Bachelor of Science
(B.Sc. - CBZ)

Animal Diversity I (Non Chordees)
(DBSZCO103T24)

Self-Learning Material
(SEM 1)

Jaipur National University
Centre for Distance and Online Education

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Jaipur National University

Course Code: DBSZCO103T24
Animal Diversity I (Non Chordates)

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EXPERT COMMITTEE

Prof. D.S. Bhatia
Former Director, Life and basic Sciences
JNU, Jaipur

Prof. (Dr.) Subhash Chandra
Head, Department: Zoology
Dean, PG Studies,
MDS University, Ajmer

COURSE COORDINATOR

Prof. (Dr.)Meena Godha
Dept. of Life Sciences
Jaipur National University, Jaipur

UNIT PREPARATION

Unit Writers	Assisting & Proof Reading	Unit Editor
Dr. Indrani Jadhav (Unit1-4) Dept. of Life Sciences, JNU, Jaipur Dr. Sunita Rao (Unit 5-9) Dept. of Life Sciences, JNU, Jaipur Dr. Reena Jain (Unit 9-13) Dept. of Humanities, JNU, Jaipur	Dr. Juhi Sharma Dept. of Life Sciences, JNU,Jaipur	Dr.Meena Godha Dept. of Life Sciences, JNU, Jaipur

Secretarial Assistance:
Mr. Suresh Sharma

COURSE INTRODUCTION

The Course entitled **"Animal Diversity I (Non Chordates)"** will provide students with a solid foundation in animal biology and appreciation for the diversity of life on Earth**.** The course will provide in depth knowledge about the classification, anatomy, physiology and ecological significance of non chordates including arthropods, mollusks, annelids and echinoderms.

Non Chordates refers to a diverse group of animals that do not posses notochord. Animal diversity among non chordates is vast and encompasses diverse groups, Arthropods being the largest phylum in the animal kingdom. They exhibit diversity in terms of body structure, habitat and behavior. Prominent examples of arthropods are insects, arachnids and crustaceans. Mollusks include snails, clams and octopuses. They possess soft bodies and hard shells exhibiting various feeding strategies and locomotion. Annelids are characterized by segmented bodies. Earth worm and leeches are included in this group.

These diverse groups of organisms play crucial roles in ecosystems including nutrient cycling, pollination, predation, soil health, aquatic ecosystem balance and many other ecological processes. These non chordates also serve as important models for scientific research to explore fundamental biological processes.

The course Animal Diversity-I is of 3 Credits. This course is divided into 13 units and each Unit is divided into sub topics.

Course Outcomes: After completion of the course, the students will be able to:

1. Identify the animals according to their taxonomic classification and recall the characteristics of each phylum.
2. Compare the body organization from phylum porifera to echinodermata.
3. Determine the connecting links between phylums.
4. Sketch the life cycle of animals belonging to phylum platyhelminthes and aschelminthes
5. Support the ecological importance of various animals including coral reefs.
6. Assemble the animals according to hierarchy and to be able to construct flow-chart for the same.

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Chapter-1

Protista

Objectives :

- List the traits of all organisms in the Kingdom Protista.
- Compare the organisms belonging to Kingdom Protista.
- Classify organisms using knowledge of this Kingdom.
- List the economic significance of protista.

1.1 Introduction :- Living organisms are classified into 5 kingdoms, Protista being 1 comprisesof unicellular and multicellular eukaryotes besidesnumerous microbes that are excluded in fungi, animals or plant. This kingdom characterize with membrane bound organelles and well defined nucleus. Natural niche like swampy terrestrial area, aquatic inhabitant, parasite to other organisms and symbionts are few indigenous place for protests.

What are Protists ?

In the year 1866, Ernst Haeckel, for the primarily time reported kingdom Protista, being primitive eukaryote they show comprehensive and expansive variety of assortment in magnitude, shape and life formulae. Membrane bound organelles like mitochondria, ER, Golgi bodies and specific structured nucleus are essential trait of protests, present as unicellular, multicellular or colonial.

Protest Exemplar :

Representative cases of Protests :

- **Amoeba:** Depending on microbes for food they are motile using extending pseudopods and unicellular in nature.
- **Paramecium:** Distinctive slipper like shape, these are ciliated unicellular protozoan.
- **Euglena:** Based on surrounding conditions, these unicellular organisms can be photosynthetic or predatory.
- **Plasmodium:** Causative organism of malaria in humans, these are parasitic protozoan.

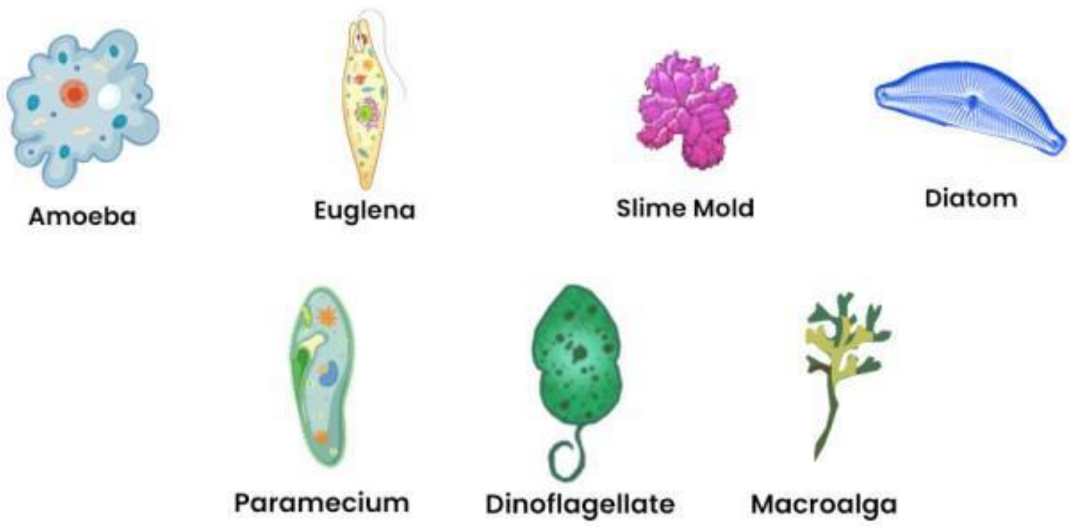


Fig. 1.1 Example of Protista

1.2 Distinctive Features of Kingdom Protista :

Typically, unicellular, colonial or multi-cellular, this kingdom has following features.

- They are eukaryotic with distinct nucleus and membrane bound organelles.
- Differentiated on the basis of size, shape and life form.
- They are autotrophic (undertake photosynthesis) or heterotrophic (extract nutrients from other organism or organic matter). Example of photosynthetic protests is algae, whereas protozoans are heterotrophic in nature.
- They reproduce by sexual and asexual means.
- Motility in protests is through flagella, cilia, or pseudopods.
- Distinctive features with the presence of cellulose, silica and calcium carbonate as basic component of their cell wall.
- They show mutualistic and parasitic relationship with other organism, and are key symbiont in indigenous ecological environment.

1.3 Classification Protista:

It is divided into diverse variety:

1. Representing plants
2. Representing fungi
3. Representing animals.

Detailed classification is as follows

1.3.1 Protists representing plant :

These photosynthetic protists, which perform photosynthesis, shows characters similar to plants. Dinoflagellates, chrysophytes, and euglenoids are a few specimens of creatures that fall into this category.

1.3.2 Dinoflagellates :

Approx. a thousand of photosynthetic protist species are included in this category which is further classified into division Pyrrophyta -

- They are eukaryotic unicellular organism motile with the help of whip-like flagella
- With chloroplasts as distinctive feature, these autotropic organisms are marine primary producer
- Bioluminescent is the distinctive feature of few species in the group
- They form mutualistic relationship with corals
- Algal bloom formed by some dinoflagellates are known as "red tides," these bloom or red tides are not only toxic to marine life but also to human when consumed.
- Mode of reproduction can be both sexual or asexual.
- **Dinoflagellates Eg**: Gonyaulax, Noctiluca, etc.

1.3.3 Chrysophytes (gems of plant kingdom) :

- Single celled free-floating found in both fresh or marine water
- The majority of Chrysophytes are photosynthetic
- Their cell wall is made up of silica and pectin
- They reproduce either sexually or asexually.
- Fossilization of cell wall of diatoms result into soft silicious sedimentary rock called diatomaceous earth
- Applications includes removal of unwanted material from potable water, prevents formation of lumps in food, medicine and plastics, control of insects etc.
- Cell walls of diatoms is known as Frustule consisting of two thin overlapping shells called Thecae fitting into each other. Larger Frustule is called epitheca and smaller one is hypotheca Two basic form of Frustule includes Centrales (round diatoms) and Pennales (elongated diatoms).

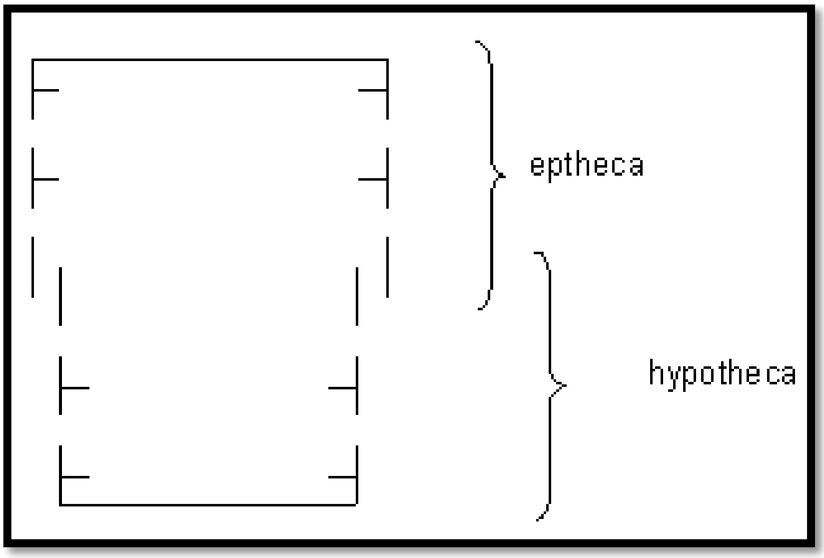


Fig. 1.2 Diagrammatic section showing Frustule terminology

- **Example**: Diatoms

1.3.4 Euglenoids

Single celled in nature they resemble both plant and animal, though they act resembles.

- They characterize the intermediate association amongst plants and animals.
- Their plant resembles lie in extracting nourishment from autotrophic sources
- Whereas unicellular flagellates that are comparable to Euglena and are found in unmoving freshwater resembles animal character
- Long Whiplash and Short Tinsel are two distinct types of flagella
- Their flexibility is due to protein rich layer that replace cell wall and is called pellicle.
- Pyrenoids are granules consisting of protein that store food.
- Their mode of reproduction is asexual.
- They show mixotrophic feature, that is, in the absence of light, photosynthetic euglenoids change to heterotrophic behaviour.

1.3.5 Slime Moulds (Fungi-Like Protists) :

Demonstrating characters of both animal and fungi, they are called as fungus-animals.

- They have numerous nuclei within a single cell and display amoeboid movement
- They include both amoeboid and multicellular stages representing a complex life cycle, reproducing by both sexual and asexual means
- Being a decomposer they helps to break down organic matter, playing a important role in ecosystem

- they are divided into sets
    1. plasmodial - cytoplasmic mass but many nuclei
    2. cellular - combinations of specific cells.
- Cellular structure and life cycle differentiate Slime molds from true fungi

1.3.6 Protozoans (Animal-Like Protists) :

Protozoans are heterotrophic organism divided into 4 groups. They are

Amoeboid Protozoans

- Omnipresent in seawater, freshwater, and wet soil.
- Resembling amoebas, they are motile via pseudopodia.
- *Entamoeba histolytica and E. gingivalis*, are additional member of the group, that can cause various digestive disorders and infections, if consumed with polluted water.

Flagellated Protozoans

- Few being parasites in the group, consist of following important members.
- Trypanosoma species responsible for the spread of dangerous diseases.
- Sand flies being vector of Leishmania species cause kala-azar.

Ciliated Protozoans

- Residing in water their motility is due to cilia.
- Dimorphism is the distinctive character with both macro and micronuclei showing similarity with Paramecium.
- Macronucleus, the vegetative nucleus is important in the for metabolic progressions and development.
- Micronucleus also called as reproductive nucleus, is significant constituent for reproduction.

1.3.7 Sporozoans

- Being obligate intracellular parasites, they have apical complex, that aids them to penetrate host cells.
- Parasitic to host cells, they cause disease symptoms and damage in host cell
- Life cycle of Sporozoans is complex involving both asexual and sexual stages.
- To complete the life cycle they require multiple host
- Eg: Plasmodium

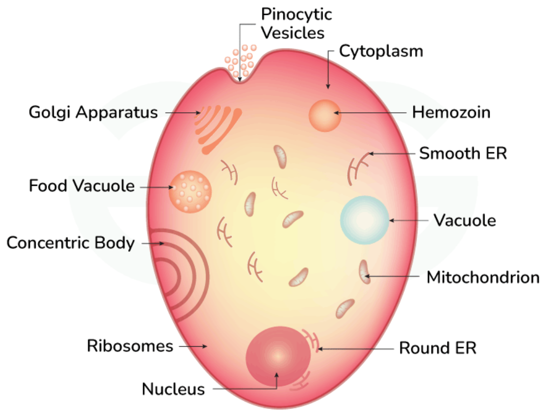


Fig. 1.3 Plasmodium

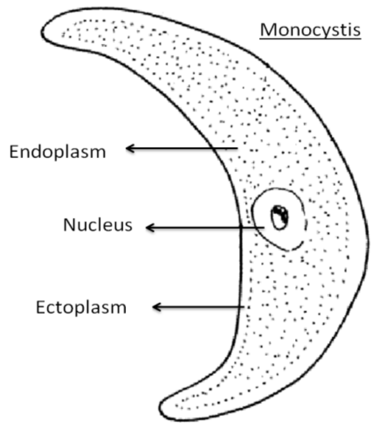


Fig 1.4: Monocystis

1.4 Economic significance

- Protists are important component of food chain.
- In several parts of globe, certain diversities of seaweeds are cast-off in preparation of jellies and cookies
- Symbiotic relationship among Protist and prokaryote may be facultative to obligate, and from mutualistic to parasitic.
- Protists can be used in various pharmaceuticals, vitamins, and cosmetics industry in manufacturing process and Storage component in sheets of these diatoms are used in preparation of product like paint, cleaners, and automobile polishes.

- Red algae provide stabilizers and algin which is used as food additive in chocolates, ice creams, jams, jellies, and other confections and in health products like lozenges, tablet and mask.
- Phytoplankton are the source food of whales, crustaceans, fishes and even for humans. They are sources of dietary supplement, calcium, magnesium etc.

Conclusion -

Members are eukaryotic organisms, including unicellular and multicellular. protists live like parasites in different organisms and these associations are species-specific, there is a enormousprobability for protist variety that contests the variety of their hosts, Members of this kingdom are autotrophic or heterotrophic. They have various economic importance as food additive, as food source and preservative etc.

1.5 Organs for locomotion in Protozoa :

1.5.1 Basic organelles are Cilia and Flagella -

- **These are hair-like assemblies** that extents from surface of cell and help the cell in moving forward.
- Cilia, found in ciliated protozoa like Paramecium and Stentor, are lessened and additional plentiful as compared to flagella.
- Some parasitic protozoa like human respiratory parasite Balantidium coli, involve them as well.
- Flagellated protozoa such as Euglena and Trypanosoma have lesser cilia.
- Parasitic and free-living bacteria, sperms also have flagella.

1.5.2 Pseudopodia - organelles used for motion

- These are cell membrane lengthening that the cell can move in any track to creeptarget.
- They are cytoplasmic prolongation that permit the cell movement by dragging or swallow target.
- To infest host tissue Pseudopodia are often used eg-Entamoeba histolytica.

1.5.3 Rippling Membrane -

- They are structures seen in flagellated protozoa that moves through waving.
- It is a kind of flagellum eg Trichomonas vaginalis.
- **these are flat, ribbon-like structures** that put the motion in the cell.

1.6 Artificial Cilia and Flagella – Biotechnological Application :

Protozoan locomotion mechanism has prejudiced the advancement in micro- and nano robots concepts which could help in biomedical applications.

- Artificial cilia and flagella should be able to show curving and spiralling and simulate their natural counterparts.

- Protozoa also synthesize cellulases and proteases which have biotechnological interventions also like biofuel production etc.
- They also help in various ecological cycle and other environment applications.
- Development of anti-parasitic drugs is also an example.

Summary

Finally, it is important to note that classification has transformed convincingly over time. Early taxonomic schemes were based on morphology. Current molecular phylogenetic analyses indicate that the traditional classification of protozoa into four groups (Sarcodina, Mastigophora, Ciliata, and Sporozoa) is inadequate and that protozoan diversity is much higher than formerly thought. Excavata, Chromalveolata, Rhizaria, Archaeplastida, Amoebozoa, and Opisthokonta are the six super groups arranged by one classification scheme. Each super group consists a numeral of subcategories, having different morphology, behaviour, and ecological position. It had highlighted the evolutionary relationships between various groups of eukaryotes.

In brief, they are divergent and engaging with noticeable methods and organs of locomotion Considering this is crucial for acquiring a greater knowledge of their ecological roles, pathogenesis, and biotechnological applications. It is envisaged that as new technology and techniques are developed, we will be able to learn more about complex and fascinating organisms.

MCQ

1. Protists survive in ________

a) dry desert

b) aquatic regions

c) dry mountains

d) hot hills

2. Which among the following comprises of animal like protists?

a) Protozoans

b) Chrysophytes

c) Slime molds

d) Dianoflagellates

3. Diatoms are grouped under __________

a) Chrysophytes

b) Protozoans

c) Dianoflagelletes

d) Euglenoids

4. Cell wall in diatoms is made of ________

a) Chitin

b) Pectin

c) Silica

d) Cellulose

5. Diatomaceous earth can be used as a pest control because __________

a) it is porous

b) it contains silica which is poisonous for pests when eaten and therefore they die

c) it snatches out lipids from the outermost waxy layer of pests called cuticle and makes them dry which results in their death

d) it acts as anesthesia when given in minor quantities but pests die when large quantities are in taken

6. Diatoms store food as ________

a) Starch

b) Glucose

c) Oil

d) Fructose

7. Chrysophytes contain chlorophyll or carotene or xanthophyll in them. Their cell wall is rigid and is made up of chitin.

a) True

b) False

8. Cell wall in dianoflagelllates contain ________

a) Chitin

b) Cortex

c) Silica

d) Pectin

Chapter-2
Amoeba

Objectives :

- Describe distribution and habitat of Amoeba proteus and Paramaceium audatui
- Prepare and grow pure culture of Amoeba in lab
- Describe structure including shape and size of Amoeba and Paramecium
- List the functions of different organelles in Amoeba and Paramecium

Amoeba belong to kingdom Protista. They are neither classified as a plant or animal. They are eukaryotic in nature.

2.1 Classification of Amoeba proteus :

Phylum : Protozoa
Subphylum : Sacromastigophora
Superclass : Sarcodina
Class : Rhizopodea
Subclass : Lobosia
Order : Amoebida
Genus : Amoeba
Species : Proteus

2.2 Distribution and Habitat *:*

Amoeba proteus is commonly found in freshwater environments such as ponds, lakes, ditches, springs, and streams. They are found in bottom mud or on the underside of vegetation of aquatic bodiesbecause of their sensitivity to light.

The organism thrives in clean, oxygen-rich water and large ecosystems abundant in phytoplanktons (microscopic plants) and plants. Due to its sensitivity to light, it often resides in sheltered areas like the sides of lotus ponds or near the bottom.

2.3 Movement and Regeneration :

Amoeba proteus moves and feeds using pseudopodia, which are temporary projections of its cytoplasm. It possesses a notable ability to regenerate.

2.4 Culture of Amoeba proteus : To study *Amoeba proteus*, one can collect it by scraping decaying vegetation from a pond's bottom. This material is allowed to settle in a container. Using fine pipette under a microscope , amoebae are isolated.

Hay-infusion method is used to prepare temporary culture of amoeba. For preparing hay infusion decaying organic matter from freshwater is collected, boiled and filtered. To this infusion Amoeba-rich water is added. The amoebae grows in number (multiply) in 2-3 days. A more stable culture can be obtained by adding pond water, mud, leaves, and a few grains of wheat to 100 ml of water.

For a pure culture, wheat grains are boiled in distilled water. The boiled seeds are allowed to cool for few days. This is followed by addition of amoebae cultuture. The jar is covered with a glass plate and kept at room temperature for ten day. The Amoeba will multiply and increase in number can be seen under the microscope.

2.4 **Structure :**

2.5.1 Shape and size

- Amoeba is unicellular having a diameter of 250–600 µm and is translucent. Therefore, it can not be seen with the unaided eye.
- Larger proteus can be seen as a whitish blob with the naked eye.
- Under the microscope it appears as a jelly-like mass of hyaline protoplasm which is colorless.
- Amoeba does not have a fixed shape; its body shape is always changing because of the development of tiny projections that resemble fingers, termed pseudopodia. It turns spherical when its pseudopodia (false foot) are retracted.
- It does not have a cell wall. Instead it is surrounded by a thin membrane known as plasmalemma.
- The outer non-granular ectoplasm is located just under the plasmalemma surrounding the granular endoplasm. There is no clear separation between the two.
- Despite its shapeless appearance, it has a definite polarity with identifiable anterior and posterior ends.
- Pseudopodia extend from the anterior end. At the posterior end there is a wrinkled region known as uroid.

2.5 .2 Pseudopodia :

- Pseudopodia (Greek: pseudos = false, podos = foot) are extensions of the protoplst that the body continuously gives forth or retracts
- These come in a range of sizes and can extend or retract, frequently rather quickly.
- They are made up of both endoplasm and ectoplasm and range in size from cylindrical to broad with rounded tips e.g., Lobopodia. They originate from the cytoplasm's liquefaction and onward movement.
- Its "false feet" are an integral component of its structure since they are employed for mobility and for engulfing prey.

With the help pseudopodia, Proteus migrate to new locations to obtain food.

2.5.3 Plasmalemma :

- The body of an amoeba is covered by plasmalemma varying from 0.00025 mm to 2 microns.
- Amoebae do not have pellicle or cell wall.
- The membrane is permeable allowing the soluble molecules and water moleculesto flow freely through the membrane.
- It is made up of protein and lipid molecules.
- Mucoprotein is thought to be present in the plasmalemma's outer layer. When disrupted, the plasmalemma can regrow on its own and keeps the protoplasm inside the cell.
- The plasmalemma is unique in that it has many tiny, ridge-like projections on the outside of it. These projections are meant to act as adhesives, making it possible for the organism to attach to its substrate.

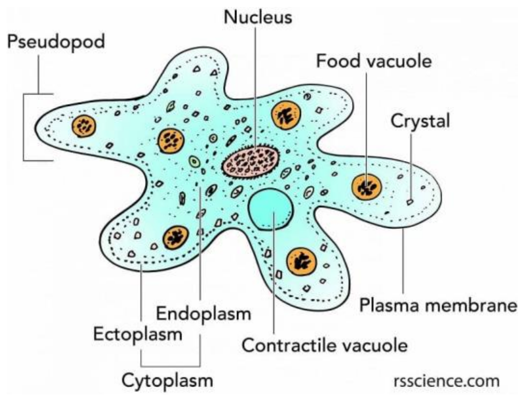


Figure 2.1: Structure of Amoeba proteus.

2.5.4 Cytoplasm :

• It is a dense mass covered by plasmalemma and is made up of two components, an inner endoplasm and an outer ectoplasm. Several organelles are embedded in cytoplasm.

a. Ectoplasm

- The ectoplasm is a thin, transparent layer that lies just beneath the plasmalemma. It is clean, clear, and fairly solid, but it can contract when under adverse conditions.
- Near the tip of the pseudopodia, the cytoplasm is thickened into a hyaline cap. Due to the presence of the longitudinal rigidity it is regarded as a supporting layer.
- Functions: It shields the body's internal organelles. It aids in keeping the body in its natural shape. It helps the amoeba create pseudopodia.

b. Endoplasm

- Ectoplasm entirely encircles endoplasm, which makes up the majority of the animal.
- It is semi-transparent, granular, and fluid-like.
- The components of endoplasm are plasmasol and plasma gel. The central flowing or sol state of the cytoplasm is called plasmasol. The peripheral gel like cytoplasm is known as plasmagel.
- The granules in the plasmagel are more solid and granular, yet they are immobile.
- The plasmasol is a very granular fluid with a variety of inclusions that moves in streaming patterns.
- It is possible to convert from plasmagel to plasmasol and vice versa.
- The endoplasm supports a variety of physiological processes and houses the cell's organelles. The production of pseudopodia is aided by frequent changes in the densities of the plasmagel and plasmasol.
- The endoplasm is home to several significant inclusions in addition to granules, including a nucleus, feeding vacuoles, contractile vacuoles, mitochondria, fat globules.

2.6 Endoplasmic organelles :

Various organelles found embedded in endoplasm are :

2.6.1 Nucleus :

- Amoeba has a true nucleus.

- There are two types of nuclei in amoeba – vesicular and ovular. Vesicular nuclei has centrally located nucleolus. Ovular nuclei has several small nuclei.
- The nucleus takes up the methyl green acetic acid stain and can be visualized under a phase contrast microscope.
- It is light-refractive and granular.
- The nuclear membrane covers the nucleus and is composed of lipid and proteins.
- Beneath the inner nuclear membrane is a honeycomb-like lattice that is crucial to preserving the nucleus's flattened shape.
- There are fewer nucleoplasms.
- **Functions:** The majority of the genetic material in the cell and all of the amoeba's regulatory mechanisms are stored in the membrane-bound nucleus of A. proteus. It has a crucial role in the cell's ability to reproduce.

2.6.2 Contractile vacuole

- Amoeba's endoplasm contains certain bubble-like vacuoles, known as contractile vacuoles.
- It grows quickly and is single, transparent, rounded, and clear.
- The liquid inside the vacuole is watery.
- It moves around in the endoplasm rather than having a fixed place.
- It is encircled by a throng of mitochondria which unite to form a bigger vacuole.
- It is continuously contracted or enlarged on the live body of Amoeba, hence the name contractile vacuoles.

Function: supports the animals' osmoregulatory and excretory processes.

2.6.3 Food vacuoles

- It is made up of small and big spherical chambers that hold food and water in different stages of digestion.
- The endoplasm contains them sporadically.
- When an amoeba swallows food with a drop of water, food vacuoles are created.
- They come in various sizes and are non-contractile.

  Functions: Food stuff is stored in food vacuoles. They aid in the process of food digestion. They play a part in the emission of feces as well.

2.6.4 Water globules

- Clear, spherical, water-filled vacuole in the *A. proteus* body, and there may be one or more of them.
- It's not tensile.

  Functions: It contains water and maintains the body's continual water balance.

Under an electron microscope, the endoplasm of an A. proteus exhibits a variety of inclusion features.

2.6.5 Additional organelles :

- Golgi bodies: They resemble tiny vesicles and tubules. Function: It facilitates food secretion and excretion.
- Mitochondria: These are roughly oval structures with tubular cristae that are found surrounding contractile vacuoles. Function: They contribute to the production of energy and respiration.
- Crystals: Bipyramidal or plate-like crystals can be discovered. These crystals are thought to be nothing more than the waste products of metabolism.Numerous mitochondria and vesicles are visible surrounding the contractile vacuole.
- Lysosomes are spherical structures with membrane bounds that are dispersed throughout the endoplasm.
- The ER develops when vesicles connect to procedure a system of tubules. The ribosome is present in endoplasmic vesicles and is also dispersed throughout the endoplasm.

2.7 Paramecium or Paramoecium :

A genus of single celled ciliated protozoa is called Paramecium or Paramoecium. Their bodies are covered in thousands of cilia, which is what makes them unique. Freshwater, marine, and brackish water are all home to them.

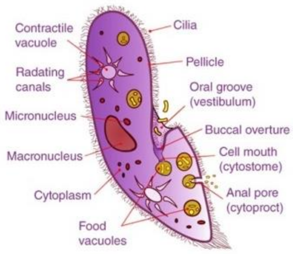


Fig.2.2 Structure of Paramecium

They are discovered affixed to the surface as well. The main method of reproduction is asexual (binary fission). They have a slipper-like form and demonstrate conjugation.

2.7.1 Classification

Paramecium is single celled and eukaryotic

Phylum-Protozoa

Sub-Phylum- Ciliophora

Class- Ciliates

Order- Hymenostomatida

Genus- Paramecium

Species- Caudatum

2.7.2 Features

- The range from 50 µ to 300 µ.
- Cell is oval, slipper shape, and a pellicle encloses the cytoplasm.
- The components of a pellet are an inner epiplasm, and a layer of alveoli that sits in among the two.
- The whole surface of the cell is covered in cilia, which protrude from the pellicle's depressions and give the cell its distinct but malleable shape.
- They move around and consume water from the gullet. The protoplasm is separated in granular inner endoplasm and outer ectoplasm.
- Trichocysts are contemporary and lodged in ectoplasm. The EG store food, making them a protective organ. There are certain secretory granules.
- Micronuclei participate in reproduction and have diploid chromosomes. Growth and all essential metabolic processes are regulated by macronuclei. The genome is duplicated in the macronucleus, making it polyploid.
- There are contractile vacuoles; the quantity varies among species. They are necessary for osmoregulation and eliminate the extra water that has been absorbed.
- The vestibuleis located at the halfway point. Food is brought into the cell by the coordinated movement of cilia.
- The cytostome, opens to the gullet or pharynx. Several food vacuoles are present to aid in food digestion.
- The furthermost predominant and well-known species in the genera is Paramecium caudatum.

