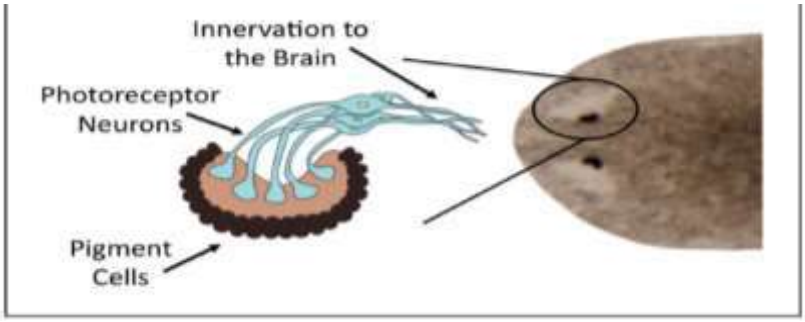
Class II: Eucestoda (or) Merozoa : Scolex with adhesive organs. More than one set of reproductive organs. Larva has 6 hooks.

Ex: *Taenia solium*

Example: Example: *Planaria:* Body of *Planaria* is elongated, bilaterally symmetrical and dorsoventrally flattened. They are 2-15 mm in length. Head is triangular with auricles and two eyes. Digestive system consist of mouth, proboscis, pharynx and branched intestine. Mouth is situated on the ventral surface behind the middle of worm. Proboscis is enclosed in the proboscis sheath. Intestine forks into three diverticulitis branches, one anterior an two posterior. Genital pore is situated a little posterior to the mouth. Planarians are used for experimental purpose.



Eyes :Eyes are two round dark spots on the dorsal surface of the head. The eye has a pigment cup with its open facing laterally forward. Projecting into the pigment cup are several retinal cells, they are bipolar nerve cells with expanded inner ends which are striated, and outer ends joined to the brain. Eyes are capable of a crude discrimination of the direction of light. The pigment cup serves as a shield and light can enter only through its opening to stimulate the photosensitive expanded ends of retinal cells, thus, the animal can detect the direction of light.

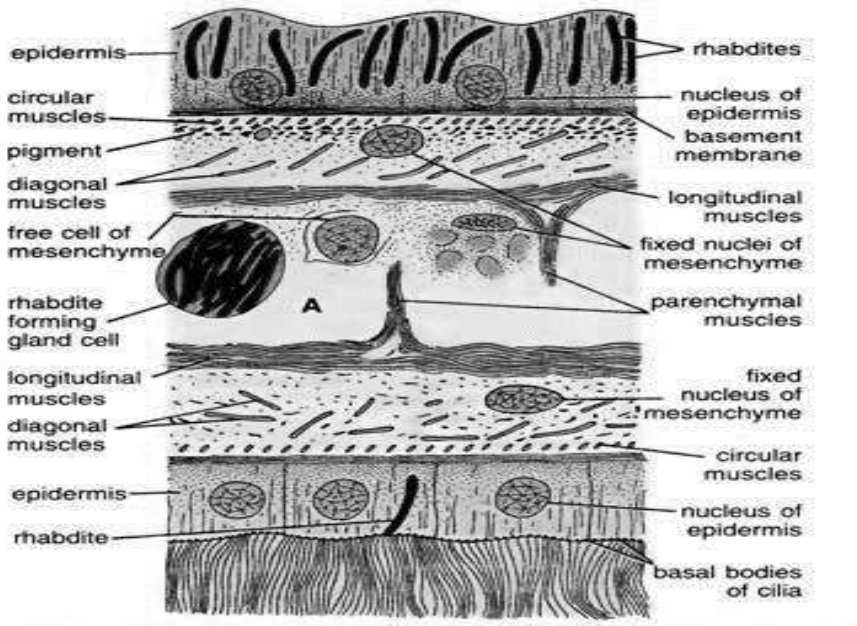


Body Wall

The body wall is made of an outer epidermis and inner muscle layers. Both these layers are separated by a basement membrane. The space between muscle layer and the alimentary canal is filled with a special type of tissue called mesenchyme or parenchyma, therefore, no coelom or body cavity is found in it.

(1) Epidermis: It is single cell-layered thick and made of cuboidal epithelial cells. The epidermis is ciliated all over in most planarians. Between the epidermal cells are sensory cells and mucous gland cells in certain areas. The gland cells provide a mucus coating for the animal locomotion. In the epidermal

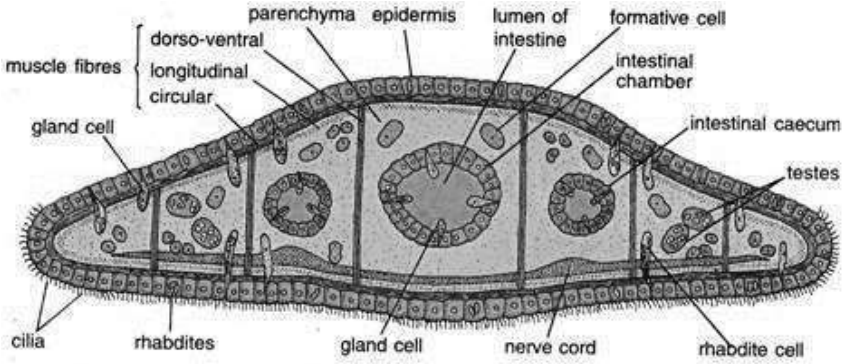
cells are hyaline rods called **rhabdites**, they are more abundant on the dorsal than the ventral side. **Rhabdites** are secreted by rhabdite gland cells usually located in mesenchyme. After the rhabdites are secreted in the rhabdite gland cells, they migrate to the epidermal cells where they lie. The function of rhabdites is not known, but they form a slimy substance on discharge to the exterior which may be protective, and help in obtaining living food.



(2) Basement Membrane: marks the boundary between the epidermis and muscle layers and it helps in maintaining general form of the body.

(3) Muscle Layer: It contains elongated contractile muscle cells. The muscle layer is differentiated into an outer layer of circular muscles, middle layer of diagonal muscles and inner layer of longitudinal muscles. The longitudinal muscle layer is more developed on the ventral side. The dorso-ventral muscles extend across the body between dorsal and ventral surfaces.

(4) Parenchyma or Mesenchyme: It is a special type of connective tissue of mesodermal origin. It is filled in the spaces between various internal organs and body wall. It is a net-like syncytium containing nuclei, free wandering mesenchyme. The mesenchyme cells serve to transport digested food and excretory wastes.

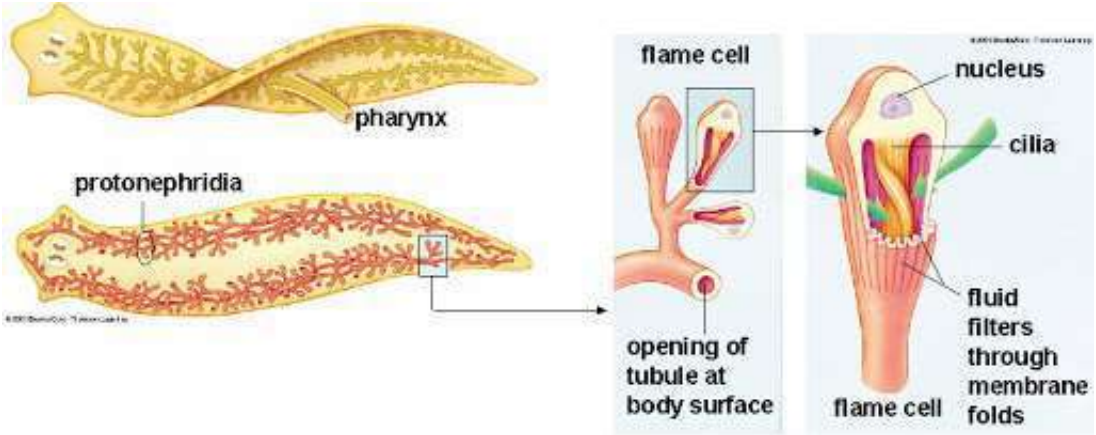


Digestive System: The flatworms are the first in the animal kingdom to possess the alimentary canal which is incomplete because anus is not found. However, the alimentary canal of consists of mouth, pharynx and intestine. Digestion is both extracellular and intracellular; the mesenchyme helps to distribute digested food.

Rejuvenation: Planarians can live without food for long periods, they obtain nourishment by dissolving their reproductive organs, parenchyma, and muscles, they get smaller in size. The missing parts are regenerated when they feed again.

Respiratory System: There are no respiratory organs. Exchange of gases takes through the body surface, i.e., respiratory exchange is by diffusion.

Excretory System: The excretory system consists of a system of excretory tubules having many excretory cells called **flame cells** or protonephridia. The flame cell is nucleated and has many protoplasmic processes reaching into the mesenchyme. The flame cell has an intracellular space which is continued into the capillary. In the space of the flame cell are many flagella which vibrate giving the appearance of a flickering candle flame, hence, the name.

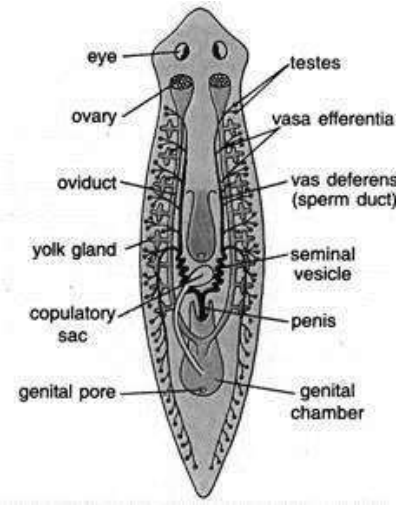


Nervous system: The nervous system represents the primitive type of centralized nervous system of higher animals. It consists of the brain, nerve cords and peripheral nerves.

Reproduction:

(i) Asexual Reproduction: Fission occurs when the animal has attained maximum size; the posterior end adheres firmly, while the anterior region advances forward so that the animal ruptures into two behind the pharynx.

(ii) Sexual Reproduction: Reproductive organs are temporary, they are formed during the breeding season, after which the reproductive organs degenerate and the animal becomes an asexual strain which will reproduce by fission till early summer of the following year. The sexual strain develops hermaphrodite organs and it reproduces sexually every year in early summer.



Regeneration: *Planaria* has great powers of regeneration. Regeneration is a process of restitution and involves the development of lost part of the body automatically.

LEC 6

Phylum: Annelida

Phylum Annelida consists of the segmented worms. It is a large phylum, numbering approximately 15,000 species, the most familiar of which are earthworms and freshwater worms (oligochaetes) and leeches (hirudineans).

Characteristics of Phylum Annelida

1. Body metameric; symmetry bilateral.
2. Body wall with outer circular and inner longitudinal muscle layers; outer transparent moist cuticle secreted by epithelium.
3. Chitinous setae often present; setae absent in leeches.
4. Coelom (schizocoel) well developed and divided by septa, except in leeches; coelomic fluid supplies turgidity and functions as hydrostatic skeleton.
5. Circulatory system closed and segmentally arranged; respiratory pigments (hemoglobin, hemerythrin, or chlorocruorin) often present; amebocytes in blood plasma.
6. Digestive system complete and not metamerically arranged.
7. Respiratory gas exchange through skin, gills, or parapodia.
8. Excretory system typically a pair of nephridia for each metamere.
9. Nervous system with a double ventral nerve cord and a pair of ganglia with lateral nerves in each metamere; brain a pair of dorsal cerebral ganglia with connectives to cord
10. Hermaphroditic or separate sexes; larvae, if present, are trochophore type; asexual reproduction by budding in some.

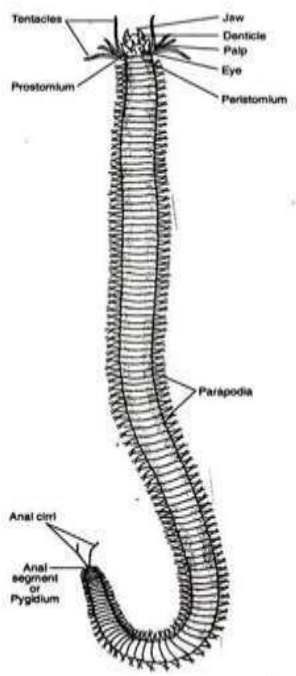
Classification:

Class Polychaeta: Mostly marine; head distinct and bearing eyes and tentacles; most segments with parapodia (lateral appendages) bearing tufts of many setae; clitellum absent; sexes usually separate; gonads transitory; asexual budding in some; trochophore larva usually present; mostly marine. Examples: *Nereis*.

Class Oligochaeta. Body with conspicuous segmentation; number of segments variable; setae few per metamere; no parapodia; head absent; coelom spacious and usually divided by intersegmental septa; hermaphroditic; development direct, no larva; chiefly terrestrial and freshwater. Examples: *Lumbricus,*

Class Hirudinea Body with fixed number of segments (normally 34; 15 or 30 in some groups) with many annuli; oral and posterior suckers usually present; clitellum present; no parapodia; setae absent (except in Acanthobdella); coelom closely packed with connective tissue and muscle; development direct; hermaphroditic; terrestrial, freshwater, and marine. Examples: *Hirudo*

Example: ***Nereis*** The body of *Nereis* is approximately 7-8 centimeters in length. The colour is light violet and the regions of the body which are richly supplied with blood vessels appear reddish. The body is divisible into about 80 segments and a distinct head is present at the anterior end. All the segments excepting the head and the last segment bear laterally placed, hollow, muscular and vertical, movable paired appendages parapodia (Single. Parapodium). The terminal segment is termed as the anal segment or pygidium and it bears at its posterior end a small round opening, the anus. Anal segment bears a pair of elongated anal cirri. On the ventral surface and near the base of the parapodium lies a nephridial aperture. Thus a pair of nephridiopores is present in each parapodial segment.



The Head:

The head is divisible into two parts: prostomium and peristomium. Prostomium is an anterior, small, roughly conical lobe of the peristomium. It lies in front of the mouth. It is not a true body segment. The lobe bears tentacles, palps and eyes which serve as sensory organs. Peristomium is the first body segment which is ring-like and bears mouth ventrally.

The prostomium bears following structures:

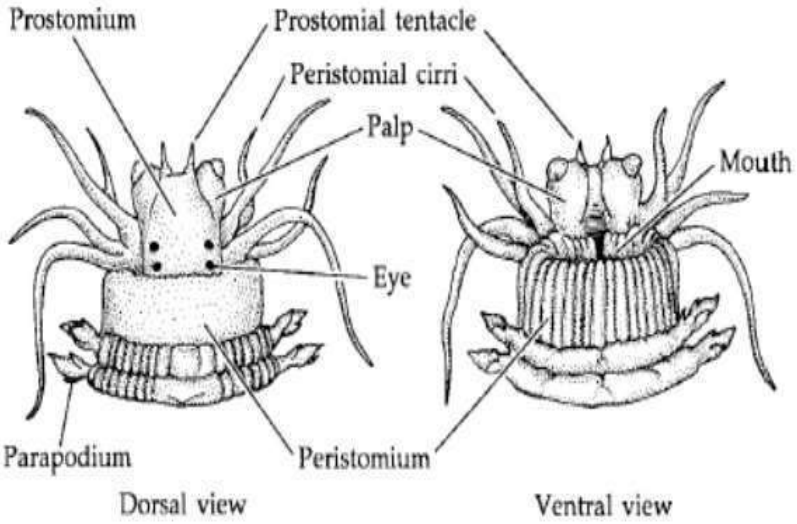
(1) Prostomial Tentacles—paired, cylindrical, small and placed in front.

(2) Palp—paired, elongated and compact and located after the tentalces.

(3) Eyes—two pairs, simple, round, pigmented and present on the dorsal side of the head. The peristomium carries:

(1) Peristomial tentacles—four pairs, long, slender, cylindrical and laterally placed.

(2) Mouth—present on the ventral side as a transverse aperture.

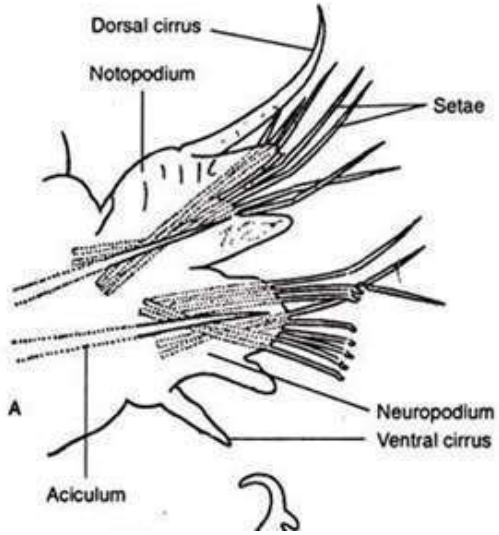


Parapodium:

All the segments excepting the first and the last segments bear on either lateral side a fleshy, flat and hollow parapodium. Largest parapodia are encountered in the middle segments of the body, then the size of the parapodia decreases towards the two ends.

Parapodium consist of: **Dorsally placed notopodium, Ventrally placed neuropodium, Dorsal cirrus, Ventral cirrus, Setae (single Seta)** and **Aciculum**.

The parapodia perform different locomotory functions, such as crawling and swimming. The parapodia in some polychaetes are highly vascularized structure and function as respiratory organs.



Setae: The setae are stiff, needle-like chitinous rods which remain in bundle within a sac in the skin. They have a locomotory function.

The excretory system: It consists of series of metamerically arranged paired tubes, called nephridia or segmental organs. They are absent in the anterior and posterior segments.

A nephridium is made up of:

-nephridial tubule: long, narrow, highly convoluted and mostly ciliated duct.

-terminal duct: it is without cilia and opens to the exterior at the base of the parapodium.

-nephridiopore: fine rounded pore, which is capable of being widened or contracted.

-nephrostome: ciliated funnel-like opening.

Digestive System:

Alimentary canal is a straight tube extending from anterior to posterior end of the body. The anterior opening is the **mouth** and posterior opening the **anus**. Mouth is located on ventral side of peristomium and opens into the **buccal cavity**, which carries teeth. **Pharynx** is a large chamber and is lined internally by cuticle. One pair of **jaws** is present at the posterior end of pharynx. Pharynx can be protruded out of mouth by protractor muscles and can be withdrawn by retractor muscles**. Oesophagus** occupies five segments and receives **a pair of glands**. It communicates with stomach–intestine, which is a straight tube that is constricted in each segment. A distinct stomach is absent in *Nereis*. Epithelial lining of mid-gut contains gland cells which secrete digestive enzymes. Rectum is the last part of intestine and opens to outside by anus. *Nereis* is a carnivore and feeds on small animals such as crustaceans, molluscs, sponges and other animals.

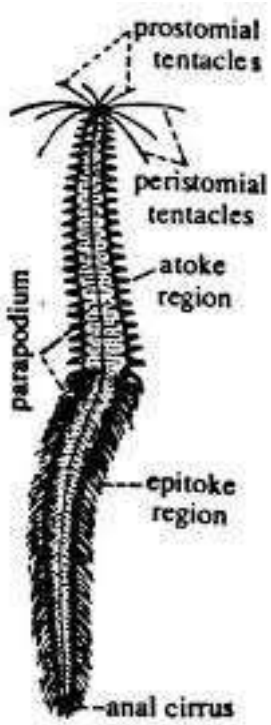
Prey is captured by the eversion of pharynx, which brings the jaws in front to grasp the prey. Retraction is caused by contractions of retractor muscle which brings the prey deep into the pharynx. The ingested food is masticated in the buccopharyngeal region by teeth. Food passes through the intestine by peristalsis and digestion is mainly extracellular and the food is digested by the digestive juices .