2.7.3 Paramecium Locomotion :

Paramecium is propelled by thousands of cilia moving in unison. When faced with an obstruction, Paramecium has the ability to reverse its path and revolve about its axis.

2.7.4 Nutrition in Paramecium :

Tiny unicellular organism usually aquatic. It follows

1. Ingestion: engulfs food by cilia which move to oral groove into gullet.
2. Digestion: digested in food vacuole by the enzymes released by cytoplasm.
3. Absorption: captivated directly into the cytoplasm by diffusion.
4. Assimilation: nutrients is deposited and exploited later for synthesis of energy.
5. Egestion: The undigested food is excluded out through anal pore.

2.7.5 Paramecium Reproduction :

In Paramecium, binary fission is the method of reproduction. The mature cell divides into 2, which rapidly proliferates to give rise to a new organism. In the right conditions, Paramecium can grow up to 3 times per day. After fission, a cell splits transversely, and the micronucleus passes through mitotic division. In the macronucleus, mitotic division takes place. It divides in half at the gullet as well.

Paramecium reproduces sexually in a number of ways.

When two complementing paramecia (syngen) come into contact during conjugation, genetic material is exchanged. To reproduce through conjugation, each individual needs 50 asexual multiplicities.

The conjugation bridge is created throughout the process, and amalgamated paramecia are referred to as conjugants. Both cells' nuclei vanish. Through meiosis, the micronucleus of each conjugant creates four haploid nuclei. A trio of nuclei undergo degeneracies. Cross-fertilization occurs when the haploid nuclei of each conjugant fuse organized to generate diploid micronuclei. Exconjugants are formed when the conjugants split apart. While they differ from the prior cells, they are the same. Every exconjugate divides once more to produce four daughter Paramecia. A new macronucleus is formed by micronuclei.

Additionally, Paramecium exhibits autogamy, or self-fertilization. They are given a fresh lease on life when a new macronucleus is created.

Cytogamy is not as common. Nuclear exchange does not occur during the contact between two paramecia in cytogamy. Paramecium regenerates and forms a fresh macronucleus.

If a Paramecia does not go through conjugation, they age and eventually die after 100–200 cycles of fission. The aging of clones is caused by the macronucleus. It results from damage to the DNA

Summary

Amoebae are eukaryotic organisms that usually have a single cell. They cannot be categorized under a single taxonomic group; in addition to existing in protozoans, they are also found in algae, fungi, and other animals. Their natural ability to change form and shape involves mostly pulling back and growing pseudopods.

Like other eukaryotic creatures, amoeba have a few distinguishing characteristics. The cell membrane encircles the cytoplasm and contents of these entities. The nucleus is a core cellular compartment that houses the amoeba's DNA. Organelles are unique structures seen in amoeba. At the cellular level, these structures perform a variety of tasks, such as protein trafficking and energy synthesis.

Chapter-3
Porifera : Sycon

Objectives :

- Describe Characteristics features of phylum Porifera
- Classify Porifera into different classes
- Describe structure and morphology of phylum Porifera
- Write significance and importance of different organisms belonging to phylum Porifera

3.1 Introduction :

The term Porifera refers to a class of multicellular creatures that can be either non-symmetrical or symmetryradial, displaying the grade at cellular level of organization with tissues and organs absent in organisms. They are primarily sedentary, aquatic, solitary, or colonial in nature, and have body perforations such as pores, canals, and cambers that allow water to pass through. Additionally, they have one or more internal cavities lined with choanocytes, and their distinctive body structure is composed of calcium, silica, or horny spongin fibers.

3.2 Characteristics features

1. Mostly Porifera are marine and fresh water by habitat, with the exception of the Spongillidae family, which is freshwater only.

2. They grow like plants and are sedentary and sessile.

3. The body is asymmetrical, radially symmetrical, or shaped like a vase or cylinder.

4. There are many pores on the body's surface, called ostia, which helps the water entery inside the body, and 1 or more sizable apertures, called oscula, by which water is present.

5. These are multicellular organism that possesses body organization at the cellular level. no separate organs or tissues.

6. They are diploblastic, consisting of an intermediate layer of mesenchyme between the outer and inner ectoderm and endoderm.

7. The body's interior is either hollow or filled with many choanocyte-lined channels. Spongocoel is the term for the internal region of the sponge body.

8. A distinctive skeletal structures consisting of calcium spicules, silica spicules, or fine, flexible fibrous spongin.

9. Digestion occurs intracellularly, no mouth.
10. There are no respiratory or excretory organs.
11. Certain freshwater forms contain contractile vacuoles.
12.There's a good chance that the nerve and sensory cells are not distinct.
13. The rudimentary nervous system, which consists of neurons grouped in a specific arrangement of multipolar cells or bipolar in certain cases, is questionable.
14. Sponge monoeciousness exists.
15. There are asexual and sexual ways to reproduce.
16. Gemmules and buds reproduce asexually.
17. The sponge has a strong capacity for regeneration.
18.In order to reproduce sexually, sperm and eggs are used.
19. Every sponge has two halves.
20. Cross-fertilization can happen, but internal fertilization is the norm.
21. Holoblastic cleavage.
22. A free swimming, ciliated larva known as an amphiblastula or parenchymula is the indirect conduit for development.
23. Because of their simple and complicated morphologies, sponges are organized into three types: sycon ascon and leuconoid.
24. Some examples are: Oscarella, Thenea, Cliona, Halichondria, Spongilla, Euspondia, Sycon, Grantia, Euplectella, Hyalonema, and Plakina.

3.3 Classification

Phylum - Porifera

Sponge species—roughly 5,000 in number—are organized into three classes within this phylum primarily based on the kinds of skeletons they possess. Although it seems to be a revision of Hyman's classification, the classification used here is based on Storer and Usinger (1971).

Class - Calcarea

- Tiny, conical,calcium carbonate sponges with a body shape like a vase or cylindrical, with a height of less than 10 cm.
- Their structures could be leuconoid, syconoid, or asconoid.
- An entirely marine skeleton composed of distinct calcareous spicules with one, three, or four rays.

Order 1- Homocoela (Asconosa)

- Asconoid sponges have radially symmetrical, cylindrical bodies with thin, unfolded body walls.
- The Spongocoel is lined by choanocytes.
- Frequently conical.
- Examples are Claudia and Leucosolenia.

Order 2- Heterocoela (Syconosa)

- Sponge species classified as syconoid and leuconoid have a vase-like body with a thick, folded body wall.
- Only the flagellated chambers, or radial canals, are lined with chonocytes.
- A line made up of flattened endoderm cells is called a sponge.
- Isolated or globular
- For Examples: Grantia, Sycon and Scypha

Class 2- Hexactinellida

- Dubbed as glass spongers.
- The size of the sponges can be up to one meter long.
- Body shaped like a vase, urn, or cup.
- The skeleton is made up of triaxon, six-rayed siliceous spicules.
- In certain,spicules combine to create a skeleton resembling a lattice.
- Absence of epidermal epithelium.
- Pointy chambers are lined with choanocytes.
- Bottom of the members is funnel-shaped.
- Habitat is tropical dark zone of sea.

Order 1- Hexasterophora

- Star shaped Spicules have a with axes that branch into rays at their ends, making them hexasters.
- Radially arranged in Regular and flocculated chambers that are typically physically linked to the substratum.
- For example Farnera and Euplectella

Order 2 - Amphidiscophora

- Spicules are amphidiscs, meaning they have a convex disc with marginal teeth pointing backward at both ends.
- Flabellated chambers exhibit a small deviation from the standard kind.
- Root tufts hold the plant firmly to the substratum.
- Examples: Hyalonema, Pheronema.

Class 3 - Demospongiae

- The class has the greatest variety of sponge species.
- Dimensions: conspicuous to huge.
- Either solitary/colony-forming.
- The main structure resembles a pillow, flower-vase, or cup.
- The main skeleton may consist of spongin fibers, silica containing spicules, or neither.
- Spicules are either monaxon or tetraxon, never having six rays, and can be further divided into tiny microscleres and huge megascleres.
- The leucon type body canal system is in place.
- Choanocytes are confined to tiny, spherical chambers; most are marine, with very few occurring in freshwater.

Subclass I - Tetractinellida

- Sponges are often made of solid, basic, spherical, cushion-like material that has been flattened and typically lacks branches. vivid to dull in color.
- The skeleton is primarily made up of siliceous tetraxon spicules, which are lacking in the Myxospongida order.
- The leuconoid type of canal system is found mainly in shallow water.

Order 1 - Myxospongida

- Easy to grasp structure.
- There are no sparse particles.
- For Examples Oscarella, Halisarca.

Order 2 - Carnosa

- Easy to understand structure.
- There is no distinction between megascleres and microscleres in specular filaments.
- There could be asteroids.
- Examples: Plakina, Chondrilla.

Order 3 - Choristida

- There are two type of spicules which is big and little.
- Thenea and Geodia are two examples.

Subclass II - Monaxonida

- Exists in many different forms, such as a circular mass, branching varieties, elongated, funnel-shaped stalks, or fan-shaped stalks.
- Monaxon capsules. Is there spitting or not ?
- Two types of sparcells are present megascleres and microscleres.
- Found in large quantities all throughout the planet, mostly in freshwater, some in deep waters, and mostly in shallow waters.

Order 1 - Hadromerina

- Tylostyles are one type of Monaxon megasclere.
- When present, microscleres take the appearance of asters.
- Spongia is not present.
- For Examples Tethya Cliona

Order 2 - Halichondrina

- There are typically two forms of monaxon megascleres: diactines and monactines.
- Microscopes are not present.
- Sponges are both rare and present.
- Take Halichondria, a sponge that resembles bread crumbs.

Order 3 - Poecilosclerina

- Distinct siliceous spicules
- demosponges with distinct organic and inorganic skeletons.
- It also includes a skeletal organization that is typically restricted to specific regions

Order 4 - Haplosclerida

- Microscleres as typically chelas, sigmas, and toxas.
- Microscleres are absent from monaxon megascleres, which are only of the diactinal kind.
- There are usually filaments of sponge.
- Examples: Chalina, Pachychalina, Spongilla.

Subclass III - Keratosa

- Microscleres are typically chelas, sigmas, and toxas.
- An abundance of noticeable oscula surround the spherical, enormous body of horny sponges with a skeleton made of spongin fibers.
- Not a single spicule.
- Found in tropical and subtropical climates' shallow, warm seas.
- Examples: Euspongia, Hippospongia.

3.4 Canal system in Sycon

A sycon, commonly referred to as a scypha, is a type of water organism that typically clings to surfaces like rocks. With the aid of an opening known as an operculum, the tube-shaped bodies of these organisms expand outward. Water is able to enter their bodies through microscopic apertures known as ostia and spiracles. The Osculum, a bigger hole utilized for breathing, is where this water exits their body after passing via canals inside.We will examine the form of this canal system, the reasons it is necessary for those species, the kind of canal system, and its importance.

The phylum Porifera is distinguished by its unique Sycon Type Canal system. The aquiferous canal system is another name for this system. The body's important processes, including respiration, excretion, and nourishment, are supported by this system.

History

Scots scientist Grant devoted a great deal of time to the study of sponges. Among the first to properly describe the internal workings of the Sycon canal system was him. For upcoming scientists, his thorough illustrations and explanations were quite useful.

German biologist Haeckel built on Grant's research to develop his own theories. Not content to only concur with Grant, he went on to design a method for classifying sponges according to their unique canal systems. This improved our knowledge of sponges.

Following that, several more scientists closely examined the Sycon canal system. They employed extremely advanced technologies, like as electron microscopes and unique biology procedures, to see minute details about how this system functions at the smallest levels.

Even in present time, scientists are still working to understand more about the Sycon canal system. They want to know how it works and why it is so vital for sponges in their natural environment. This tells us more about these fascinating species while also demonstrating how life on Earth has evolved over time.

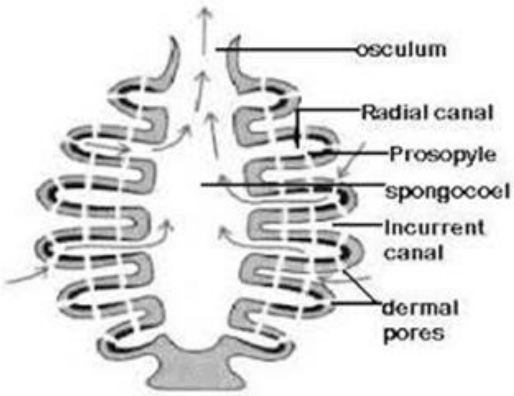


Fig. 3.1: Canal System

Many pores and canals can be found in the Sycon Type Water Canal System, including -

Dermal Ostia: Ostia that regulate the amount of water that enters the body and transmit water into the incurrent canal.

Incurrent Canal: Water is transferred from dermal pores into the pinocyte-lined, internally narrowed concurrent canal. The canal's inner end is closed, and water enters the radial canal through a tiny opening known as the prosopyle that exists between the radial canal and the incurrent canal.

Water was transferred from the incurrent canal to the radial canal by the prosopyle.

Choanocytes or flagellated cells, border the radial canal. Water enters the body as a result of flagellated cells' activity.

Apopyles, a tiny pore or aperture, opens them from the outside. They are closed internally.

Excurrent Canal: An apopyle opening allows the radial canal to enter the excurrent chamber. Pinacocytes line the walls of this chamber. This passes via a large aperture known as the stomach ostium to enter the spongocoel.

Spongocoel: A pinacocyte-lined, narrow hollow. Through the osculum, it opens to the outside. Myocytes round the osculum, forming an oscular sphincter that further controls the diameter of the oscular opening.

3.4.1 Types of Canal System

Four different types of canal systems are found across the phylum Porifera.

1) **Ascon type :**

Pores-------Internal ostia --------------Spongocoel ----------osculum---------Outside

Water Path of ascon type canal system

There is simplest type of canal system present in these .In this water enters through pores in the body and exist through a single cavity osculum.Example- Leucosolenia

2) **Sycon canal system:**

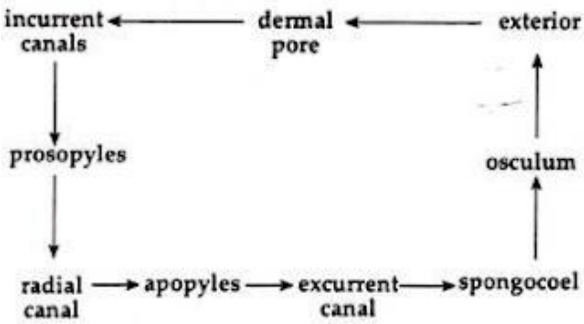


Fig. 3.2 Water path of **Sycon canal system**

3) **Leucon type :**

There is complex canal system in the radial canal divided into small flagellated chambers. Example : Spongilla

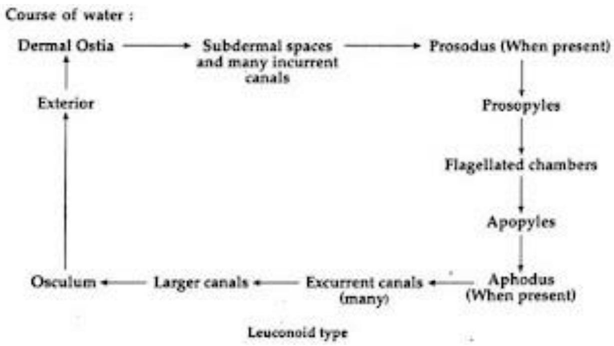


Fig. 3.3 Water path of **Leucon canal system**

4) Rhagon type:

There is type of canal system is present in larval form of demospongia.

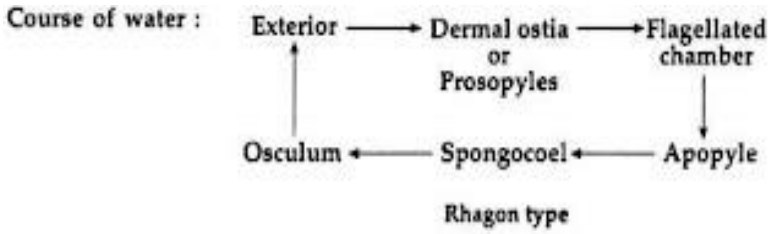


Fig. 3.4 Water path of **Rhagon canal system**

3.5 The canal system of Sycon –

The Sycon type canal system is composed of three main components: incurrent canals, radial canals, and excurrent canals. The incurrent canals are responsible for drawing water into the sponge, while the radial canals ensure the efficient distribution of water throughout the body. On the other hand, the excurrent canals allow the filtered water to exit the sponge. The intricate arrangement of these canals facilitates vital processes within the sponge.

Now let's take a deeper look at the structure of the Sycon type canal system. The incurrent canals, also known as inhalant canals, are lined with specialized cells called porocytesBecause of their distinct shape, these porocytes are able to control how much water enters the sponge. Water seeps via these microscopic pores that the porocytes have made, carrying with it the oxygen and vital nutrients that the sponge needs to survive.

Once inside the sponge, water is directed towards the radial canals. These canals radiate outward from the central cavity of the sponge as their name suggests. They are lined with collar cells or choanocytes that play a crucial role in filtration. Collar cells have whip-like structures called flagella that create a current and draw water through these canals. As water passes through, collar cells trap and filter out microscopic particles such as bacteria and organic matter which serve as food for sponges.

The filtered water, now free from impurities, continues its journey through excurrent canals also known as exhalant canals which carry clean water out of sponges. Excurrent canals are lined with epithelial cells that prevent any unwanted substances from re-entering sponges. This ensures that only purified water is expelled, maintaining an optimal internal environment for sponges.

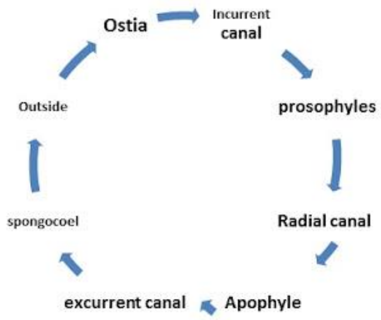


Fig. 3.5 Canal system of Sycon

3.6 Significance of the Canal system - The Sycon canal system is really important for sponges. It helps them filter and take in stuff they need to grow and make more sponges. Also, it helps sponges stay clean inside by getting rid of waste. here are some important points -

1. Nutrition - The beating of choanocyte flagella produces a water stream that passes through Ostia and into the spongocoel.

It feeds almost every sycon cell with food particles. A water current that travels through the sponge canal allows for the absorption of silica, calcium salts, and other substances.

2. Respiration - Through Ostia, which has abundant oxygen, freshwater is brought within. Simple diffusion is used to carry out respiration. The osculum is used to remove the carbon dioxide.

3. Excretion - With the assistance of the osculum, the body's waste is all expelled.

4. Reproduction - The incurrent canal is where the spermatozoa enter the water and aid

5. Defence - Sycon sponges' canal system may have a defensive purpose by aiding in the removal of unwanted particles or organisms that could endanger the sponge.

6. Habitat - Sycon sponges, with their intricate canal systems, serve as the foundation for distinctive ecosystems in the marine environment. These sponges provide shelter to a variety of small invertebrates and microorganisms, which inhabit the nooks and crannies within their canals, effectively transforming them into miniature ecosystems.

7. Potential In Medicine - Scientists can discover new medicines and treatments by studying how the Sycon type canal system works in sponges and the chemicals they produce. These substances have potential to fight against infections, reduce inflammation, and even treat cancer, among other important abilities.

MCQ

1. A key evolutionary development seen for first time in spongesis

a. A complete digestive system

b. Tissue organization

c. body symmetry

d. multicellularity

2. The name of skeleton of 'Venus flower basket'

a. Euplectella

b. Euspongia

c. Leucosolenia

d. Spongila

3. Which of the following is an example of the medusa body form

a. A hydra

b. A coral

c. An Anemone

d. a jelly fish

4. Animals those are not having excretory, respiratory and circulatory structures are

a. Tapeworms

b. Liver fluke

c.Threadworms

d. Sponges

5. These are multicellular grade of organization

a. Sponges

b. Prokaryotes

c. Coelenterates

d. vertebrates

6. Sycons are the organisms those belong to

a. Multicellular having tissue organization, but not a body cavity

b. Unicellular or acellular

c. Multicellular with a gastrovascular cavity

d. Multicellular with no tissue organization

7. Collared, flagellated cells that cover large parts of the inner chambers of sponges, helping water circulation to continue are

(a) Porocytes

(b) Choanocytes

(c) Amoebocytes

(d) Pinacocytes

8. The larva of Leucosolenia which is flagellated is known as

a. Maggot

b. Media

c. Planu

d. Parenchymula

9. Poriferan evolution from protozoans is evidenced by animals such as

a. Paramecium

b. Euglena

c. Chlamydomonas

d. Proterospongia

10. The chamber common to all the types of the canal system of sponges is

a. Excurrent canal

b. Radial chamber

c. Incurrent canal

d. Paragastric cavity

Chapter-4

Cnidaria

Objectives :

- Describe the occurrence of cnidae in different aquatic habitats including freshwater and marine habitats.
- Describe Characteristics features of phylum Cnidaria.
- Identify systematic position and structure of Hydra and other cnidae.
- Write significance and importance of different organisms belonging to phylum Cnidaria.

4.1 Introduction :

4.1.1 Phylum Cnidaria: Cnidos, a Greek word meaning "stinging thread," is the source of the English term "cnidaria." The occurrence of cnidae sets these species apart from others.10,000 species of hydras, sea anemones, corals, and jellyfish are known to exist in the phylum Cnidaria in the Animalia Kingdom. In freshwater and marine habitats, these aquatic species can be found. Biological entities having actual tissues are the most fundamental ones. It was believed that these animals were the first to have a distinct form in the history of evolution.

Figure 4.1: Representative members of Cnidaria

4.2 Historical concept

Cnidaria has been found to have old origin, dating back over 580 million years. There is evidence that corals lived 490 million years ago in certain fossils. The Phylum Cnidaria is thought to have begun during the Cryogenian epoch.

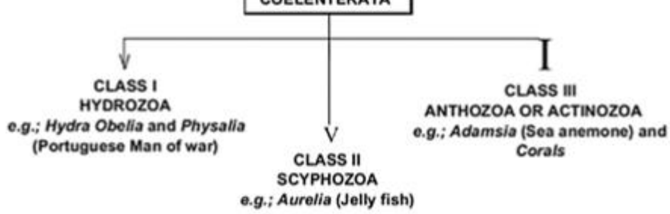
4.3 Characteristics:

1) The name "Cnidaria" or "Coelenterata" is derived from their characteristic stinging cells called "cnidoblasts" and a cavity called "coelenteron “

2) They are only marine and aquatic.
3) These animals are diploblastic and radially symmetrical.
4) Cnidoblasts, also known as stinging cells, are a unique form of cell. These cells paralyze their target and use in defense. They cover the tentacles and are seen in huge quantities surrounding the mouth.
5) They demonstrate the gastrointestinal cavity's intracellular and extracellular digestion.
6) Cnidaria have no respiratory, excretory & circulatory system. Gaseous exchange and excretion of waste material takes place through exterior cuticle of the body.
7) The body of Cnidaria has non-complex or complex sensory organs, like statocysts and tentaculocysts, to help with balancing.
8) Nervous system has been found to be less-developed that manifest as a nerve net in the tentacles and body walls.
9) Polymorphism showed by cnidarians. There are two types of body forms: the sexual medusa stage and the asexual polyp.
10) In Hydra, the Polyp is shaped like a cylinder.
11) The jellyfish Medusae is formed like an umbrella.
12) Spores or budding are the means of asexual reproduction.
13) Gametes are produced during sexual reproduction. Male and female sex organs are present.
14) The embryo exhibits indirect growth.
15) Fertilization was seen to be external in majority of the organism of this phylum.
16) A few display generational alternation, or metagenesis, a phenomena in which the sexual (medusa) and asexual (polyp) generations alternate.
17) A few such instances are Hydra, Aurelia (Jellyfish – Medusae form), Adamsia (Sea anemone – Polyp form), Pennatula (Sea pen), and Gorgonia (Sea Fan).The (Portuguese man-of-war) _Physalia, Meandrina (brain coral), and Obelia (polyp and medusa).

4.4 Classification of Cnidarians

There are 3 classes in Cnidaria phylum, often known as Colenterata. These are described below:



4.4.1 Hydrozoa: The Greek words for "water" and "animal" are "hydro" and "zon," respectively.

A portion of them are freshwater creatures, while the majority are marine.

b) The majority of them are colonial, however few of them are solitary.

c) These exhibit sexual medusa stage and the asexual polyp.

d) It has been seen that polyp stage dominating.

e) There is presence of actual velum.

f) There is a cellular mesoglea.

g) Gonads originate on the epidermis.

h) They have statocysts to keep themselves in balance.

i) Some examples are *Tubularia, Physalia, Obelia, Hydra*, etc.

4.4.2 Scyphozoa:"Skyphos" in Greek depicts to "cup," and "Zoon" means "animal."

a) Habitat aquatic.

b) The predominate form of life is the umbrella-shaped Medusa form.

c) Mesoglea cells are found.

c) The polyp shape is simple.

e) There is a pseudo velum.

f) The origin of gonads is endodermal.

g) They have tentaculocyst to keep their balance.

h) For examples: Rhizostoma, Aurelia, Jellyfish.

4.4.3 Anthozoa: The “Zoon=animal” and “Anthos=flower” as per Greek signify the same.

a) Exclusively marine , exhibits colonial characteristics.

b) The stage of polyps is active.

c) The stage of medusa is missing.

d) The lack of velum.

e) The epidermal and gastrodermal regions contain chondocytes.

f) The mouth is circular in shape and has a whorl of tentacles surrounding it that resembles a flower's structure.

g) Gonads originate from the endoderm.

h) For Example: *Telesto* ,Monactis, *Tubipora, Xenia*, etc.

4.5 Systematic position and structure of Hydra:

Kingdom : Animalia

Phylum : Cnidaria

Class : Hydrozoa

Order : Anthoathecata

Genus : Hydra

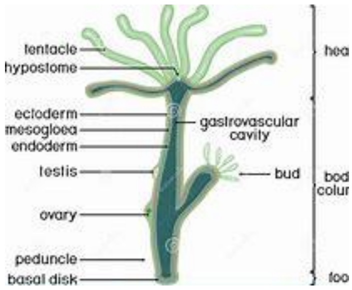


Fig. 4.2 : Hydra

4.6 Structure of Hydra

1. They are small, multicellular, cylindrical, diploblastic, radially symmetrical, fresh water creatures.

2. They have two different kinds of tissue layers: endoderm and ectoderm.

3. They are discovered affixed to solid materials in water, including weeds, stones, and leaves.

4. A Hydra's body is shaped like a tube, resembling a polyp, and its tentacles are positioned all around its head pole.

5. They are both male and female.

6. They use a mechanism called budding to reproduce asexually.

4.7 Some important examples

4.7.1 Physalia *(Portuguese Man of War)*

a. Classification :

Kingdom : Animalia

Phylum : Cnidaria

Class : Hydrozoa

Order : Siphonophorae

Family : Physaliidae

Genus : *Physalia*

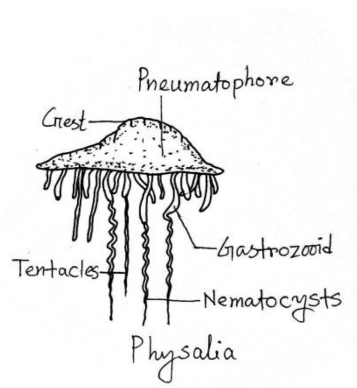


Fig. 4.3 : Physalia

b. Characterstic feautres

1. Their exhibits polymorphism.
2. These are referred as sponges of colonialism. There is a transparent, balloon-like appearance, huge pneumatophore, is carried at the top of the colony.
3. The entire jellyfish colony stays submerged in water, while the pneumatophore floats above the surface.
4. Gases like CO_2 and H_2O are secreted and absorbed, which causes the body to move up and down in the water.
5. The gas glands are the source of these gasses.
6. The process of sexual reproduction is called "broadcast spawning."

4.7.2 Jelly fish

a. Classification

Kingdom: Animalia

Phylum: Cnidaria

Class: Scyphozoa

Order: Semaeostomeae

Family: Ulmaridae

Genus: *Aurelia*

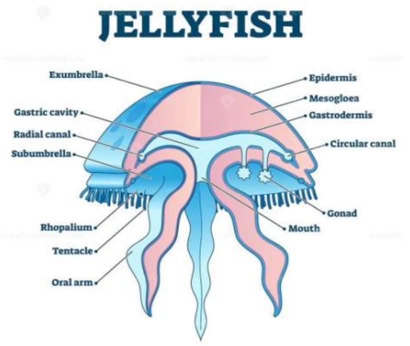


Fig. 4.4 : Jellyfish

b. Characterstic features

1. They have two different kinds of tissue layers: endoderm and ectoderm.
2. The middle of their body is where their mouth is located.
3. The three main sections of a jellyfish's body, which exhibits radial symmetry, are the tentacles, which are loaded with small, stinging cells, the oral arms, which surround the mouth, and the umbrella.
4. The tentacles are a potent tool for collecting prey and act as defense mechanisms.
5. They lack eyeballs, bones, a heart, and a brain.
6. They exhibit bioluminescence, which indicates that they generate their own light.