Reproductive System *Nereis* is dioecious as sexes are separate. Gonads develop only during the breeding season, in the summer months. Gametes are released as spermatogonia in male and as oogonia in female into the coelomic cavity where they undergo maturation to develop into spermatozoa and ova, respectively. There are no gonoducts and mature sperms and ova are discharged to the outside in water either through nephridial tubules or by the rupture of body wall. Eggs hatch into a larval stage called trochophore. This larva is ciliated, unsegmented and almost pear-shaped. The trochophore swims about

by its ciliated bands. Gradually the larva metamorphoses into a young worm which settles at the bottom of the sea and starts burrowing life.

Heteronereis: Some species of *Nereis* exhibit dimorphism and two distinct phase. The body is divisible into two parts. The anterior or asexual part is called '**Atoke**' and the posterior or sexual part is called **'Epitoke'**. The changes of the posterior half of the body are:

1- Parapodia become enlarged.
2- Setae become oar-shaped which help in swimming.
3- Dorsal and ventral cirri appears to be highly large.
4- The notopodium and neuropodium become large and leaf like and act as fins and gills.
5- Due to excessive development of gonads, the muscles and alimentary canal are reduced.



Example: *Lumbricus* (Earth worm)

The common earthworm, *Lumbricus terrestris*, or one of its near relatives, is usually used as a type in introductory courses in Zoology.

External features. - The body of *Lumbricus* is cylindroid, and varies in length from about six inches to a foot. The segments are easily determined externally because of the grooves extending around the body. At the anterior end a fleshy lobe, the prostomium, projects over the mouth; this is not considered a true segment. Segments 31or 32 to 37 are swollen in mature worms, forming a saddle-shaped enlargement, the clitellum, of use during reproduction. Every segment except the first and last bears four pairs chitinous bristles, these may be moved by retractor and protractor muscles, and are renewed if lost. The setae on ,segment or somite 26 are, in mature worms, modified for reproductive purposes. The body is covered by a thin, transparent cuticle secreted by the cells lying just beneath it. The cuticle protects the body from physical and chemical injury; it contains numerous pores to allow the secretions from unicellular glands to pass through.

A number of external openings of various sizes allow the entrance of food into the body, and the exit of feces, excretory products, reproductive cells (1) The mouth (2) The oval anal aperture lies in the last

somite. (3) The openings of the sperm ducts one on either side of somite 15. (4) The openings of the oviducts, one on either side of somite 14; eggs pass out of the body through them. (5) The openings of the seminal receptacles appear as two pairs of minute pores concealed within the grooves which separate somites 9 and 10, and 10 and 11. (6) A pair of nephridiopores by means of dorsal pores.

Internal anatomy:

The body is essentially a double tube , the body wall constituting the outer, the straight alimentary canal, the inner; between the two is a cavity, the coelom. The external segmentation corresponds to an internal division of the coelomic cavity into partitions, called septa, which lie beneath the grooves.

Digestive system. - The alimentary canal consists of (1) a mouth cavity or buccal pouch in somites 1 to 3, (2) a thick muscular pharynx lying in somites 4 and 5, (3) a narrow straight tube, esophagous which extends through somites 11 to 14, (4) a thin-walled enlargement, the crop or proventriculus, in somites 15 and 16, (5) a thick muscular-walled gizzard in somites 17 and 18, and, the gizzard is a grinding organ; in it the food is broken up into minute fragments by being squeezed and rolled about.(6) a thin-walled intestine extending from somite 19 to the anal aperture. The intestine is not a simple cylindrical tube; but its dorsal wall is folded, forming an internal longitudinal ridge, the typhlosole. This increases the digestive surface. Surrounding the alimentary canal and dorsal blood vessel is a layer of chloragogen cells. The functions of these cells are not known, but they probably aid in the elaboration of food and are excretory. Three pairs of calciferous glands lie at the sides of the esophagus in segments 10 to 12; they produce carbonate of lime, which probably neutralizes acid foods.

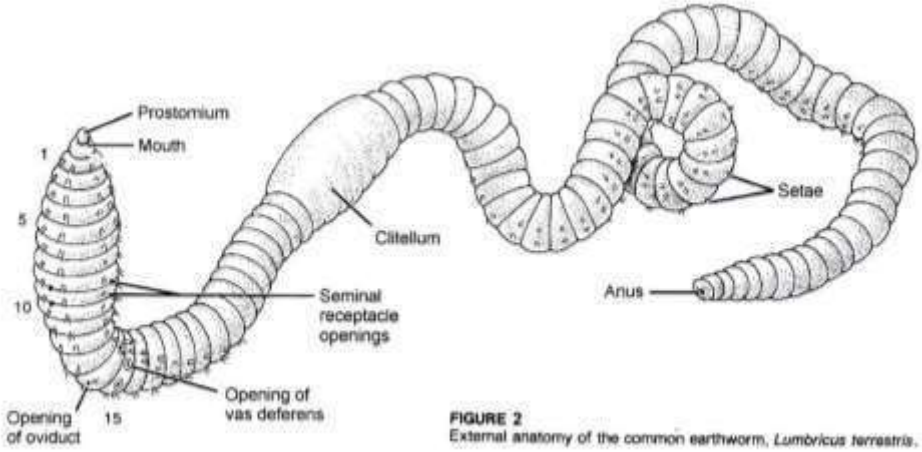
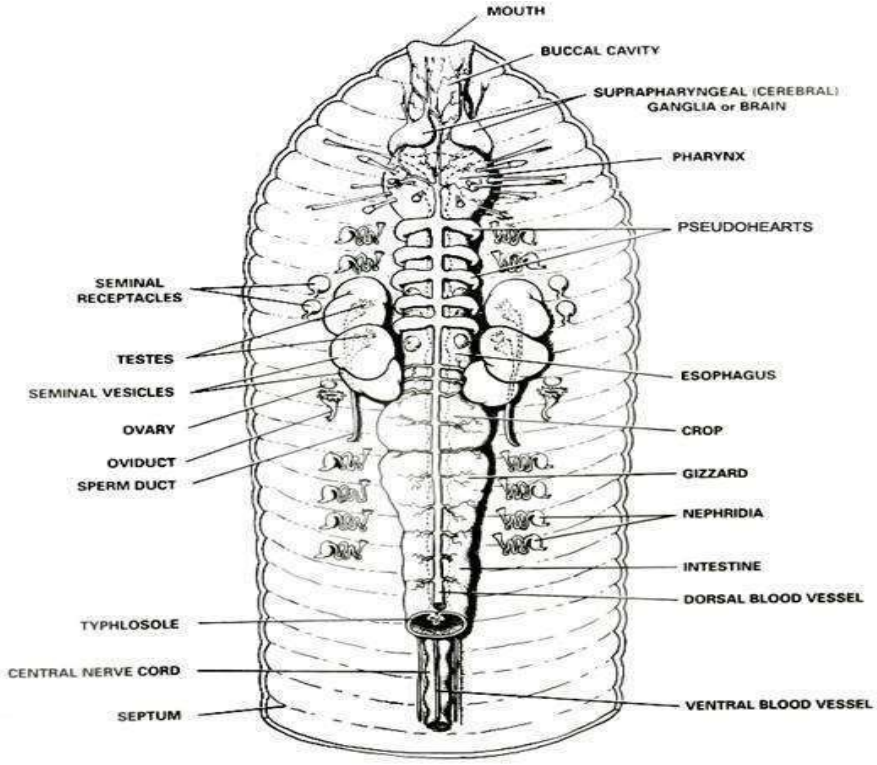


FIGURE 2
External anatomy of the common earthworm, *Lumbricus terrestris*.



Excretory system. - Most of the excretory matter is carried outside of the body by a number of coiled tubes, termed nephridia, a pair of which are present in every somite except the first three and the last.

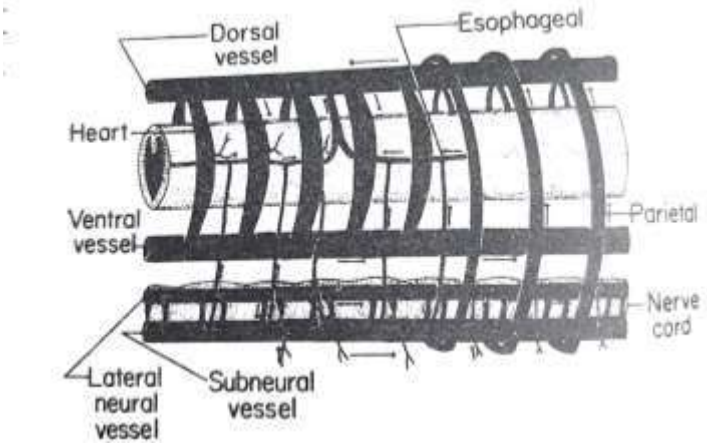
Reproduction. -Both male and female sexual organs occur in a single earthworm. The female system consists of: (1) a pair of ovaries in segment 13; (2) a pair of oviducts which open by a ciliated funnel in segment 13, enlarge into an egg sac in segment 14, and then open to the exterior; and (3) two pairs of seminal receptacles in somites 9 and 10. The male organs are (1) two pairs of glove-shaped testes in segments 10 and 11, (2) two vasa deferentia which lead from ciliated funnels to the exterior in segment 15, and (3) three pairs of seminal vesicles in segments 9, 11, and 12, and two central reservoirs. Self-fertilization does not take place, but spermatozoa are transferred from one worm to another during a process called copulation.

Two worms come together, slime tubes are formed, and then a band-like cocoon is secreted about the clitellar region. Eggs and spermatozoa are deposited in the cocoon, but fertilization does not occur until the cocoon is slipped over the head.

Respiration. - The earthworm possesses no respiratory system, but obtains oxygen and gets rid of carbon dioxide through the moist outer membrane.

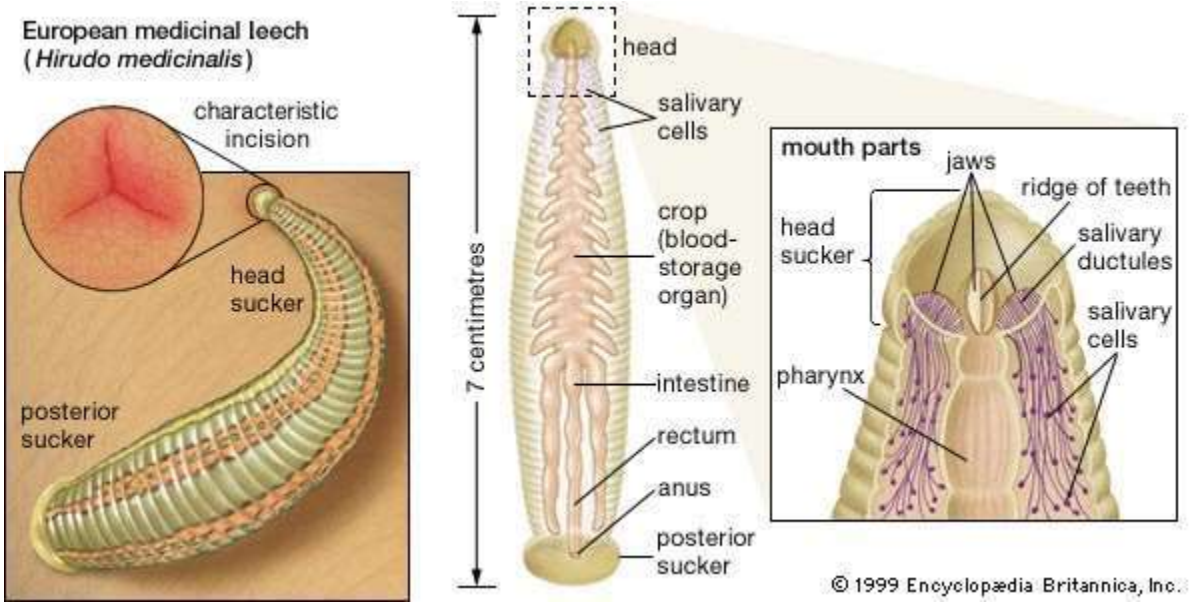
Circulation: The blood of the earthworm circulates through a complex series of closed tubes. Of these, the dorsal blood vessel is largest and is present just dorsal to the digestive tract. It is connected with the

smaller ventral blood vessel by a series of 5 pairs of hearts which pass around the digestive tract in segments 7-11.



Example: Hirudo medicinalis

Commonly called Indian Cattle leech. Ectoparasite on cattle and even on man. Setae, prostomium, appendages and distinct head are absent. Only a well-developed posterior sucker is present. The anterior sucker being reduced. Each segment is further divided into 5 annuli except first two and last seven segments. Anterior and posterior segments smaller in size and middle ones larger. First five segments bear paired eyes. Tri-radiate mouth is located on ventral side, proboscis non- protrusible and Jaws three and well developed. Male genital pore is located on 10th and female genital pore on 11th segments mid-ventrally. Hermaphrodite and reproduction sexual. Salivary glands are found in pharyngeal wall secret anticoagulant enzyme (Hirudin).



Phylum Arthropoda

Phylum Arthropoda (ar-throp_o-da) (Gr. *arthron,* joint, _ *pous, podos,* foot) is the largest group of the animal kingdom, composed of more than 80% of all known species. Approximately 800,000 species of arthropods have been recorded, and probably at least as many more remain to be classified.

Characteristics of Phylum Arthropoda

1. **Triploblastic** animal with **Bilateral symmetry**; metameric body (external metamerism) divided into tagmata consisting of **head, thorax, and abdomen**; or **cephalothorax** and **abdomen**
2. Jointed appendages; primitively, one pair to each somite, these appendages give arthropods generalized appendages which were modified, specialized and adapted for:
    - **Locomotion**: (walking legs, tails and wings)
    - **Feeding**: (mouth parts and pincers)
    - **Sensory reception**: (antennae)
    - **Defense**: (pincers, stingers)
3. Body is covered with exoskeleton made of chitinous cuticle which is often hard, but it is flexible in trunk and limbs to provide moveable joints. This exoskeleton is secreted by underlying epidermis and shed (molted) at intervals. The presence of thick cuticle prevents the water loss, and enabled arthropod to invade land, so arthropod regard the only invertebrates which have adapted to live on land on a high level scale.
4. Complex muscular system.
5. **Reduced coelom** in adult; most of body cavity consisting of haemocoel (sinuses) filled with blood.
6. **Complete digestive system**; starts with mouth and ends with anus.
7. **Open circulatory system,** with dorsal heart and arteries but without capillaries.
8. Respiration by **body surface**, **gills, tracheae (air tubes),** or **book lungs**.

9. Paired excretory glands called **coxal green, or maxillary glands**, some with other excretory organs, called **Malpighian**.
10. Nervous system has paired dorsal ganglia over the mouth, with connectives to a pair of ventral nerve cords.
11. Sexes **usually separate**, with paired reproductive organs and ducts; usually internal fertilization; **oviparous** or **ovoviviparous**.
12. Cilia are entirely absent from all parts of the body.

Classification of Arthropoda

Arthropoda can be classified in to four sub phyla

1. **Sub phylum: Onychophora** **Ex: *Peripatus***
2. **Sub phylum :Trilobitomorpha**
3. **Sub phylum : Mandibulata**
   - **a- Class: Crustacea** **Ex: *Astacus* (Crayfish)**
   - **b- Class: Insecta**
   - **c- Class: Chilopoda** **Ex: *Scolopendra***
   - **d- Class: Diplopoda** **Ex: *Julus***
   - **e- Class:Pauropoda** **Ex: *Pauropus***
   - **f- Class:Symphyla**
4. **Sub phylum :Chelicerata**
   - **a- Class: Merostomata** **Ex: *Limulus***
   - **b- Class: Arachnida** **Ex: *Buthus, Argiope***
   - **c- Class: Pycnogonida** **Ex: *Pycnochonum***
   - **d- Class: Tardigrada**
   - **e- Class: Pentastomida**

1-Sub phylum :Onychophora (Example :*Peripatus*)

Members of Sub phylum Onychophora (on-y-kof_o-ra) (Gr. *onychos,* claw, _ *phora,* to bearing) are commonly called "velvet worms". They live in rain forests and other moist, leafy habitats in tropical and subtropical regions. The onchophoran have been described as the connecting link between arthropods and annelids.

Characteristic features of Onychophora

1. Indistinctly segmented, with elongated bodies
2. Short antennae
3. Stumpy legs present on all segments except the first and last
4. Entirely terrestrial and found in moist tropical areas.

Ex: *Peripatus*

Habitat of *Peripatus*:

Peripatus is a terrestrial animal, found living in moist places such as crevices of rock, under bark, under fallen leave and damp places. It is a nocturnal in nature and carnivorous in feeding habit. Most species of it are predaceous and feed on small intestine for instance, snails, insects and worms.

External Morphology of *Peripatus*

The body of this animal is characterised by its caterpillar-like with soft and bilateral symmetry. Its length ranged from 1.4 cm – 15 cm, the external segmentation is indistinct and marked only by the presence of paired appendages. The color varies according to the species from dark grey to brown.

The entire body of *Peripatus* is divided into indistinct head and elongated trunk (Fig. 1).

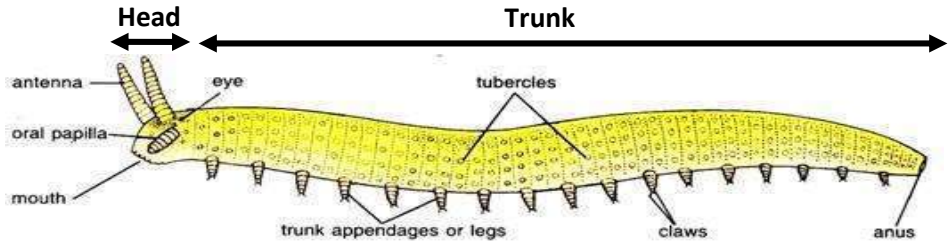


Figure (1): *Peripatus* external feature

1. **The head:** the head of *Peripatus* bears a pair of simple and dorsal eyes, a pair of antennae which represent the first pair of appendages, a pair of jaws or mandibles which represent the second pair of appendages, and a pair of oral papillae which regarded as a third pair of appendages, and found on both sides of head (figure 2-A). On the terminal end of each oral papillae, there is a special kind of gland called slime gland. Mouth is located on the ventral side of the head. The anus lies on the posterior end of the body, and the genital opening lies on the ventral surface between the last pair (Fig.2-B).

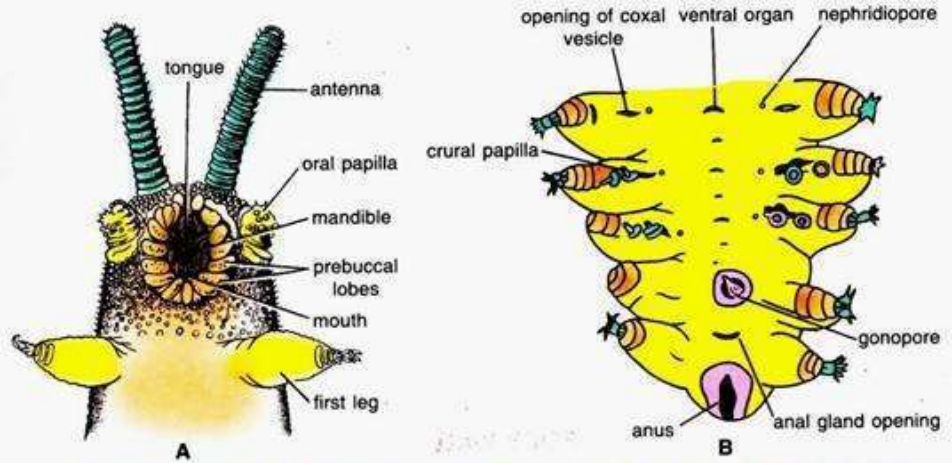


Figure (3): ***Peripatus*** **A- Anterior end in ventral view B- Posterior end in ventral view**

2. **The trunk**: This structure is lacking of exoskeletal covering, and its skin has many papillae like ridges. It posses appendages or legs which differ in number from 14-43 pairs depending on the species and sex. Each leg consists of two main divisions, the leg and foot. The foot is large, hollow, conical and unjointed protuberance bearing a pair of terminal claws (Fig 3). At the distal end of each leg on the ventral are three to six transverse spiniferous pads, on which the leg rests when walking. The entire surface of the leg consists of numerous papillae. The foot is attached to the distal end of the leg. It is narrow and bears two sickle shaped claw, in addition two, three or four papillae.

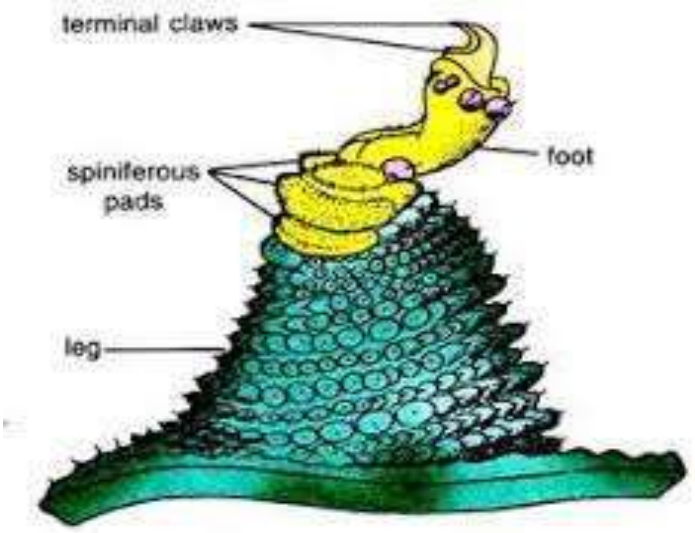


Figure (3): *Peripatus* leg

The body cavity: The body cavity is a haemocoel as in arthropods lined with epithelium, and consist of four parts, one central, two lateral and one pericardial. The central part is the largest and contains alimentary canal, reproductive organs and the slime gland. The lateral parts are much smaller, and extent within the leg. The pericardial part contains a special cellular tissue like heart (Fig.4).

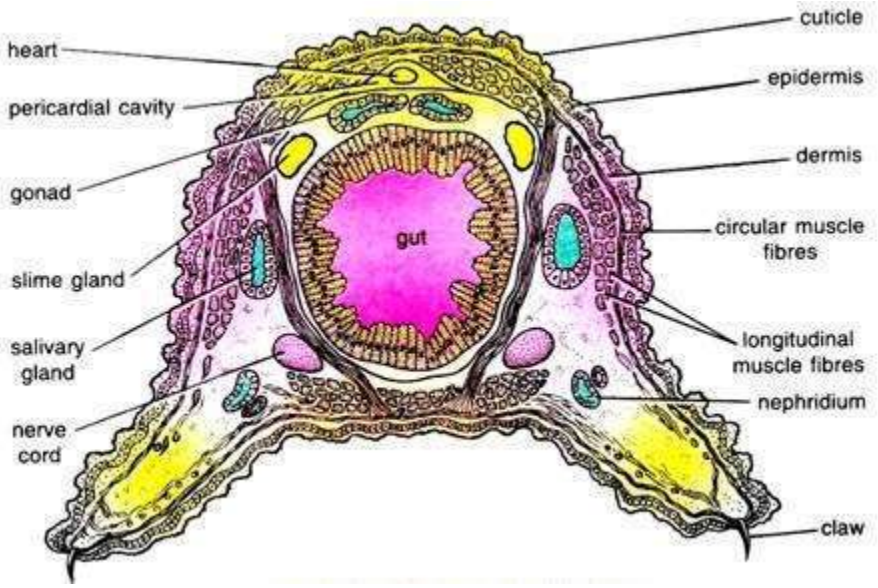


Figure (4): The body cavity

Slime glands: These glands located on each side of the body cavity, and open on the oral papillae. When disturbed by a predator, the animal can eject from the slime glands two streams of a sticky substance that rapidly hardens.

The mouth, surrounded by lobes of skin, contains a dorsal tooth and a pair of lateral mandibles for grasping and cutting prey. There is a muscular pharynx and a straight digestive tract.

Each segment contains a pair of **nephridia,** each nephridium with a vesicle, ciliated funnel and duct, and nephridiopore opening at the base of a leg.

Onychophorans are dioecious, with paired reproductive organs. Males usually deposit their sperm in spermatophores in the female seminal receptacle. A male deposits the spermatophores on a female's back, which may accumulate a number of them, then sperm can enter the body cavity and migrate into the blood to the ovaries to fertilize the eggs.

Affinities of *Peripatus*

Peripatus has no economic importance; but it is zoologically very interesting , because it exhibits both arthropod and annelid characteristics as well as peculiarities of its own.

A. Annelidan characteristics

1. Vermiform body.
2. Absence of true head.
3. Dermo-muscular body –wall, consisting of a thin flexible cuticle and the underlying circular and longitudinal muscles.
4. Locomotion slow and peristalsis as in earthworm.
5. Structure of the simple eye as in polychaeta
6. Unjointed , hollow , stumpy appendages of the nature of the extensions of the body-wall , like the parapodia of Polychaeta.
7. Simple and straight alimentary canal.
8. Segmantally arranged paired nephridia.
9. Presence of cilia in the reproductive ducts.

B. Arthropodan characteristics

1. Presence of antennae.
2. Mandibles are modified appendages provided with striped muscles.
3. Locomotion by define legs, having definite muscular and provided with claws.
4. Cuticle has a thin deposit of chitin, like that of arthropods.
5. Body-cavity is a haemocoel.
6. Coelom reduce to the cavities of excretory and reproductive organs.
7. Dorsal tubular heart with lateral ostia.
8. Presence of a tracheal respiratory system
9. Brain is large and typically arthropodan.

C. Onychophoran characteristics

1. Body shows no or indistinct external segmentation.
2. Texture of the skin.
3. Antennae not homologous to the antennae of other arthropods.
4. Three segmented head.
5. Restriction of mandibles to a single pair.
6. Irregular distribution of spiracles or tracheal openings.
7. Two ventral nerve cords widely separated and without true ganglia.
8. Structure of eyes is less complicated.

2-Subphylum Trilobita

Trilobites have been extinct for 200 million years. Their name refers to the trilobed shape of the body, caused by a pair of longitudinal grooves, they ranged from 2 to 67 cm in length.

1. Their exoskeleton contained chitin, strengthened in some areas by calcium carbonate.
2. There were three tagmata in the body: **head, thorax, and pygidium.**
3. Their head was one piece.
4. Two longitudinal furrows divided the body longitudinally.
5. Their thorax had a variable number of somites; and the somites of the pygidium, at the posterior end, were fused into a plate.
6. Their head bears a pair of antennae, compound eyes, mouth, and four pairs of jointed appendages.
7. Each body somite except the last one also bear a pair of biramous (two-branched) appendages. One of the branches had a fringe of filaments that may have served as gills (Figure 5).

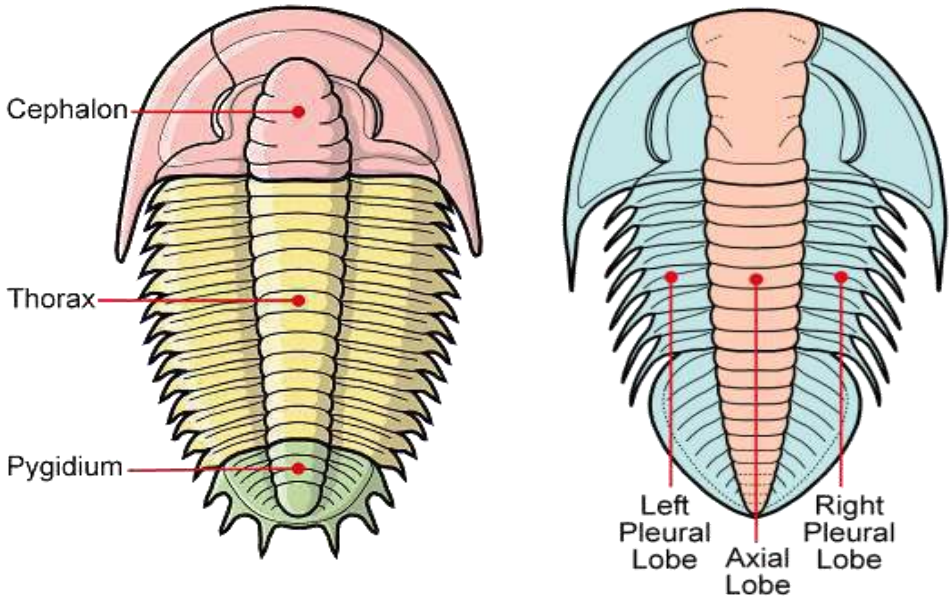


Figure (5): External feature of Trilobita

3-Subphylum Mandibulata

A- Class: Crustacea

- Body divided into cephalothorax (head+thorax) and abdomen.
- The length of crustacea ranged from less than a millimetre to 4 metres.
- Crustaceans are the only arthropods with **two pairs of antennae.**
- A pair of mandibles and two pairs of maxillae on the head, followed by a pair of appendages on each body segment or somite. All appendages, except the first antennae, are primitively **biramous** (two main branches)
- Respiration by **gills or body surface.**

Example *Astacus* (Crayfish)

External features

The body of Crayfish consist **of two well defined regions**: the anterior **cephalothorax** and posterior **abdomen**.

Cephalothorax segments consists of (**5 cephalic segments + 8 thoracic segments**) and covered by a hardened **carapace**, and it has a projection to the front of the head called **rostrum**, this structure have eye stalks on both sides of it, these stalks bears a compound eye (Figure 6). The portion of carapace covering the head region is separated from that covering the thoracic region by the dorsal cervical groove. On the lateral side of the carapace, the branchiostegite (dorsal and lateral branchial region of carapace), covers the gills.

Abdomen: The abdomen is composed of **six segments** and modified posterior extension, the telson which may or may not be considered a true segment (Figure 6).

Openings: Several openings may be seen on the ventral side such as (Figure 7):

- Mouth: mouth is in the head region and is surrounded by the jaws and other mouthparts.
- Anus: the anus is in the telson.
- Opening of the oviducts are at the base of the **third** pairs of walking legs.
- Openings from vas deference are at the base of the **fifth** walking legs.

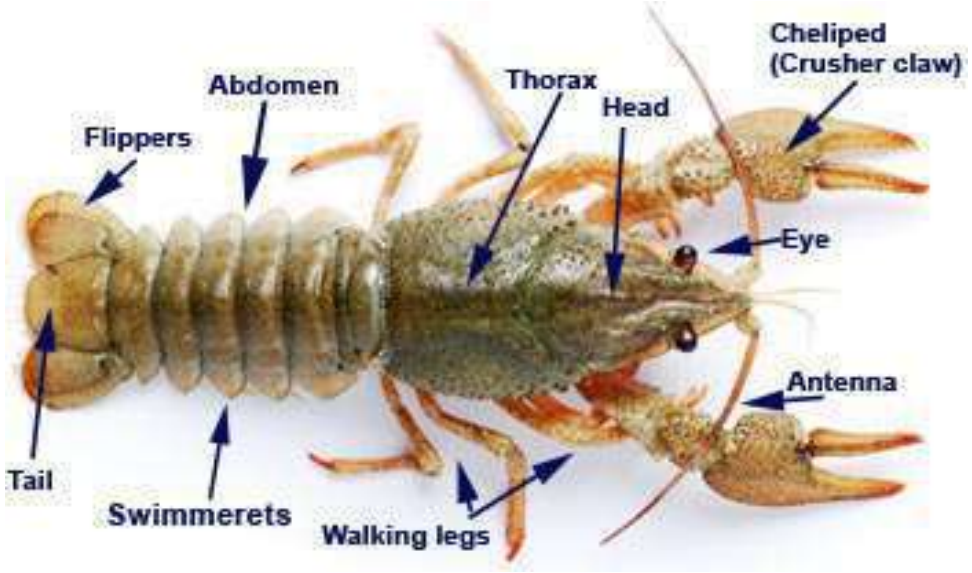


Figure (6): External feature of *Astacus*.

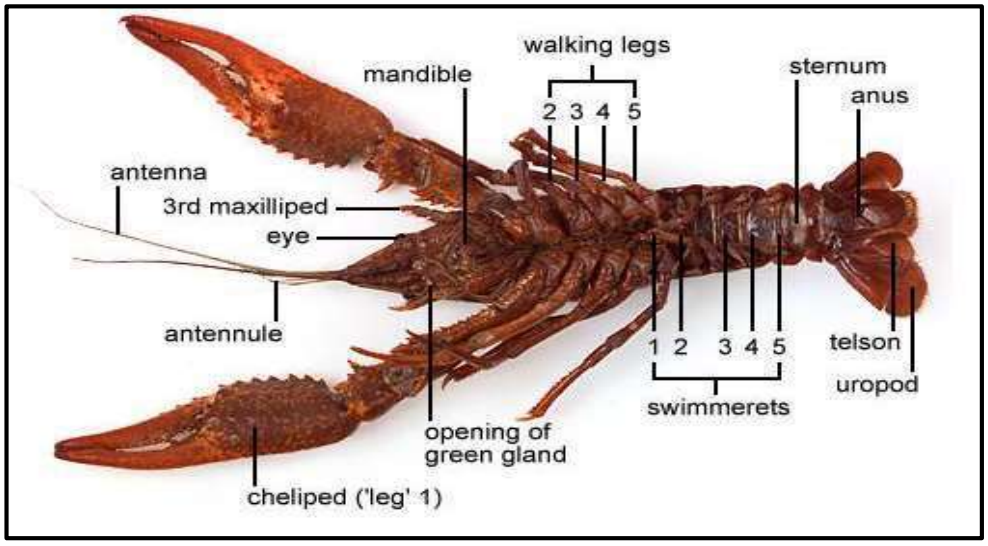
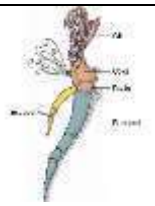
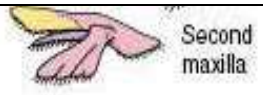


Figure (7): The ventral side of *Astacus*

Appendages: there are three **types** of appendages in *Astacus*

1- **Biramous**: The basal portion, bears a lateral exopod and a medial endopod. ex: **swimmerets** and **antennules.**	
2- **Follaceous:** its segment modified to leaf-like structure ex:second maxillae.	
3- **Uniramous:** having a single branch only (endopod) ex: walking legs.	

Appendages of Crayfish (Figure 8):

1- Cephalic Appendages:	**The function**
• Antennae(1^{st} & 2^{nd})	Touch , taste
• Mandibles	Crushing food
• 1^{st} ,2^{nd} Maxillae	Food handling and bailing water from gill chamber.
2- Thoracic Appendages	**The function**
• 1^{st} , 2^{nd} & 3^{rd} Maxillipeds	Touch , test and food handeling
• 1^{st} walking leg (Cheliped)	Offense and defense
• 2^{nd} & 3^{rd} walking legs	Walking & prehension
• 4^{th} & 5^{th} Walking legs	Walking
3- Abdominal Appendages	**The function**
• 1^{st} swimmeret	In female protopod reduced or absent in male modified to transfer sperm to female.
• 2^{nd} swimmeret Male Female	 Transfer sperm to female Creating water currents ; carrying eggs and young.
• 3^{rd} , 4^{th} and 5^{th} swimmeret	Creating water currents; in female carrying eggs and young.
• Uropod	Swimming; egg protection in female.

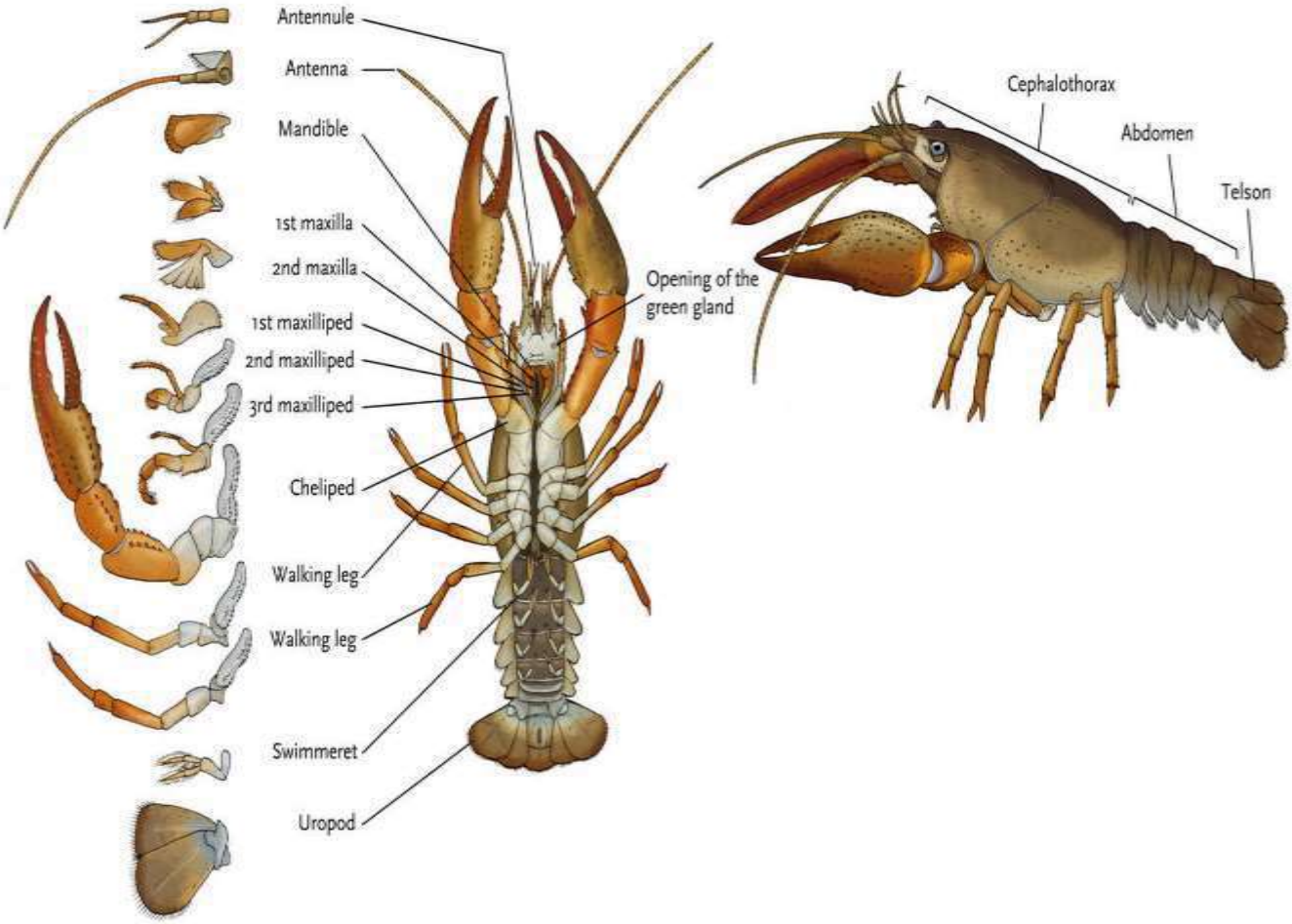


Figure (8): Types of appendages in *Astacus*

Internal Anatomy:

Digestive System:

Digestive tract divided into three main regions:

1- Foregut **2- Midgut** **3- Hindgut**

1- Foregut: the **mouth**, which opens between the jaws on the ventral surface, leads into the short **esophagus** and then into the stomach. The stomach is divided into **two main parts**: the **cardiac stomach** and the **pyloric stomach**. The cardiac stomach is a large sac-like structure in which food is stored, while the digestion occurs in a pyloric stomach. Digestive glands (liver) are located on each side of pyloric stomach which produce digestive enzymes. Undigested material passes into the hindgut (rectum) that opens into anus.