4.7.3 Sea Anemone

a. Classification

Kingdom: Animalia

Phylum: Cnidaria

Class: Anthozoa

Order: Actiniaria

Family: *Hormathiidae*

Genus: *Monactis*

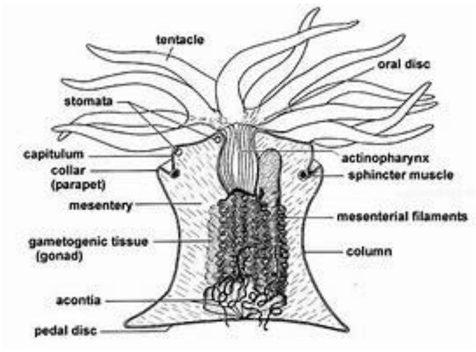


Fig. 4.5 :Sea Animone

b. Characterstics

1. Although these members resemble flowers, they are actually animal that consume flesh.

2. They have a central intestinal cavity and a soft, straightforward body shaped like a polyp made of two tissue layers: the ectoderm and the endoderm

3. Tentacles that sting surround the mouth.

4. There are no internal or exterior calcareous skeletons on their bodies.

5. Their associations with other marine species are symbiotic.

6. They demonstrate both asexual and sexual reproduction.

4.8 The economic and ecological importance of Phylum Cnidaria is mentioned:

4.8.1 Economic importance

1. Visitors visit the coral reefs for the purpose of diving and snorkeling.
2. To give aquariums a marine feel, a lot of coral is used in them.
3. The jewelry business uses corals.
4. Cancer and other diseases are treated with certain substances derived from cnidarians.
5. Cement is made using the skeletons of coral.

4.8.2 Ecological Importance

1. A variety of organisms, including fish, algae, seaweed, etc., find home in corals.
2. A lot of marine species eat them, and some Cnidaria—like sea anemones—are consumed by humans.
3. The land is shielded from ocean waves by coral reefs.

Summary

There are relatively few freshwater species in the Phylum Cnidaria, while the majority of its members are marine. Members of this phylum are diploblastic and exhibit radial, biradial symmetry. Despite their lack of familiarity, the species within this phylum are an important component the animal kingdom and serve a crucial purpose, particularly in the fresh and marine environment. Cnidarians are known from the beginning of life on earth species that include jellyfish, corals, and hydra, which are the most well-known creatures in this phylum.

Short Questions

Q.1. Which organisms belong to the Phylum Cnidaria?

Answer: A variety of species, including Hydra, Sea Anemones, Jellyfish, Corals, Physalia, Obelia, and Tubularia, are found in the Phylum Cnidaria.

Q.2. What are the several classes within the Cnidaria phylum?

Answer: The Phylum Cnidaria is divided into three classes: Scyphozoa, Anthozoa, and Hydrozoa.

Q.3. What does "cnidaria" mean in language Greek.

Answer: "Cnidos," which meaning "Stinging Nettle," is the source of the name "Cnidaria."

Q.4. What are the five traits do cnidarians possess?

1) Their names Cnidaria and Coelenterata are justified since they have stinging cells called cnidoblasts and a cavity known as coelenterate.

2) They are only marine and aquatic.

3) These animals are diploblastic and radially symmetrical.

4) Cnidoblasts, also known as stinging cells, are a unique form of cell that are present in the ectoderm of codfish. These cells contain hypnotoxin, which paralyzes the prey and is utilized for defense. They cover the tentacles and are seen in huge quantities surrounding the mouth.

5) There are two different body forms: the sexual medusa stage and the asexual polyp.

Chapter-5
Hydrozoa

Objectives :

- Describe the occurrence of an organism in two or more different morphological and functional forms in polymorphs.
- Write characteristics features of polyps and zooids.
- Explain Significance of polymorphism.
- Understand significance and importance of coral reef in protection of coastlines, in medicines and in supporting biodiversity of marine environment.

5.1 Polymorphism (poly means **many morph means forms)**

- Occurrence of an organism in two or more different morphological and functional forms within a population is known as Polymorphism. Polymorphismis observed in the same species of individual.
- It occurs in the same species of an individual.

5.2 Zooids :

Zooids are animal coming after budding or binary fission

5.2.1 Types of zooids

Zooids are of two types, depending on the shape structure and functions

A. Polyps:

- The body of polyp is tubular In Hydrozoa, at one end mouth surrounded by tentacles Other end of body is blind having pedal disc polyp attach to substratum
- Polyp are cylindrical and sessile forms having wide cavity called gastrovascular cavity. These polyp feed the colony therefore they are called nutritive zooids, trophozooids or gastrozooids.
- Mode of reproduction is asexual

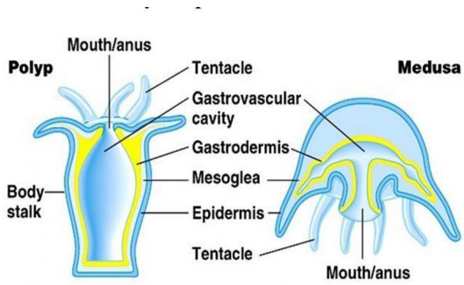


Fig. 5.1 Polymorphism in Hydrozoa

B. **Medusae:**

- The body is bowl or umbrella shaped having marginal tentacles. On the ventral concave surface mouth is located centrally known as manubrium
- They are motile and mode of reproduction is sexual

5.3 Significance of polymorphism :

- The polymorphism assigns specific function to different individual leading to division of labour their further modification may be due to their simple organization and lack of specialization
- Different form of organism have different function eg polyps are responsible for feeding, asexual reproduction and protection whereas sexual reproduction is carried out by medusa.
- The colony have competitive edge in protection and gathering of food eventually leading to survival

5.4 Types of polymorphism :

5.4.1 Monomorphic: Have one type of zooid. Example- Hydra

5.4.2 Dimorphism: there are two tyoes of zooids in Campanularia and Tubularia,

a. gastrozooids:
b. medusea or sexual zooids

5.4.3 Trimorphism: example of it is Obelia and Plumularia

a. Gastrozooids- nutritive zooids
b. Dactlozooids- protective zooids
c. Medusae – sexual zooids

5.4.4 Polymorphism: zooids are modified for different function

5.5 Coral Reefs

Colonies of tiny living organism present in ocean are coral reefs, moulded together by $CaCO_3$ they are usually underwater structure and inhabiting ocean's surface (0.1%) indigenous to marine species (25%) . They befall in depth less than 150 feet but can range deeper, up to about 450 feet

5.5.1 About Coral Reefs

Calcium carbonate exoskeletons of ancestor lead the foundation of individual corals called as Coral polyps. Mainly reside in ocean, maximum of them is found in clear shallow waters of the tropics and subtropics region. The Great Barrier Reef in Australia is more than 1500 miles long and is the largest coral reef system

5.5.2 Factors Affecting Coral Reefs

- **Extreme climatic environments:** Degradation of corals occurs at high temperature as they cannot tolerate high temperature. Global warming leading to ocean environment change can soon lead to reduction of coral in the world.
- **Overfishing:** This leads to ecological imbalance that could ultimately reduce the coral reefs
- Increase in encroachment and tourism activities maysubstantial damages of reef
- **Pollution:** Increasing air and water pollution, waste that are directed to ocean without treatment all these results in intoxication by increasing nitrogen level and enhanced algal growth also reduce and damage coral reefs
- **Sedimentation:** Sediments in the river due to soil erosion is also the result of Construction along the coasts and islands that pose challenge for coral reef for their survival

5.5.3 Growth Conditions

- The water temperature above 20°C. The ideal temperature is between and it should not surpass.
- The ideal temp for growth of coral ranges between 23°C and 25°C, temp above 35°C and below 20°C has adverse effects on growth of corals

- Halophilic condition are required for Corals growth with an average salinity between 27% and 40%.
- Optimum water state shallow water less than 50 meters deep, and the water deepness would not outdo 200 meters.

5.5.4 Categories of Coral Reefs

3 types on the basis of shape and nature.

Fringing Reef: Most common reef among the three. It is seaward from the shore. They form a border along the surrounding shore line and surrounding environment**.** eg, South Florida Reef

Barrier Reef: Among the they are the uppermost and broadest and most commonly found. They are formed parallel to the shore and off the coast. Expanse of water separates barrier reef from the land.

Atolls: An atoll is ring shaped reef, series of island or islets. An atolls surrounds a large central lagoon with a deepness of 80-150 metres. These are developed with underwater volcanos knows as sea mounts. On eruption of volcano the lava is pilled up on the sea floor as the volcano continue to erupt elevation of sea mount grow higher ultimately breaking water surface top of the volcano for oceanic island egis Funafoothis Atoll of Ellice.

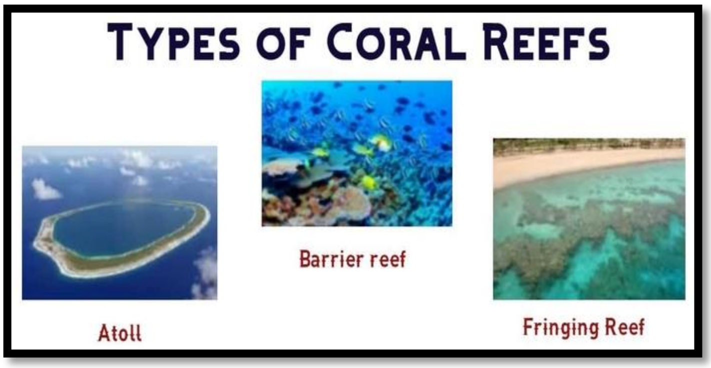


Fig. 5.2 : Coral reefs

5.5.5 Importance of Coral Reefs

- Protection of coastlines by mitigating the possessions of tropical storms and wave action
- They also are source of not only food and but also new medicines.
- Supports biodiversity of the marine environment

- Drug discovery from the animal and plants of coral reef for cure of arthritis, bacterial infection, cancer etc.
- carbon and nitrogen-fixation is also aided by reefs
- They play a vital role nutrient recycling.
- They are filter feeder consuming suspended particulate matter in water leading to enhance water quality.
- Local economy is often supported by coral reef in the form of tourism industry, fishing industry and recreational
- They crucial pointers of world ecosystem wellbeing.

5.5.6 Coral Reefs in India

India has 7500 kilometres ranging over its coastline. subtropical climatic conditions in India results in reduction of coral reefs in India.

There are two widely separated areas having coral reef in mainland coast of India includes

Palk Bay

Located in the, Palk Bay at locat 9 °17’N and 79° 15′. with maximum depth of 3 m.

Gulf of Mannar

Located along 21 islands,it stretches 140 km amongst Tuticorin and Rameswaram. These islands are positioned between latitude and longitude 8°47′ N and 9°15′ N and 78°12′ E and 79°14′ E, respectively, forming 140 km long and 25 km widepart of the Mannar Barrier Reef.

Andaman and Nicobar Islands

They are situated in the south eastof the Bay of Bengalbetween 6°-14° N latitude and 91°-94° E longitude. The archipelago entails of 350 islands, of which only 38 are populated.

Gulf of Kutch

Positioned in the north of the Saurashtra Peninsula, casing an area of approximately 7,350 square kilometers. These fringing reefs span about 170 kilometers in length and 75 kilometers in width at the mouth, narrowing at 72°20′ E longitude.

Lakshadweep Islands

They are scattered in the Arabian Sea, approximately 225 to 450 kilometers off the Kerala coast. Covering an area of 32 square kilometers, the archipelago consists of 36 islands, 12 atolls, 3 reefs, and 5 submerged banks, with lagoons spanning around 4,200 square kilometers.

5.5.7 Coral Bleaching

Symbiotic relationship is established between coral and the zooxanthellae. 90 % of nutrients produced by zooxanthellae is consumed by corals

Loss of symbiotic algae (zooxanthellae) under severe environmental stress affects reef. Coral bleaching is a result of accumulation of white calcium-carbonate exoskeleton as transparent tissue. Coral become susceptible at high temperature or if the algae begins to die

5.5.8 Threats to Coral Reefs

20 percent of the world coral reef is lost even it is established that they have economic, ecological and aesthetic values. Next 24 percent of coral are endangered due to breakdown chances and other 26 percent are at risk due to anthropogenic activities. If this rate continues we will lose 70 percent coral reef by 2050

Various factors that cause threat to coral reefs are enlisted below:

Overutilization for various applications like for food, medicine, and industry

- Marine contamination such as oil spills, release of ballast water and discharge of leftover from ships is harmful to them
- Tourism effects coral reef directly and indirectly activities like boating diving and snorkelling may cause physical damage to the corals whereas use of reef species for food, aquariums, and souvenirs can may result in extinction od species.
- Climate change due to global warming result in an evolving threat to coral reefs.
- They are also vulnerable by rising temp, bleaching, sea level increase, amplified dissolved CO_2, and ocean acidification.

5.5.9 Snowflake Coral –Biodiversity

Snowflake coral also called Carijoa Riisei is reported off the coast of Thiruvananthapuram and Kanyakumari. it is an invasive species. Off coast Kovalam at Thiruvananthapuram and Enayam at Kanyakumari at 10 and 18 m respectively these are fast growing species.

Marine ecosystem is in threat due to snowflake coral due to following

1. Zooplanktons consumed by them in large amount, these zooplanktons have a positive ecological impact which is devoid by coral
2. The replace the native species and raise threat to biodiversity and also control food resources
3. Marine biodiversity is also effected as it occupy space and crowd out corals, algae and sponges

5.5.10 Coral Reefs Conservation Efforts

World have till date lost 20 percent of the reef so future conservation is utmost importance.

1. Protect the marine area from over exploitation
2. Executing legislation to prevent over-harvesting
3. Monitoring coral reefs is crucial for emerging effective organization strategies
4. Creating responsiveness about them, and their variety, and the facilities they deliver significantly assist mitigate threats to these fragile ecosystems
5. Few laws are there in the country for the protection of coral reef like EPA 1986, and WPA 1972
6. All coral reef area are declared as protected areas in WPA in 1972
7. Secondary contribution and sustainable livelihoods in communities that depend on reefs

5.5.11 Microbial Biodiversity of Coral Reefs

It has been studied that coral reefs of Pacific Ocean host for more than 3 million varieties of bacteria. This suggest that high percent of microbiome is still to be discovered

5.5.12 Importance of Microbes in Coral Reefs:

- Microbial diversity and microbiome in coral reefs serves as ecological insurance
- Various types of bacteria can execute alike functions, such as delivering essential nutrients to coral polyps.

Summary

Biodiversity Hotspots: they are the planet's most varied ecosystems, supporting thousands of marine species, including fish, invertebrates, and algae.

Economic Contributions: They generate significant economic benefits through tourism, fisheries, and marine biotechnology, serving as a vital source of income for many coastal communities.

Shoreline Protection: Reefs function as natural barriers, mitigating erosion and reducing the impact of storm surges by absorbing wave energy.

Climate Regulation: Coral reefs are integral to carbon and nitrogen cycling, which aids in regulating the Earth's climate.

Scientific Discovery: These ecosystems provide invaluable opportunities for scientific research, leading to advancements in medicine, biotechnology, and environmental conservation.

Cultural Importance: For many indigenous and local communities, coral reefs are culturally and spiritually significant, deeply embedded in their traditions and way of life.

Food Provision: Reefs are a crucial food source for millions of people globally, enhancing food security through sustainable fisheries.

Chapter-6

Ctenophora

Objectives :

- Describe basic habitat of ctenophore and their body structure.
- Classify phylum ctenophore in classes *Tentaculata* and *Nuda.*
- Explain economic importance of phylum Ctenophora such a usefulness to serve as biomarkers and biotag.
- Describe crucial role in modifying the underwater plankton population due to their rapid reproduction and efficient predatory behavior.

6.1 Introduction

Previously included in eumetazoans, Ctenophores have been reclassified as sister group to all other metazoans after whole-genome analyses Ctenophores (Greek means "comb-bearers") feature eight "comb rows" of fused cilia arrayed sideways of the animal. Motility in Ctenophores is due to propelling of water by cilia. Few animals move by flapping their lobes or by undulating their bodies, two lengthy tentacles are their important feature others on the contrary shows' absence of tentacles. Due to their nature of destructive predation, they are also called comb jellies, sea gooseberries, sea walnuts, or Venus's girdles. They share numerous superficial similarities with cnidarians but they lack stinging cells on the contrary they have colloblasts, the sticky cell, which help them to catch prey. For protection from gelatinous prey they have special cilia in mouth

6.2 Ctenophore Bodies

Two layer of epithelial tissue makes the outer epidermis and inner gastrodermis layers having jelly-like layer of mesenchymal tissue called mesoglea, is clubbed between the two layer. Mesenchyme have True muscle cells grouped in longitudinal and radial fibers to support and assist feeding motions. Ctenes are the exterior body of comb jelly having eight plates of long, fused cilia. principal machinery of motility are ciliary bands and an apical sensory organ containing a calcareous statolith coordinates their beating.

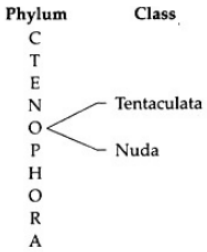
6.3 Characteristics faetures

- Their basic habitat is sea, they are solitary and free-swimming animals.
- Body is translucent, gelatinous, soft, and lacks segmentation having pair of long, firm, retractile tentacles protrude from the bi-radially symmetrical body

- Invertebrates shows Tissue-level organization
- Movement is aided by Comb rows which are eight strands of cilia
- They are hermaphrodite creatures with External fertilization and indirect development are used by these species.

- They possess both external and intracellular digestive systemshaving aboral sense organ called the statocyst for balance. without separate organs for respiration and excretion, they rely on their body surface to perform these functions.
- Their size and shape vary widely, from microscopic spheroids (0.04 inches) to long ribbons (4.9 feet). Ctenophores are typically lobe-shaped animals.

6.4 Classification



The Ctenophora Phylum is separated into two classes, as listed below :

Tentaculata

- They possess two tentacles with specialized sheaths and a retractable tiny stomodaeum.
- Sea walnuts feature a large mouth and primarily feed on mollusk larvae and copepods.
- Venus girdles are flattened, ribbonlike Ctenophora commonly found in tropical waters.
- Sea gooseberries typically have smaller secondary tentacles and reduced primary tentacles. These species are prevalent along the Atlantic and Pacific coasts.
- Examples include Sea Walnut, Sea Gooseberry, Venus Girdle, and others.

Nuda

- Tentacles are absent in this animal class.
- They primarily feed on jellyfish and other ctenophores, possessing a large mouth.

- These creatures are free-swimmers and can be found in all oceans and seas worldwide.
- Examples include Beroe, Mnemiopsis, and other species.

6.5 Ctenophora Phylum's Importance:

6.5.1 Importance to the Economy

- Ctenophores possess beneficial genetics, particularly their ability for prompt luminescence, which serves as a useful "biomarker" or "biotag."
- Academics exploit them in studies targeting to recognize activation genes. They realize this by generating various glowing animals such as cats, mice, and others, and observing the effectiveness of genetic alterations made to these organisms.

Summary

Phylum Ctenophora comprises marine species entirely, with no senates in freshwater habitats. They mostly inhabit the ocean's surface or deep waters and exhibit bi-radial symmetry. Despite their ecological significance, these organisms are relatively unfamiliar to humans.

Examples of animals within this phylum include Sea Walnut, Sea Gooseberry, Venus Girdle, and others. Ctenophores play a crucial role in modifiable the underwater plankton population due to their rapid reproduction and efficient predatory behavior.

Chapter-7

Platyhelminthes

Objectives :

- Describe characteristic features of phylum Platyhelminthes
- Classify phylum Platyhelminthes into classes Turbellaria, Trematoda & Cestoda
- Explain life cycle of parasite *Taenia solium*as an example in phylum Platyhelminthes
- Describe prevention, control and epidemiology of flatworms

7.1 Platyherlminthes (flatworms)

Platyhelminthes are acoelomate flatworms that are dorsoventrally flattened, bilaterally symmetric, and triploblastic. & possess a construction grade organ devoid of a distinct respiratory, circulatory, or anus system. Instead, mesenchyme and the protonephridial excretory system fill the spaces between the body's organs.

7.2 Characteristics Phylum Platyhelminthes (flatworms)

- They can live freely or as parasites.
- They are triploblastic worms that are bilaterally symmetrical and flattened dorsoventrally.
- Head and tail ends have defined polarity and are bilaterally symmetrical. The term "triploid" refers to a body that is consist of 3 layers of embryonc germ cells:, endoderm, ectoderm, & mesoderm. It also describes a a fully formed ventral surface
- that includes a gonopore & mouth.
- Although their bodies typically resemble worms, they can also be lengthy, ribbon-like, and leaf-like, or fairly elongated and flattened.
- Their sizes range from tiny to exceedingly elongated, extending up to 10-15 meters, and they are modest to intermediate in size.
- They are not segmented, with the exception of class Cestoda.
- While body are gray, brown-black, or brightly colorful, the bulk of them are white and colorless, with some gaining color from food consumed.
- Distinguished head from body positioned at anterior end.
- Their parasitic form features sticky structures such, spines, suckers, hooks, & adhesive secretions

- On the ventral side, the mouth and genital apertures are highly pronounced in turbellarians but less in trematodes & cestodes
- The skin is covered in syncytial or cellular sometimes ciliated epidermis; in contrast, trematodes cestodes covering having cuticle & their bodies instead of epidermis; the absence of both exo- and endoskeleton contributes to the body's overall softness. Cuticle, spines, thorns, hooks, and teeth make up the hard portion. They are acoelomate, meaning they have no bodily cavities.
- Their digestive system is branching, lacking an anus, unfinished, & completely lacking in acoela and cestode.
- The space between various organs is filled with unique mesodermal tissues, the mesenchyme, and parenchyma.
- A lateral canal and one or two protonephridia with flame cells or bulbs make up the excretory system.
- They lack skeletal, respiratory, and circulatory systems. Not present in some rudimentary form.They have a simple, ladder-like nervous system. Their basic sensory organs are comprised of one, 3 pairs of transversal nerves connecting longitudinal nerve cords , & pair of ganglia or the brain, which make up the major nervous system. a frequent in tubellaria which is significantly reduced in parasitic form
- Most of them are monoecious (hermaphrodite), and they frequently take the shape of ciliated pits and grooves in chemo- and tangoreceptors.
- Fission is the method of asexual reproduction used by many freshwater turbellaria
- The yolk is absent from eggs in most forms. Fertilization occurs internally, however in trematodes and cestodes there is self-fertilization and cross-fertilization. They are created independently in the vitelline or yolk glands.
- They have a life cycle which is complex in nature that involves one or more hosts.
- Tapeworms & trematodes frequently undergo polyembryony & parthenogenesis. Tapeworms produce by external & endogenous budding.
- Flatworm can be parasitic, endo-or ectocommensal, or free-living.

7.3 Phylum Platyhelminthes Classification-(flatworms)

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

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

- While all of them free-living, some categorized as endo-commensals, parasites, or marine, terrestrial or freshwater ectocommensals.
- The muscular pharynx comes before the mouth ventral intestine, a rod-shaped organ that contains cells that secrete mucus.
- An abundance of sticky organs, such as suckers
- An unsegmented body covered in ciliated cellular or syncytial epidermis.
- Tango, photoreceptors, and chemosensors are examples of common sense organs creatures.
- The flame cells, or prototonephridia, that make up the excretory system
- Primarily through sexual, asexual, regenerative reproduction.
- life cycle is simple

Order 1- Acoela

- Tiny, only found in the sea, 2mm or less.
- There is no muscular throat, no gut, no ventral mouth, and absolutely no excretory system.
- Absence of yolk glands, distinct gonads, gonoducts, and flame cells.
- Some are pigmented or brown by symbiotic algae; most are free-living, located beneath stones or bottom muck, and some even reside in the intestines of sea cucumbers and urchins.
- Examples: Afronta, Convoluta, *&* Ectocotyle

Order 2- Rhabdocoela

- Tiny (less than 3 mm) terrestrial, freshwater & marine, forms.
- A sac-like gut devoid of diverticula, and a simple throat.
- There are two primary longitudinal trunks in the nervous system.
- The excretory system of protonema.
- Eye is often visible.
- The reproductive system consists of a structure, gonoducts, and a few compact gonads that is cuticularized in place of papilla. Does yolk gland exist or not?
- Found in marine or freshwater or land. Parasitic in nature, or commensal form
- Examples: *Macrostomum*, *Mesostoma Catenula*, & *Microstomum*.

Suborder 1. Notandropora

- Exist in only freshwater formations.
- A straightforward throat.
- There is just one median protonephridia in the excretory system.
- Penis unarmed, testicles a single, compact mass.
- Lack of yolk gland.
- The zooids form a chain, which triggers fission of asexual nature.
- Examples: *Catenula.*

Suborder 2. Opisthandropora

- Freshwater or marine or form; paired nephridia make up the excretory system.
- Penis equipped with a stylet, sperm compact.
- Yolk gland is absent.
- Reproduction asexual in nature through zooids in a chain.
- Examples: Microstomum & Macrostomum

Suborder 3. Lecithopora

- Terrestrial, Freshwater or marine forms.
- A bulbous pharynx.
- Nephridia are paired organs that make up the excretory system.
- Ovaries and yolk glands should be kept apart.
- Only sexual activity is involved in reproduction.
- Most living things are free-living, while others are parasitic or commensal.
- Examples: *Anoplodium, Mesostoma*.

Suborder 4. Temnocephalida

- Ectocommensals develop in freshwater.
- Body's anterior part is equipped between two and twelve tentacles
- There are one or two sticky disks on the posterior end of the body.
- Dolii create the throat.
- A basic gonopore.
- Temnocephala and Monodiscus are two examples.

Order 3- Alloecoela

- Most commonly found in freshwater and brackish habitats; moderate in size, ranging from 1 to 10 mm; marine in origin.
- Straight or branching intestine (short diverticula); simple, bulbous, or plicate pharynx.

  Nematopores and paired protonephridia with two or three major branches make up the excretory system.
- Three or four longitudinal nerve cord pairs joined by transverse connectives make up the nervous system. There are several testes in the reproductive system and two ovaries. There is a good amount of the penis papilla.
- Some are ectocommensals or ectoparasitic in the habit.
- Geocentrophora, Prorhynchus & Plagiostomum are a few examples.

Suborder 1. Archophora

- Form found in the sea.
- Pharynx in duplicate.
- No female ducts, primitive female reproductive system.
- A simple posterior aperture of the male copulatory system
- Examples: (only examples) *Proporoplana*.

Suborder 2. Lecithoepitheliata

- Freshwater, terrestrial, marine forms.
- Bulbous or simple pharynx.
- Cuticular stylet on Penis.
- Basic or nonexistent female ducts.
- There is no yolk glands.
- Ovum is encircled by nutrient cells.
- Examples: *Geocentophora & Prorhynchus*,

Suborder 3. Cumulata

- Marine or freshwater form.
- The plicate or bulbous pharynx.
- Diverticula are often absent from the intestine.
- Penis unarmed. Yolk glands and distinct ovaries, or germovitellaria, comprise the reproductive system in females.

- Examples: *Hypotrichina*.

Suborder 4. Seriata

- Marine & freshwater forms predominate.
- Duplicate Pharynx
- The stomach often has lateral diverticula.
- The majority of the reproductive system of female system is made up of distinct yolk glands and ovaries.
- Examples: *Bothrioplana*&*Otoplana*

Order 4- Tricladida

- Turbellarians that are big (2 to 60 cm long).
- Freshwater, marine, or terrestrial forms.
- Mid-ventral mouth.
- Pharynx plicate is often oriented in reverse.
- 3 branches of stomach, with many diverticula.
- Eyes are generally visible.
- Phridia as many nephridiopores arranged in lateral networks.
- There is a penis papilla present, and the reproductive system in male comprises of 2 or more testes.
- A copulatory brusa and two ovaries with yolk glands make up the female reproductive organ.
- Gonopore is one.
- Examples: *Bdelloura*, *Geoplana Gunda*, & *Dugesia*.

Suborder 1. Maricola

- Found in marine form.
- 2 eyes and auricle grooves.
- A typical penis papilla that occasionally holds a stylet.
- Rounded copulatory brusa.
- Sexual mode of reproduction.
- Examples: *Bdelloura*,

Suborder 2. Paludicola

- Mostly freshwater very seldom do brackish water varieties exist. Several eyes or none at all.
- Brusa typically appears before penis.
- Asexual mode of reproduction predominates in life cycle.
- Examples: *Dugesia & Planaria*

Suborder 3. Terricola

- Subtropical, tropical, and terrestrial forms.
- Mainly an extended body.
- Too many eyes, two.
- Brusa is largely missing.
- Typically, male and female antras separate.
- Reproduction that is asexual can also happen.
- Examples: *Geoplana*&*Bipalium*,

Order 5- Polycladida

- Turbellarians with moderate sizes (2 to 20 mm).
- The ocean; its littoral zones and countless bottom inhabitants.
- Highly branching intestine, delicate throat.
- Nerve cords distributed & make up the nervous system.
- Many eyeballs.
- Gonopores in male and female is distinct.
- No yolk glands.
- Many, dispersed testes and ovaries.
- Examples: *Cestoplana*, *Planocera*, *Thysanozoon, Leptoplana*, *Notoplana* .

Suborder 1. Acotylea

- Usually usually shaped like a vertical curtain.
- Absence of suckers in gonopore.
- Tentacles are of Nuchal kind.
- Eyes are never visible on the anterior end
- Examples: *Leptoplana*, *Euplana*, etc.