2- Midgut: the digestion and absorption of food occur in the midgut. This portion of the digestive tract consist of short intestine to which are connected large digestive diverticula, these are complex in both structure and function. Two diverticula are lateral in position and one is dorsal. the two lateral ones are often termed "**livers**" their secretion is both **proteolytic and lipolytic**.

3-Hindgut: the hindgut consists of the long straight intestine which broadens into the short rectum just before the anus (figure 9).

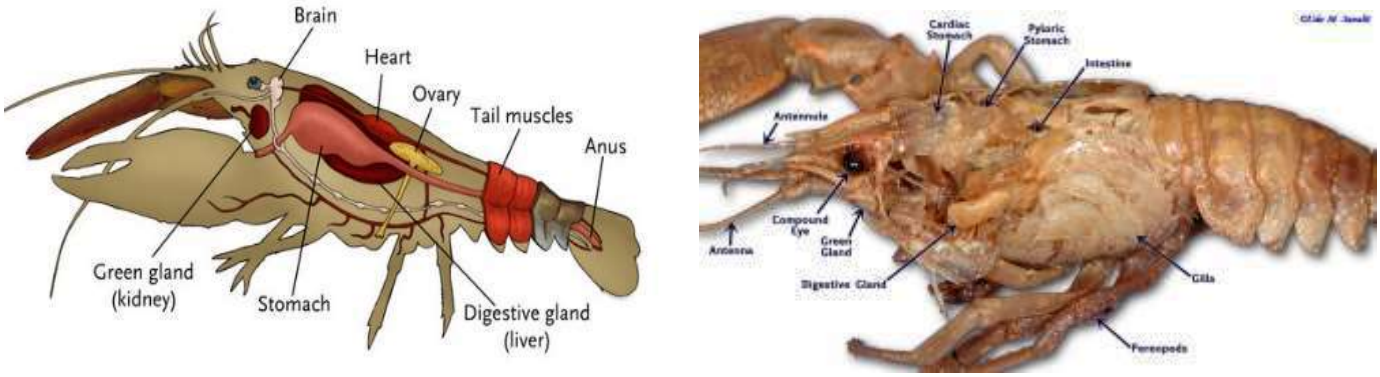


Figure (9): Digestive system in *Astacus*

Nervous Systems The nervous systems of crustaceans and annelids have much in common, although those of crustaceans have more fusion of ganglia. The brain is a pair of **supraesophageal ganglia** that supplies nerves to the eyes and two pairs of antennae. A fusion of at least five pairs of ganglia that supply nerves to the mouth, appendages, esophagus, and antennal glands. The double ventral nerve cord has a pair of ganglia for each somite and nerves serving the appendages, muscles, and other parts (figure 10).

Circulatory System: heart is a single-chambered sac of striated muscle located in the dorsal portion of the thoracic region, blood enters the heart through three pairs of ostia. Crayfish has open circulatory system (no veins), the abdominal aorta (toward the posterior, and anterior dorsal aorta (toward the anterior). Blood flows from the dorsal arteries to capillaries and then into tissue spaces called sinuses which function as veins. The blood flows over the gills before returning to the heart.

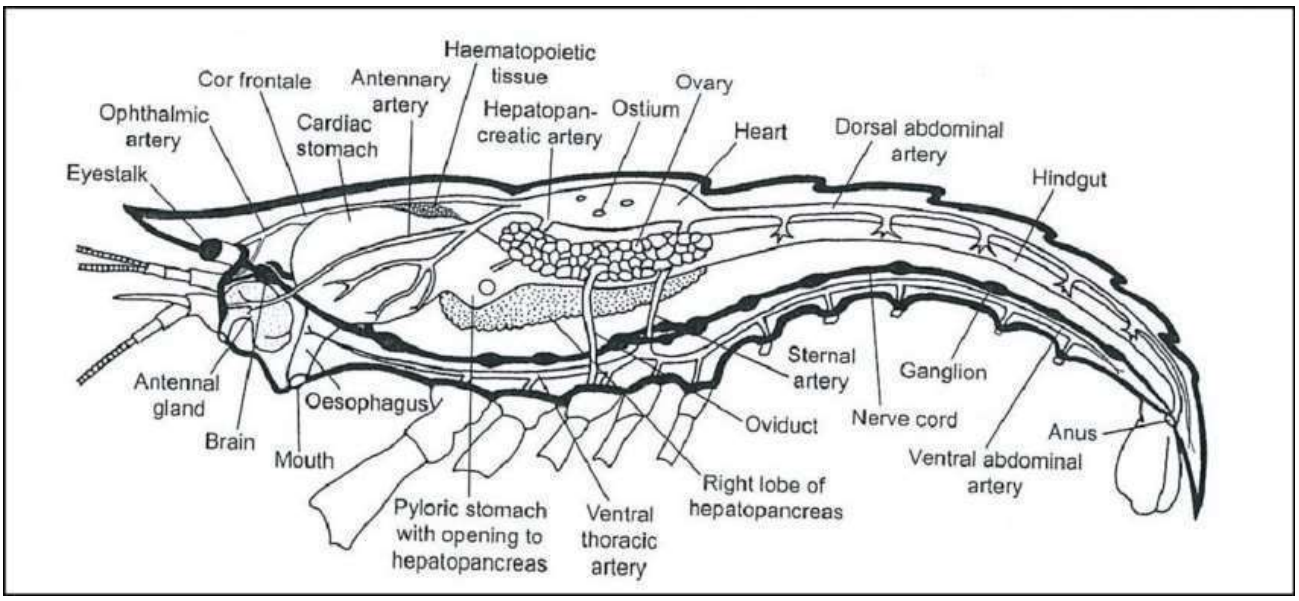


Figure (10): Internal anatomy of *Astacus*

Excretory System: The excretory system consist of a pair of green gland lying in the head region, each organ possesses end sac, glandular region (labyrinth) for waste removal and bladder. The labyrinth connects by an excretory tubule to a dorsal bladder, which opens to the exterior by a pore on the ventral surface of the basal antennal segment (figure 11).

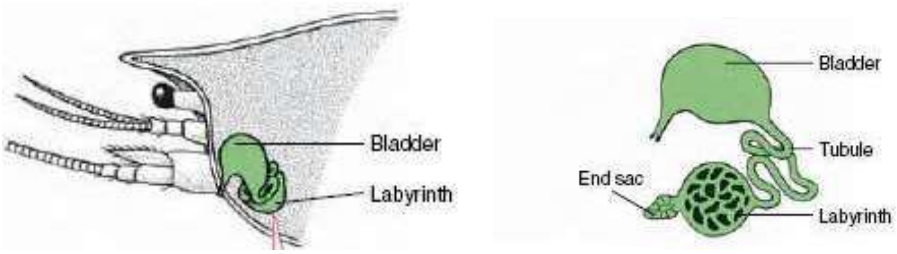


Figure (11) Excretory system in crayfish

Respiratory system: 17 pairs of gills located in the bronchial chamber on the lateral side between carapace and the body. These gills are attached to the chelipeds and walking legs. The blood passes through the gills where the carbon dioxide releases and oxygen picks up (figure 12).

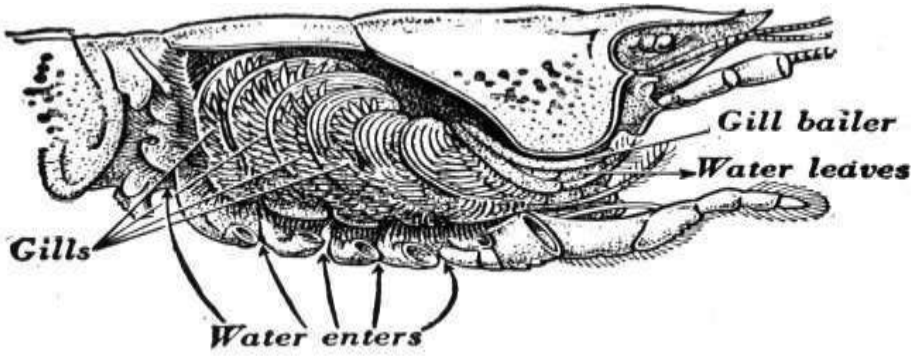


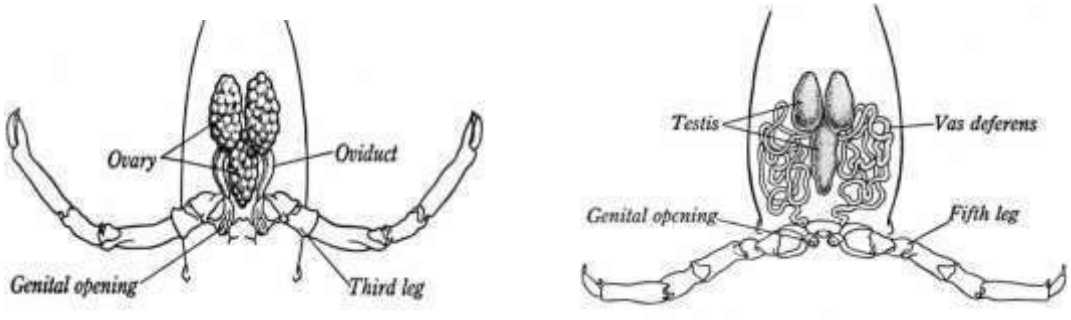
Figure (12): Respiratory system in crayfish

Reproductive system: the gonads lie in the **cephalothorax** beneath the **pericardium** and above the **gut**.

The ovaries and the testes are similar in shape and each consist of hollow, three –lobed, two sac laying anteriorly and one posteriorly.

The oviducts are short, thin walled, and almost straight, passing vertically downwards to their openings on the **3rd** walking legs (figure 13-A).

The vasa deferentia are long , and coiled , the straighter , terminal , muscular portions leading downwards to open on the **5th** walking legs (figure 13-B).



A B

Figure (13): reproductive system in *Astacus*;

A- female reproductive system, B- Male reproductive system

Regeneration & Autotomy: crayfish are able to regenerate broken or lost appendages. For example, if an entire eye is removed, it is replaced by antenna like structure.

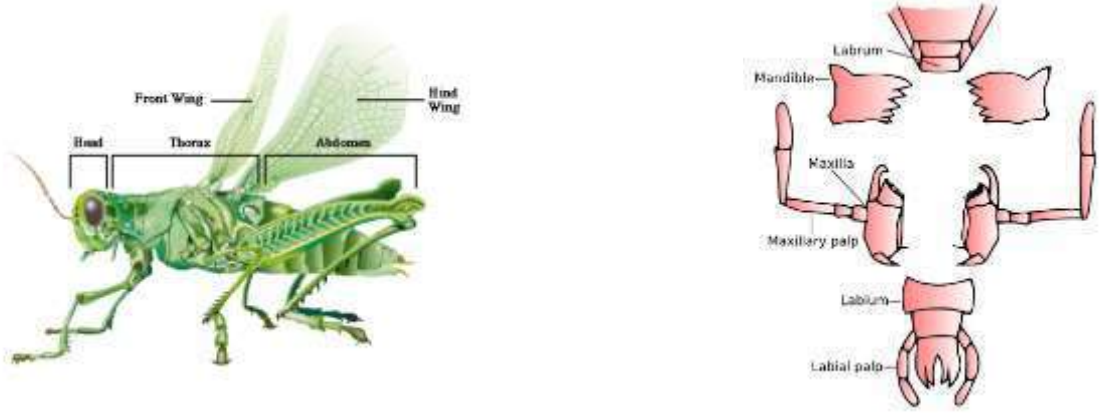
If walking legs is injured, the crayfish is able to cast it off in a process known as autotomy.

B- Class: Insecta (Hexapoda)

Insecta are the most diverse and abundant of all groups of arthropods. The general characteristic of insect are:

- The body is divided into three regions :**head , thorax and abdomen** . **three pairs of legs** are present on the thorax, and often there are one or **two pairs of wing** (figure 14-A).

- The mouth parts consist of: **the labrum, the mandibles, maxillae, labium and hypopharynx** (figure 14-B)**.**
- Most forms respire by **trachea**; only some aquatic forms possess **gills.**
- The insects are well supplies with sense organ.



A **B**

Figure 14: A- Body regions in insects **B- Mouth parts in insects**

C- Class: Chilopoda(Centipeds)

Chilopoda (ki-lop_o-da) (Gr. *cheilos,*margin, lip, _ *pous, podos,* foot), or centipedes, are land forms with somewhat flattened bodies that may contain from a few to 177 somites.

- Body is dorso-ventrally depressed.
- Antennae are long and many jointed
- Mandibles are toothed and cutting.
- Two pairs of maxillae.
- First pair of legs(maxillepeds) form poison claws
- The genital opening is situated at the hind end of the body
- Carnivorous.

Example :*Scolopendra* (ام اربعة واربعين)

- Body is elongated, dark greenish brown in color and dorsoventally flattened with numerous of segment.

- Body is divided into head and trunk.
- Head is distinct and bears a pair of antennae, a pair of mandibles and two pairs of maxillae.
- Trunk segment are 22 in number and nearly all alike
- First pair of trunk appendages or maxillipeds bears a sharp claw connected with poison gland.
- Sex are separated, genital opening situated in the last segment.
- Carnivorous, feeding on insect spiders and worms (figure 15).

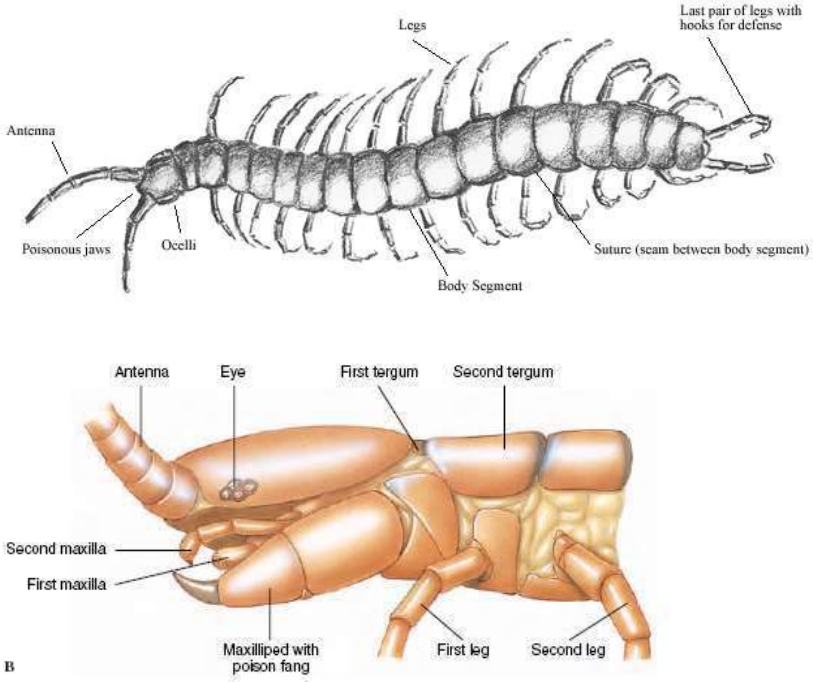


Figure (15): External feature of *Scolopendra*

D- Class: Diplopoda(Millipedes)

The Diplopoda (Gr. *diploo,* double, two _ *pous, podos,* foot) are commonly called millipedes, which literally means "thousand feet".

- Body is cylindrical or sub cylindrical.
- Antennae are short with fewer segments

- Mandible are broad and masticating
- One pair of maxillae
- Each trunk segment bears two pairs of legs mid-ventrally.
- Poison claws are absent
- The genital opening is situated at the anterior end of the body.
- Herbivorous.

Example : *Julus* (خاتم سليمان)

- *Julus* is commonly called millipede or wire worm.
- Body is elongated and cylindrical, consist of large number of segments.
- Body is divided into head, thorax and abdomen.
- Head consists of five segments, thorax of four segments and abdomen of 20-100 segments.
- Head bears a pair of short antennae, a pair of mandibles and a pair of maxillae.
- Thoracic segments with one pair of legs in each , while abdominal segments bear two pairs of legs.
- Poison claws are absent.
- Stink glands present along the sides of the body , secreting noxious substance.
- Sex are separated (figure 16).

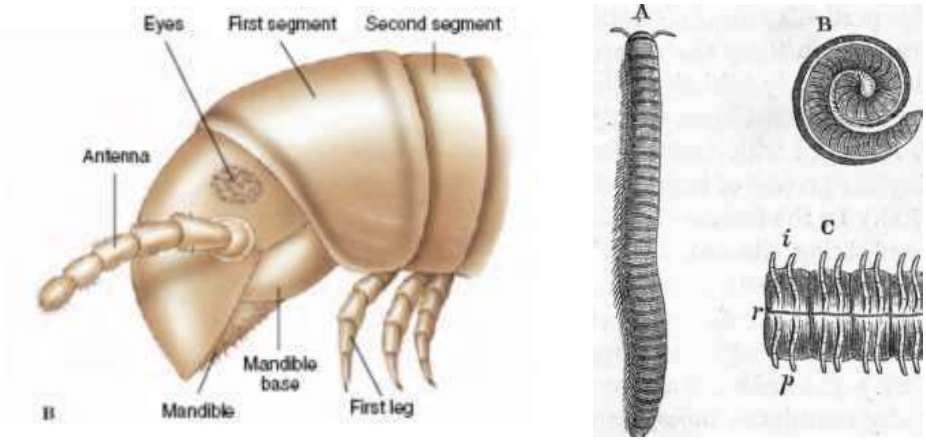


Figure (16): External feature of *Julus*.

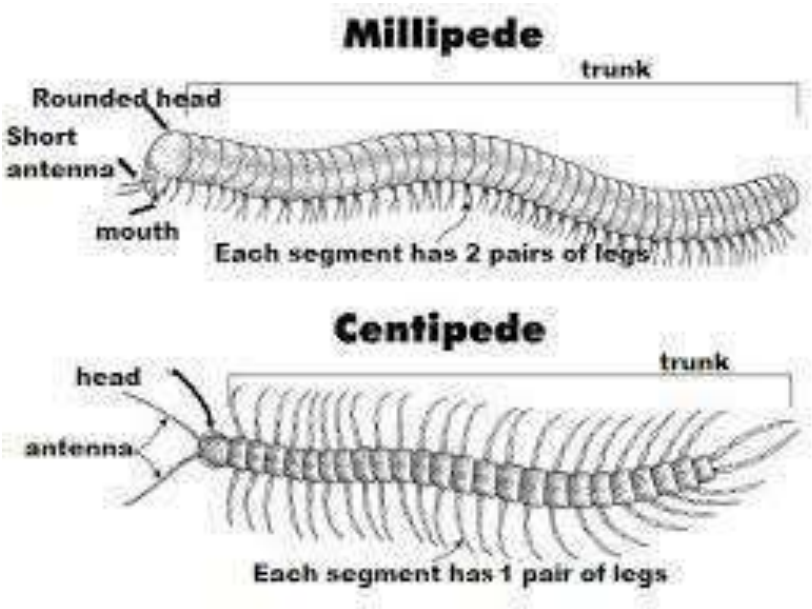


Figure (17): Difference between class: Millipede and class: Centipede

E- Class: Pauropoda

Pauropoda (Gr. *pauros,* small, _ *pous, podos,* foot)

- Pauropoda are a group of minute (2 mm or less), soft-bodies myriapods, numbering almost 500 species.
- They have a small head with branched antennae and no eyes, but they have a pair of sense organs that resemble eyes.
- Their 12 trunk segments usually bear nine pairs of legs (none on the first or the last two segments).
- They have only one tergal plate covering each two segments.
- Tracheae, spiracles, and circulatory system are lacking (figure 17).

  Ex: *Pauropus*

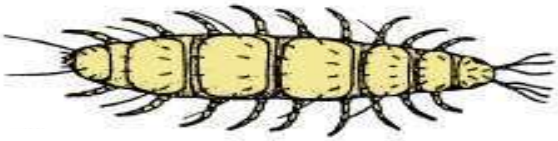
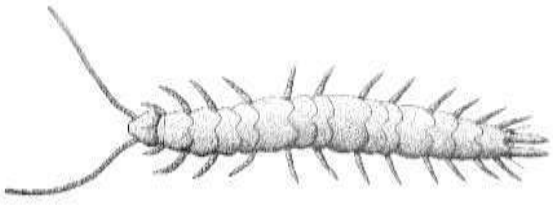


Figure (18): External feature of *Pauropus*

F- Class: Symphyla

- Are small (2 to 10 mm) and have centipede-like bodies.
- They live in humus, leaf mold, and debris.
- They are soft bodied, with 14 segments, 12 of which bear legs and one a pair of spinnerets.
- The antennae are long and unbranched.
- Only 160 species have been described.



4-Sub phylum Chelicerata

Characteristic features of Chelicerata:

- They have **no head**.
- Only **one pair** of mouth parts.
- **Unlike** all other groups of arthropods, **no antennae**.
- The body is divided into an anterior **prosoma** and a posterior **opisthosoma**. The prosoma usually consists of **eight** segments. The first segment **never bears appendages**, the second **bears paired chelicerae (feeding and grasping structures)** and the third bears **paired pedipalpi (sensory, prehensile** or **reproductive appendages**). **The fourth to seventh segments bear walking** legs (i.e. four pairs) which have small pincers (chelae) at their ends.

A- Class: Merostomata

- All are marine
- Appendages on the opisthosoma are flattened and **modified for gas exchanges as "book gills".**
- Terminal portion of the body (telson) drawn out into an elongated spike.

Example: *Limulus* (horseshoe crab)

External features

Prosoma (Cephalothorax): the body is covered by an exoskeleton consist of two tagmata **prosoma**, **opisthosoma**, in addition to the **tail spine**. The prosoma is a convex carapace horseshoe, the opisthosoma is a middle portion, and thin elongated tail called telson. The prosoma bears a pair of lateral compound eyes and pair of median simple eyes on dorsal side. Also it contains a six pairs of appendages located On the ventral side around the mouth which are:

Chelicera	Are small and are used for feeding.
Pedipalps (1^{st} walking leg)	In females they are morphologically and functionally similar to other walking legs. In male it is modified for grasping the female during mating.
2^{nd} , 3^{rd} , 4^{th} walking legs (bear claws)	In both sexes , the first 4 pairs of walking legs, including pedipalps , are each modified near the base to form a toothed food-grinding surface called gnathobase.
5^{th} walking legs(not bear claws)	Is slightly modified for cleaning the gills, and for removing mud during burrowing.

Opisthosoma (Abdomen): the abdomen bears six pairs of spines along the sides, and its ventral side, six pair of flat , plate-like appendages.

- The first of these forms the genital operculum, on the underside of which are two genital pore.
- The other five abdominal appendages are modified as gills. the underside of each gill flap bears approximately 150 leaf-like fold called lamellae.

Telson:the long slender telson or tail spine, is used for anchoring when the animal is burrowing or plowing through the sand , the anus located under the proximal end of the telson (Figure 19).

Reproduction: after several weeks of mating the egg hatch as free-swimming **trilobite** larvae, so named because their resemblance to trilobite, the larvae looks much like the adult except that it lacks the tail spine and have only two of the five pairs of book gills.

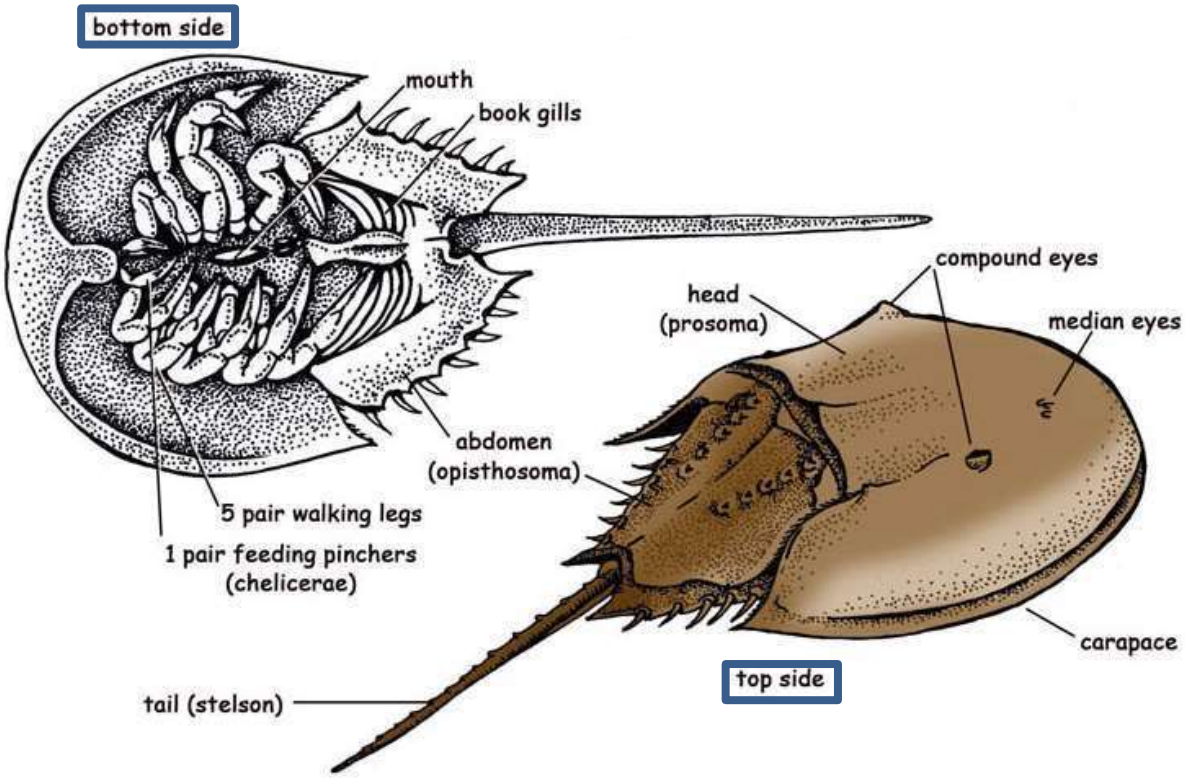


Figure (19): *Limulus* top and bottom side

B- Class: Arachnida

- The adult has six pairs of appendages: pair of chelicerae, pair of palps and four pair of walking legs.
- Segmented or unsegmented abdomen with or without appendages and generally distinct from cephalothorax.

- Respiration by **gills, tracheae, or book lungs**.
- Excretion by **malpighian tubules** or **coxal glands**.
- Dorsal bilobed brain connected to the ventral ganglionic mass with nerves, simple eyes.
- Chiefly oviparous.

Order Scorpionida

- Elongated and distinguished from the other arachnids by their large size.
- Prosoma is short and unsegmented , **broadly joined to abdomen.**
- Carapace bear 2 median and 6-10 lateral eyes.
- Opisthosoma differentiated into two portion : **mesosoma** and **metasoma.**
- Small chelicerae.
- Large and powerful pedipalps
- Respiratory by 4 pairs of **book lungs**.

Example : *Buthus* (Scorpion)

The Scorpion is a **dangerous** arthropod, widely spread in tropical and temprate region. It is nocturnal hiding away in the day time and become active during the night.

External Features:

The body, is divided into an anterior **prosoma or cephalothorax** and posterior **opisthosoma or abdomen,** the last one is subdivided into broad **mesosoma** and selender **metasoma** that end with terminal sting which have venome of different toxicity which is used to defend themselves, and to seize the prey, the pedipals are large, pincer like with sensory hairs on them which used to sense vibrations (figure 20).

The Prosoma, is covered by a dorsal **carapace** which carries dorsally a pair of large median eyes and two groups of five smaller lateral eyes; all the eyes are simple. The mouth is small and ventral. The prosoma carries **6 pairs** of appendages:

1st appendages	Chelicerae	Consist of 3 joints the distal two of which form a chela.
2nd appendages	Pedipalps	Each pedipalps consist 6 jointes, the distal two of which form large toothed pincers (offensive).
3rd , 4th , 5th & 6th appendages	Walking legs	Each consist of 7 segments: coxa, trochanter, femur, patella, libia, basitarsus and tarsus which usually bears two dorsal claws.

The mesosoma , is consist of **7 segments** in the adult, the exosceleton of each is formed of a dorsal tergum , a ventral sternum and two lateral pleural membranes.

The 1st segment	carries on its ventral surface a genital operculum which covers the single genital operator.
The 2nd segment	carries a pair of camb-like structures known as pectens (modified appendages , tactile in function) with teeth like processes on their posterior edge.
3rd ,4th , 5th & 6th segments	There are 4 paired stigmata or spiracle , they led into lung-books.
7th segment	Has no appendages

The metasoma, consist of **5 short cylindrical segments with no appendages**, each has its tergum fused with its sternum, thus forming narrow cylindrical segments. Metasoma end with **stinging apparatus** which is bulbous at the base and curved to form a sharp spine or hook, **two poison glands** that contains a neurotoxin produce by the glands and transfer via ducts to be discharge through a pore at the end of the sharp spine.

Scorpion poison is used for defense and assassinating the prey, in addition it is a lethal to human (figure 20)

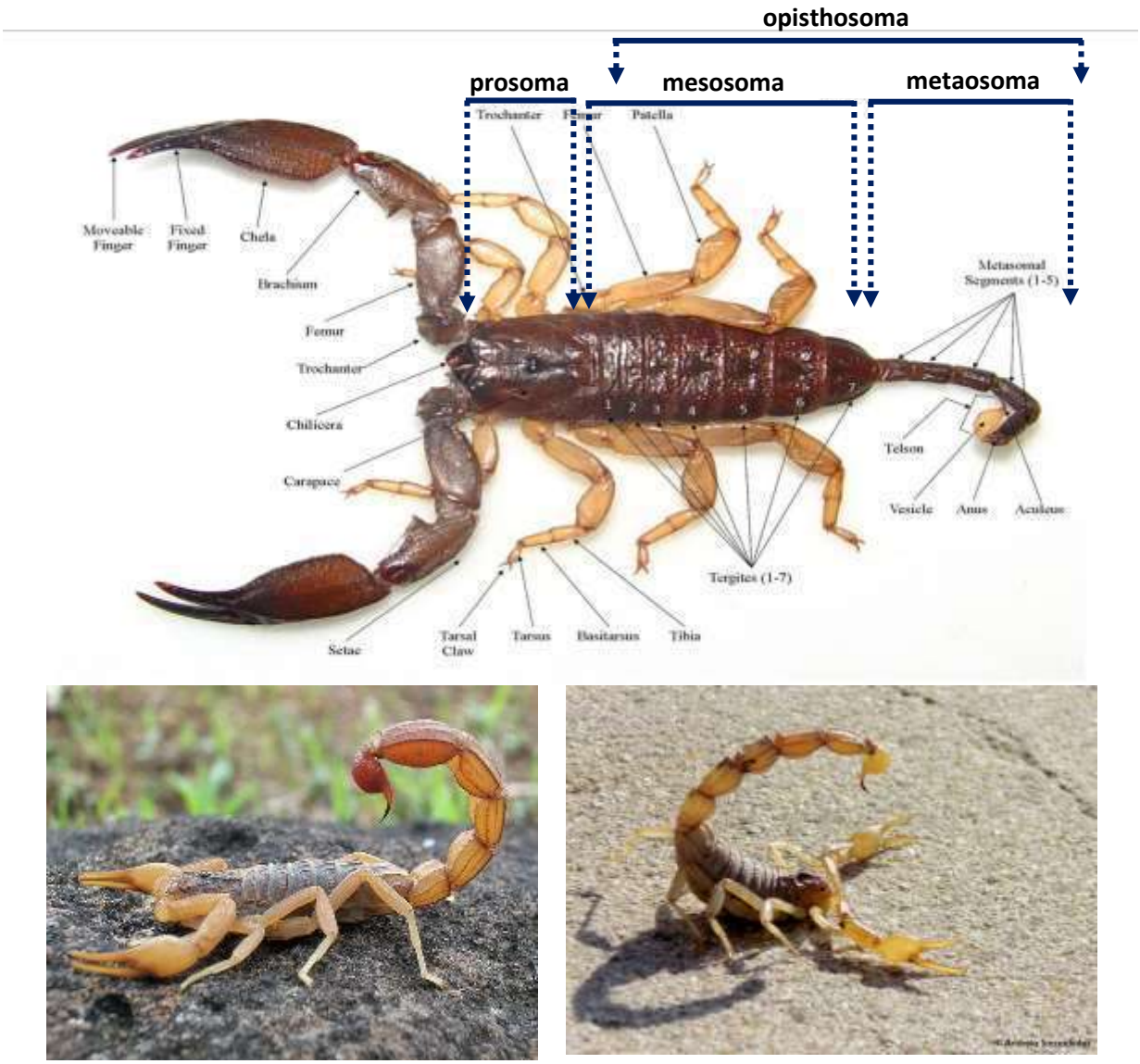


Figure (20): External morphology of *Buthus*.

Anatomy:

The heart: It is dorsal, tubular and extends within mesostoma, and has 7 pairs of ostia located in the heart wall through which the blood enters the heart. Blood leaves the heart into anterior and posterior aortae and paired lateral arteries (figure 21).

Digestive system : alimentary canal is a straight tube differentiated into:

- Mouth and pharynx
- The Mesentron : stomach and intestine
- The proctodaeum it is extremely short, and ends by the anus (figure 21) .

The Excretory System: Excretion in the scorpion is carried out by:

- **The coxal glands**: which are two small oval glands, that lie in the posterior part of the prosoma, and each opens to the exterior by short duct on coxa of the **3rd** walking legs (figure 21).
- **The Malpighian tubules**: are 2 pairs of branching tubules open in the **intestine** (figure 21)**.**

The reproductive system: the sexes are separated, the gonads lie in the mesosoma, in the male there are 2 testes, in the female , there is a single ovary (figure 21).

Nervous system: like other artropoda.

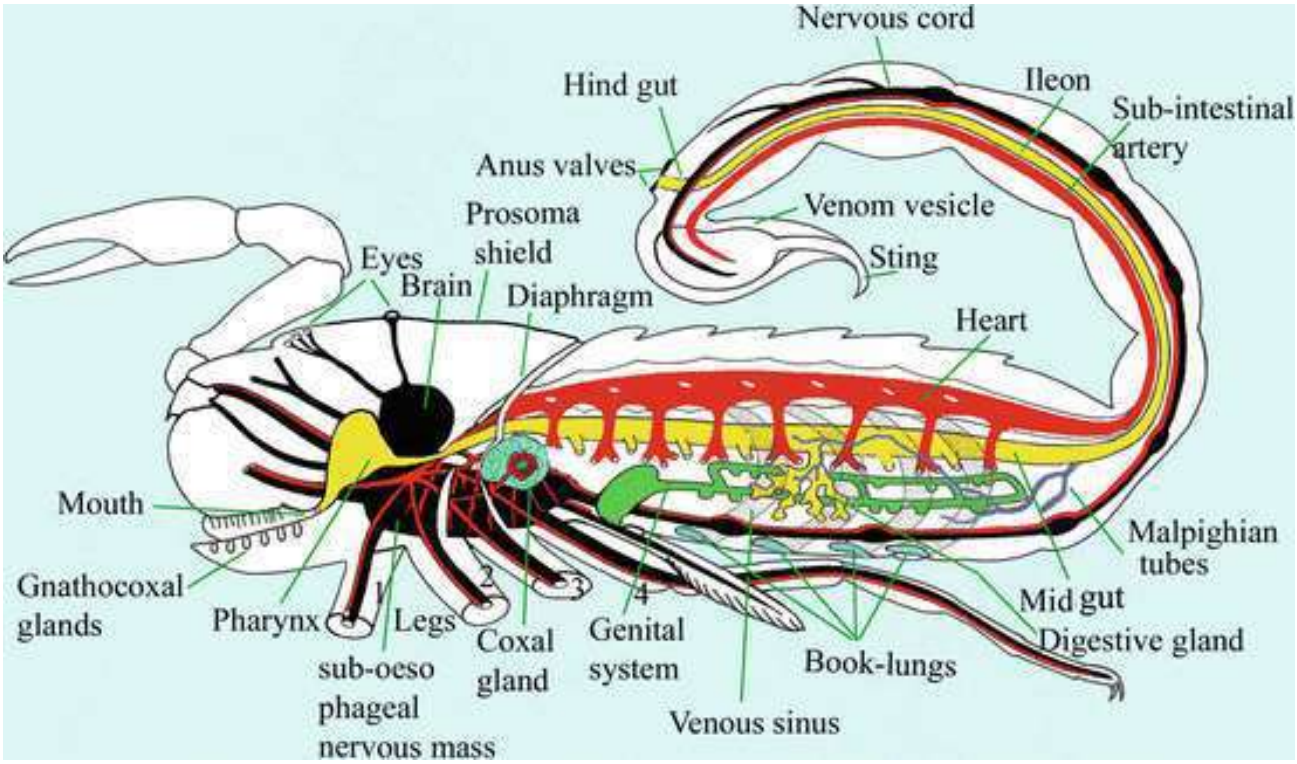


Figure (21): Internal anatomy of scorpion.

Order Araeneae (True spiders)

- Prosoma and opisthosoma both unsegmented and jointed **by slender pedicel.**
- Prosoma covered by a uniform carapace bearing not more than 8 simple eyes anteriorly.
- Opisthosoma soft, rounded, **without a telson** , **bearing 2-4 pairs of spinnerets which extrude silk**. The protein that forms silk is emitted as a liquid, but hardens as it is drawn out.
- Chelicerae, **contain poison gland**
- Pedipalps, **simple** form copulatory organ in male
- Respiratory organs 2-4 **book lungs or trachea or both**.