Suborder 2. Cotylea

- The throat in the tubules.
- There is a sucker are present behind the female pore.
- A group of eyes near the anterior margin, or two marginal tentacles with eyes on them.
- Examples: *Yungia*&*Thysanozoon*

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

- Often known as Endoparasitic or ectoparasitic,
- Unsegmented body, flattened leaf-like dorsoventrally.
- Thick tendons devoid of rhabdites & cilia.
- Unbroken body having cuticle covering.
- Hooks and/or suckers may be present
- The front mouth, straightforward throat, and two forked or many branches of the intestine make up the incomplete digestive system; the anus is lacking.
- There are 3 longitudinal nerve cord pairs.
- Flame cell-based mechanism of protonephrid excretion
- Most are monoecious hermaphrodites.
- 1 ovary and 2 to many testes.
- Direct (for ectoparasites) or indirect (for endoparasites) development with host substitution.

Order 1. Monogenea

- In cold-blooded aquatic animals, mostly ectoparasites.
- Oral suckers that are missing or feeble.
- The front end is equipped with two sticky structures.
- Usually has hooks and a sticky disk attached to the posterior end.
- Two excretory openings located on the dorsal side are located anteriorly.
- The gonopores of men and women typically divide.
- One or two vagina. The uterus has a few shelled eggs and is tiny.
- The life cycle has a single host.
- Ciliated, free-swimming larvae known as
- Examples: *Gyrodactylus*, *Dactylogyrus, Diplozon*, &*Polystoma*

Order 2. Digenea

- Two suckers without hooks: the ventral sucker, or acetabulum, and the oral sucker, which surrounds the mouth, are endoparasites of both vertebrates and invertebrates.
- A solitary excretory pore at the back.
- Absent vagina. A large number of shelled eggs often fill the uterus.
- The intricate life cycle, which includes several larval stages?
- Asexual reproduction takes place in the stages of larvae prior to metamorphosis
- The life cycle involves one or more intermediate hosts.
- Examples: *Bucephalus*, *Fasciola*, *Paragonimus*, *Opisthorchis*,*Schistosoma*.

Order 3. Aspidocotylea (=Aspidogastraea)

- Avoid using mouth suckers.
- Several suckers without hooks split from a large ventral sucker.
- The male system has a single testis.
- Endoparasites found in fish and reptile stomachs.
- Examples: *Aspidogaster*, *Cotylapsis*, *Stichocotyle*.

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

- Term for endoparasitic worms that live in vertebrates' intestines.
- Body split into several flat, elongated, segmented (proglottids), and ribbon-like structures; rarely, undivided.
- A tissue devoid of microvilli.
- Body coated with cuticles but lacking cilia and epidermis.
- With the exception of cestodaria, the anterior end (scolex) is equipped with sticky structures (hooks and suckers).
- There is no digestive system or mouth.
- Protonephridia in the excretory system have a characteristic terminal flame.
- Each adult segment, or proglottid, is monoecious, having both male and female organs; the neurological system is typically composed of two lateral longitudinal nerve cords and a pair of ganglia.
- Complicated life cycles, typically involving two or more hosts.
- An embryo's hooks.

Subclass 1. Cestodaria

- Unsegmented, leaf-like body without scolex and strobila; endoparasitic in the stomach or coelom of vertebrates (monozoic).
- Lack of a feeding tube.
- A monoecious reproductive system consisting of just one pair.
- Ten-hooked larval lycophore.

Order 1. Amphilinidea

- Fish endoparasitic forms in their coelom.
- A flattened, elongated, or oval body.
- Not a sucker.
- Scholex is not present.
- The protruding throat.
- Frontal glands are located on the anterior end.
- Vaginal and male pores are located posteriorly.
- The uterus has a highly coiled entrance that is located close to the front.
- Examples: *Amphilina*.

Order 2. Gyrocotylidea

- Fish intestines contain organisms which are endoparasitic.
- Body grew longer and flatter.
- The presence of an anterior sucker and a posterior sticky organ structured like a rosette.
- Eversible proboscis is present on the anterior end.
- The front portion of the body is home to the uterus's small, straight urethra, which leads to the pores.
- Examples: *Gyrocotyle*.

Subclass 2. Eucestoda

- Endoparasitic form in fish gut.
- Long, ribbon-like body.
- The body is composed of many proglottids (polyzoic) in the scolex, neck, and strobila.
- Scolex extended sticky bearing structures.
- Having several sets of monoecious reproductive organs in most cases.
- Larve has six appendages.

Order 1. Tetraphyllidea

- Endoparasitic forms; only encountered in elasmobranch fishes' intestines.
- Scolex, which has four leaf-like bothria (sessile suckers),
- Ovaries are behind testes.
- Dispersed vitelline glands.
- Cirrus equipped with hooks & spines
- Marginal & common genital atrium.
- Examples: *Myzophyllobothrium & Phyllobothrium*

Order 2. Diphyllidea

- Elasmobranch fishes have a pyloric gut.
- The scolex has two bothria and a spiny head stalk.
- There are no more than 20 proglottids in a strobila.
- Examples: *Echinobothrium*.

Order 3. Trypanorhyncha

- Pathogenic in the elasmobranch's spiral valve fishes' digestive tracts.
- Body of a moderate size.
- The scolex has four bothria and 4^{th} spiky proboscides that protrude.
- A continuous layer of vitellaria in the cortical parenchyma.
- Testes are positioned behind the ovary.
- Uterus open ventrally; laterally located gonopores.
- Examples: *Haplobothrium*, *Tetrarhynchus*.

Order 4. Pseudophyllidea

- Segmented becomes unsegmented or strobila
- Scolex typically has two to six shallow bothria (suckers), and sticky organs are infrequent.
- The mesenchyma of proglottids contains many, follicular, and bilobed testes.
- Many, follicular vitellaria.
- Gonopores are midventral.
- Examples: *Dibothriocephalus & Bothriocephalu*.

Order 5. Taenioidea or Cyclophyllidea

- Large-sized tapeworm
- Pathogenic in the intestines of birds, mammals, and reptiles.

- Scholex produces four largest in cupped suckers (acetabula), which frequently have hooks attached to the apical rostellum.
- Absence of uterine entrance; ovaries lobed in two or more.
- On one or both margins, gonocores.
- There are four longitudinal vessels in the excretory system.
- A single, compact vitellaria (yolk gland).
- Examples: Taenia, Echinococcus, *Hymenolepis*, *Moniezia*.

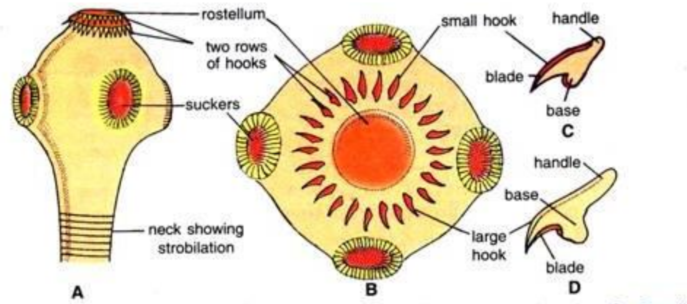
7.4 Taenia solium

Taenia solium, sometimes referred to as the armed tapeworm or pork tapeworm, is a kind of tapeworm that resembles a flat ribbon and is the cause of intestinal taeniasis. Although worms that are adults are uncommon harmful, the worm's encysted larval stage (*Cysticercus cellulosae*) can cause the deadly illness Cysticercosis in humans.

7.4.1 Habitat:

- The adult worm lives in humans' small intestine, or upper jejunum.

7.4.2 Morphology:



Taenia solium. Scolex. A—Scolex magnified; B—Frontal view of scolex; C—Small hook; D—Large hook.

Fig. 7.1 : Tenia Solium

1. Adult worm :

- Adult *Taenia solium* is white, the flattened tapeworm resembles a ribbon.
- The adult worm's length is around two to three meters.
- Parasite's body composed of 3 parts:- Neck, body, and head (strobila & Scolex)

i. Scolex (Head):

- It is roughly the size of a pin head, measuring 1 mm in diameter.
- Has 4 circular suckers and globular form.

- A rostellum, measuring 130-180 mm in length, is attached to the head, containing two rows of alternating big and tiny hooklets.
- The armed tape worm got its moniker because of its hooklets.

ii. Neck:

- The neck is small, with a length of 5 to 10 mm.

iii. Body (Strobila):

- The body, or Strobila, is composed of segments, or proglottids. In total, there are about 800-900 proglottids.
- Proglottids might be gravid, immature, or mature.
- When completely matured, the gravid segment has a dimension of 12 X 6 mm and appears translucent and grayish-black in color.
- The worm is a hermaphrodite, with reproductive organs found in both male and female segments.
- The thick-lipped, marginal genital pore located around the center of each segment, alternating between left and right sides.
- The testes have between 150 and 200 follicles.
- An ovary consists of two halves, with an additional accessory lobe.
- The location of the ovary is on the back side of the segment.
- Gravid is made up of the uterus's median longitudinal stem, which has seven to thirteen branches on either side of the segment.
- The whole uterus is packed with eggs, with each gravid containing between 30,000–50,000 eggs.
- Sphincters made of muscles do not defend the vaginal entrance.
- The gravid segments are not ejected separately, but rather passively in chains of five to six at a time.

2. Eggs :

- Taenia saginata eggs resemble those of other species.
- Every egg is round, has a brown hue, and has a diameter of 40–50 µm.
- Every egg has a pair of shells
- The thin, translucent outer shell is what's left of the yolk bulk.
- The inner shell, referred to as the embryophore, has strong walls, radial striating, and is brown in color. That contains the embryo.

- The embryo's diameter, including the hooklets, is between 14 and 20 µm.
- Eggs do not float in a saturated solution of ordinary salt (NaCl).
- Pigs may contract an infection from eggs just like people do.

3. Cysticercus cellulosae larvae

- Cysticercus cellulosae larvae are the infectious type of parasites. Taenia cyst is another name for it.
- Both pig muscle and human organs are the larval form's sites of development.
- An opalescent ellipsoidal entity with dimensions of 8–10 mm in width and 15 mm in length is a mature cyst. Its structure resembles a milky white bladder filled with fluid.
- The long axis of a cyst is parallel to the muscle fiber
- A thin capsule of collagen separates the cyst from the host tissue.
- There is a thick, milky white area on the side of the scolex that still has its hooks and suckers in place.
- A transparent fluid containing salts and albumin is seen inside the cyst's interior.
- The larvae can only mature into adults when they are consumed by humans, and they can only survive for around eight months in pig muscles.

7.4.3 Life cycle of Taenia solium *:*

- Two hosts complete the life cycle.
- The ultimate host: Human
- Intermediate hosts: occasionally human, mostly pigs.
- Inadequately or badly cooked pork contaminated with cysticerci can infect humans.
- When the scolex comes into touch with bile inside the human alimentary canal, it exvaginates and uses its hooks and suckers to anchor itself to the gut wall.
- The larvae undergo incremental strobilization to eventually mature into adult worms.
- After reaching sexual maturity in two to three months, the worm begins to produce eggs, which are excreted in the feces together with the gravid segments.
- The pig becomes infected when it consumes eggs or gravid proglottids that are excreted in human waste.
- Pig intestines are the host organs where oncospheres emerge from eggs.
- By use of hooks, they cling to the intestinal mucosa, pierce the gut wall, and enter the portal arteries or mesenteric lymphatic, ultimately arriving in the systematic circulation.

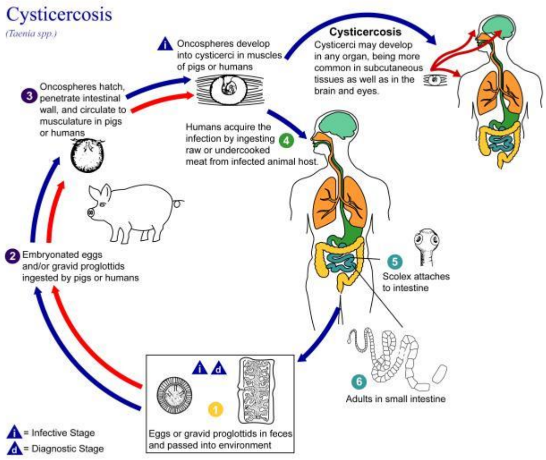
- The portal vein is often used to carry them to the liver, right side of the heart, lungs, left side of the heart, brain, or other high-blood-flowing tissues.
- 

Fig. 7.2 : Life cycle of *Taenia solium*

- The bare onchospheres are extracted from the bloodstream and enter the muscle tissue, where they eventually settle and continue to grow.
- In nine to ten weeks, they shed their hooklets, grow, and become a cyst filled with fluid.
- They can survive in pig muscle for up to eight weeks, during which time they can infect humans.
- The cycle is perpetuated when the contaminated pig flesh is consumed by the new host, which then becomes infected.
- Humans can occasionally become infected by consuming food or water tainted with eggs.
- The gut releases the onchospheres upon eating from the eggs. After invading the intestinal mucosa, these larvae are then transported by the bloodstream to other tissues, where they mature into cysts.
- The majority of cysts in humans form in the brain, skeletal muscles, eyes, and subcutaneous tissue, leading to a disorder known as cysticercosis.

7.5 Mode of transmission :

- Consumption of raw pork contaminated with tapeworms
- Consumption of food and water tainted by the eggs found in a Taenia carrier's infectious feces.
- Anus-hand-mouth transmission of eggs by hands that are infected of a person with inadequate personal hygiene is known as endogenous auto infection.

- *T. solium* eggs are thrown back to the duodenum during reverse peristalsis, where they hatch and induce tissue infection. This process is known as autoinfection.

7.6 Pathogenesis of *Taenia solium* :

- Adult cysts and worms are both harmful.
- The worms are less harmful as adults. Their armed scolex can occasionally cause Moderate irritation or inflammation of the mucosa of the digestive trac Cysticercus cellulosae, the cysts, are more pathogenic.
- They usually form cysts in the skin, skeletal muscles, eyes, and central nervous system (CNS), which can lead to the deadly illness cysticercosis in humans.
- The cyst may continue to grow for a few years.
- The cyst in the brain overcomes the host's defenses to live.
- It secretes prostaglandins and other chemicals that prevent the complement system from activating and cytokine synthesis from occurring.
- The living cysticercus is surrounded by low host inflammation as a result.
- There is a limited minimum cellular response encircling the living cyst, with a small number of macrophages and eosinophils.
- The dead cyst is covered in a thick layer of inflammatory cells, including leucocytes, multinucleated big macrophages, inflammatory cells, and less frequently, foreign body giant cells.
- Outside of this area, there is a zone of fibrosis and ongoing inflammatory infiltration.

7.7 Clinical diseases caused by *Taenia solium* infection

7.7.1 Intestinal Taeniasis:

- The infection usually shows no symptoms.
- When there are symptoms, the clinical signs and symptoms might be vague and minor, such as nausea, pain in the abdomen, difficulty eating, weight loss, persistent dyspepsia, and so on.
- In fewer instances, nausea, vomiting, headaches, and diarrhea are experienced less often.

7.7.2 Cysticercosis:

- The illness caused by the parasite in its larval stage is known as cysticercosis.

- Humans can become infected either by autoinfection by oral contamination by *T. solium* eggs from tapeworm carriers can cause fungal infections.
- The damaged organ determines the clinical presentation; neurocysticercosis and ocular cysticercosis are linked to significant morbidity.

7.7.3 Extraneural cysticercosis:

- Subcutaneous cysticercosis often manifests as tiny, moveable, painless modules in the arms or chest.
- The modules become bloated, painful, and inflammatory after a few months or even years, and then they gradually dissipate.
- One causative finding is muscular cysticercosis, which manifests as ellipsoidal or dot-shaped calcifications.
- Rarely, extremely significant parasite loads cause the patient's limbs to expand (muscular pseudohypertrophy).
- Another infrequent site of infection is the heart, where 5% of patients with cardiac cysticercosis have no symptoms.

7.7.4 Ophthalmic cysticercosis:

- In 20% of instances, this condition is present.
- The majority of cysts are located in the conjunctiva, subretinal region, and vitreous. Iritis, ureitis, and palpebral conjunctivitis are possible presentation of the illness.
- Cysts in subretinal or subconjunctival regions may appear as slowly expanding nodules that are mistaken for malignancies.
- Blindness resulting from retinal detachment can occasionally be caused by subretinal eye cysts.

7.7.5 Neurocysticercosis :

- Neurocysticercosis is a clinical condition frequently caused by parasite infections of the central nervous system.
- Cysticerci are apparent after they infiltrate the central nervous system and result in minor inflammatory alterations in the surrounding tissue.
- Most of the symptoms that accompany cyst degeneration are directly caused by the inflammatory process that occurs alongside the cyst.
- Cysticerci can produce symptoms due to mass effect or by obstructing the circulation of cerebrospinal fluid.

- The indications and symptoms are diverse and non-specific.
- The most prevalent presentation, epilepsy seizures typically serve as the main or only sign of the illness.
- Fifty to eighty percent of patients with parenchymal brain cysts or calcifications experience seizures.
- The illness also presents as intracranial hypertension, hydrocephalus, or both in 20–30% of cases.
- The condition is associated with parasites located in the basal cisterns or cerebral ventricles that obstruct CSF circulation. It can be caused by residual fibrosis, ependymal inflammation, or the parasite itself.
- Sometimes a cyst enlarges beyond normal and behaves similarly to a tumor mass (giant cyst).
- These enormous cysts squeeze nearby brain regions, leading to intracranial pressure and regional impairments.
- Additionally, oedema resulting from cyst degeneration or a stroke exacerbating the illness might induce motor impairments.
- Acute encephalitic presentations can occur in adolescents and teens, with females more prone to have them than males.
- There are also massive, non-encephalitic types.
- In 1% of adult instances, the spine is compromised, resulting in symptoms like as compressive manifestation.

7.8 Laboratory Diagnosis of *Taenia solium:*

7.8.1 Specimen:

- Faeces, muscle tissue, blood, csf

1. Macroscopic examination :

- For segment or proglottids, a bare inspection of the specimen might be performed.
- When contrasted with the dark yellow mass of the feces, the white section is immediately identifiable.

2. Stool Microscopy :

- Diagnostic tool is the appearance of eggs and, less commonly, scolex, & proglottids in feces.
- Eggs: An inspection of a thick feces stain is used to demonstrate eggs.

- Eggs shed sporadically, thus it is best to collect two to three stool samples.
- Eggs are visible in the perianal region and can be identified using a cellophane swab.
- Acid-fast staining can be used to diagnose the species since the eggs of T. soluim and T. saginata are identical to one another.
- While T. saginata eggs are acid fast, T. soluim eggs are not.

7.8.2 Proglottids :

- The gravid proglottids are found in excrement or are extracted from undergarments.
- After being cleaned with clean water, they are sandwiched between two sides.
- Adhesive tape is used at both ends to hold the sides in place while lateral branches are manually checked.
- Staining them with india ink injected via the vaginal pores can help with demonstration.
- Note: Taenia soluim: utetine stem with 7–12 lateral branches on either side
- Ten to twenty lateral branches adorn either side of the utenine stem of T. saginata.
- Scolex: T. soluim – has a row of hooks on it
- T. saginata is devoid of hooks.
- The procedure is risky, and the scolex does not always heal after the therapy.

7.8.3 Antigen detection:

- This is a really helpful tool for intestinal taeniasis screening.
- To identify antigen in feces, ELISA polyclonal antisera produced against Taenia is used to collect antigens.

7.8.4 Serodiagnosis :

- The use of serological assays is used to detect antibodies against cystic fibrosis in CSF or blood. ELISA (75% specificity, 85% sensitivity).
- ELISA may be used to identify antigen using certain monoclonal antibodies.
- Electrochemical-enzyme-linked immunoblot (EIIB). 90% sensitivity, 50%-70% specificity.
- Antigens in serum or CSF suggest a recent or active infection.

7.8.5 Histopathological diagnosis

- When brain biopsy tissue is taken after death, cysticerci in the tissue can be used to make the diagnosis of neurocycticercosis (NCC).
- The diagnosis of skeletal cysticercosis can be made by biopsy histological analysis.

1. Imaging method:

- An X-ray of the soft tissues in the neck, chest, and arms may reveal elongated, lifeless cysts.
- An X-ray of the skull may show intracranial lesions and cerebral calcification in cases of neurocysticercosis.
- The most effective technique to identify numerous, calcified, and deceased cysts, which are indicative of neurocysticercosis, is a CT scan.
- NCC is pathognomonic for a mural nodule seen on MRI that is located within the cyst.

7.8.6 Other test:

- Neurocycticercosis is associated with high levels of CSF protein.
- CSF may exhibit lymphocytosis; frequent mononuclear pleocytosis
- Low glucose levels can range from modest to high.
- Seldom do cell numbers surpass 300/mm3.
- Eosinophils are a frequent yet nonspecific binding component of the CSF.

7.9 Treatment of tape worm infection:

i. Praziquantel– drug of choice.

- Dose- oral.
- Body weight of 50 mg/kg
- 3 divided doses for 15 days.

ii. **Niclosamide :**

i**ii. Albendazole :**

- A dose of 400 mg twice daily for 30 days.

iv. Surgery:

- For cysticercosis of ocular, ventricular and spinal cord.

7.10 Prevention and control of taeniasis:

- Avoiding eating pork that is either raw or not cooked enough
- Pork is examined for cysticerci.
- Appropriate facilities for sanitation.

- Handling of afflicted individuals.
- Steer clear of food tainted with T. solium eggs.

7.11 Epidemiology and geographical distribution

- Taenia solium may be found all over the world.
- It is very common in countries where pork is consumed, usually in low-income neighborhoods with poor sanitation.
- Globally, 50 million people are afflicted.
- ***T. solium*** infections are widespread in South and Central America, non-Islamic South East Asian nations, and South Africa, particularly among Bantu people.
- The locations with the greatest frequency of outside of Eastern Europe and China are Latin America and Africa.

Summary

Intestinal infection with adult tapeworms, known as taeniasis or *Taenia solium* infection, is brought on by eating tainted pork. Adult worms can transmit a motile segment via the stool or produce moderate gastrointestinal symptoms. Infection with *T. solium* larvae causes cysticercosis, which arises by ingesting eggs produced in human feces. Until larvae infiltrate the central nervous system and create neurocysticercosis, which can result in seizures and other neurologic symptoms, cysticercosis is often asymptomatic. Neuroimaging investigations may reveal neurocysticercosis. Less than half of neurocysticercosis patients have adult T. solium in their intestines, which results in proglottids or eggs in their feces. You can use niclosamide or praziquantel to get rid of adult worms. The difficult treatment for symptomatic neurocysticercosis involves corticosteroids, antiseizure medications, and in some situations, albendazole or praziquantel. Surgery may be required.

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Chapter-8
Nemathelminthes

Objectives :

- Describe characteristic features of phylum Nematoda and its species
- Describe structure including shape and size of Nematods
- Explain life cycle of *Ascaris lumbricoides*and its clinical manifestation
- Signify importance of Nematods

8.1 Introduction

Another name for the creatures that make up the phylum Nematoda is "roundworms." To present, 28000 species of Nematoda have been recognized. These creatures are unsegmented vermiforms. Dorsal and ventral nerve cords are present in the epidermis.

Fig. 8.1 Nematoda

The nematodes that are found in the soil are crucial to the recycling of nutrients because they consume bacteria, fungus, and other nematodes. In addition, they eliminate pests and assault insects. On the other hand, they seriously harm plants. They consume the roots of the plants, which lowers the plant's capacity to absorb nutrients and withstand stress. Numerous Nematodes can be found in a armload of soil.

In humans, these can cause illnesses such Ascariasis, Trichuriasis, Filariasis, Hookworm, Enterobiasis, and Angiostrongyliasis.

They fit into the following categories and descriptions.

8.2 Characteristics features of Nematoda

1. They have a triploblastic, bilaterally symmetric body.
2. Cylindrical body

3. They show organization at the tissue level.

4. pseudocoelomate

5. The mouth and the anus are separate parts of the alimentary canal.

6. They exhibit sexual dimorphism.

7. Respiratory and circulatory systems absent .

8. They either live freely or as parasites.

9. Pathogenic nematodes infect hosts with illnesses.

10. Sexual reproduction follows internal fertilization.

11. They undergo periodic cuticle moults.

12. Dorsal or ventral nerve cords are present in the synctical epidermis.

13. The muscles of the body wall are longitudinal. .

14. chemosensory organs aphids found on the lips.

8.3 Classification of Nematodes

Class 1: Phasmidia or Secernentea

- The majority of organisms are parasitic in nature so they require a host to feed on.
- This class has no caudal glands.
- Plasmids, which resemble single-celled similar to pouch sensory organ present.
- There is two lateral canal in the excretory system.
- For example, Enterobius and Ascaris

The class has following order

Rhabditida

- Their cuticle is ringed and smooth
- The throat has a posterior lobe.
- They are parasitic and free-living.
- Male spicules are copulatory.
- Eg., Rhabditis

Strongylida

- They are parasitic vertebrates without lips.
- There is no bulb in the pharynx.
- The buccal capsule is fully grown in them.
- Their copulatory bursa is real.
- Strongylus, for instance

Oxyurida

- Their sizes range from little to substantial.
- Male spicules are copulatory.
- The caudal alae are found.
- Vertebrates or invertebrates may be among them.
- The mouth has three or four basic lips.
- For eg., Oxyuris

Ascaridida

- These are huge, robust, oviparous worms that live as parasites in vertebrates' intestines.
- A posterior bulb may or may not be present in the pharynx.
- The mouth has three prominent lips.
- The buccal capsule is absent.
- Example:Ascaris

Spirurida

- The organisms are somewhat to largely sized creatures that resemble threads.
- There is no bulb in the pharynx.
- Females can be either oviparous or viviparous, and they are bigger than males.
- There are two noticeable lips in the mouth.
- Example Spirura

Trichuroida

- These organisms are referred as whip-worms.
- They can have a slender pharynx.
- The mouth of the organisms do not have presence of lips.
- For example Trichuris

Camallanida

- These organisms are thread-like organisms and oviparous.
- The male organisms had no bursa.
- The bursa of adult females is degenerated.
- For example Camallanus

Aphasmidia or Adenophorea

- These organisms are independent live creature.
- The excretion is performed by no lateral canals.
- Presence of Caudal glands
- Presence of no Phasmids.
- For example Capillaria, Trichinella

Aphasmidia has following orders :

Enoplida

- These organisms are inhabiting marine.
- These organisms have bristles on cuticle.
- They have Cyanthiform amphids.
- For example Anticoma

Dorylaimida

- Cuticle resembles smooth appearance without bristles.
- The organisms are terrestrial in habitat.
- Buccal cavity of the organisms have protrusible spear.
- There are 6-10 labial papillae.
- Example is Trichodoris

Mermithida

- The cuticle of the organisms is smooth in appearance.
- Amphids of the organisms is in reduced form.
- The larval stage of the organism have parasite but adult stage living freely.
- Examples are Mermis, Agamermis

Chromedorida

- These organisms are free-living or marine.
- The cuticle is found to be smooth or ringed some times.
- The cuticle is devoid of any bristles.

- There is a presence of posterior bulb at the pharynx of the organisms.
- For eg., Paracanthonchus

Desmoscolecida

- They are marine or free-living.
- The cuticle is with rings with prominent bristles.
- The presence of 4 bristles functionally sensory at the anterior end.
- Desmoscolex is representative organism

Monohysterida

- They can be marine, freshwater, or terrestrial.
- The cuticle is smooth in appearance with ring like structure and contains bristles.
- They have circular amphids.
- For eg., Monohystera

Araeolaimida

- The cuticle is smooth with one or no bristles.
- The amphids are spirally arranged
- They possess labial papillae.
- For eg., Plectus

8.4 Ascaris lumbricoides

8.4.1 Life cycle

- Ascaris only has one host, which is humans, making its life cycle monogenetic.
- There is no secondary host in the Ascaris life cycle.

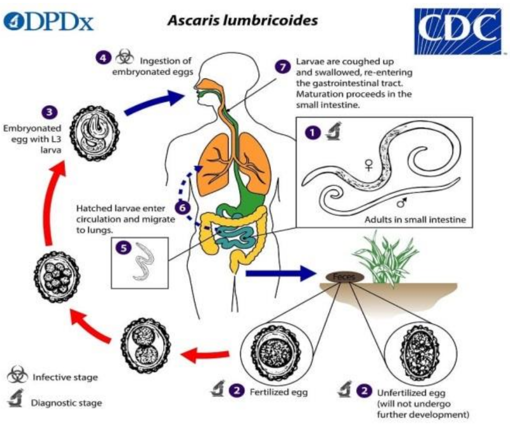

Figure:8.2 Life cycle of *Ascaris lumbricoides*. Image Source: CDC.

1. Presence of eggs in fecal matters

- The mature female those are having well-developed sexual organs can generate up to 200,000 eggs/day, which are excreted in unembryonic form with faeces. They don't spread infection.

2. Development in soil

- The ideal temperature for embryonation is between 20 and 25°C, together with presence of moisture and oxygen.
- The infectious larva grows inside the egg between three to six weeks.

3. Infection to host

- When an infected egg enters the host's small intestine, the eggshell dissolves due to the action of digestive juice, releasing the juveniles (second stage larva) and causing man to become infected directly.
- This occurs when an infected egg contains contaminated food or water.
- With the exception of their reproductive organs, juveniles have the same features as adults and measure between 0.2 and 0.3 mm in length and 13 and 15 μ in diameter.
- The larval stage do not grow in the gut; instead, it begins to bore through the host's intestinal wall, enter the mesenteric circulation, travel through the hepatic portal vein, and enter the liver.
- From the liver, it eventually passes through a post-caval vein to the right side of the heart.
- The pulmonary artery carries it from the heart to the lung, where it stays for a few days and enlarges.
- Juveniles break through blood capillaries in the lungs and reach the alveoli, where they dwell for a few days, grow larger, and undergo two more moults to transform into fourth-stage larvae, which are two to three millimeters longer than the original stage larvae.
- The fourth stage larva emerges from the lung alveoli and enters the trachea via bronchioles and bronchus.It travels from the trachea to the pharynx, where it is coughed up and subsequently ingested into the small intestine/gut for the second time.

- The fourth and final moulting occurs in the gut, and they reach adulthood in approximately 2 months.
- An adult reaches to sexual mature stage in eight to ten weeks.
- A parasite has a life cycle of 12 to 18 months.

8.5 Pathogenicity of Ascaris lumbricoides :

1. By Migrating Larvae

- Their wandering habits allow them to enter the pancreatic or bile ducts and obstruct digestion, or they can damage the intestine and cause peritonitis.
- They are more harmful than adult worms because they cause hemorrhages.
- They create blocks in the small intestine and appendix.
- The migratory larval-stage causes pathologically identifiable patches. The amount of migratory larvae, the nutritional state of the host, and the sensitivity of the host all affect how severe the lesions are.
- Larvae have the potential to induce acute pneumonia during migration and mold across the lungs, which can be lethal. infection that frequently results in eosinophilia, leukocytosis, anemia, coughing, and low-grade fever.

2. By adults

- Adult worms mainly cause enteritis and can induce inflammation of the gall bladder, common bile duct, and vermiform appendix by migration.
- Few worms in the gut cause no notable symptoms, although they can occasionally cause stomach pain, especially in youngsters.
- The worms create a toxin that can cause convulsions, delirium, or overall anxiety. It can also irritate the gut's mucous membrane or hinder the host's ability to digest proteins.
- By stealing nourishment, a significant number of adult worms impact the host's nutritional state.
- A worm-produced material mixes with trypsin to disrupt the digestion of proteins, resulting in a protein shortage.
- The illness is more frequent in youngsters, who experience stunted development, malnutrition, and weak mental function.

- The metabolites of both living and dead worms are immunogenic and poisonous. Lumbricoides also creates a variety of allergy toxins that cause irritation, fever, and conjunctivitis.
- If there aren't many parasites in the worm, it might cause minor fever, diarrhea, vomiting, and colic in the intestines.

8.6 Clinical manifestation of Ascaris lumbricoides

Ascariasis is the common name for the disease caused by Ascaris. Ascariasis affects youngsters more frequently than it does adults. The majority of the illnesses they cause have no symptoms. There are two types of ascariasis symptoms. such as lung and intestinal ascariasis.

1. Intestinal ascariasis

Ascariasis's initial symptoms, which include cough, wheezing, pneumonitis, and eosinophilia, appear during the larval migratory stage. Abdominal pain and appetite loss are common symptoms of minor illnesses. Major infections can cause weariness, vomiting (often with the ejection of adult worms), weight loss, and obstruction and inflammation of intestinal organs (appendicitis, pancreatitis, etc.). Nutrient shortage, development retardation, and cognitive impairment can also occur in youngsters.

The majority of Ascaris spp. infections have no symptoms. Live worms are frequently the first detectable sign of infection; they can be passed in feces or infrequently from the mouth, anus, or nose. In certain patients, larval migration can cause lung symptoms such wheeze, coughing, fever, eosinophilia, and pulmonary infiltration. Dyspepsia, an appetite loss, and mild gastrointestinal discomfort are possible outcomes of light infections. Excessive infections can cause exhaustion, vomiting, weight loss, and excruciating abdominal discomfort. Nutrient deficiencies in children exhibiting these symptoms may lead to delayed growth and/or cognitive impairment. A bolus of adult worms can cause intestinal obstruction, and one or more adult worms can obstruct the bile duct, pancreatic duct, or appendix. Serious consequences are uncommon but can be fatal.

2. Pulmonary ascariasis

One of the most prevalent helminth infections on the planet, pneumo ascariasis is an invasion of the respiratory system caused by worms. The worm, known by the name Ascaris lumbricoides, enters and contaminates the human body through the fecal-oral pathway. The fertilized Ascaris ova, or simply egg, would grow into larvae that would pass through the portal vein system and enter the liver and lungs. In the human respiratory system, these larvae will quickly mature into full worms inside the lungs, namely in the bronchioles. Common symptoms including wheezing, shortness of breath, and chronic cough are brought on by these Ascaris larvae.

Summary

The roundworm nematode Ascaris lumbricoides lives in the human small intestine like a parasite. These worms belong to the order Oxyurida, class Secernentea, and family Ascarididae. Pigs are a common host for these worms. These are big, roundworms with three lips that encircle a mouth that may reach a length of 40 cm. Ascariasis is a small intestine illness caused by Ascaris roundworms. Although there are no signs of this virus, a severe infestation in youngsters can cause growth retardation, malnutrition, and digestive problems. There are between 807 million and 1.2 billion cases of ascariasis in the globe.

MCQ

1. ______________________ cells comprise the excretory system of Ascaris.

a. Green gland

c. flame cell

b.nephron

d. Renette

2. The location of synchytial epidermis is _______.

(a) Ascaris

(b) Metaphire

(c) Housefly

(d) Periplaneta

3. An example of a coelom formed from blastocoel is ______________.

(a) Enterocoel

(b) Haemocoel

(c) Pseudocoel

(d) Schizocoel

4. This is the method used to identify female Ascaris.

(a) Two spicules found at the posterior end

(b) Presence of postanal and preanal papillae

(c) Straight posterior end

(d) Common cloacal aperture

5. The time that Ascaris spends incubating outside of the human body is

(a) More than 30 days

(b) 15-30 days

(c) 8-14 days

(d) 4-8 days

6. The infectious stage of the Ascaris life cycle is

(a) Third lava

(b) Second larva

(c) Cyst

(d) Fertilized egg

7. Pseudocoel as the Ascaris body cavity

(a) it is filled with pseudocoelomic fluid

(b) has very little parenchyma

(c) contains large cells termed pseudocoelocytes

(d) bound extremely by muscle layer and internally by intestines

8. It is discovered that Ascaris lumbricoides inhabits the gut of

(a) Pig

(b) Homo sapiens

(c) Monkey

(d) Goat and sheep

9. The method by which the morphology of the male and female sexes differs is called

(a) sexual dimorphism

(b) polymorphism

(c) variation

(d) none of the above

10. There is no substitute host for this.

(a) *Plasmodium vivax*

(b) *Tapeworm*

(c) *Fasiola hepatica*

(d) *Ascaris lumbricoides*

Space for notes

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Chapter-9

Parasitic Adaptation in helminthes

Objectives :

- Describe Survival of the parasite in the host cell
- Explain acclimatization of Helmin this to microenvironment.
- Describe structure including shape and size of Helminthis
- Learn enhanced management practices can eradicate the parasites at various evolving stages, both in the environment and within intermediate hosts.

9.1 Parasitic Adaptations of Helminths | Parasitology

Survival of the parasite in the host cell depend upon its ability to adapt itself in the body of host to the surrounding environment at the site of infection this environment is known as micro environment.

In order acclimatize to this microenvironment the parasite undergoes certain morphological, physiological, immunological and life cycle adaptation, because of these changes the parasite is able to survive in host. These changes are known as parasitic adaptation

The parasite undergoes loss of organ partial degradation in the organs which are of no or little use to the parasite.

9.2 Morphological Adaptation

Adaptation to the microenvironment includes-

- It includes modification of tegmental surface providing protection and leading to increase in adaptive surface area
- Development of specialized organ for attachment
- Complete loss of internal digestive system in some cases

MORPHOLOGICAL ADAPTATIONS		
DEGENERATION OF ORGANS	**NEW ORGAN FORMATION**	**MODIFICATION OF EXISTING ORGANS**
Loss of Sense organs	Development of adhesive organs	Flat body
Loss of Locomotory organs	Cuticle	Shell around eggs
Loss of digestive system		

PHYSIOLOGICAL ADAPTATIONS

ANAEROBIC RESPIRATION	**ANTIENZYMES**	**EXCESSIVE REPRODUCTIVE POTENTIAL**

NUTRITIONAL ADAPTATIONS			
Carbohydrates as source of energy	Amino acids and fatty acids are required for synthesising of macromolecules and the production of eggs	tegument help in attainment of nutrients from the host	For anaerobic respiration in host microenvironment parasite develop Glycocalyx Layer (carbohydrate rich layer) Glycocalyx layer enhances absorption of nutrient and secretion enzymes which helps primary digestion
LIFE CYCLE ADAPTATIONS			
They have small head and neck	Body consists of Gonads in repeated serially	Undertake hermaphroditism and parthenogenesis	Reproductive potential is increased at various phase of life cycle through asexual reproduction

IMMUNOLOGICAL ADAPTATIONS		
suppress the immune system without killing the host	Developed sophisticated mechanisms to escape host immune response	Anatomical seclusion in immunologically privileged sites, Antigenic variation, Coating with host protein and Shedding of surface antigen``

BIOCHEMICAL ADAPTATIONS		
They have multiple host (not host specific) and can also be free living	Parasitic helminths in free living stages derive energy and nutrition from aerobic degradation	adult helminth parasites are anaerobic, they characteristically breakdown carbohydrate to organic acids

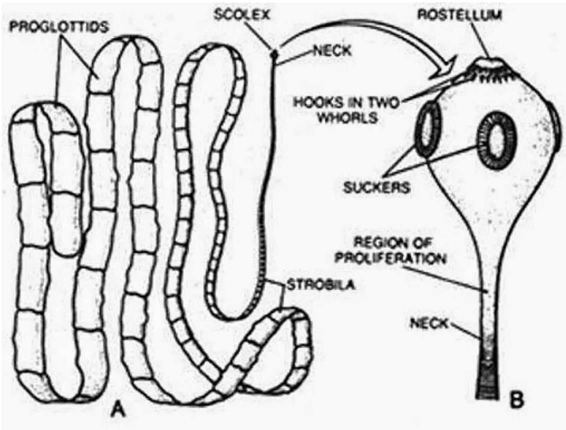


Fig. 9.1. Morphological and physiological adaptations in Helminthes leading parasitic life

9.3 New attainment:

They undertake attainment to help in food absorption, for protection, attachment and reproduction

1. For entry inside the host:

i. microscopic passage is created in host tissue through secretion of liquid from unicellular gland

ii. Tissue is dissolve with the help of hooklet, secretion aids in this process

2. Organs for attachment:

i. Hooks are arranged in double rows, forming a crown around the rostellum, e.g. Taenia solium (Fig. 17.3).

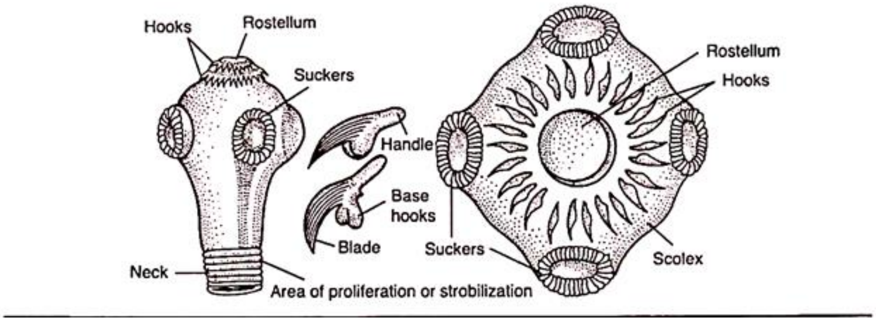


Fig 9.2 A. Scolex of T. solium B. small hooks below larger hook C. Frontal View of Scolex

ii.Adult parasitic flatworms like liver-fluke have Acetabula or sucker. They have 4 suckers 2 ventral one anteriorly and one posteriorly placed

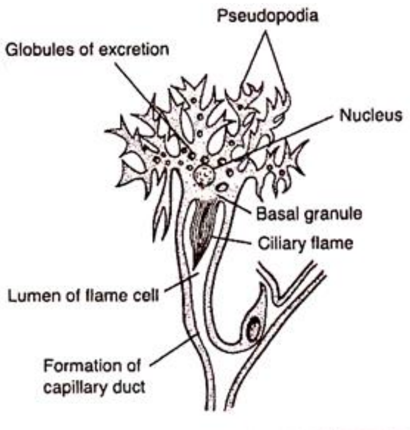


Fig. 9.3 An excretory unit of T. solium- a flame cell

iii. In Ophiotaenia—One apical and four suckers are present.

Iv. In Dipylidium canium numerous rows of hooks are existing around the retractile rostellum

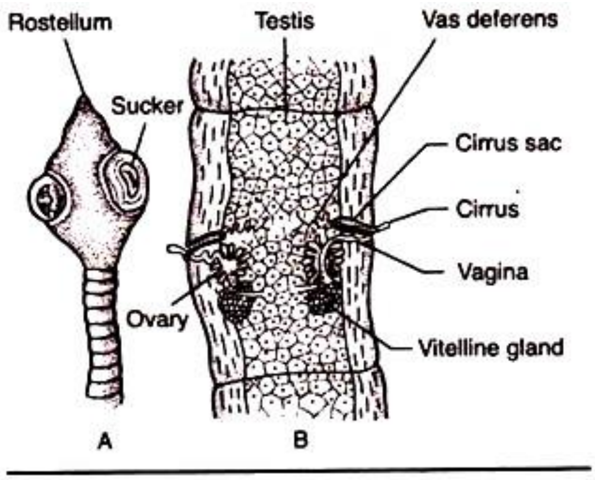


Fig. 9.4 A. Diplidium Showing rostelium and suckers

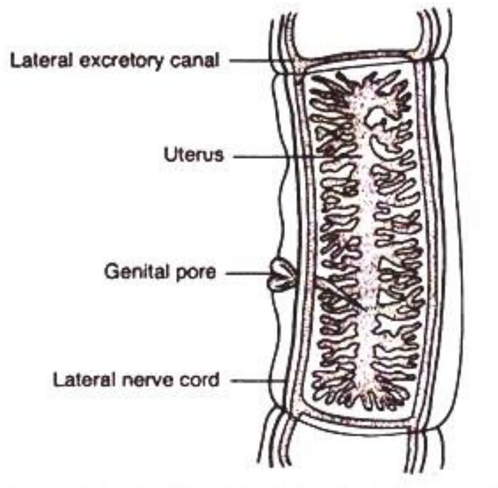
3. For protection—Cuticle:

i.Body has Cyst membrane e.g., Metacercaria larva of liver-fluke.

ii. Protection from Digestive juice is due to the cuticle

iii.cuticle becomes thick In gut parasites, which help in enzyme resistant impregnated with impermeable chitin like substances

iv. Presence of spinous integument—in many Trematodes.



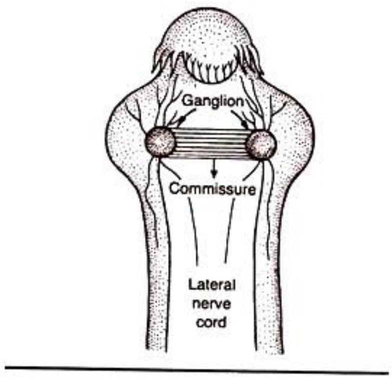
Fig, 9.5 Gravid proglottida

4. Musculature:

Musculature distribute elongated snake like bodies throughout the length of the intestine of the host. gut peristalsis and maintenance of their position in the intestine is due to due to specialised musculature as the parasite gets the pre- digested nutrients

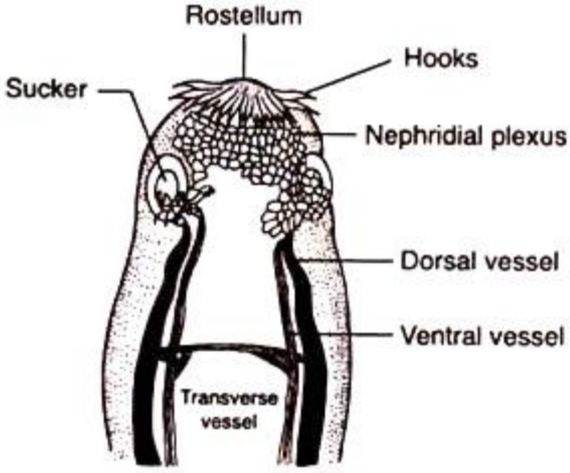
5. Simplified systems:

i. Nervous system is greatly condensed. Ladder-like nervous system is the characteristic feature of Platyhelminthes (Fig. 17.8).



Fig, 9.6 Disposition of nerves in the anterior region

ii. Diminutive adaptation to parasitic mode of life is the feature of Excretory system The characteristic feature of excretory vessel in Cestoda is ladder like. The longitudinal lateral canals are provided with a number of flame cells (Fig. 17.4 and 17.9).



Fig, 9.7 Disposition of excretory vessels

iii. Reproductive system:

Reproductive organ in helminths are associated with marked increase in gamete production. Eg. Cestodes have a small head and neck and rest body has repeated gonads

Summary

Morphologic adaptations: Changes in morphological adaptation is different after years of co evolution, but external parasite develop attachment methods for protection Nutritional adaptations: Proteases are to be targeted for vaccine development against helminth parasites. They undertake many modification for nutritional benefit from host. Lifecycle adaptations: Enhanced management practices can eradicate the parasites at various evolving stages, both in the environment and within intermediate hosts. Parasites have advanced behavioral adaptations to locate hosts, find contamination sites within final and intermediate hosts, evade immune responses, and attract other hosts to consume their current host, among other strategies.

Chapter-10

Annelida

Objectives :

- Describe habitat of Annelids found in both marine and freshwater habitat
- Classify Annelida into classes; Polychaeta, Oligochaeta, Hirudinea, & Archiannellida
- Learn about Metamerism in Annelids
- Explain Significance of Metamerism

10.1 Introducion :

Annelids have a bilateral symmetry, with metamerically segmented body, triploblastic true coelomate, The body is covered with thin and flexible cuticle

Fig:10.1 Phylum Annelida. Source: Wikipedia

10.2 Characteristics

- Annelids are habitually aquatic animal found in both marine or freshwater habitat, some of them are terrestrial while others are burrowing or tubicolous. They may be sedentary, parasitic and. Commensal
- Elongated body having truly coelomate
- The bodies id divided into number of segments by transverse grooves externally, internally body is divided by septa each division is called metamere, somite or segment
- organ grade organization
- unilayered epidermis and is made up of epidermis enclosed by thin cuticle

- Annelids have contractile or dermo-muscular body wall made up of circular outer muscle fiber and inner muscle are longitudinal
- Joint Appendages
- Each segment has chitinous bristles know as setae or chaetae as Locomotory organs, they are present on lateral fleshy appendages called parapodia
- The alimentary canal extend from mouth to annus and is straight like a tube
- Respiration takes place through moist skin or gills present in the parapodia.
- Closed type vascular system is present. pigment erythromycin is present on plasma giving red color to blood
- Receptor organs of annelids includes eyes, taste buds, tactile organs, statocysts, photoreceptor cells.
- They are monoecious or dioecious in some asexual reproduction present.
- Monoecious or dioecious
- Regeneration is common.

10.3 Classification

8,700 known species of Annelida is divided into 4 classes

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

- Exclusively aquatic
- Carnivorous
- Metameric division
- First 2 segments known as prostomium and peristomium on which eyes, tentacles and cirri are present
- on parapodia numerous Setae are present
- clitellum absent.
- respiration by Cirri or branchiae
- In alimentary canal protrusible pharynx is present
- For excretion segmentally paired nephridia is present which is paired segmentally
- Hermaphrodite.
- Fertilization external.
- Mode of Asexual reproduction is budding.
- larva is Trochophore

This class is divided into 2 subclasses.

Subclass 1. Errantia

- predatory polychaetes having characters like swarming, delving or Free-swimming
- The sensory organs is the distinctive feature of prostomium
- Parapodia present on each segment.
- Pharynx protrusible.
- Examples: *Nereis, Polynoe, Aphrodite*
- **Subclass 2. Sedentaraia**
- Mainly Burrowing
- Small head on which eyes and tentacles absent
- Pharynx non-protrusible
- anterior segments have gills
- plankton Feeders
- Examples: *Chaetopterus*, *Sabellaria.*

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

- external and internal segmented body
- indistinct Head, with no sensory organs.
- limited Setae rooted in the skin.
- No Parapodia.
- Glandular clitellum
- jaws absent, pharynx is not eversible
- Bisexual.
- External fertilization without larval stage

Order 1. Archioligochaeta

- Exclusively fresh water animal
- Segmented body (few).
- Setae present.
- Simpler clitellum composed of single layer of cells
- Eyespots present.
- Testes lie in front of ovary.
- Mode of reproduction sexual as well as asexual
- Examples: *Tubifex*, *Aelosoma.*

Order 2. Neooligochaeta

- Mainly terrestrial.

- Several segmented on large body.
- Setae present.
- advanced gizzard.
- Two or more layers of cells present on clitellum
- On 14th segment Female genital opening present
- Vasa differentia are extended upto 3 or 4 segments.
- Eyespots absent.
- Reproduce sexually.
- Eg *Eutypheus*

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

- Mainly ectoparasitic
- Dorso-ventrally or cylindrically flattened body.
- 33 segments divided into multiple rings
- Only external Segmentation
- No setae.
- suckers are situated ventrally at both ends
- anterior suckers have mouth open ventrally and anus opens dorsally on posterior sucker
- Coelom filled by botryoidal tissues.
- Hermaphrodite.
- Fertilization internal.
- Direct Development

Order 1. Acanthobdellida

- Parasitic in nature
- 30 segments present.
- primitive, anterior suckers, proboscis, and jaw absent
- setae present in Double rows.
- spacious body cavity
- Examples: *Acanthobdella*

Order 2. Rhynchobdellida

- Parasitic (snails, frogs and fishes)
- Segmented body with 3,6 or 12 rings.
- small median aperture known as mouth.

- A protrusible proboscis with no jaws.
- Coelom without division
- colorless. blood
- Eg. *Piscicola*,

Order 3. Gnathobdellia

- Ectoparasitic blood-sucking animals.
- Body segmented with 5 rings or annuli.
- No proboscis
- red-colored blood
- Botryoidal tissues present
- Examples: *Hirudo*, *Hirudinaria*, *Haemadipsa*, *Herpobdella*.

Order 4. Pharyngobdellida

- Members are Terrestrial.
- No protrusible.
- Eg., *Dina*.

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

- Mainly marine.
- worm-like elongated body.
- No Setae and parapodia.
- 2 or 3 tentacles in Prostomium
- hermaphrodite.
- trochophore larva.
- Examples: Polygordius, Dinophilus, Protodrilus.

10.4 Metamerism in Annelida

Metamerism was first observed in animal in annelids. Annelids have longitudinally segmented body and each segment known as metameres or somites. The segments are similar and there is serial repetition of organ system in each segments and this phenomenon is called metamerism. In these segments all systems are repeatedly arranged. Metamerism is limited to trunk region (intermediate segments) and anterior region known as acron (head) and posterior region (pygidium) do not exhibit metamerism.

10.4.1 Types of metamerism

There are four types of metamerism found in annelids

Homonomous -All the metameres are similar in structure and function through out the body eg. Earthworm – each segments bear nearly identical set of muscle and organ

Heteronomous the anterior segment cephalisation that is they are modified into head with sense organ. Example chordata and arthropoda. Heteronomous segments vary in structure and function eg. Insects

True Metamerism: segments are formed from mesodermal outpocketings of the embryonic coelom, It is also called eucoelomate segmentation. Each segments contain a coelomic cavity contributing to the locomotion and flexibility of animal eg. annelids, arthropods, and chordates

Pseudometamerism: In **Pseudometamerism there is** external segmentation and but no corresponding internal segmentation For eg. In tapeworm, the body is divided into proglottids which are not true segments however they are repeated body units lacking internal segmentation.

Each type of metamerism corresponds to evolutionary strategies for function, growth and development, indicating the diversity of segmented body plans in the animal kingdom.

10.4.2 Significance of Metamerism :

1. Metamerism provide effective locomotory segmentation. The coordinated contractions generate undulating along the length of body.
2. The coelomic compartment filled with fluid provide hydrostatic skeleton for burrowing the coelomic fluid from 1 part of the body to the other resulting in differential togor pressure resulting in movement of the annelids.
3. Different metameres may be specialized for various function leading to development of high grade organization. This feature is not observed in annelids

10.5 Earthworm

Lumbricus terrestris - “Lumbricus” - worm, while “terrestris” is “land”, “land” or “earth”, Their size varies from 110 to 200 mm

10.5.1 Classification

Kingdom: Animalia

Phylum: Annelida

Class: Clitellata

Order: Opisthopora

Suborder: Lumbricina

10.5.2 Morphology of Earthworm

Reddish- brown tubular body, usually segmented into smaller unit. They are nocturnal and cold blood animals having dark blood vessel on the dorsal side and genital openings on the ventral side.

They are hermaphrodite reproducing both sexually and asexually however for exchange of spermatozoa they undergo copulation

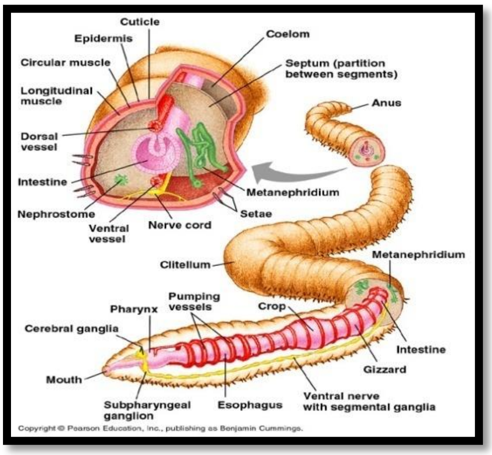
They have inner mouth and prostomium with Criterlam present in adult earthworm

The body is divided into: prepatellar bursitis, prepatellar bursitis, and prepatellar bursitis. Segments 5-9 have 4 pairs of sperm. female genital pores is in 14 segment, Eid, and the 18th segment contains the male genital pair. Movement of earthworms is governed by S-shaped bristles. Classified under annelid phylum they are terrestrial invertebrates with tubical body and, are segments are externaland internal, shows the presence of bristles in every segment. They are omnipresent residing in soil with the ability to degrade organic matter. including plants etc.

Found in temperate and tropical soil, their digestive system along body. Their mode of respiration is skin also have a fluid-filled body cavity and a simple closed circulation system

Movement is governed by perimeter and longitudinal muscles, similar movement in intestine shifts digested food to anus. Lined segment aids in movement. They lack a true skeleton but has fluid-filled coelomic chamber that acts as a hydrostatic skeleton

Megadrills- Large terrestrial worms have true capillaries.