Example: *Argiope*

The body, is divided into anterior **prosoma** and posterior **opisthosoma**, connected to each other by narrow soft pedicel.

The prosoma (the fusion of head an thorax), is covered by a dorsal carapace, it carry 4 simple eye.

The prosoma carries 6 pairs of appendages:

1st pair	Chelicerata	Each formed only of 2 joints, a large conical joint which contains a poison gland, and hook like terminal joint which bears the orifice of the poison gland.
2nd pair	Pedipalps	Are short leg-like feeler. In male the terminal segment of each pedipalp is enlarged and modified into sexual organ , in which the sperms are sucked up and transferred to the female.
3rd ,4th ,5th and 6th pairs	Walking legs	The 4 pairs of walking leg are long and each composed of 7 segments covered with hairs , and end with 2 or 3 claws

The opisthosoma is oval, with no trace of segmentation and its skin is uniformly soft, covered with hairs, the opisthsoma carry the following:

1- **Stigmata**: there are 2 lateral stigmata which lead into a pair of book lungs.
2- **Genital opening**,
3- **Spinnerets**: there are three pairs of jointed movable processes known as the spinnerets (2 superior , 2 inferior and 2 middle) the tip of which are perforated by numerous opening of silk gland which secreted the protein that formed silk.
4- **The anus**. **(Check figure 22)**

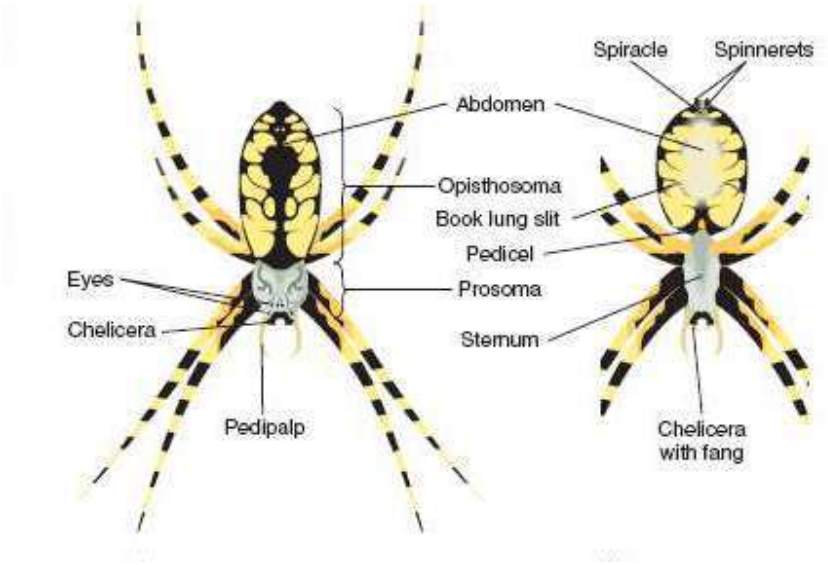


Figure 22: External morphology of *Argiope*

Respiratory System: compose of one or two pairs of book lungs and trachea, each lung compose of 15-20 thin lamellae (figure 23) .

Digestive System

All spiders are predaceous, feeding largely on insects. After a spider seizes prey with its chelicerae and injects venom, it liquefies the tissues with a digestive fluid and sucks the resulting broth into the stomach. Spiders with teeth at the bases of chelicerae crush or chew prey, aiding digestion by enzymes from their mouth.

Mouth, Esophagus, Sucking stomach, True stomach, Two caeca branched into 5caeca, Intestine associated with Liver, Rectum, (check figure 23).

Excretory System

Spiders and insects have a unique **excretory system of Malpighian tubules**, which work in conjunction with specialized rectal glands. Potassium and other solutes and waste materials are secreted into the tubules, which drain the fluid, or "urine," into the intestine. Rectal glands reabsorb most potassium and water, leaving behind such wastes as uric acid (figure 23).

Reproduction

Before mating, a male spins a small web, deposits a drop of sperm on it, and then picks the sperm up and stores it in special cavities of his pedipalps. When he mates, he inserts his pedipalps into the female genital opening to store the sperm in his mate's seminal receptacles. A female lays her eggs in a silken net, which she may carry about or attach to a web or plant. A cocoon may contain hundreds of eggs, which hatch in approximately two weeks. Young usually remain in the egg sac for a few weeks and molt once before leaving it. Several molts occur before adulthood.

Circulatory System

Circulatory System in spider compose of : Blood , Blood sinuses , heart and blood vessel , the tube like heart lie in the dorsal region and it is surrounded with pericardium , the heart connected with 2 blood vessel :

Posterior aorta: provide the posterior region

Anterior aorta: provide the cephalothorax region

From the blood sinuses the blood transported to the book lung where it oxygenated then it returns back to the heart (figure 23).

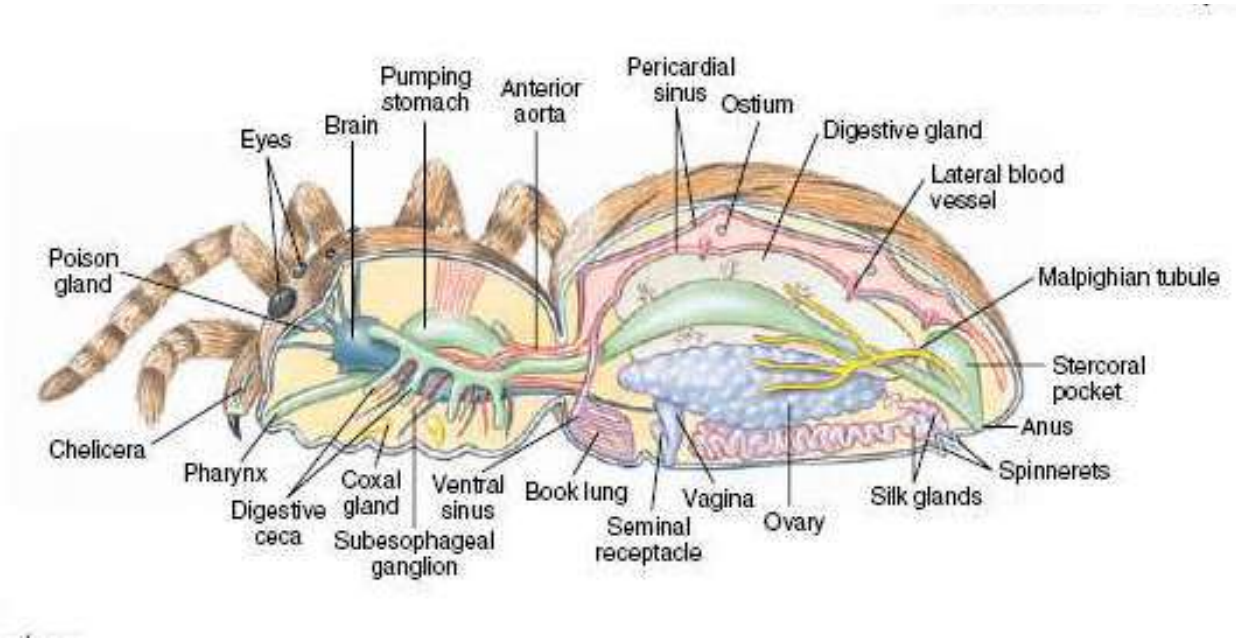


Figure (23): Internal anatomy of *Argiope*

C-Class Pycnogonida

(pik_no-gon_ida) (Gr. *pyknos,* compact, _ *gony,* knee, angle): **sea spiders.**

- Small (3 to 4 mm), but some reach 500 mm;
- Body chiefly cephalothorax; tiny abdomen;
- Usually four pairs of long walking legs (some with five or six pairs);
- Mouth on long proboscis;
- Four simple eyes;
- No respiratory or excretory system.

Example: *Pycnogonum.* (Figure 24)

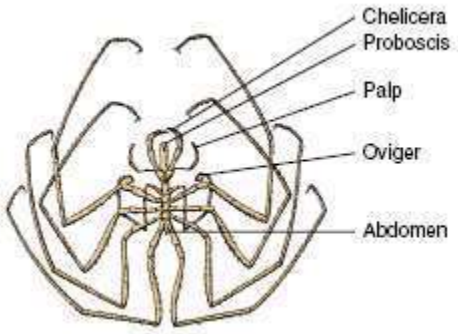


Figure (24): External morphology of *Pycnogonum*

D- Class: Tardigrada

(tar-di-gray_da) (L. *tardus,*slow, _ *gradus,* step), or "water bears," are minute organisms usually less than a millimeter in length.

- They have an elongated, cylindrical, or a long oval body that is unsegmented.
- The head is merely the anterior part of the trunk. The trunk bears four pairs of short, stubby, unjointed legs, each armed with four to eight claws .
- The body is covered by a nonchitinous cuticle that is molted along with the claws and buccal apparatus four or more times in the life history.
- Cilia are absent (figure 25).

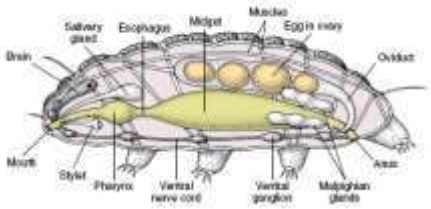


Figure (25): External morphology of water bears.

E- Class: Pentastomida

Pentastomida (pen-ta-stom_i-da) (Gr. *pente,* five, _ *stoma,* mouth),

- Adults range from 1 to 13 cm in length.
- Transverse rings give their bodies a segmented appearance
- The body is covered with a chitinous cuticle that is molted periodically during larval stages.
- The anterior end may bear five short protuberances (hence the name Pentastomida). Four of these bear claws. The fifth bears the mouth and two pairs of hooks for attachment to the host tissues.
- There is a simple straight digestive system, adapted for sucking. The nervous system, similar to that of annelids and arthropods
- There are no circulatory, excretory, or respiratory organs.
- Sexes are separate, and females are usually larger than males (figure 26).

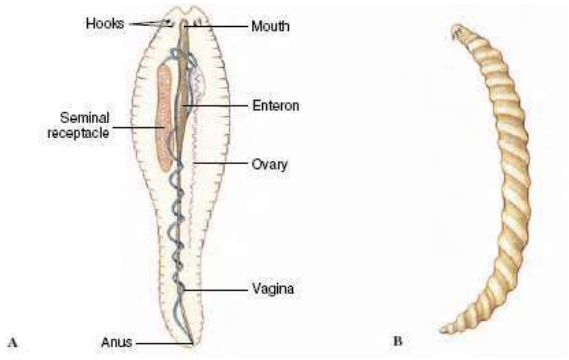


Figure (26): External morphology of Pentastomida.

The Importance of Arthropoda

Advantages

- Food for human: The larger crustaceans—shrimps, lobsters, and crabs—are used as food throughout the world.
- Small planktonic crustaceans, such as copepods, and other , are a major link in the food chain between the photosynthetic phytoplankton and the larger carnivores, such as many fish and whales.
- Approximately two-thirds of all flowering plants are pollinated by insects. Some are used in biological control.
- Recently insects have also gained attention as potential sources of drugs and other medicinal substances.

Disadvantages

- Diseases carried by blood-sucking insects may infect human and livestock animals.
- Many species of arthropods, principally insects but also mites, are agricultural and forest pests.
- Some arthropods, may act as intermediate host of some parasites.

Phylum: Mollusca

Mollusca (mol-lus_ka) (L. *molluscus,* soft) is one of the largest animal phyla after Arthropoda. There are nearly 50,000 living species and some 35,000 fossil species. The name Mollusca indicates one of their distinctive characteristics, a soft body.

Characteristics of Phylum Mollusca

1. Body bilaterally symmetrical (bilateral asymmetry in some); unsegmented; often with definite head.

2. Ventral body wall specialized as a muscular **foot,** variously modified but used chiefly for locomotion.

3. Dorsal body wall forms pair of folds called the **mantle,** which encloses the **mantle cavity,** is modified into **gills** or **lungs,** and secretes the **shell** (shell absent in some).

4. Surface epithelium usually ciliated and bearing mucous glands and sensory nerve endings.

5. **Coelom** limited mainly to area around heart, and perhaps lumen of gonads and part of kidneys.

6. Complex digestive system; rasping organ ***(radula)** usually present; anus usually emptying into mantle cavity.

7. **Open circulatory system** .

8. Gaseous exchange by **gills, lungs, mantle,** or **body surface.**

9. One or two kidneys **(metanephridia)** opening into the pericardial cavity and usually emptying into the mantle cavity.

10. Nervous system of paired cerebral, pleural, pedal, and visceral ganglia, with nerve cords and subepidermal plexus.

11. Sensory organs of touch, smell, taste, equilibrium, and vision (in some); eyes highly developed in cephalopods.

12. Both **monoecious** and **dioecious** forms; **spiral cleaveage;** larva primitively a **trochophore,** many with a **veliger** larva, some with direct development.

(Check figure 27).

-Radula

The radula is a rasping, tongue-like organ found in all molluscs except bivalves. It is a ribbon-like membrane on which are mounted rows of tiny teeth that point backward. Complex muscles move the radula and its supporting cartilages **(odontophore)** in and out while the membrane is partly rotated over the tips of the cartilages. There may be a few or as many as 250,000 teeth, which, when protruded, can scrape, pierce, tear, or cut. The usual function of the radula is twofold: to rasp off fine particles of food material from hard surfaces and to serve as a conveyor belt for carrying particles in a continuous stream toward the digestive tract (figure 27).

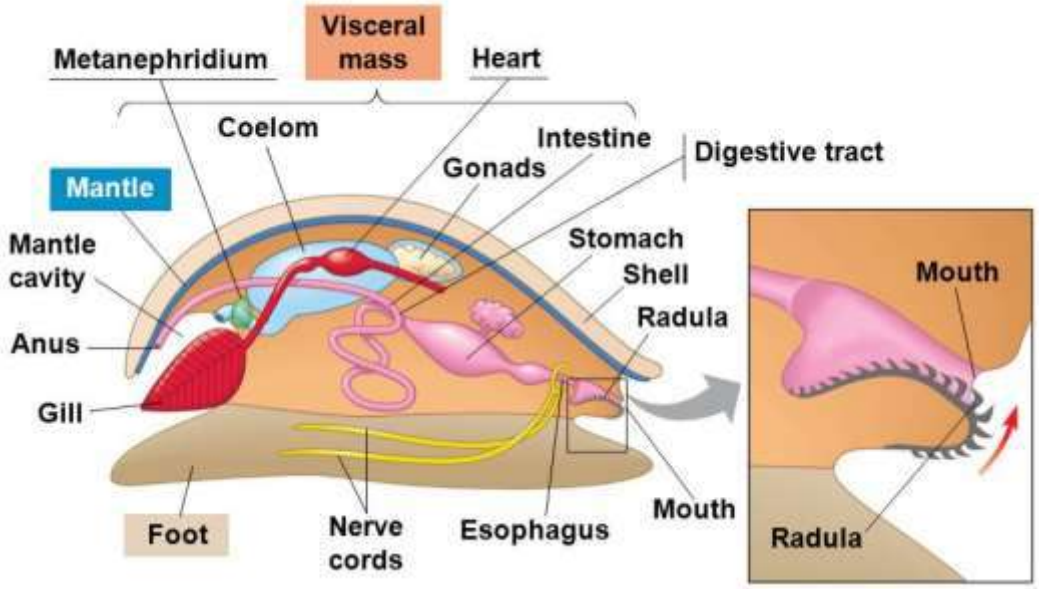


Figure (27): Internal morphology and radula structure in mollusca

Classification of Mollusca

1. **Class :** Monoplacophora **Ex:** ***Neopilina***
2. **Class:** Polyplacophora **Ex:** ***Chiton***
3. **Class:** Aplacophora **Ex:** ***Neomenia***
4. **Class:** Gastropoda
   Order: Prosobranchiata
   Order: Opistobranchiata
   Order: Pulmonata **Ex:** ***Helix***
5. **Class:** Scaphopoda **Ex:** ***Dentalium***
6. **Class:** Lamillibranchiata **Ex:** ***Anodonta***
7. **Class:** Cephalopoda
   Order: Dibranchiata **Ex:** ***Octopus , Sepia***
   Order: Tetrabranchiata **Ex:** ***Nautilus***

1- Class: Monoplacophora

- Body oval and bilaterally symmetrical, with internal metamerism.
- Shell is made of a single piece.
- Foot is flat, and located on the ventral side.
- 2 ventricles, 5 or 6 pairs of gills and 6 pairs of nephridia present.

Ex: *Neopilina*

Until 1952 it was thought that Monoplacophora were extinct; However, in that year living specimens of *Neopilina* were dredged up from the ocean bottom near the west coast of Costa Rica.

Neopilina has:

- Five pairs of gills,
- Two pairs of auricles,
- Six pairs of nephridia,
- The mouth bears the characteristic radula.

Body of *Neopilina* is oval , has single shell (35 mm) , one ventral foot (Figure 28).

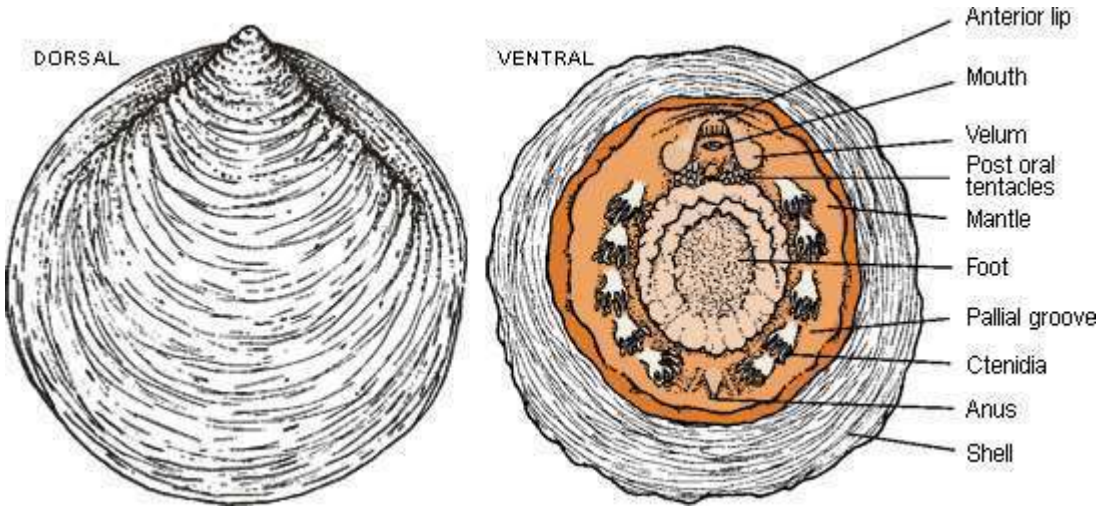


Figure (28): Dorsal and ventral side of *Neopilina*

2- Class: Polyplacophora

- Body elliptical and flattened.
- Shell of mid dorsal row of 8 broad plates.
- Foot ventral , large , broad muscular.
- Mantle surrounds the shell as fleshy girdle with scale and spines.
- Sexes separated.

Ex: *Chiton*

Is a sluggish, marine animal found attached to the rocks.

- Body is elongated, bilateral symmetrical and dorso-ventrally compressed and consist of shell, foot , mantle and the visceral mass.
- Shell is calcareous present in the dorsal side and composed of eight overlapping plates.
- Head is not distinct.
- Foot is ventral , muscular with a flat sole extending along the whole length of body.
- Mantle covers grater part of the body and partly covers the edges of the shell plates.
- Mouth and anus are at opposite ends.
- Sexes are separated gonad is single and median gonoducts are paired.
- Development includes a trochophore larva (figure 29).