10.5.3 Anatomy

Metameres are segments of cylindrical body. Genital opening is at ventral surface and mid-dorsal line in dorsal surface. periosteum is the 1st segment containing mouth and clitoris is dark band having 1416 segment

Genital foramen: midline ofsegment14 has single genital foramen and male genital is at 18 segments

Movement: S-shaped bristles that facilitate movement are present in segments, except the first, last, and clitellum, contain

Digestive system: GI tract is comprised of straight tube running upto anus. This system is divided into pharynx, esophagus intestine and gizzards each with specific function. The food including soil enter the mouth, it is then bought to pharynx the food then passes via the esophagus, that has calciferous gland. CaCo3 is secreted by the esophagus to remove excess calcium from the body food enter for storage and finally moves into the gizzards, stones eaten by the earthworm and present in the gizzards. grinds the food completely, from gizzardsthe food passes to intestine. The fluid is released by gland cell of intestine aiding in the digestive process. The blood vessel of the intestinal wall engrosses the digested food and transport it to different part of body

Vascular System: Includes the heart, blood vessels, and capillaries. Three main vessel suppling blood to organ are dorsal and ventral blood vessel Aortic arties,- 5 pair of these pump blood into dorsal and ventral blood vessel . the dorsal blood vessel supply blood to the front part of the body whereas ventral blood vessel carry blood to the ventral part of the body Blood cells, dissolved in plasma, and blood glands producing haemoglobin are located in the fourth, fifth, and sixth segments. Earthworm has closed system consisting of heart blood vessel and capillaries. Blood gland are located in segments 4^{th} 5^{th} and 6st . the produce haemoglobin liquified in blood plasma and the blood cell are phagocytic in nature. Blood is pumped by heart for circulation in one direction gut nerve cord and walls receive blood cell from smaller blood vessel

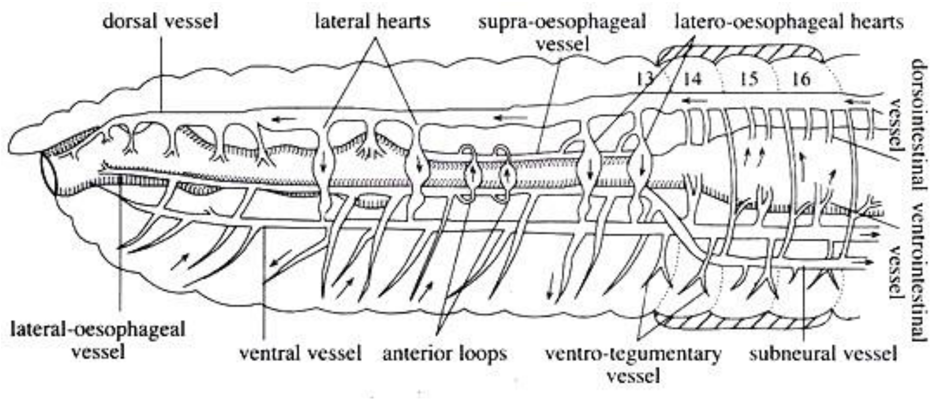


Fig. 10.2 **Vascular System of Earth warm**

Respiratory system- Earthworm breathe through the skin as they have no lungexchange of gases is through the skin by diffusion the skin is kept moist by body fliud and the mucous released by the earthworm . this is required for the diffusion to occur. They cannot see but the have the ability to detect light the tissue are located on the head which is subtle to light. These tissue help they detect light preventing them to surface throughout the day as they can be exaggerated by the sun

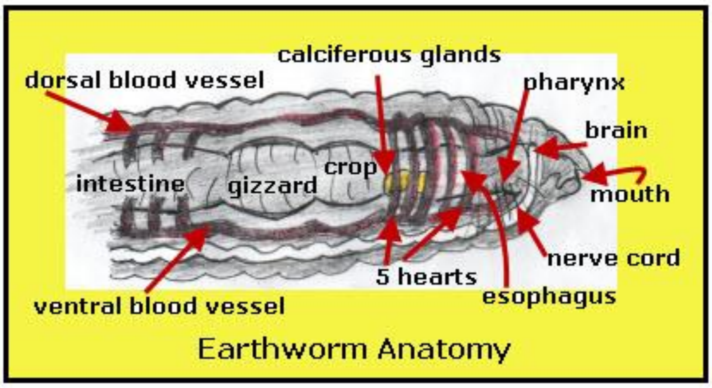


Fig. 10.3 Anatomy of Earthwarm

Reproduction: They are has male and female sex organ, producing sperms and egg respectively such organism are called hermaphrodite. Though they are hermaphrodite in nature ta mate is required to reproduce. two worms are allied inverted to each other during mating in order to get sperm swapped. Each has2 male opening and receptacles each for sperm exchange. Slime tube is formed by clitellum the tube is filled with albuminous fluid; earthworm move forward by slime tube. The tube further move down the earthworm passing over the male pore known as spermathecae having stored sperm called as spermatozoa. The egg fertilize and the worm move out of the slime tube resulting in the closure of slime tube. This egg cocoon is formed which remains in the soil and fertilized egg develop into young worms

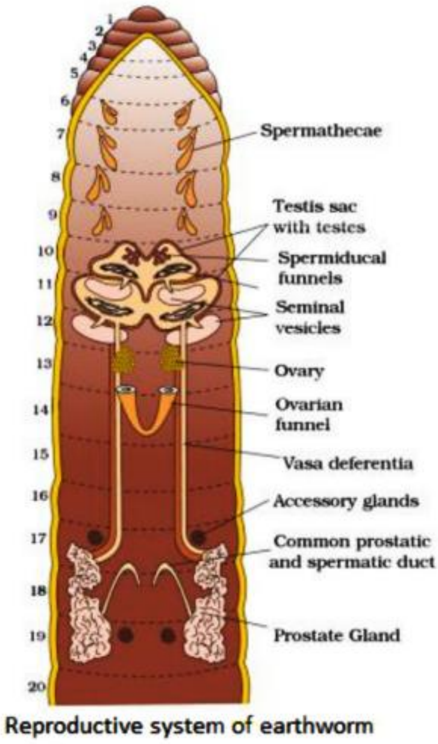


Fig. 10.4: Reproductive system of Earthwarm

10.6 Copulation And Cocoon Development

During copulation spermatozoa of one worm is relocated for cross fertilization to alternative worm

Throughout rainy season earthworm ventrally get attached to each other, and remain together by secretion of accessory gland. Spermathecal pore result in exchange and storage of sperm and prostatic fluid,

After the maturation of ovaries cocoon formation takes place, nourishment of the growing embryo is derived from albumen from Albumen gland cell, when exposed to air girdle hardens this is called cocoon . after passing female genital pore girdle hardens, from the anterior end girdle is thrown off . ovum is fertilized by sperm in cocoon where fertization occur. In 2- 3 weeks one earthworm can release from cocoon.

Excretory system :

nephridia is the excretory organ of earthworm analogous to vertebrate kidney. Nephridia is thin long coiled tube and porous in nature contemporary metamere excluding first 3 segments. Differentvariety of nephridia based on location in body are

Septal Nephridia or typical nephridia – they are involved to both side of each intersegmental septum behind the fifth section. 40-50 Septal Nephridia are present in each system. It consists :

- **Nephridiostome (Nephrostome):**shape is like funnel with cilia externally locatedand the nephridiostome opens into the coelomic cavity.
- **Body:** chief tubular fragment of the nephridium,twisted around its axis. It has two sections:
  - **Straight Short Lobe:** A short, straight tube forming one half of the twisted loop, attached to it.
  - **Long Twisted Loop:** Includes a narrow apical lobe and forms the other half of the twisted structure.
- **Terminal Duct:** The final part of the main body, consisting of a single intracellular canal.
- **Nephridial Tube:** The nephridium comprises a glandular mass that is syncytial containing twisted tubules that terminate in a narrow terminal duct.

Pharyngeal Nephridia:

- Located in pairs within the forth, fifth, and sixth segments.
- Structurally alike of septal nephridia but nephrostome is absent
- Include a short straight lobe and a spirally twisted loop.
- ciliated canal in lumen

Integumentary Nephridia:

- septal nephridia is larger in size
- V-shapednephridium, short straight lobe and a twisted loop, nephridiostome or funnel absent

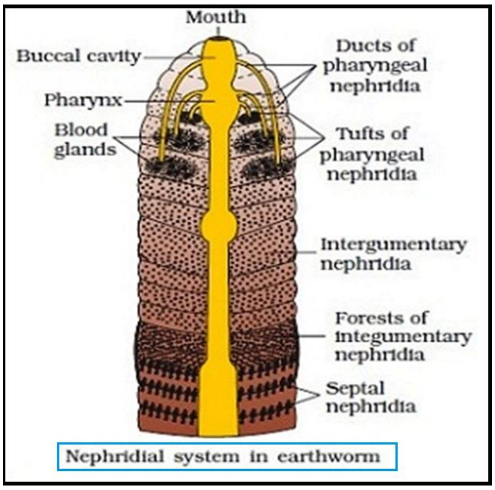


Fig. 10.5 Nephridial System

Nephridia collect the nitrogenous consisting of comprise of 40% urea, 20% ammonia, 40% amino acid waste matter with the help of capillaries in every three days.

10.7 Economic Importance

- Earthworms pointedly augment soil fertility through various means, making them vivacious for agriculture.
- Porous soil structure is created by burrowing and feeding habits, which facilitates aeration and rapid water absorption, allowing plant roots to penetrate easily and deeply.
- Earthworms also transport nutrient-rich subsoil to the surface, enriching it with organic matter.
- Earthworms help to create equilibrium in soil pH levels, dropping alkalinity and acidity to create optimal environments for plant growth.

Chapter-11

Arthropoda

Objectives :

- Describe characteristics features of Phylum Arthropoda
- Classify Arthropods in different sub phylums and classes
- Give examples of Arthropodas that live as parasitic crustaceans that lives as ecoparasites
- Signify importance of Arthropodas

11.1 Introduction :

They are triloblastic, exhibit bilateral symmetry, metamerically segmented body having a reduced and modified coelom. Their appendages are linked, and they have an external chitinous exoskeleton covering their body that molts on occasion.

11.2 Characteristics :

- Body organization is of organ-system level.
- A thick layer of chitin covers the body called cuticle forming an exoskeleton.
- Lateral and joined appendages with a variety of functions, such as jaws, gills, legs, etc., are often present in body segments.
- The body is divided into the belly, thorax, and head. Frequently, the head and thorax merged to form a cephalothorax.
- Instead of being continuous, the musculature is made up of discrete, striped muscles that may contract quickly.
- The human body is hemocolel. The areas between the genital and excretory organs comprise the genuine coelom.
- The whole digestive tract, including the mouth and the anus. mouthpieces designed for different feeding techniques.
- An open circulatory system without capillaries but having an artery and dorsal heart.
- Swallowing via the skin on the outside of the body, the trachea or book-lungs in aquatic animals, or both.
- Not a real nephridia. The Malpighian tubules, coxal glands, or green glands are examples of excretion organs.
- The neurological system is usually annelidan, consisting of two ventral nerve cords and a dorsal brain joined by a nerve ring.
- All regions of the body are completely devoid of cilia.

- The sensory organs include the balance, tactile, chemo- and basic eyes, as well as the auditory and chemo-organs.
- Generally speaking, the sexes are dioecious. Pairs of reproductive organs and ducts.
- Fertilization within. either ovoviviparous or oviparous.
- Larval phases are typically used to indirectly develop. In certain people, parthenogenesis.
- A lot of arthropods have clearly visible parental care.
- The greatest diversity of groupings living on land, in water, and in the air.

Fig. 11.1 Examples of Artopoda

11.3 Phylum Arthropoda Classification

Diverse researchers have categorized the phylum Arthropoda and its constituent groups in diverse ways. Vandal (1949), Snodgrass (1960), and Strorer (1979) are the classifications that come after this one. Nowadays, onychophora are regarded as a distinct group of segmented creatures rather than as a class of arthropods.

Subphylum 1- Trilobitomorpha (Gr., tria=tree+ lobos=lobe+ morphe=form)

- The members of the Subphylum are extinct trilobites they are marine creatures benthozoic, or bottom dwellers.
- They all lived from the Cambrian to the Permian.
- Two longitudinal furrows divide the three lobes that make up the body.
- Each segment, with the exception of the last ones, has a distinct head with a single pair of antennae.
- Examples : *Triarthrus*, *Dalmanites*.

Subphylum 2- Chelicerata (Gr., chele=claw+ keros=horn+ ata=group)

- The body divided into 2 parts -anterior cephalothorax (prosoma) and posterior abdomen, (opisthosoma)
- 6 pairs of Prosomatic appendages, first pair of appendages are clawed preoral chelicerae that operate as feeding apparatus.
- Mostly terrestrial and predaceous
- Lacks real jaws and antennae
- The second set of appendages are Postoral pedipalpi. They are followed by four pairs of appendages functioning as walking legs.

Class 1. Merostomata (Gr., meros=thigh+ stoma= mouth)

- Members of class Merostomata have 5 to 6 pairs of appendages on the abdominal modified as gills or branchiae for breathing.
- all marine forms
- Eyes are Median simple and lateral compound
- The abdomen ends with a spine or telson that is sharp.
- Expulsion via the coxal glands.
- Not one Malpighian tubule.

Subclass 1. Xiphosura (Gr., xiphos=sword+aura=tail)

- The horseshoe-shaped carapace covering the protosoma is convex, and it has six pairs of appendages.
- A lengthy terminal telson and an unsegmented abdomen.
- Pairs of genital apertures protected by an operculum.
- The lamelliform or book-gills, which are connected to the abdominal appendages, are used for respiration.
- Example: *Limulus* (horseshoe or king crab).

Subclass 2. Eurypterida (Gr., eurys=broad+ pteryx=wing)

- Extinct arthropod
- Aquatic giant scorpions.
- cephalothorax is small with a dorsal carapace
- A thin cephalothorax, which comes after a 12-segmented abdomen.

- Six pairs of appendages on a cephalothorax
- Examples: *Eurypterus*, *Pterygotus*.

Class 2. Arachnida (Gr., arachne=spider+ oid=like)

- Marine or terrestrial types.
- Eyes are plain. compound eyes absent
- Four pairs of walking legs, one pair of pedipalpi, and one pair of chelicerae make up the six pairs of appendages on the prosome.
- The belly is free of appendages.
- The respiratory system's tracheae, sometimes known as book-lungs or book-gills.
- Excretion through Malpighian tubules and coxal glands.
- Separate (dioecious) sexes. mostly oviparous, engaging in courting prior to mating.
- Development straight.

Order 1. Scorpionida (=scorpiones)

- Long, fair-shaped genuine scorpions
- MostlyTerrestrial forms found in tropical and subtropical beneath stones
- Broad connection between small and large opisthosoma.
- The prosoma, which is dorsally covered in a carapace, has four pairs of walking legs, two pairs of pedipalpi, and two pairs of chelicerae.
- Opisthosoma is separated into a narrow posterior 5-segmented metasoma and a broad anterior 7-segmented mesosoma.
- A toxic sting and telson are the results of metasoma.
- Two pectines on the second abdominal segment that resemble ventral combs.
- The respiratory system's book-lungs.

- Examples: *Androctonus Buthus*, *Palamnaeus*

Order 2. Pseudoscorpionida (=Chelonethida)

- They are small fake scorpions that are hidden behind tree bark.
- They have an 11-segmented abdomen without a telson or sting, two joints on their chelicerae that have comb-like secretions, and a prosoma that is divided into six fused segments covered dorsally by the carapace.
- They breathe through their trachea.
- Eg., *Chelifer*, *Microcreagris*.

Order 3. Palpigradi

- They are known as microwhip scorpions
- Eyeless.
- The prosomal carapace is divided with smaller posterior and larger anterior sections.
- A pedicle connects the 10-segment opisthosoma to the prosoma.
- Telson with the flagellum joined at the ends.
- Helicerae resemble legs and are chelate.
- Three sets of book-lungs used as breathing apparatus.
- Example: *Koenenia*.

Order 4. Solifugae (=solifugida)

- they that are fakespiders. and referred to as wind or sun spiders.
- Prosoma and opisthosoma make up the body.
- The prosoma is separated between a tiny posterior portion and a big anterior component.
- A 10 or 11 segment opisthosoma.
- Absent spinnerets.
- Pedipalpi are lengthy and resemble legs, whereas chelicerates are big and extended.
- There are no poison glands.
- Breathing via the trachea.
- A flagellum for sperm transmission on each male chelicera.
- For instance, Galedodes.
- Three sets of book-lungs used as breathing apparatus.

Order 5. Amblypygi (= Phrynichida)

- They are whip tailless whip scorpions or spiders
- One intact carapace. Big, rhaptorial pedipalps.
- Moderate chelicerae size.
- Abdomen with 12 segments without flagellum.
- The first walking legs are long and sensory, like a whip.
- Example: *Charinus*.

Order 6. Uropygi (=pedipalpi)

- Frequently called a whip scorpion.
- Are made up of two eyes.

- The whole protosomal carapace.
- Chelicerae are moderately sized, two-jointed animals.
- Big, hefty, and often possessing pedipalpi pincers at the end.
- Opisthosoma with 12 segments. last section with a lengthy telson or flagellum.
- Examples: *Thelyphonus, Mastigoproctus*.

Order 7. Araneae

- Real spiders: Prosoma and opisthosoma make up the body.
- Prosoma and opisthosoma joined by a thin pedicle, but without discernible segmentation.
- Prosoma possesses six pairs of appendages.
- The Chelicerae have two joints and with terminal claw with poison duct. Simple pedipalps are simple resembling legs used by males to transport sperm.
- Opisthosoma with three spinneret pairs. Not a Telson.
- The prosoma's carapace has eight eyes placed dorsally in two rows.
- Breathing organ is trachea, book lungs, or both.
- Examples: *Agelena* (funnel-web spider).*Aranea* (house spider), *Argiope* (writing spider), Lycosa (wolf spider)

Order 8. Ricinulei (=Podogna)

- Infrequent, tiny, heavy-bodied, tick-like arachnids with prosoma and opisthosoma in their bodies.
- Prosoma with a moveable plate (Cucullus) resembling an anterior hood.
- Opisthosoma has nine segments and a pedicle connecting it to the prosoma.
- Pedipalpi and Helicerae are chelate.
- In males, the copulatory organs are formed by the third set of legs.
- Breathing via the trachea.
- Eg., *Cryptocellus*, *Ricinoides*.

Order 9. Phalangida or Opiliones

- Daddy Longlegs, Harvest-men, or Harvest-spiders, are spider-like creatures.
- Small, oval-shaped body. legs that are very long and thin.
- Prosoma that is not segmented, but opisthosoma has ten segments.
- Opisthosoma and prososoma are widely linked.
- No glands whirling.

- Tracheal respiration.
- Eg., *Leiobunum, Phalangium*

Order 10. Acarina

- All together known as mites and ticks
- Parasitic or Autotrophic.
- Prosoma and opisthosoma merged into a small, elliptical, unsegmented body.
- Tiny helicerae and pedipalpi are connected to mouthparts that are designed for sucking, biting, and piercing.
- The trachea or skin are respiratory organs.
- Eg., *Idodex* (Tick).*Chorioptes* (Mites), *Sarcoptes* (Itch-mite)

Class 3. Pycnogonida

- Usually called marine spiders.
- Extremely tiny in size; the body is mostly made up of the decreased abdomen and cephalothorax.
- Pedipalpi with short segments and tiny chelicerae.
- Typically, eight lengthy walking leg pairs.
- The mouth rests on the lengthy proboscis.
- Four digits and plain eyes.
- Lack of excretory or respiratory organs.
- Dioecious women and men separate. females equipped with two ovigers to transport eggs.
- Examples: *Pycnogonum, Nymphon*.

Subphylum 3- Mandibulata (L., mandibula=mandible+ ata=group)

• Body divided into three parts thorax head and abdomen or cephalothorax and abdomen.

• Terrestrial and aquatic, both freshwater and marine.

• Head appendages consist of

a. One or two sets of antennae

b. one pair of mandibles

c. one or two pairs of maxillae

- Typically, compound eyes.
- Perspiration through the tracheae or gills.
- The green glands or Malpighian tubules as the excretory system.
- Sexual dimorphism causes the sexes to diverge.
- Larval phases are involved in development.

Class 1. Crustacea (L., *crusta*= a hard shell)

- Generally free-living, with a small number of parasitic species
- Mostly aquatic, marine, however, a few freshwater and few thriving in damp environments.
- Often united with the thorax to create a cephalothorax, which is dorsally covered in a carapace.
- A hard, crumbly exoskeleton is present
- Head consist of five-segment bearing
  - apair of mandibles
  - two pairs of each maxillae and antennae
- Usually, appendages with two legs.
- Sweating on the surface of the body or via the gills.
- The hemocoel is a sign of reduced coelom.
- The heart's dorsal contractile chamber and the surrounding pericardial sinus are connected via valvular osteoa in the blood circulatory system.
- Either the antennary (green) glands or the maxillary glands excrete.
- Usually distinct Male sexual dimorphism is widespread.
- The nauplius stage of development.

Subclass 1. Cephalocarida

- A horseshoe-shaped head and a 19-segment trunk make up the body.
- Only the front 9 segments of the trunk have appendages that resemble triramous structures.
- Lack of carapace and eyes.

- The head has two sets of antennae, two sets of jaws, and two sets of maxillae.
- Bottom dweller and marine species
- Genital apertures on the 19th segment
- Example: *Hutchinsoniella*.

Subclass 2. Branchiopoda

- A tiny, primitive, free-living, freshwater organism with a carapace that is either missing or resembles a bivalved shell.
- Thoracic appendages, which are bristled and resemble flattened, lobed leaves.
- Appendages are used for feeding through filters, breathing (gills), and movement.
- Despite having no stomach appendages, it has two caudal styles.
- Reduced or missing antennae and second maxillae.
- Parthenogenesis is quite prevalent.
- It is a nauplius larva.

Order 1. Anostraca

- Known by the common name "fairy shrimps," they have at least 19 trunk segments.
- The first 11 to 19 portions alone.
- Longer body. Lackluster carapace development.
- Glacked eyes.
- Antennae unicarmus.
- rodlike or bladelike caudal stylets.
- Examples: *Branchipus*, *Artemia*, *Eubranchipus*.

Order 2. Notostraca

- Broad, shield-shaped carapace and elongated body.
- Stalkless eyes with stalk absent.
- A smaller antenna, the front part of which has 35–71 pairs of appendages.
- Numerous joined caudal stylets.
- Often known as tadpole shrimps.
- Eg *Apus*, *Lepidurus*.

Order 3. Diplostraca

- Body flattened laterally

- Sessile eyes that are typically joined together.
- The enormous, biramous antennae are utilized for swimming.
- A disjointed, claw-like caudal style.
- Also known as water fleas or clam shrimps.
- Eg *Daphnia, Limentis*.

Subclass 3. Ostracoda

- Mainly both freshwater and the ocean. Their poorly segmented bodies are completely encased in a bivalved carapace.
- Two sturdy, cylindrical thoracic appendages.
- Big antennae and antennules for swimming.
- Palps accompany the mandibles.
- Parthenogenesis occurring often.
- Also known as seed shrimps or minute mussels.

Order 1. Myodocopa

- Found in seawater.
- Carapace with antennal notches.
- 2^{nd} antennae biramous, enlarged at base.
- 2^{nd} antennae used in swimming.
- Example: *Cypridina*.

Order 2. Podocopa

- Both marine varieties.
- A carapace without notches or antennal openings.
- Two sets of thoracic appendages.
- Two uniramous antennae with clawed ends that resemble legs.
- Eg *Cypris, Darwinula*.

Order 3. Platycopa

- Mainly seawater.
- uniramous antennae.
- trunk appendages present.
- Antennae not castoff to swim.
- Example: *Cytherella*.

Order 4. Cladocopa

- Found in seawater.
- Both pairs of antennae used for swimming.
- Example: *Polycope*.

Subclass 4. Mystacocarida

- The elongated bodies of small crustaceans are divided into three segments: the head, the thorax, and the abdomen.
- The first thoracic pair (Maxillipedes) are likewise well-developed head appendages.
- Notable antennae and antennules.
- compound eyes absent
- Abdomen without legs.
- The caudal stylets, two of them.
- Men and women are distinct.
- Metanauplius is known larval stage.
- Example: *Derocheilocaris*.

Subclass 5. Copepoda

- Crustaceans are free or parasitic.
- Small body, divided into the belly, thorax, and head.
- No carnepace.
- All thoracic appendages save the first are usually biramous.
- Abdomen without legs. Two caudal styles in Telson.
- Only one median eye, not any compound eyes, are visible.
- Extended antennae. little antennas.
- Mandibles that palpate typically.
- Females transport their eggs in an egg sac or sacs.
- It is a nauplius larva.

Order 1. Calanoida

- Body constricted slightly beyond the segment containing the fifth leg; • Biramous antennae
- Found in freshwater lakes, ponds, and ocean.
- Examples: *Calanus*, *Diaptomus*.

Order 2. Harpacticoida

- Mostly aquatic.

- Biramous antennae.
- Example*: Harpacticus.*

Order 3. Cyclopoida

- Constriction in the body between segments containing the 4th and 5th legs is plainly visible
- Uniramous antennae.
- Occurs in both freshwater lakes and ponds and saltwater.
- Example: *Cyclops*.

Order 4. Monstrilloida

- Larvae parasitic in marine polychaete worms.
- mouthparts and antennae absent
- Example: *Monstrilla*.

Order 5. Caligoida

- harbor ectoparasitic forms.
- In males, the articulation between the third and fourth thoracic segments is visible.
- Ectoparasitic in fish gill chambers.
- Affixed with antennae to the host body.
- Eg *Caligus*.

Order 6. Lernaeopodoida

- Both freshwater and marine fishes harbor ectoparasitic forms.
- Absence of obvious body segmentation.
- Fewer or absent appendages.
- Usually connected by the second maxillae to the host body.
- Examples: *Lernaea*, *Salmincola*.

Subclass 6. Branchiura

- Fish lice are a common term for parasitic crustaceans that live as ectoparasites on the skin and gill chambers of fish and some amphibians.
- Flattened body dorso-ventrally.
- Head and thorax covered by a shield-like carapace.
- The buccal cavity.
- Single pair of sessile compound eyes.
- Lack of antennules and antennae.

- Five sets of appendages in the thorax.
- The first maxillae become suckers.
- An unpartitioned, bilobed abdomen.
- caudal claws small
- Eg *Argulus*, *Dolops*.

Subclass 7. Cirripedia

- Only found in sedentary, marine forms; commonly referred to as barnacles.
- Adults that are parasitic, attached, or sessile.
- Inadequately designed bodily segmentation.
- The outside of the carapace is coated with calcareous plates and forms two folds of mantle around the body.
- Adults do not have complex eyes or antennae.
- The six pairs of thoracic appendages are usually cirriform and biramous in nature.
- The basic abdominal structure often has two caudal styles.
- Cement glands for attachment form antennae.
- Hermaphrodites are monoecious.
- The larva of naplius goes through phases of cypris.

Order 1. Thoracica

- Sedentary forms that are not parasitic.
- All hermaphrodites, stalked or not.
- The body was encased in a calcium shell.
- thoracic appendages present
- There is an alimentary canal.
- Examples: Lepas (Goose barnacle), Balanus (Acorn barnacle).

Order 2. Acrothoracica

- Parasitic forms
- Unisexual and Sessile.
- No calcareous shell
- 6 pairs of thoracic appendages, cirriform.
- Alimentary canal.
- Eg: *Alcippe*, *Cryptophialus*.

Order 3. Ascothoracica

- Parasitic forms on Anthozoa as Echinodermata.
- Bivalved or saccular mantle.
- 6 pairs of thoracic appendages.
- Mouth appendages are modified
- alimentary canal absent
- Eg: *Laura*, *Petrarca*.

Order 4. Apoda

- They are Parasitic forms.
- Mantle, appendages and anus is absent
- bodyis Maggot-like.
- No anus.
- Hermaphrodites organism
- Eg., *Proteolepas.*

Order 5. Rhizocephala

- Totally degraded body; no appendages or alimentary canals; parasitic forms on decapod crustaceans.
- No indication of segmentation.
- The tendril develops absorbent branches that resemble roots and spread throughout the tissues of the host.
- Example: S*acculina*.

Subclass 8. Malacostraca

- Large crustaceans with nineteen segments.
- cephalothorax is formed by head and one or more thoracicsegments
- The number of segments in Thorax and abdomen are 8 and 6 segments, carapace is well formed vestigial or may be absent in some organism
- It has a pair of stalked compound eyes
- The abdomen ends in a telson
- caudal styles are absent
- Development occurs through Zoaea stages
- Nauplius stages are sporadic.

Order 1. Nebaliacea

- Crustacea primate species found in marine environment
- A carapace has two valves and an adductor muscle.

- Thorax has 8 pairs of gills they resemble leaves.
- A telson and seven abdominal segments as opposed to six.

- Eyes are staked.
- Caudal style present at telson
- Eg *Nebalia* sp.

Order 2. Mysidacea

- They are crustaceans found in Marine forms with elongated body
- Thorax is covered byThin carapace
- Eyes are stalked
- thoracic appendages are biramous
- broad fan-like tail fin are formed by Uropods
- eg., *Hemimysis Mysis*

Order 3. Isopoda

- Members of order Isopoda are crustaceans that are freshwater, marine, terrestrial, or parasitic.
- Body is dorsoventrally flat.
- Cervical segments one or two and the head constitute a cephalothorax.
- Without a carapace. eyes that are sessile.
- Often having a short abdomen, they are known as woodlice.
- Eg., *Bopyrus Oniscus*

Order 4. Amphipoda

- Most of them are marine crustaceans.
- Body is Laterally compressed
- Carapace and thoracic Gills absent
- Eyes are Sessile and lateral.
- Commonly known as sandhoppers.
- Eg *Gammarus Caprella*

Order 5. Stomatopoda

- Marine forms.
- Flattened body.
- Small carapace covering 3 thoracic segments.
- Abdomen is large and broad as compared to cephalothorax.

- Eyes are Staked
- Gills are present in first five pairs of abdominal appendages.
- Heart isElongated.
- 2nd Maxillipedes raptorial.
- Commonly known as mantis shrimps.
- Eg., squilla.

Order 6. Decapoda

- The majority are marine varieties.
- A fully formed carapace that encases the whole thorax.
- The remaining five pairs of thoracic limbs function as walking legs, while the first three pairs form Maxillipedes.
- On the thorax, gills are often found in three series.
- There is a statocyst.
- Larva stage is Zoaea

Suborder 1. Macrura

- Abdomen is elongated and well developed.
- Members have antennules and antennae
- Eyes are not enclosed in eye sockets.
- Eg: *Astacus Palaemon*

Suborder 2. Anomura

- abdomen is reduced or fixed
- Eg *Eupagurus Hippa*,

Suborder 3. Brachyura

- Abdomen Greatly reduced. It is hard and folded beneath the body.
- Eg., *Carcinus*.*Cancer*

Class 2. Chilipoda (Gr., cheilos=lip+ pous=foot)

- **Chilipoda have** 100-leggers, or centipedes.
- Body dorso-ventrallyFlattened, divided into 15–173 segments of the trunk and a head.
- Two mandibles, two maxillae, and two antennae are present on the head.
- one pair of legsare present in each segment of the trunk the first pair of leg forms poisonous claws.
- They are predaceous in nature

Order 1. Scutigeromorpha

- Fifteen paisa of long legs
- Antennae are Elongated.
- Spiracles are dorsally placed unpairedand median,.
- Eg: *Scutigera.*

Order 2. Lithobiomorpha

- Characterized by15 pairs of very short legs
- Antennae are numerous elongated with 19-70 segments.
- Spiracles are paired and lateral
- Eg*Lithobius*.

Order 3. Geophilomorpha

- Shapes that burrow with thin bodies.
- The legs are small, ranging from 31 to 170 pairs.
- Spiracles arranged laterally and in pairs.
- There are 14 segments on the antennae, but no eyes.
- Eg *Geophilus*.

Order 4. Scolopendromorpha

- Body is long having head may be with or without eyes; 21 to 23 pairs of legs attached to body head 17–30 jointed antennae.
- Only in the anterior trunk segments are there paired, laterally positioned spiracles.
- Example: *Scolopendra*.

Class 3. Symphyla (Gr., **syn=**together+ **phylon**= tribe)

- centipedes (pseudo centipedes) from gardens belong to class Symphyla
- they are Extra-terrestrial, and found in moist areas with humus.
- Body is Slender composed of a head with two sets of maxillaeone pair each of mandibles, and antennae trunk is segmented with 10–12 pairs of legs.
- Eyes absent
- The head is the only organ with spirals.
- The mid-ventrally located genital openings are located between the fourth pairs of legs.
- Eg *Scolopendrella Scutigerella*, .

Class 4. Pauropoda (Gr., **pauros**=small + **Pous**=foot)

- A body like a minute grub, with nine or ten pairs of legs and a skull that may be divided into parts.
- Soft-bodied arthropods that are typically found under dirt, beneath stones, logs, and fallen leaves, and in dark, damp areas.
- Two pairs of maxillae that comprise the lower lip, two mandibles, and a pair of antennae are present on the head.
- Eyeless.
- The third segment's gonocores are located mid-ventrally.
- eg: *Decapauropus Pauropus*, .

Class 5. Diplopoda (Gr., **diplos**=double+ **pous**= foot)

- It consists of 1000 leggers or millipedes.
- Long, slender, cylindrical, sub-cylindrical, and able to be wrapped around the torso.
- The body is composed of the head, thorax, and abdomen.
- 4 segments for the thorax, 5 segments for the head, and 20–100 segments for the abdomen.
- One pair of maxillae, one pair of mandibles, and one set of antennae are present on the head.
- Thoracic segments containing a single leg pair.
- Each abdominal segment has two pairs of legs (Diplopoda).
- No poisonous claws.
- Vegetarian by nature.
- Gonopores on the third abdominal segment, located mid-ventrally.

Order 1. Pselaphognatha

- Minute, with a body coated with bristles.
- The trunk has 11 or 13 segments.
- Gnathochilarium, which has two palps and fused maxillae from both sides.
- Silky tissues.
- Stink glands absent
- Eg *Lophoproctus Polyxenus*, .

Order 2. Pentazonia

- Capable of rolling into a snug ball.
- Trunk: 13–15 segments, 5 sclerites in each segment.
- Male gonopods, or present clasping organs, 1 or 2 pars.
- There are no stink glands.
- eg: *Onomeris Glomeris*, .

Order 3. Nematomorpha

- Trunk sections 26 to 32; body segments 26 to 60
- Two or three gland pairs that rotate.
- On the seventh segment, one or two pairs of male gonopods.
- The eyes are open.
- Usually called silk-spinning millipedes.
- Eg : *Cleidogono Striaria*, .

Order 4. Juliformia

- A trunk that has forty or more segments, also referred to as a snake millipede.
- One or two male gonopod pairs on the seventh segment.
- No glands that spin.
- The majority of trunk segments have stink glands.
- Examples: *Julus*, *Spirobolus.*

Order 5. Colobognatha

- Suctorial millipedes, a kind of trunk that has 30 to 192 flattened segments.
- Small mouthparts and a conical skull.
- In segments 7 and 8, there are two pairs of male gonopods, one pair in each.
- The presence of stink glands.
- eg: *Platydesmus Polyzonium*, .

Order 6. Polydesmoidea

- The flat-backed millipede, or trunk with 19–22 segments, has one or two pairs of male gonopods on the seventh segment.
- There are stink glands but no spinning glands.
- Examples: *Polydesmus*, *Oxidus*.

Class 6. Insecta (L., *insectum*=being cut into)

- arthropods that breathe air, generally terrestrial but sporadically aquatic.
- The thorax (three segments), abdomen (up to eleven segments), and head (six fused segments) make up the body.
- A thorax with one or two missing wings and three jointed pairs of legs.
- Appendages are absent from the abdomen.
- There is generally a liver present, but not always.
- The abdomen contains an elongated, tubular heart that is split into eight chambers.
- Breathing via trachea that are branched.
- Removal through Malpighian tubules.
- Single.
- Internal Fertilization.
- While transformation frequently complicates development, it can occur directly at times.

Subclass 1. Apterygota (Ametabola) (Gr., *a*=without *ptera*=wings)

- A style-like appendage and cerci on the abdomen.
- There is minimal or no metamorphosis .

Order 1. Protura

- No antennae and complex eyes; minute soft-bodied insects.
- No transformation.
- The mouth is gnawing.
- An eleven-segment abdomen with a telson.
- No throat.
- eg *Acerentomon*.

Order 2. Thysanura

- Tiny ancestor bugs.
- Small silvery scales cover the body.
- Biting of the mouth: well-developed, long antennae.
- Cerci, telson, and 11 segments of the abdomen.
- Transformation from a primate.
- Example: *Lepisma* (Sliver fish).

Order 3. Aptera

- Tiny, blind insects that are white or pale.
- The body became flabby.
- Chewing on a mouth pat.
- Extended, multisegmented antennas.
- Caudal filaments are absent.
- No transformation.
- eg *Campodea*.

Order 4. Collembola

- Tiny insects, with a body either hairless or coated with scales.
- Absence of the trachea, Malpighian tubules, eyes, and transformation.
- Chewing or sucking with the lips.
- Anemones with four to six segments.
- An abdomen with six segments, typically accompanied by a tenaculum, ventral tube, and spring.
- eg Springtails, Snow flies.

Subclass 2. Pterygota (Metabola) (Gr., *ptera*=wings)

- The wings are there. lost in some secondary ways.
- Cerci are the only appendages on the abdomen.
- Either an easy or hard transformation.

Division1. Exopterygota (Heterometabola)

- Wings form buds on the outside.
- An easy or simple transformation.
- Stages under age are nymphs.

Order 5. Orthoptera

- Bugs that are big or medium in size.
- A pair of wings. Tegmina, or forewings, are straight and leathery.
- Membrane hindwings that fold while at rest.
- Powerful biting and chewing of the mouth.
- A large chest cavity. leaping using the hindlegs.
- Usually two or three ocelli and compound eyes.

- Segmented, simple, long, or short cerci.
- A basic transformation.
- Examples: *Locusts*, *Grasshoppers*, *Crickets,* etc.

Order 6. Grylloblattodea

- The tiny thysanuriform insects.
- In absence of wings.
- Biting kinds of mouthparts.
- Filiform, maybe with divided antennas.
- Dim compound eyes with no ocelli.
- Simple transformation.
- Example: *Grylloblatta*.

Order 7. Blattaria

- Insects with a medium–large size range.
- Wings in place or not.
- The antennae are filiform, long, and have many segments.
- Chewing and biting kind of mouthparts.
- Cerci that are pronounced and divided.
- Merely changing form.
- Examples: *Periplaneta*, *Blatta*.

Order 8. Phasmida

- Big bugs that resemble leaves or sticks.
- Typically, antennae are long, filiform, and have several segments.
- Small compound eyes with absent or only two ocelli.
- Biting kind of mouthparts.
- Wings in place or missing.
- Tightly packed, divided cerci.
- eg: *Phyllium,*

Order 9. Mantodea

- Insects, big to medium.
- Huge compound eyes with three or more ocelli are located in a tiny, triangular skull.

- Biting kinds of the mouth.
- A significantly extended thorax.
- Modified forelegs used to seize and hold prey.
- Big, little, or nonexistent wings.
- A basic transformation.
- Example: *Mantis* (praying mantis).

Order 10. Dermaptera

- Insects that are little to medium in size.
- Long body covered with a smooth, durable, or chitinous coating.
- Biting kind of mouthparts.
- There are cerci that resemble forceps at the posterior end of the abdomen.
- A basic transformation.
- Example: *Forficula*.

Order 11. Diploglossata

- Small insects.
- Short hairs covering a depressed body.
- Biting kinds of the mouth.
- Without wings or eyes.
- Two segmented cerci are seen.
- A basic transformation.
- Example: *Hemimerus*.

Order 12. Plecoptera

- Huge to medium in size.
- Long, soft-bodied insects with a somewhat flattened body.
- Two long, filiform antennae with 25–100 segments each are present on the broadhead.
- Complementary compound eyes that have two, three, or no ocelli.
- Biting kind of mouthparts.
- Two pairs of wings, the rear pair having a broad anal region, that are equally veined.
- An abdomen with 11 segments, the last section being smaller and bearing multisegmented elongated, filiform cerci.

- A simple or hemimetabolous transformation.
- Naiads are the name for the aquatic larvae.
- eg Salmon flies Stoneflies,.

Order 13. Isoptera

- Polymorphic, social insects with a caste system in place that live in colonies.
- Tiny to medium-sized insects, mainly with soft bodies and light colors.
- Moniliform, long, multi-segmented antennae with a small to big head.
- Chewing or biting portions of the mouth.
- Remnants of complex eyes that have two or none at all.
- Wings: two pairs, comparable in size, form, and venation when present.
- 2–8 segmented or short, basic cerci.
- An easy transformation.
- A colony consists of sterile laborers and warriors as well as winged and wingless sexual beings.
- Examples: Termites, white ants.

Order 14. Zoraptera

- Insects with only one or two wings.
- The antennas are moniliform and have nine segments.
- Compound eyes and ocelli are presentIn forms with wings without wings, they are missing.
- Biting kind of mouthparts.
- The cerci are segmented and short.
- An easy transformation.
- Example: *Zorotypus*.

Order 15. Embioptera

- These insects are small, thin, and have relatively flattened bodies.
- A filiform antenna is located in the big head.
- No ocelli, small compound eyes in females, big eyes in men.
- Biting and chewing sorts of mouthparts.
- Nearly as long as the abdomen is the thorax.
- Two pairs of wings membrane-based.

- First tarsal segment of forelegs expanded to carry glands and spinnerets.
- Hemimetabolous or simple metamorphosis.
- Eg: *Oligotoma*.

Order 16. Corrodentia

- Insects with small, compact wings or without wings.
- Either long or short filiform antennae are present on the broad, free head.
- Usually have big compound eyes devoid of ocelli.
- Modified biting kinds in the mouth.
- Non cerci.
- An easy transformation.
- Examples: Booklice, Bark lice, Dust lice.

Order 17. Mallophaga

- Microscopic ectoparasitic insects lacking wings.
- Wide or long, tough, well-chitinized, and flattened dorsally.
- Head lacking clavate or setiform antennae, hypognathous.
- Ocelli absent, complex eyes diminished.
- Biting kind of mouthparts.
- Small stature, without cerci; strong claws for gripping hairs and feathers.
- Example: Bird lice.

Order 18. Anoplura

- Permanently ectoparasitic on animals, minute to tiny in size.
- Long, flaccid body devoid of wings.
- Small, with small setiform antennae on the head that are segmented into 3-5 pieces.
- Lessened or absent ocelli and compound eyes.
- The sort that pierces and suckers the mouth.
- Long legs without cerci; only one claw designed for gripping hairs.
- Example: *Pediculus* (Human louse).

Order 19. Ephemerida

- Insects have short setiform antennae that are delicate, small to medium in size, and soft bodies.

- Vowels are only skeletal.
- Three ocelli are present and the compound eyes are underdeveloped.
- One or two pairs of delicate wings with many veins.
- Simple or hemimetabolous transformation; prolonged, filiform, multisegmented cerci with a comparable median caudal filament.
- Water-loving naiads, or nymphs, have tracheal gills in their abdomen.
- Example: *Ephemera* (mayfly).

Order 20. Odonata

- Large compound eyes and ocelli are present in the movable head of these medium- to large-sized, slender, fast-moving predatory insects.
- Biting kind of mouthparts.
- Two sets of comparable long, thin wings with net veins.
- Simple or hemimetabolous metamorphosis; naiads, or nymphs, are aquatic organisms with or without external gills.
- Examples: Dragonflies, Damselflies.

Order 21. Thysanoptera

- Tiny, terrestrial insects with thin bodies.
- Nearly cylindrical body or somewhat dorsally compressed.
- Antenae with six to nine short segments.
- Three ocelli in compound eyes.
- Mouthpieces altered to pierce, chafe, and sucke.
- If present, two long, thin pairs of wings with few veins.
- An ovipositor in an abdomen segmented 10–11.
- A basic transformation
- Example: *Thrips*.

Order 22. Hemiptera

- Small to big terrestrial or aquatic insects that are oval or elongated and flattened dorso-ventrally.
- Segmented antennae with two to ten, or very seldom, twenty-five.
- Big eyes, either with or without ocelli.
- The sort that pierces and suckers the mouth.

- No cerci
- When two pairs of wings are present, the front pair is typically thicker basally and membranous apically in Heteroptera and completely membranous in Homoptera.
- Anal filaments in male coccids and anal respiratory filaments in some aquatic species.
- An easy transformation.
- While some are predaceous, most are phytophagous.
- Examples: *Belostoma*, *Aphids*, *Cicadas*, scale insects.

Division 2. Endopterygota (Holometabolan)

- Whole metamorphosis, comprising larval and pupal phases; young stages are called larvae; in pupal instances, wings form inside.

Order 23. Megaloptera

- Prognathous head with many segmented thin antennae
- Medium to large-sized insects.
- Biting kind of the mouthparts.
- Two pairs of wings with comparable venation, size, and form.
- Non cerci.
- Intricate transformation involving larvae that live in water.
- Examples: *Sialis*, *Corydalus*.

Order 24. Neuroptera

- Mostly terrestrial insects, ranging in size from tiny to medium.
- Large, widely spaced compound eyes are present in a hypognathous head.
- Huge, many veined, membrane-covered wings.
- Typically filiform, long antennae.
- Chewing kind of mouthparts.
- Non cerci.
- Carnivorous are larvae. In aquatic larvae, abdominal gills; intricate transformation.
- Examples: *Crysopa* (Lacewing), *Myrmeleon* (Antlion).

Order 25. Raphidiodea

- Fragile, elongated, small to medium-sized terrestrial insects.
- Many segmented, setiform antennae.

- Notable compound eyes that have three or more ocelli.
- Biting kind of mouthparts.
- Two sets of comparable wings.
- Female with ovipositor that is lengthy and thin.
- A difficult transformation.
- Snake flies and serpent flies are two examples.

Order 26. Mecoptera

- Slim, small to medium-sized insects that feed on prey.
- Generally a vertically enlarged head.
- Several segments, filiform, and long antennae.
- Long, identical, thin, membrane-covered wings.
- Big compound eyes with lots of space between them; three or none at all.
- The long-beaked, biting kind of mouthparts.
- Short, straightforward, or bifurcated cerci.
- The tip of the abdomen curled like a stinger in males.
- A difficult transformation.
- For instance, Panorpa (Scorpion flies).

Order 27. Trichoptera

- Moth-like insects vary in size, that are nocturnal and waking.
- Several segments, filiform, and long antennae.
- Compound eyes that are fully grown, with three or no ocelli.
- Two long, hairy wings that are folded over the abdomens like a roof.
- Biting sort of mouth portion.
- A segmented cerci, or several of them.
- Holometabolic or complex transformations.
- Aquatic larvae.
- Example: *Philopotamus* (caddis fly).

Order 28. Lepidoptera

- Entire body and wing covering of flat overlapping scales and hairs; medium to big sized flying terrestrial insects.
- The antennae are frequently plumose, hooked, knobbed, or clavate or serrate.

- The lips pursed tightly beneath the skull.
- Big compound eyes that have two ocelli or none at all.
- Two sets of wings, the biggest usually being the front pair.
- Hard transformation.
- The caterpillar larvae have two to four pairs of abdominal prolegs, a chewing mouth, and three pairs of thoracic legs.
- Butterflies and moths are two instances.

Order 29. Coleoptera

- Small to big insects possessing a leathery integument.
- The size and structure of antennae vary, often consisting of 11 segments.
- Leaky front wings (elytra). folded, membranous hindwings.
- Noticeable eyes but without ocelli. \
- Chewing and biting of the mouth portion.
- Abdomens divided into ten segments typical.
- Non cerci.
- A difficult transformation.
- Beetles and weevils are two examples.

Order 30. Strepsiptera

- Dimorphic insects that are both endoparasitic and free-living.
- Short antennae flabellate.
- Noticeable eyes but without ocelli.
- Atrophied biting portion of the mouth.
- Huge hindwings fashioned like fans, little white forewings.
- Hyper and complicated metamorphoses.
- Example: *Stylops*.

Order 31. Hymenoptera

- Small to big, gregarious, or parasitic insects.
- There are often ocelli.

- Two comparable pairs of membrane-covered wings. During flight, the sides hooked together.
- Biting, sucking, lapping, and chewing-specific mouth parts. Female ovipositor stings are often penetrating.
- Basal pedicel always present in the abdomen.
- A difficult transformation. \
- asps, bees, and ants are a few examples.

Order 32. Diptera

- Terrestrial, aquatic, diurnal, and minute to medium-sized insects.
- Narrow build with delicate integuments.
- Variable antennae, either straight or with arista.
- Three ocelli in large, distinct eyes.
- A single pair of wings.
- Wings evolved as knob-like halters on the hind wings and forewings for flying.
- Pierce-sucking or sponging of the mouth parts.
- A difficult transformation.
- Vermiform, limbless larvae called maggots.
- Instances include midges, houseflies, and mosquitoes.

Order 33. Siphonoptera

- Ectoparasitic insects, minute to tiny, that feed on mammals and birds.
- Compressed body on the left side. Wingless, secondarily.
- Ocelli and eyes on a little head, or not.
- Acute antennae with a short length.
- Legs that can jump high.
- The kind that suckers and pierces the mouthparts.
- No cerci.
- Hard transformation.
- Two such examples are Xenopsylla (a flea) and Pulex.

11.4 Social life in bees and termites

Those that are classified as social insects are those that live in colonies and exhibit some sort of labor division, whereby colony members are adapted based on the tasks they carry out.

11.4.1 Termites (Isoptera)

Termites, often called white ants, are among the rare animal species that can only feed on cellulose and have flagellates in their stomachs that break down cellulose. By building complex aboveground natural air conditioners known as termite-hills, they create underground nests known as termatorium, where they are able to maintain a steady temperature and humidity even when the outside ground temperature goes above 60 degrees. The termite hill's ventilation passages allow wind to quickly lower the nest's temperature. They make clay tunnels on trees, buildings, or the ground and walk through them in the darkness. They never go outside.

It makes sense that their eyes are primitive and that they speak a chemical language nearly entirely. Their unusual underground home and shy disposition have developed as a result of the abundance of predatory species, such as gigantic anteaters, scaly anteaters, spiny anteaters, and others, who are always on the lookout for termites and only consume them.

Social Structure

Approximately 300 million years ago, they were the first creatures to live in colonies and have a well-organized social structure, far before ants and honey bees. Termites have a maximum size of 3–4 mm, but their queen is a 4 inch monster that sits inert in the royal chamber due to the small size of its legs. It is known as physogastry when a termite queen exhibits this massive abdominal growth.

All daily tasks must be completed by the workers. Termite queens are remarkable machines that lay eggs, producing one egg every second for up to 20 years throughout their 24-hour lifespan. Up to 60,000 eggs can be laid daily by certain Australian species. The sole purpose of a termite queen's existence is to produce eggs. The colony is much valued by the other castes, laborers, and warriors, who give their all without expecting anything in return from society.

Workers chew wood to feed the queen and larvae and cultivate fungal gardens during lean times, while soldiers use their long, dagger-like mandibles to protect their nest. Nasutes are soldiers trained specifically for chemical warfare. They can disintegrate an enemy's skin and aid in creating tunnels through rocks by releasing a jet of very corrosive chemical from their bodies. The colony's bulldozers are these. Newly born males and females develop wings and learn to fly in nuptial flight during the mating season, which often falls during the rainy season. By creating a shallow gallery and depositing eggs that all hatch into workers to grow the colony, they form pairs and look for a new location.

Certain termites—like those in the Hodotermitidae and Kalotermitidae families—live on trees in temporary nests rather than digging subterranean nests. With the exception of those that mature into marriage during the rainy season, termite nymphs are diploid male and female insects that become sterile adults. In the seven stages of nymph development, the final three stages are devoted to labor.

In contrast to honey bees, termites develop from fertilized eggs, making their adults diploid in both sexes. Hormones that prevent nymphs from maturing into new queens are secreted by queens. Termites feed their larvae worker saliva to help them differentiate between various castes. When larvae are given more saliva, they become sexual forms; when nymphs are fed wood and fungus, they become workers and soldiers.

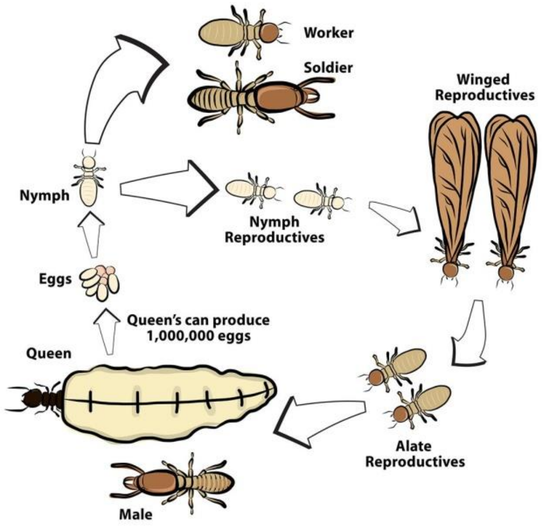


Fig. 11.3 Termite :Social structure

11.4.2 Honey Bee (Hymenoptera)

Colony-living insects known as honey bees gather sap, and process it into a viscous, fragrant, golden-yellow liquid known as honey—also referred to as the "liquid gold". About 80% of the sugars in honey are carbohydrate. Honey barely contains 1% to 2% harmful sugar. Furthermore, honey has every necessary vitamin, mineral, and protein. It eliminates stomach issues, balances out the body's metabolism, has antibacterial qualities, and is an excellent blood purifier. It provides athletes with rapid energy.

Social Structure

One queen, around two dozen drones, and 20,000 workers make up a bee colony. Pleometrosis is the term used to describe the occurrence of many queens in a hive throughout the mating season.

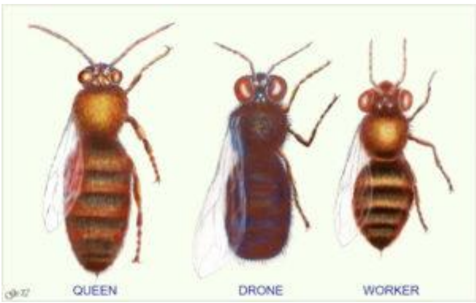


Fig. 11.4 : Honey bees

Although typical fertility is around each day 600 eggs, the queen is the fertile female and may lay around 3000 eggs each day, which is double the weight. Male or female progeny can be chosen by the queen; male offspring is produced by unfertilized eggs, while fertilized eggs give rise to female offspring. By feeding them royal jelly or pollen and honey by the workers, growing larvae—both of which are genetically female—can mature into queens or workers.

A multitude of pheromones produced by the queen draw laborers and maintain the colony's unity. Through a process known as trophallaxis, workers lick the secretions of the queen's tarsal, tergal, and mandibular glands, which are then transferred to other larvae and colony members. Workers raise a new queen from the developing female larvae if a queen is killed because they lack queen pheromones. Moreover, workers' ovaries are prevented from developing by queen pheromone.

The actions of workers, like as constructing combs, raising brood, foraging, and producing honey, are stimulated by queen pheromone. Workers raise a replacement queen in the event of a queen's death or disappearance by choosing a larva, altering its cell to create a queen cell, and providing it with only royal jelly.

The term "drone" refers to males who are bigger, darker, more muscular, and have hair than laborers. Their haploid development begins with unfertilized eggs. A colony containing around twenty of them chases the queen whenever she takes a flight during her nuptials. During the nuptial flight, drones are drawn to the secretions of the queen's sting apparatus and the mandibularglands. In the course of one such flight, one of them succeeds in mating with her and perishes. After the queen is fertilized, drones are often forced out of the hive, where they inevitably starve to death.

Although the workers are infertile due to not being fed royal jelly during their larval stage, they are genetically female. Their six-week lifecycle is divided into two halves, during which time they tend to domestic duties, secrete wax, construct the hive, make a very nourishing royal jelly, and turn nectar into honey. Later in life, they turn into foragers, working nonstop to gather pollen and nectar. As the end approaches, they lose their ability to gather nectar and transform into water-carriers.

They finally pass away while working, which is a great example of unselfish dedication to the community. One remarkable observation about honeybees is that, in the event of a disaster, they have the ability to reverse their age. When a crisis arises, such when the hive is destroyed, the four to five week old foragers begin to age backward in order to create royal jelly and wax, fix their hive, raise a new queen from the larvae, and restore their colony. Even under ideal circumstances, colony members are inextricably linked to one another and cannot endure alone. They use gestures, dances, pheromones, and ultrasonic signals to communicate.

Employees have morphological modifications that help them perform their jobs. Their pharyngeal glands emit a gelatinous, extremely nourishing material called Royal Jelly; their mandibular glands secrete a chemical that softens wax; and their stomach has numerous glands that aid in the conversion of nectar into honey. Abdominal segments 4–7 have wax glands that open via several channels to the sternites 4–7. The tibia and basitarus of the hind legs have been altered to create a pollen basket and press. The chewing and lap types of mouth parts. Because workers are sterile females, their ovipositors have been altered to produce stings, and their supplementary reproductive glands have been altered to produce poison glands.

Over its life, a worker produces roughly the equivalent of a teaspoon of honey. Bees must take nectar from about 4 million flowers, which requires them to travel around 50,000 times around the 5-kilometer foraging area, in order to produce 500 grams of honey. By lifting the abdomen tip and extending the sting apparatus, worker bees emit chemicals associated with alarm and aggressiveness.

Due to their docile character and preference for confined environments, two kinds of honeybees—the native Indian Apis cerina indica and the American Apis mellifera, sometimes known as the Italian bee—are raised in closed wooden hives for the purpose of producing honey for commercial use. The other two species are wild bees that are inferocious by nature and cannot be tamed. The smaller species, the bush bee, Apis florea, creates a tiny colony amid the bushes that is the size of a human hand, while the bigger rock bee, Apis dorsata, develops enormous colonies on the high branches of trees or on the sides of rock cliffs.

MCQ

1. **Which of the following arthropods is known for its ability to regenerate lost limbs?**
    - A. Grasshopper
    - B. Crab
    - C. Beetle
    - D. Spider

    Answer: B. Crab

2. **Which class of arthropods is characterized by having four pairs of legs?**
    - A. Insecta
    - B. Crustacea
    - C. Myriapoda
    - D. Arachnida

    Answer: D. Arachnida

3. **Arthropods with three body segments (head, thorax, abdomen) and usually two pairs of wings belong to which class?**
    - A. Arachnida
    - B. Crustacea
    - C. Insecta
    - D. Myriapoda

    Answer: C. Insecta

4. **Which of the following is NOT a function of the arthropod exoskeleton?**
    - A. Protection
    - B. Muscle attachment
    - C. Sensory reception
    - D. Respiration

    Answer: D. Respiration

5. **Which structure is primarily used by aquatic arthropods for respiration?**
    - A. Tracheae
    - B. Book lungs
    - C. Gills
    - D. Spiracles

   Answer: C. Gills

6. **The primary difference between centipedes and millipedes is:**
    - A. Centipedes have one pair of legs per body segment, while millipedes have two pairs per segment.
    - B. Centipedes have two pairs of legs per body segment, while millipedes have one pair per segment.
    - C. Centipedes are herbivores, while millipedes are carnivores.
    - D. Centipedes have a soft exoskeleton, while millipedes have a hard exoskeleton.

   Answer: A. Centipedes have one pair of legs per body segment, while millipedes have two pairs per segment.

7. **Which of the following is a larval stage of an arthropod?**
    - A. Nymph
    - B. Pupa
    - C. Caterpillar
    - D. All of the above

   Answer: D. All of the above

8. **The compound eyes of arthropods are made up of numerous small units called:**
    - A. Ommatidia
    - B. Photoreceptors
    - C. Lenses
    - D. Retinas

   Answer: A. Ommatidia

9. **Which of the following arthropods undergoes complete metamorphosis?**
   - A. Butterfly
   - B. Grasshopper
   - C. Spider
   - D. Lobster

   Answer: A. Butterfly

10. **The excretory organs of many terrestrial arthropods are called:**
   - A. Kidneys
   - B. Malpighian tubules
   - C. Nephridia
   - D. Green glands

   Answer: B. Malpighian tubules

Chapter-12
Mollusca

Objectives :

- Describe characteristics features of Mollusca including their habitat and morphological structures.
- Classify Mollusca in different sub phylums and classes
- Describe Pila as gastropod mollusc commonly referred to as apple snails.
- Explain digestive system of Pila and their functions

12.1 Introduction :

Molluscs (often referred as mollusks) they are bilateral symmetric, soft body, coelomate animals

- **They are present in all types of water bodies** are also present inside host as parasite
- Size varies from milimeter snails to giant squids.
- Bodies of molluscs are bilaterally symmetrical.
- radula and mantle are important characters which are absent elsewhere
- unsegmented soft body with organisation of tissue-system grade.
- The mollusc body is typically devided into three parts (i) The Head (ii) The Foot (iii) Visceral Mass.
- calcareous exoskeleton shell protects the body.
- pelecypoda and scaphodoa is absent and separate head and mouth, eyes, tentacles and other sense organs are present
- For burrowing the foot is modified to the surface which is like muscular plough. The digestive of mollusc varies depending on the species and their diet
- With anterior mouth and anus at posterior end simple digestive tract is simple
- Except for cephalopods it has open circulatory system
- With osphradiuma at the base, ctenidia contain gills for respiration
- respiratory pigments are Haemocyanin
- metanephridia is used for excretion
- transverse and longitudinal connections is joined by cerebral, pleural, pedal and visceral ganglia
- have Sense organs and receptors like eyes, statocysts

- They are dioecious or monoecious (hermaphroditic) with both internal or external fertilization
- metamorphosis through veliger larva.