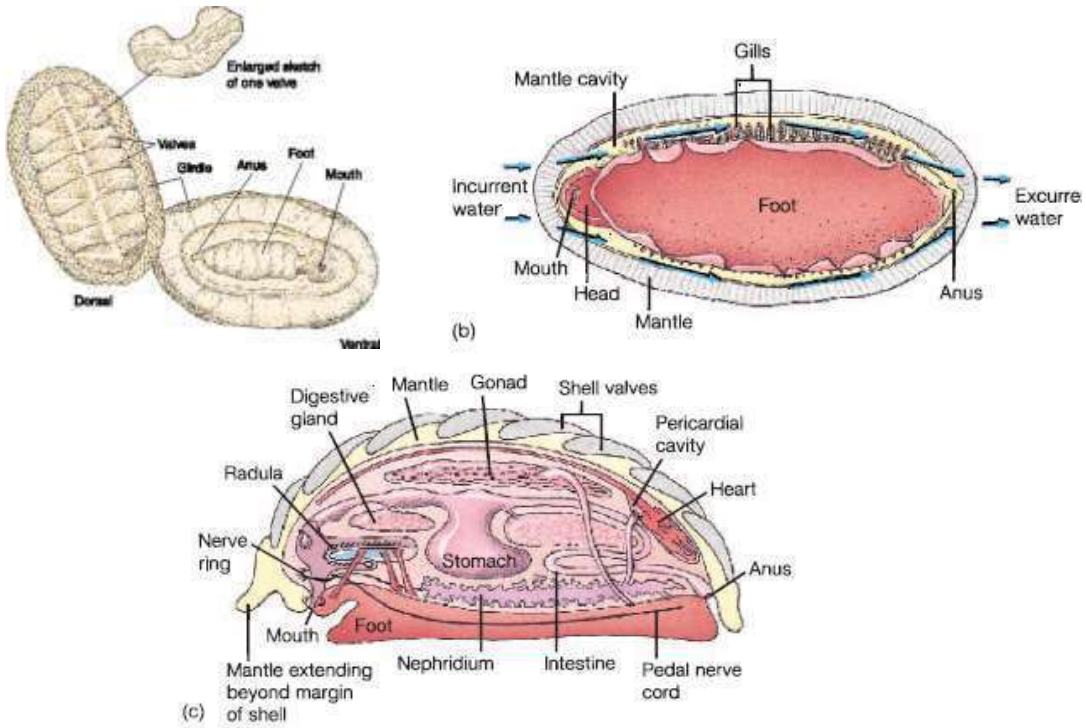


Figure (29): Dorsal and ventral side of *Chiton*.

3- Class: Aplacophora

- Body worm like , bilaterally symmetrical and cylindrical.
- Head , mantle , foot ,shell and nephridia are absent.
- Body covered with cuticle beset with numerous calcareous spicule.
- Mouth and anus are terminal or sub-terminal at opposite end.
- Digestive tract straight generally provided with radula.
- A mid dorsal longitudinal keel or crest is often present.
- Sexes are separated or united (figure 30).

Ex: *Neomenia*

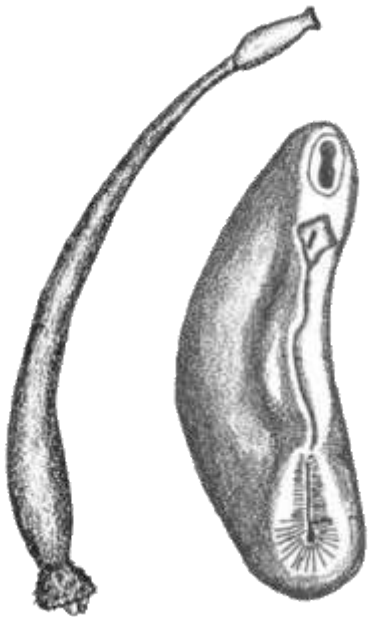


Figure (30): *Neomenia*

4- Class: Gastropoda

- Head distinct with one or two pairs of tentacles and eyes and containing a scraping radula.
- Shell univalved , often spiral or conical or absent.
- A large ventral foot in the form of a creeping sole.
- Gills 1 or 2 or replaced by secondary gills or lung.
- Nepheridia 1 or 2.

- These animals are basically bilaterally symmetrical, but because of torsion, a twisting process that occurs in the veliger stage, their visceral mass has become asymmetrical.
- Sexes separated or united.
- Marine, fresh water or terrestrial.

Order:Prosobranchiata:

- Mantle cavity opens anteriorly and contains gills anterior to heart
- Sexes are separated.

Order:Opistobranchiata

- Mantle cavity opens posteriorly and contains one gill.
- Sexes are united.

Order: Pulmonata

- Anterior mantle cavity vascularized as lung
- Sexes are united.

Ex: *Helix* (garden snail)

Is common terrestrial , air breathing gastropod . it is nocturnal and feeds on leafy vegetation.

Mantle: The thin mantle covers the visceral hump and forms the roof of the mantle cavity. It is thickening anteriorly to form **collar** that secret the shell.

Shell: the shell is thin, with low conical spire, measuring 4 cm in length ,the shell has a smooth aperture and prominent lines of growth.

Foot: foot is undivided longitudinally.

Head: head comprise of two pairs of tentacles and mouth . the posterior pair of tentacles bears eye and it is longer than the anterior tentacles , the mouth is provided with three prominent lips.

Digestive system:

- mouth is opened into buccal cavity with buccal mass (radula , cartilages and muscles) ,

- the buccal cavity connected with esophagus and crop which surrounded with salivary gland.
- Stomach
- Two digestive gland : occupy the most space of visceral hump , these two glands secrete amylase.
- Intestine and rectum which lead to anus.

Respiratory system: Gills are absent in *Helix*

There is a small opening called pneumostome under the edge of the collar. It is open into a highly vascular portion of the mantle cavity, that serve as lung . here diffusion of gases occurs between the air and the blood.

Blood vascular system: Heart is located in the pericardium at the upper mantle rim, behind the respiratory cavity. It is divided into two chambers, an atrium and a ventricle, both connected by a narrow duct, a valve avoiding blood fluid flowing back.

Excretory system: only one kidney leads to ureter which open near the anus.

Reproductive system:

- Helix is a hermaphrodite animal cross fertilization occure between two animals.
- Direct development no larval stages.
- Sperms and eggs are synthesize in ovotestis (figure 31).

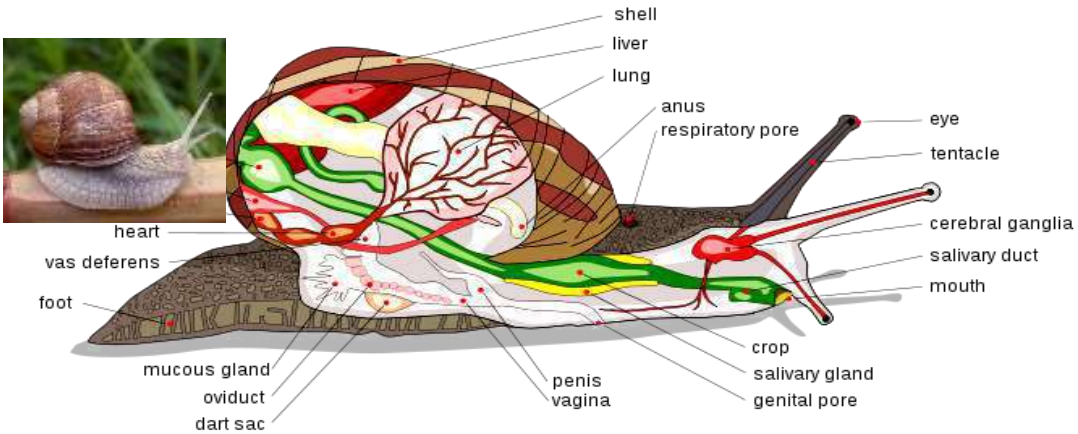


Figure (31): Internal anatomy of *Helix*

Torsion in Gastropoda

Of all molluscs, only gastropods undergo torsion. Torsion is a peculiar phenomenon that moves the mantle cavity, which was originally (primitively) posterior, to the front of the body, thus twisting the visceral organs as well through a 90- to 180-degree rotation. It occurs during the veliger stage, and in some species the first part may take only a few minutes. The second 90 degrees typically takes a longer period. Before torsion occurs, the embryo's mouth is anterior and the anus and mantle cavity are posterior (figure 32).

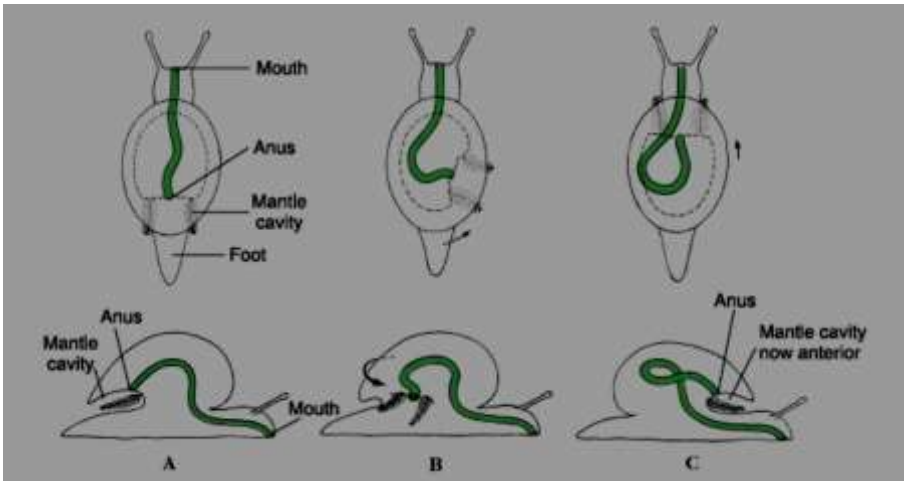


Figure (32): Torsion in *Helix*

5- Class: Scaphopoda

- Burrowing and marine molluscs known as tooth shell.
- Body, bilaterally symmetrical, elongated with no distinct head, and without eyes and gills.
- Shell and mantle univalve, cylinder or tubular and open at both ends.
- Foot small , conical .
- Sexes separated.

Ex: *Dentalium*

Shape and size: the body is headless , bilaterally symmetrical , slender antrero-posteriorly and slightly curved. The larger end is ventral and concave side dorsal , *Dentalium* is 13-25 cm long an 2.5 cm diameter.

Mantle: the body is completely enveloped in a tubular mantle derived from two larval mantle folds which become united ventrally to form a cylinder open at both ends.

Shell: in *Dentalium* the mantle secretes an external, cylindrically tubular , slightly curved and tapering shell open at both ends . it is shaped like trumpet or elephant's tusk.

Foot: the foot which protrudes from the larger anterior end of the shell, is long , pointed , spade like and highly extensible . In *Dentalium* , the free end of the foot is conical and trilobed , carrying wing like ridge on either side. The conical foot is well adapted for burrowing.

Respiratory system: gills are absent , the respiratory exchange of gases taking place through the mantle surface.

Digestive gland: the mouth situated on the oral proboscis leads into true buccal cavity , containing a mandible dorsally and odontophore with radulla ventrally. The short esophagus lead into a simple stomach with a caecum and gastric shield. It receives the ducts of a large bilobed digestive gland. The much coiled intestine end into short caeca which open by anus. Anus lying mid-ventrally behind the base of foot in mantle cavity.

Blood vascular system: the circulatory system is extremely simple. The colourless blood circulates in a system of rudimentary sinuses without an endothelium lining . the pericardium is lacking and rudimentary heart is merely an enlargement of sinus near anus.

Excretory system: A pair of symmetrical , sac –like (kidney) nephredia is situated in front of the gonad , one on each side of rectum. They open into mantle cavity by a nephridiopore on either side of anus.

Reproductive system: the sexes are separated. There is a single , median and extremely long gonad occupying the postero-dorsal region high up into visceral dome. The sexual products are discharged through the right kidney serving as the gonoduct (figure 33).

Nervous system: composed of 4 pairs of ganglia:

- Pairs of cerebral gangelia
- Pairs of plural ganglia
- Pairs of pedal ganglia
- Pairs of visceral ganglia.

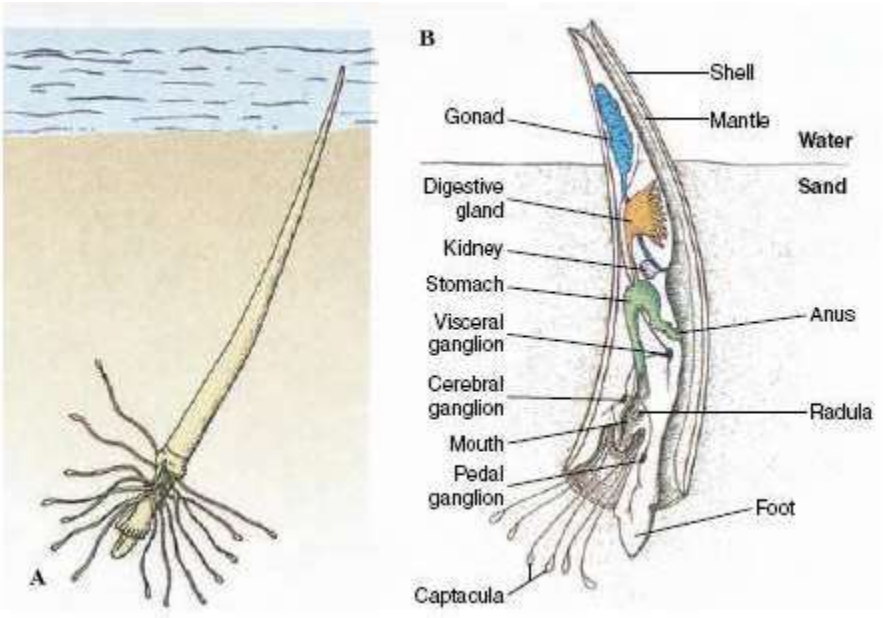


Figure (33): *Dentalium*

6- Class: Lamellibranchiata (Pelecypoda)

- Body bilaterally compressed, with no distinct head and **without pharynx, jaws, radula and tentacles.**
- Shell bivalve, one right, one left.
- Gills plate –like, 1 or 2 pairs.
- Sexes separated.
- Marine and freshwater.

Ex: *Anodonta*

Shells: Dorsally the shells or valves of *Anodonta* are connected by the hinge teeth and an elastic hinge ligament. The hinge teeth not only hold the valves together, but also aid in their opening and closing.

On the outer surface of the shell lines of growth may be seen, with the heavier lines representing the annual growth rings. The oldest part of the valve is the swollen anterio-dorsal portion known as the umbo (figure 34).

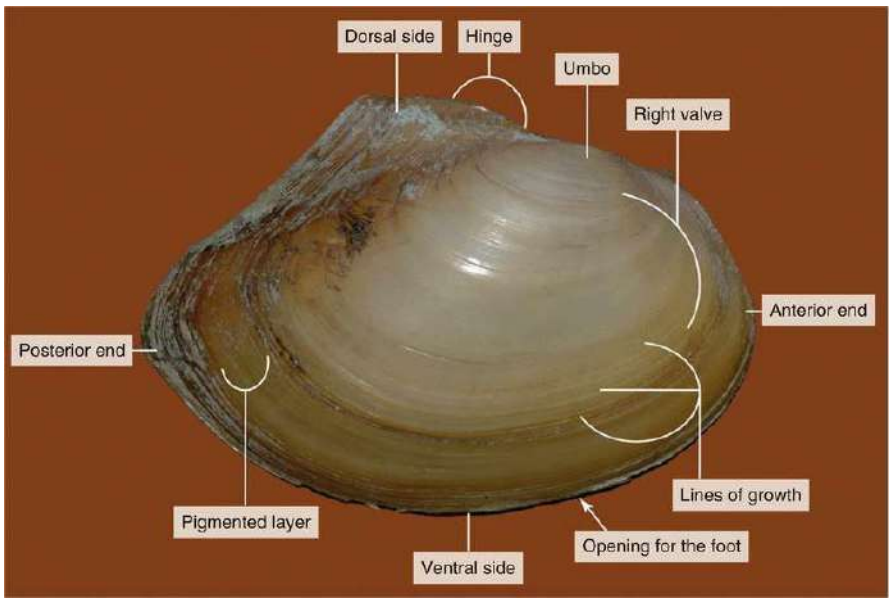


Figure (34): *Anodonta* External morphology

In a shell cross section, the shell is seen to be made up of three distinct layers:

- An outer periostracum layer: which is work as a protective layer, and it is thin and darkly colored.
- The middle prismatic layer: which is the thickest one, and is formed chiefly of calcium carbonate.
- The inner layer (the nacre or mother of pearl) (check figure 35).

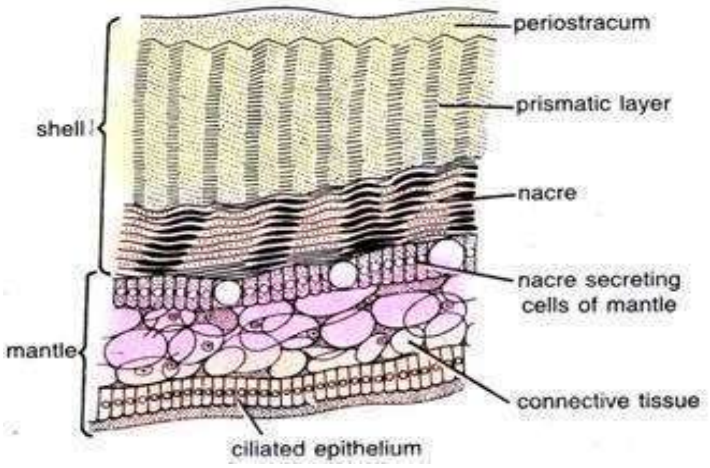


Figure (35): Cross section of shell and mantle in *Anodonta*

Muscles: Large muscles are fastened to the dorsal inner portion of the shell:

- The anterior and posterior adductors which withdraw the valves together.
- The anterior and posterior retractors which withdraw the foot.
- The anterior protractor which extends the foot. (Check figure 36).

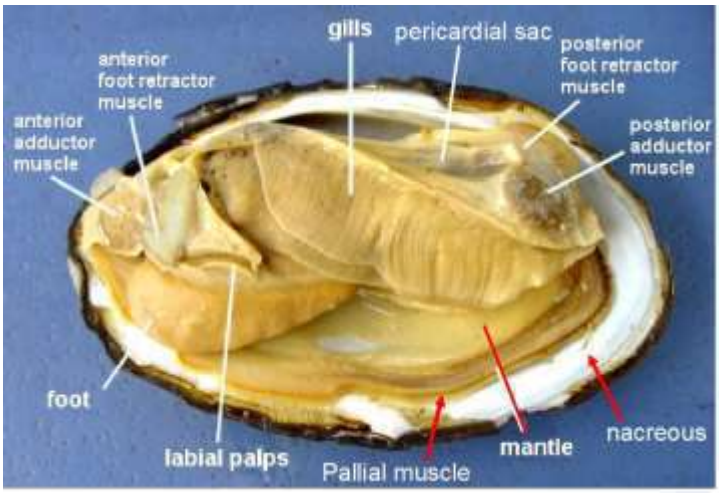


Figure (36): Muscle types in *Anodonta*.

Foot: in the anterio-ventral region is a large muscular foot which capable of being thrust out between the valves and is used for locomotion.

Mantle: The mantle is a sheet-like structure which secretes the shell. The mantle is attached to the shell, but has free margins which are capable of being drawn together to produce the mantle cavity. The posterior margin of the mantle forms two openings or siphons:

- The incurrent siphon, which act as passageway permitting the water carrying food and oxygen to pass in.
- The excurrent siphon, the passageway, which permits the escape of water (figure 37)

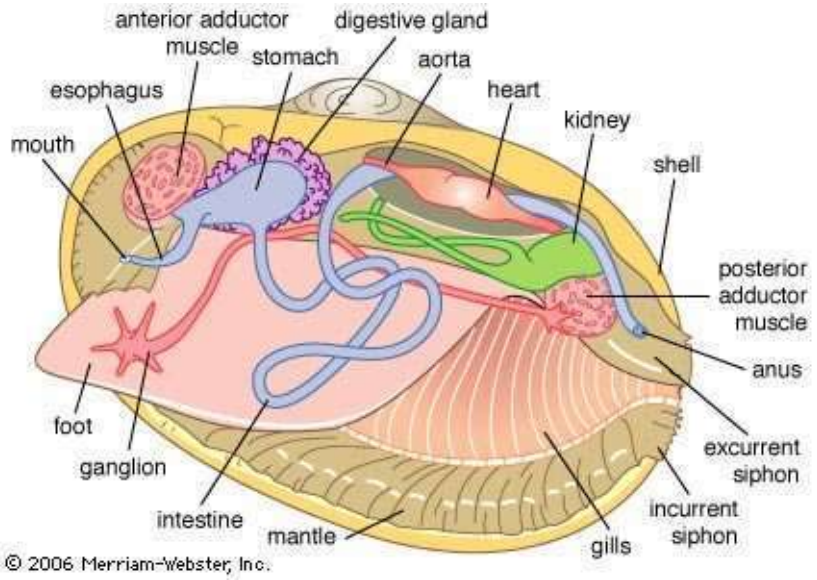


Figure (37): incurrent and excurrent siphon in *Anodonta*

The Digestive system: the digestive tract begins at the anterior portion in the mouth, which is located between the two labial palps. There is no radula. Posterior to the mouth are a short esophagus and rounded stomach, located in the visceral mass. From the stomach, the long coiled intestine passes posteriorly. Posteriorly it becomes the rectum, which surrounded by the heart. The anus opening is in the region of the dorsal siphon (check figure 38).

Surrounding the stomach is a large digestive gland , which produces digestive enzyme.

Circulatory System: the heart is consisting of two auricles and a ventricle within the pericardial cavity leading from the ventricle are:

- Anterior aorta: which carries blood to the foot and visceral mass.
- Posterior aorta: which supply rectum and mantle.

Blood is pumped both backward and forward. Some of the blood is oxygenated in the mantle and returned directly to the auricle. In the organs the blood is circulated through veins and sinuses. From the organs other than the mantle, the blood passes through the kidney into the gills where it is oxygenated and then returns to the auricle (check figure 38).

Respiration: respiratory exchange takes place in the gills, each of which consist of two very thin sheets, or lamellae. Above the gills, there is special chamber called the suprabranchial chamber. water coming in through the incurrent siphon passes into the gill lamellae, which are divided by partitions into many vertical water tubes. The water is finally collected in the suprabranchial chamber and passed out through the excurrent siphon (check figure 38).

The nervous system consists of three pairs of widely separated ganglia connected by commissures and a system of nerves. Sense organs are poorly developed (check figure 38).

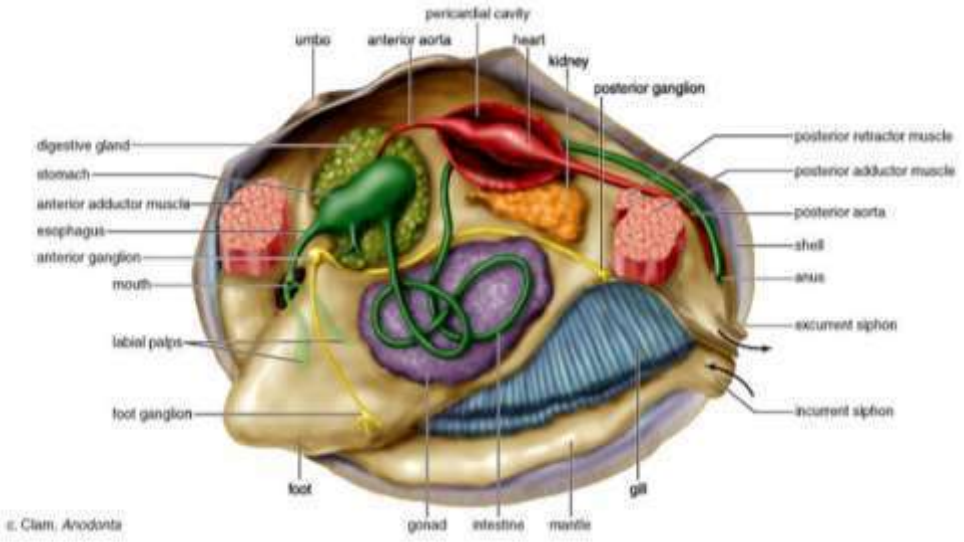


Figure (38): Internal anatomy of *Anodonta*

Reproduction and Development: In most freshwater clams fertilization is internal. Eggs drop into the water tubes of the gills where they are fertilized by the sperm entering with the incurrent flow. They develop there into a bivalved **glochidium larva** stage, which is a specialized veliger. When discharged, glochidia are carried by water currents, and if they come in contact with a passing fish, they attach to its gills or skin and live as parasites for several weeks. Then they sink to the bottom to begin independent lives. Larval "hitchhiking" helps distribute a form whose locomotion is very limited (figure 39).

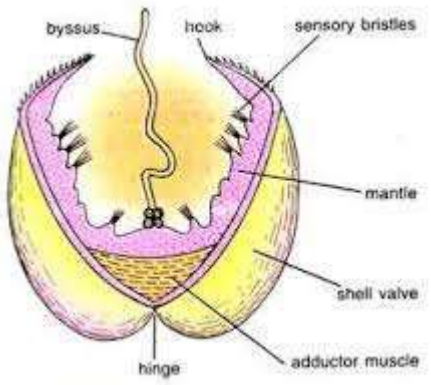


Figure (39): glochidium larva

Pearl Formation:

The pearl is secreted by the mantle as protective measure against foreign objects like sand particles, parasites, small larvae or any object of organic and inorganic origin. In fact as soon as foreign object, somehow , enters the body of a bivalve in between the shell and mantle , the mantle immediately gets irritated and at once enclose it like a sac .the mantle wall then starts secreting layers of nacre around the foreign object from defense point of view , thus mantle wall secrets continuously several layers of nacre around the foreign object and finally pearl is formed (figure 40).

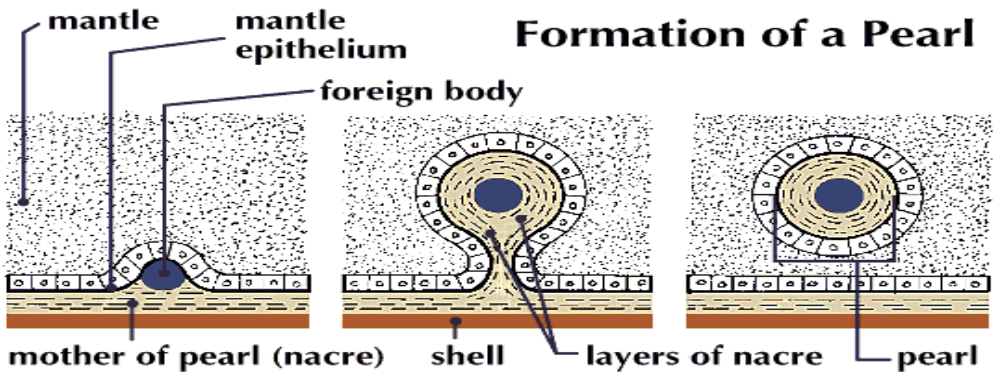


Figure (40): Pearl formation in *Anodonta*.

7-Class: Cephalopoda

- Body elongated dorso-ventrally and bilaterally symmetrical, with distinct head bearing large eyes, radula and jaws.
- Shell external, internal or absent.
- Foot modified into arms or tentacles attached to the head and the siphon.
- Dioecious, development direct.
- All marine and free-swimming.

Order :Dibranchiata

- Shell internal, reduced or absent.
- A few tentacles (8-10) bear suckers.
- 1 pair of gills, 1 pair of nephridia

Example 1: *Octopus*

Octopus is a marine , bottom dwelling nocturnal cephalopod spending daylight hours in rocky crevice.

- Octopus is popularly known as a devil-fish.
- Body is globes and bag-like with large head and trunk.
- Head bears a pair of eyes and eight elongated equal arms which surrounded the mouth.
- Each arm bears suckers arranged in two rows. suckers are sessile and large.
- Third right arm in male is modified into spoon – shaped structure which serves for transferring spermatophore into the mantle cavity of the female for fertilizing ova.
- Nidamental glands absent. Nidamental glands secrete a capsule or covering material for an egg or egg masses
- Shell is absent.
- Mantle encloses the mantle cavity and visceral mass (figure 41).

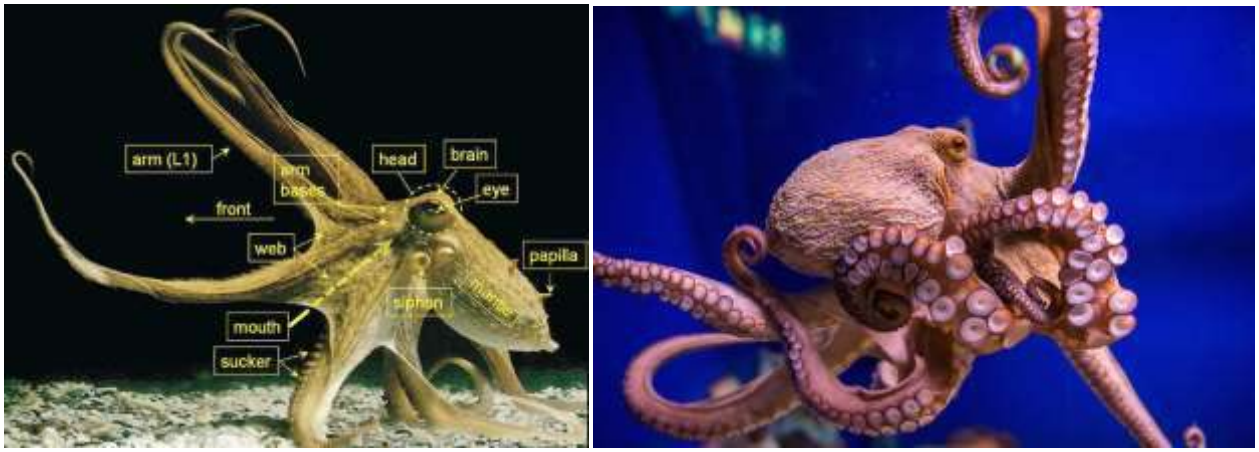


Figure (41): External morphology of *Octopus*.

Example 2: *Sepia*

Sepia is a marine form, found in the shallow waters. It is a good swimmer. It usually swims at night and rest flat on the bottom during day time. It is carnivorous feeds on small fishes, crustaceans and other animals.

- Body is bilaterally symmetrical , dorso-ventrally flattened and is divisible into head , collar and trunk.
- Head bears large eyes and five pairs of arms surrounding the mouth.
- Of the five pairs of arms , four pairs are short and stout bearing four longitudinal rows of suckers on the inner flat surface.
- The fifth pair of arms is known as tentacles which are comparatively long and narrow and provided with suckers only towards their free ends.
- Collar is constricted and connects the head with the trunk.
- Trunk is elongated, bordered by narrow lateral fin on either side.
- Mantle is thick and muscular, enclosing a large mantle cavity on the ventral side which contains the viscera.
- Funnel is tubular opening into the mantle cavity.
- Shell is internal.
- A pair of large plume-shaped gills , one on each side of the mantle cavity, performs the respiratory function.

- A pear-shaped ink-sac lies over the posterior ventral surface.
- In male , the left fourth arm is modified to serve as intromittent organ.
- Sexes are separated. The males are usually smaller.
- Nidamental glands usually present in female , nidamental glands secrete a capsule or covering material for an egg or egg masses. (Check figure 42).

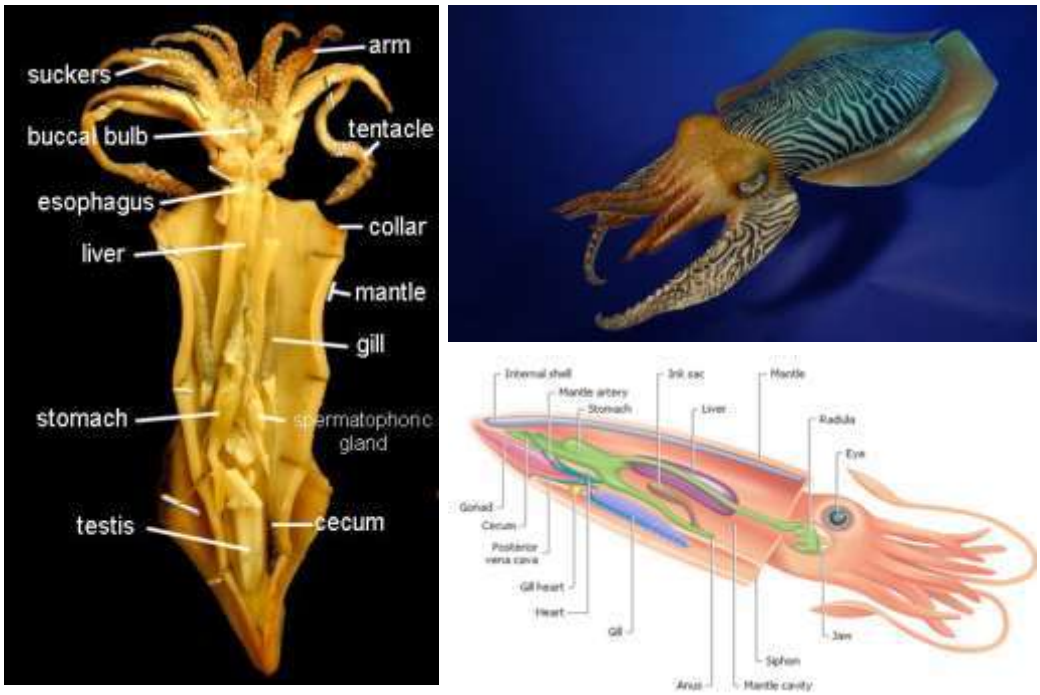


Figure (42): ***Sepia***

Order: Tetrabranchiata

- External shell , coiled or straight.
- Tentacles many , suckerless.
- 2 pairs of gills , 2 pairs of nephridia.

Example: ***Nautilus***

Nautilus is a marine animal, found living in deep water near the shores and coral reefs, it is a nocturnal cephalopod, crawling over the bottom at night time in search of animal food.

- Body is enclosed in a calcareous spirally coiled many chambered shell**.** the shell is about 25cm in diameter.

- The animal occupies the outermost and largest chamber into which body can be withdrawn for protection.
- The chambers are separated by a system of septa.
- Except the outermost chamber, all chambers are filled with air so that the shell can float and animal can swim easily.
- Body of the animal consists of head bearing eyes and a system of tentacles and a sac-like trunk.
- Mouth is situated at the end of the head and surrounded by numerous lobes bearing two rows of retractile tentacles.
- Arms and suckers are absent.
- two pairs of gills, two pairs of nephridia and two pairs of auricle are present.
- Sexes are separate (figure 43).

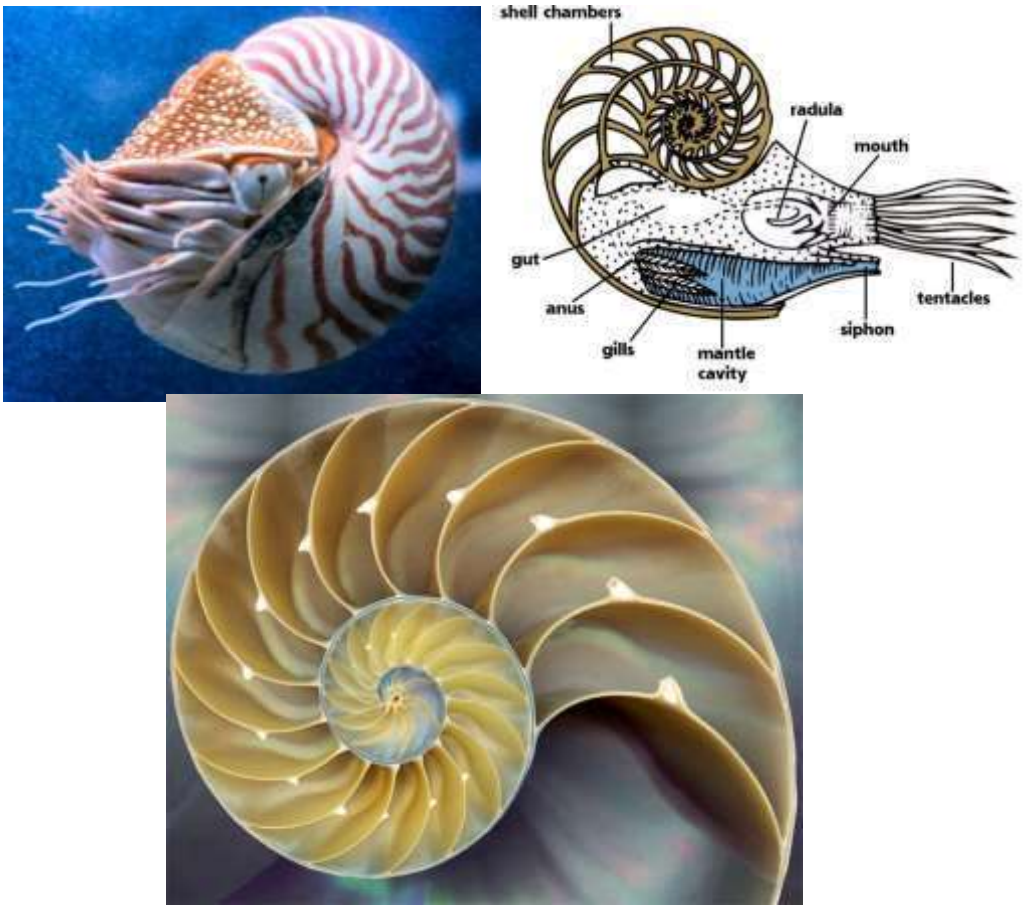


Figure (43): External, internal and septa system in *Nautilus*

Importance of Mollusca:

Advantages:

- Many mollusks are great source of food for man in many parts of world. Large quantity of clams, oysters and mussels are eaten in Fareast, Europe and America.
- Shell of fresh water mussels is used in button industry.
- The shell of oyster are mixed with tar for making roads in America.
- Shells in certain parts of world are also used for making ornaments.
- Some oysters also make valuable pearls.

Disadvantages:

- Slugs are injurious in gardens and cultivations. They not only eat leaves but also destroy plants by cutting up their roots and stems.
- Some of snail act as intermediate host of some parasites (*Schistosoma* spp , *Fasciola hepatica* …)