12.2 Phylum Mollusca Classification

On the basis of symmetry and characters Mollusca (mollusks) are classified into 6 classes

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

- body divided with bilateral symmetry with shell having one valve
- Protoconch is spirally coiled
- No eyes and tentacles.
- pedal retractor muscles and broad foot present
- pallial grooves have 5 pair of external gills.
- two gonoducts and 4 nephridia present.
- pairs of auricles and ventricle present in Heart are 2
- longitudinal pallial and pedal cords are presence in nervous system.
- **dioecious**
- Examples: *Neopilina galatheae*.

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

- condensed head and body which is extended.
- Radula is therein the body
- Spiculesor Shell plates
- Mouth have 2 interconnected nerve
- fertilization is external with trochophore larve type.

Subclass 1. Aplacophora

- The body has a mantle
- Foot and shell are absent
- Cuticle has spicules which are Calcareous
- Examples: *Neomenia*, *Nematomein*, *Chaetoderma*.

Subclass 2. Polyplacophora

- Small head and dorso-ventrally flattened body
- Tentacles & eyes absent
- Foot, Radula, Posterior mantle and the presence of external gills.
- 8 calcareous dorsal plates forming shell

Order 1. Lepidopleurina

- Insertion plates in shell valves absent.
- Scarce Ctenidia in posterior end.
- Examples: *Lepidopleurus.*

Order 2. Chitonida

- Plates are inserted in plates.
- Mantle grooves along the length have gills
- Examples: *Chaetopleura*, *Ischnochiton*.

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

- Are mainly saltloving.
- bilateral symmetry with closed ends.
- Eyes, heads are absent&mouth contain tentacles
- Gills are absent but conical foot&radulas arepresent.
- body is enclosed with Mantle tubular.
- Mouth walled by lobular processes.
- rudimentary heart with paired kidney and single gonad
- **Dioecious** with Trochophore larve
- Examples: *Dentalium, Cadulus, Pulsellum*.

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

- These are fresh water inhabitants and are parasitic on echinoderms.
- Spirally coiled body not segmented with univalves
- Head separate having tentacles, eyes, and mouth.
- During development **Torsion** coiling of body occur
- Mantle cavity is the empty space between the body lining
- Buccal cavity comprises of **odontophore** with teethchitinous in nature
- Main component of digestive system are long esophagus, muscular pharynx,stomach, and coiled intestine.
- Mode of Respiration is **ctenidia**
- Pericardium enclosed heart in open circulatory system.
- Mostly primitive forms of metanephridia, reduced to single nephridium
- Nervous system consists of in addition to the buccal, pedal, parietal, and visceral ganglia, the cerebral and pleural.
- Mollusc is dioecious in nature
- Development comprises **trochophore** and **veliger**

Subclass 1. Prosobranchia (streptoneura)

- Exclusively these are terrestrial forms but also marine in nature
- figure f "8".is formed by **torsion** of the visceral mass
- Head with tentacles.
- Anterior Mantle cavity
- operculum borne on foot.
- ventral parts of the body is formed by Muscular foot.

Order 1. Archaeogastropoda (Aspidobranchia)

- No proboscis
- One or two bipectinate ctenidia.
- No operculum (few exceptions).
- Kidneys 2 in number and heart with 2 auricles in number, 2 osphradia usually present.
- Right nephridia discharge Sex cells into sea
- Examples: *Fissurella*

Order 2. Mesogastropoda (Pectinibranchia)

- The siphon, penis, and non-calcified operculum are present in prosobranchs.
- 1 kidney, 1 auricle, & 1 mono- ctenidiumpectinate.
- 1ospharadium.
- nervous system contains no pedal cords.
- Fertilization take place internally; larva usually a free-swimming.
- Examples: *Crepidula*

Order 3. Neogastropoda (Stenoglossa)

- Shell may be short or long
- Radula consists of rows of teeth.
- Intense nervous system
- Large Osphradium &huge.
- veliger curbed.
- Examples: *Murex*, *Nassarius*.

Subclass 2. Opisthobranchia

- Gastropods found in salty water.
- Shell with no operculum.
- Shell covered with mantle.
- Body mass detorted.

- heart has gills at posterior end and 1 auricle posterior to the ventricle.
- 1 kidney&1 gonad.
- Detorsion result in concentration of nervous system
- Monoecious with larva veliger.

Order 1. Cephalaspidea

- Mantle contains shell that is partly or wholly enclosed.
- Head that contains the shield which is tentacular.
- parapodial lobes which are present laterally and are prominent in nature.
- Examples: *Acteon*, *Hydatina*, *Bulla*.

Order 2. Anaspidea

- Extensively exit in subtropical &tropical waters.
- Mantles covers the shell.
- parapodial lobes are well developed.
- has two tentacles, two rhinophores, and two eyes on the anterior end.
- Examples: *Aplysia*, *Akera*.

Order 3. Pteropoda

- snails which contain or contain no shell.
- for swimming it uses Parapodial fins
- mantle cavity may or may present
- pair of rhinophores in head.
- Examples: *Clione*, *Peraclis*,*Spiratella*, *Cavolina*.

Order 4. Sacoglossa

- Shell absent or present in body
- Suctorial pharynx.
- ClosedSperm duct.
- cerata & parapodia present.
- Examples: *Oxynoe*.

Order 5. Acochilidiacea

- Miniature which is small-sized.
- Shell is not present
- Visceral, gills& parapodia are present in sac
- Found in coarse sand.
- Examples: *Acochlidium*.

Order 6. Notaspidea

- Internal&external shell
- No Parapodia.
- Cavity not present in mantle.
- Examples: *Tylodina*, *Pleurobranchus*.

Order 7. Nudibranchia

- Shell is not present
- mantle cavity, Internal gills and osphradium absent in the body.
- Secondary branchiae aid in respiration
- Examples: *Eolis*, *Tritonia* , *Doris& Armina*.

Order 8. Pyramidellacea

- Spirally twisted shells are present.
- No Operculum.
- Radula & gill is present
- Extended invaginble proboscis.
- Semi-parasitic.
- Examples: *Odostomia&Turbonilla*

Order 9. **Philinoglossacea**

- Small snails.
- head appendages and gill is absent
- Visceral mass differentiated into superficial groove.
- Examples: *Philinoglossa*.

Order 10. Rhodopacea

- Worm-shaped snail.
- Deprived of external limbs
- Protonephridial typeNephridia.
- Right side of the body anus is present
- Examples: *Rhodope*.

Order 11. Onchidiacea

- Opisthobranchs absent.
- Mantle projects extensively across foot.
- Head has tentacles.
- posterior end has Pulmonary anus and female gonopores and anterior has Male gonopore
- Examples: *Onchidella&Onchidium*,

Order 12. Parasita

- gastropods which is endoparasitic in nature
- Deteriorated snails.
- Embryos shelled.
- Examples: *Entoconcha*, *Thyonicola*.

Subclass 3. Pulmonata

- mainly terrestrial& freshwater animals
- Typically spiral shell which sometimes diminished or nonexistent, if it is present and partially or fully covered by the mantle
- Operculum is absent
- The mantle cavity becomes a pulmonary sac
- No Gills.
- Heart, one auricle anterior to the ventricles.

Order 1. Basommatophora

- Extensively found in Freshwater.
- Female & male gonopore discrete.
- Examples: *Lymnaea*, *Planorbis&Siphonaria.*

Order 2. Stylommatophora

- Pulmonates are terrestrial.
- Examples: *Partula*, *Retinella, Limax& Helix*, .

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

- Extensively present in water.
- Body with bilateral symmetry.
- Bivalve shells.
- In some, head not differentiate into, radula, &tentacles, pharynx, jaws
- bilobed mantle, **ctenidia** are paired
- coelom is concise to a pericardium which is dorsally placed.
- digestive gland coils alimentary canal
- Heart contains pericardium andventricle median &2 auricles.
- The excretory organ has nephridia
- Filter,feeding.
- accompanied by a transformation that develops in to a **trochophore larva.**

Order 1. Protobranchia

- Just one set of ctenidia

- Mouth placed at muscular proboscides.
- The foot has a flattened ventral surface
- 2 muscles adductor present.
- Examples: *Solenomya& Nucula*.

Order 2. Filibranchia

- Occurrence of a chitinous gastric shield.
- Style sac contains a crystalline style.
- inter-filamentar junctions absent
- Lack of an interlamellar connection or non-vascular
- Muscles Adductor 2 in number, with the anterior muscle possibly reduced or absent.
- A small foot
- Examples: *Mytilus*, *Arca*.

Order 3. Pseudolamellibranchia

- Gills in the form vertical folds.
- Intersections between filaments that are ciliary or vascular.
- Vascular, non-vascular& inter-lamellar
- Examples: *MelagrinaPecten& Ostraea*.

Order 4. Eulamellibranchia

- Gill is filamentous in nature which are firm and basket-like help in food gathering
- Siphon present.
- No Foot.
- Petitesac style.
- Examples: *Anodonta*, *Unio*, *Cardium*, Venus, Mya, *Teredo*.

Order 5. Septibranchia

- Gill is absent
- Musclesadductor is present.
- Stomach contains chitin having lacking style sac.
- Hermaphrodite .
- Examples: *Poromya*, *Cuspidaria*.

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

- Marine mostly.
- Bilateral body with head and trunk.
- Body which is dorso-ventral
- external, internal shell or absent.

- distinct head with eyes and mouth.
- The trunk has **uncoiled** visceral mass.
- Mantle with mantle cavity which is large.
- Changed into a string of suckers with arms
- Moth have jaws and radula.
- bipectinate gills.
- Circulatory system **closed**

Subclass 1. Nautiloidea (=Tetrabranchia).

- funnel is present but not create a full tube
- 4 kidneys, 4 gills&ctenidia, 4 auricles present.
- There are no chromatophores or ink glands from the body.
- Eyes are simple
- Examples: *Nautilus*.

Subclass 2. Smmonoidea

- Shell is present externally and wound with sutures and septa
- Examples: *Pachydiscus*.

Subclass 3. Coeloidea (=Dibranchia)

- Shell typically reduced and is internal, covered by the mantle; its cavity is septa-free when external.
- The primary portion of footsare transformed into 10 or 8 sucker-baring arms surrounding mouth.
- Features include 2 ctenidia (gills), 2 kidneys, 2 auricles, and 2 branchial hearts.
- Ink gland duct and chromatophores are contemporary.
- Eyes have a multifaceted structure.

Order 1. Decapoda

- Elongated body with fins which are lateral in position.
- Heart which is enclosed in the coelom which is developed.
- Examples: *Loligo, Spirula &Sepia*

Order 2. Octopoda

- No Nidamental glands
- The heart is not in reduced coelom.
- Examples: *Octopus*, *Agronauta*.

12.3 Pila

Pila is a gastropod molluscfound in aquatic environment from the family Ampullariidae, commonly referred to as apple snails.

12.3.1 Classification of *Pila*

Kingdom- Animalia

Phylum- Mollusca

Class- Gastropoda

Order- Architaenioglossa

Family- Ampullariidae

Genus- *Pila*

12.3.2 Pila Structure

Body

- unsegmented & soft body, pila has a soft one piece body
- It is divided into three parts
  (i) Head –located at anterior end
  (ii) Visceral Mass – It occupies the posterior section most of the internal organs are present inside the visceral mass.
  (iii) Foot – It is a broad muscular structure present on the ventral side (under side) for locomotion

Head

(i) A pair of eyes are located on tentacles for light perception

(ii) Two pairs of tentacles are present. One pair is used to sense the chemical in the environment including food and mates. (Chemo receptors)

(iii) Other type of tentacles help to feel and touch its surroundings (mechano receptors)

(iv) Ventral slit mouth (aperture) – it is used for feeding.

Visceral Mass

(i) Enclosed by the cell and contains internal organ systems like circulatory system ,digestive system, respiratory system and reproductive system.

Foot

(i) It is a muscular, broad, flat and almost a triangular structure
(ii) It enables the organism to crawl
(iii) A calcareous plate on the underside of the foot is present. Snail can use this plate to seal the opening of the shell to protect itself.

Shell

(i) It is a spirally coiled structure which provides protection to the soft body
(ii) It is made of calcium carbonate.
(iii) The tip of oldest part of shell is known as apex

Nervous System of Pila

Gastropod nervous system like Pila is composed of five pairs of ganglia, connectives, commissures, and network of nerves which are connecting to numerous organs.

Ganglia

Five pairs of ganglia are present in Pila. They are clusters of nerve cells which acts as processing centers. A Celebral ganglion is locaged in the head and is responsible for site and touch.

Pleuropedal ganglia is located near the base of the foot, control locomotion.

Visceral ganglia regulates functions of internal organs like digestion and reproduction. It is present inside the visceral mass.

Buccal ganglia is located near the mouth and controls feeding movement.

Supraintestinal ganglia – It works with visceral ganglia to control visceral organs.

Commissures

Influences from a nerve between two ganglia. These ganglion pairs are connected by agreeing commissures, which are situated on different sides of the body. The cerebral commissure connects the cerebral ganglia, the buccal commissure connects the buccal ganglia, and the pedal commissure connects the pleuropedal ganglia.

Connectives

Nerves known as connectives attach to two distinct kinds of ganglia. The cerebral and buccal ganglia are connected by the cerebrobuccal connective. Cerebropleural and cerebropedal connectives link each pleuropedal ganglion to the cerebral ganglia.

Nerves

Nerves to the eyes and tentacles on the body's sides are supplied by the brain ganglia.

• The foot receives nerve supply from the pedal ganglia.

• The mantle is innervated by the pleural ganglia.

• The pulmonary sac and ctenidium receive nerve signals from the supraintestinal ganglia.

• Nerves are extended to the buccal mass by the buccal ganglia.

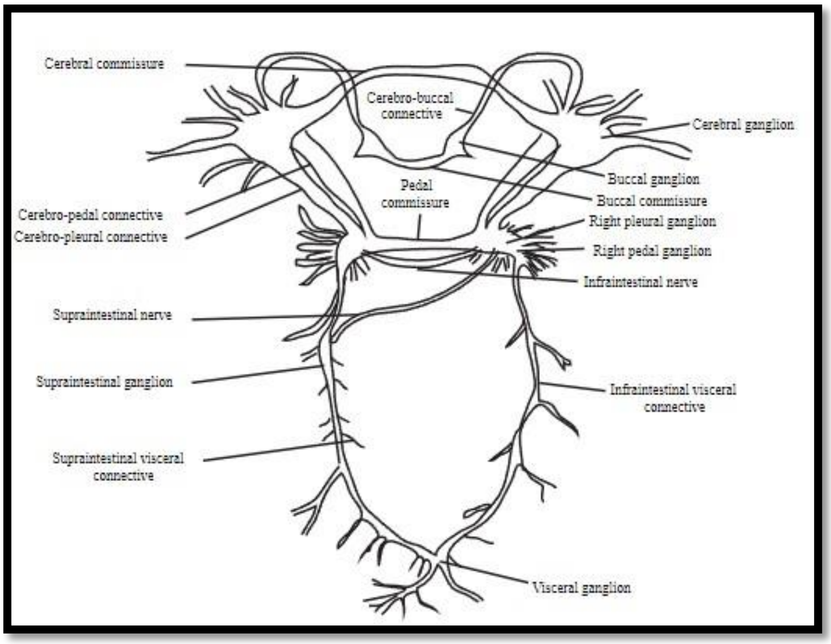


Fig. 12.1 **Nervous System of Pila**

Digestive System in Pila

Comprises of digestive glands & alimentary canal.

Alimentary Canal-

Consist of following parts-

Mouth- anterior end that open in buccal cavity is as mouth

Buccal Cavity- made up of thick muscular jaws and radula

Radula- 7 teeth arrange in transverse row

Oesophagus- oesophageal cavities which are two in number at the junction of oesophagus & buccal cavity

Stomach - It has 2 parts anterior and posterior which is present in the **Oesophagus**

Intestine –intestine finally opens in to rectum

Digestive glands

1. **Buccal glands -** function is not clear but secrete a juice
2. **Salivary glands -** salivary ducts. That digest carbohydrate

3. **Digestive gland-** inhabits larger part of the visceral mass consist of Secretory Cells, Intracellular digesting Cells and Calcium Cells

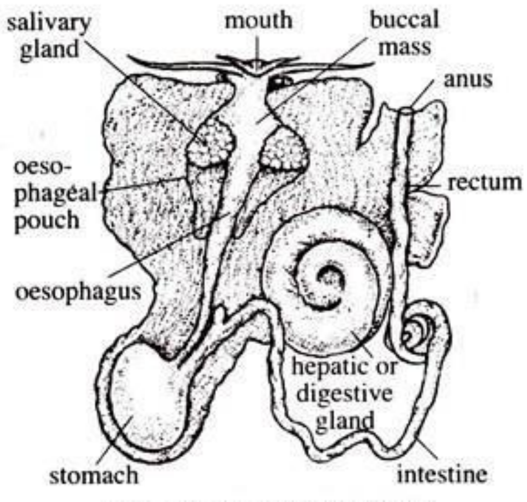


Fig. 12.2 PILA Digestive system

Respiration in *Pila*

- **Double mode of respiration, absorb DO by** ctenidium called as Branchial Respiration.
- Incomplete division of mantle into branchial and pulmonary
- respiration is performed by the single ctenidium

There are three types of cells in the each epithelial layers: (i) Ciliated columnar cells, (ii) Non-ciliated columnar cells and (iii) Few glandular cells

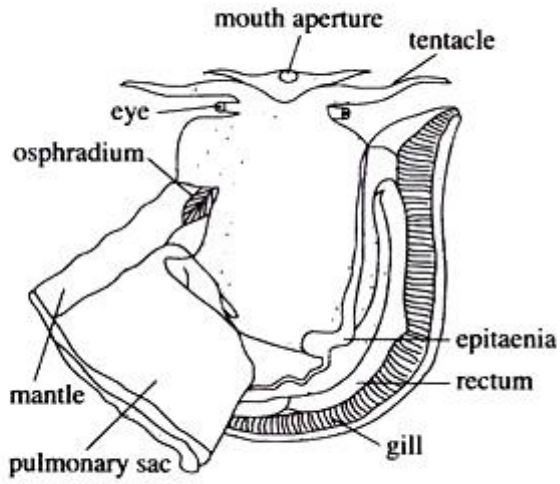


Fig. 12.4 Respiration in *Pila*

12.4 Pearl formation in bivalves

molluscs forms compaction called as pearl. Argonite and conchiolin forms mother of pearl. father of pearl industry is Kokichi Mikimoto. He induced the foreign particle between the mantle and shell

Pearl Formation

As an adaptation for outer material oysters produce pearl

12.5 Pearl Cultivation:

Pearl cultivation is a delicate and intricate process that involves several steps:

- Collecting oysters
- Preparing graft tissue
- Preparing the nucleus
- Implantation
- Rearing oysters
- Harvesting

Collection of Oysters:

- Oysters for pearl cultivation are gathered using three methods:

- Pearl oysters are harvested from the sea floor.
- Spats (young oysters) are collected by placing cages in areas where spats settle.
- In the laboratory, pearl oyster eggs are fertilized to produce young oysters.

Preparation of Graft Tissue:

The graft tissue, used for insertion into the oyster, is a segment cut from the mantle of another oyster. This graft is meticulously shaped into a square measuring 2 x 2 mm.

Preparation of Nucleus:

The nucleus, a foreign material, is carefully inserted into the oyster.

Implantation:

The graft tissue is placed on the incision, and then the oyster is released into cages.

Rearing of Oysters:

The worked oysters are housed in cages, deferred from rafts in the sea, a method known as raft culture.

Harvesting:

Pearls grasp their extreme size within three years. At this point, the oysters are uninvolved from the cages, and the pearls are extracted.

MCQ

Which phylum do mollusks belong to?
a) Arthropoda
b) Mollusca
c) Annelida
d) Cnidaria

What is the primary function of the mantle in mollusks?
a) Reproduction
b) Protection
c) Respiration
d) Shell formation

Which structure do mollusks use for feeding?

a) Tentacles

b) Mandibles

c) Radula

d) Siphons

What is the role of the nucleus in pearl formation?

a) It secretes nacre

b) It provides color to the pearl

c) It initiates the formation of the pearl sac

d) It acts as a foreign irritant around which nacre is deposited

Where is the nucleus typically inserted in pearl cultivation?

a) mantle

b) gonad

c) foot

d) pearl sac

What is the material secreted by the mantle that forms the layers of a pearl?

a) Calcium carbonate

b) Nacre

c) Chitin

d) Silica

Which type of mollusk is commonly used for pearl cultivation?

a) Octopus

b) Squid

c) Oyster

d) Snail

What is the main component of pearls?

a) Coral

b) Shell

c) Mother-of-pearl

d) Nacre

Which mollusk of the following makes black pearls?

a)Pinctada fucata

b), Pinctada maxima,

c) Pinctada margaritifera,

d)Pinctada radiata are the four species.

What is the process called when a nucleus is inserted into an oyster to initiate pearl formation?

a) Grafting

b) Implantation

c) Incision

d) Extraction

Chapter-13

Echinodermata

Objectives :

- Describe general characteristics features of Phylum Echinodermata including their occurrence and habitat
- Classify Phylum Echinodermata in different sub phylums and classes
- Describe structure of Echinodermataincluding shape and size
- Explain significance and importance of Echinodermata

13.1 Introduction :

Echinoderms are salt loving and mostly found at the bottom dwellers comprises of enterocoelous coelomate, triploblastic animals. This particular group consist of five radial symmetry which is obtained bilateral symmetry. They are multicellular organisms consist of structured organ systems. The vascular system associated with water in this phylum are listed for gaseous exchange , nutrient movement, excretion of waste .gaseous forms

13.2 Characterstics :

1. These are found in salt water distributed in different zones with pentamerous symmetry
2. The structure of the system is three layered coelomate with oral and aboral surfaces, with differentiated head and segmentation and minute structure showing star like structure
3. The structure in the system is sometimes smooth which is mostly encovered by symmetrically radiating the grooves known as ambulacra which comprises alternate inter-radii or inter-ambulacra.
4. The outer cover of body comprises of an exterior epidermis, a center dermis, and with internal lining of peritoneum comprises of internal skeletoncompactly fitted, which form a cover known as theca which comprises small ossicles.
5. Coelome having space which is lined by peritoneum, comprises of alimentary and reproductive system, which form embryonic archenteron .Vascular system shows origin, comprises tube feet for movement .
6. The digestive system incorporate coiled tube which extendthrough the upper part to the anus on the surface exposed to the surface of the body

7. The system related to Vascular , haemaland lacunar system, in coelomic peripheral compartments includes gaseous exchange organs such as brancheal form , tube-feets, respiratory tree, bursae are also present.
8. The system involve in nervous system in which brain,circumoral ring , radial nerve is not found commonly.
9. The organs responsible for tactility are receptors relarted to chemical secretion, tentacles light sensitive receptors are the prime components of sense organ, dual mode of reproduction is found
10. The reproductive system comprises of large gonads with single or multiple; fertilization which can external, viviparous forms of reproduction is also found.
11. The growth part which is found intermediately which include larvae involve in metamorphosis with adults originate radially . the care by adults include the enclosed inside the female who will give birth to young ones,

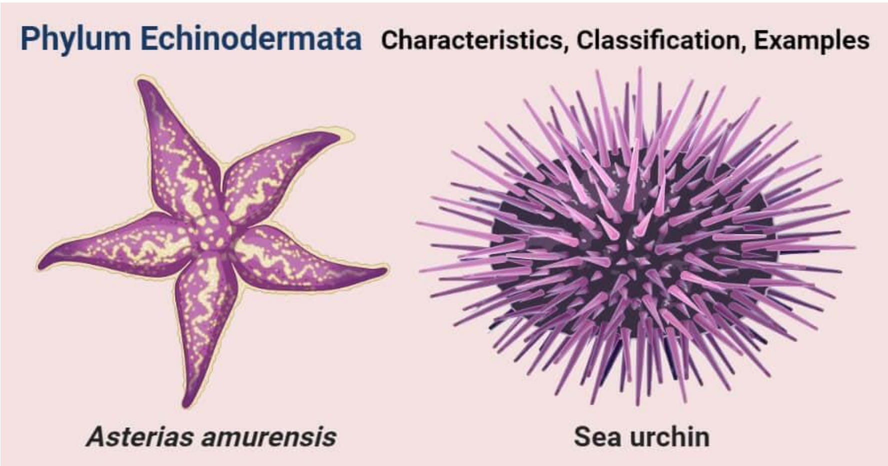


Fig. 13.1 Echinodermata Created with BioRender.com

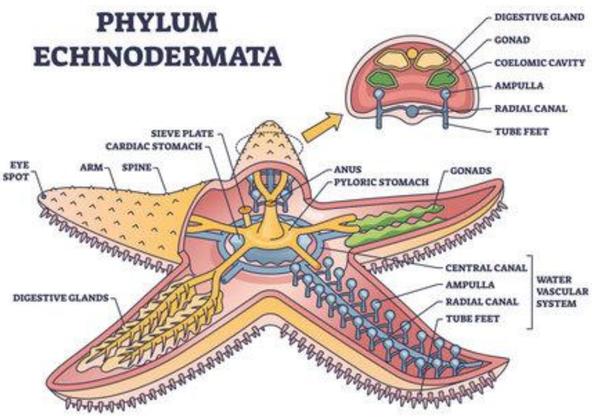


Fig. 13.1 Echinodermata Image Source : https://stock.adobe.com/in/search?k=echinodermata

13.3 Classification :

Subphylum 1. Pelmatozoa (Greek mmean., *pelmatos*=stalk : *zoon* means animals)

- These are enlisted to be extinct echinoderms or found stationed at one place .
- The structure comprises of attached to the surface to the environment by stalk which . is a characteristic feature
- In the calcerous structure is found in which mouth and anal aperture is found perturbing in upward direction.
- Suckers are not found in this phylum , food is captured by tube feet or podia
- Known as Lillies of the sea or r stars feather comprises of the forms ie. not found and live forms ,
- The forms which are living reported not to have stalk and ound to be freely moving.
- The body comprises of the following parts such as the cup arboral, calyx and oral roof, the tegmen, and mainly five star structurein structures.
- Arms are movable mostly simple, or branched, may be 5 or 10 in numbers with or without pinnules.
- The grooves related to ambulacral are opened which may extend besides arms and pinnules with separate reproductive organ.

Order 1. Articulata

- The crinoids may be living or extinct and commonly free
- Pentamerous calyx mostly flexible which incorporate calcareous particles
- The mouth and the ambulacral grooves are most commonly exposed Examples:

Zygophyllum dumosum

Pulicaria incisa,

Subphylum 2. Eleutherozoa (Greek means., *eleutheros/*free+ *zoon means*:animals)

- Living forms of this phylum are found comprise with Stem / stalk are not present
- The structure of the body are pentamerous with oral surface in one side only.
- The posterior part on the arboreal surface with grooves are not involved in food capturing , act as locomotary organ.

Class 1. Holothuroidea

- They are known as sea cucumbers with**b**ody bilaterally symmetrical, elongated in the oral-aboral axis having a mouth at one end and posterior at the extreme end.

- Endoskeleton which is reduced to microscopic spicules or plates mostly found embedded in the body wall.
- Mouth is located anterior, which is surrounded by tentacles
- Podia or tubely feet present in the locomotory. with coiled alimentary canal having cloaca usually with respiratory trees for respiration .Sexes separate and gonad single or paired tufts or tubules.

Order 1. Aspidochirota

- The feet look like Tube is found enormously and is well developed with mouth portion which is surrounded by about 10-30 most commonly 20 oral tentacles without retractile muscle.

Examples:

- *Holothuroidea*
- *Rhizocrinus,*

Order 2. Elasipoda

- Various podias or tube feetstentacles are look like leaf with tubular foot which are in network of web.
- The anterior portion is usually ventral found surrounded by 10-20 peltate or which the oral retractors are are not present

  Examples:
- *Deima,*
- *Benthodytes.*

Order 3. Dendrochirota

- Tube like feet comprises of many ambulactal with irregularly branched respiratory trees which is preent

Examples: *Cucumaria,*

Order 4. Molpadonia

- The tube feeted are not ound but fifteen digitate finger like tentacles comprise of posterior end looks like tail
- Oral retractors are absent in preence of respiratory trees

  Examples:
- *Molpadia,* etc

Order 5. Apoda

- They are known to be legless and having the structure known a blind worms with no tube feet digitate are found and pinnate. pharyngeal retractors , body shows with verm like forms .
- Examples: *Synapta*

Class 2. Echinoidea (Greek means., *echinos* +hedgehog*eidos*)

The structure of the body is heart shaped enclosed in an shell with calcareous plates with five alternating ambulateral area with tube feeted which is comprise of ambulacral plates and mouth is placed centrally with peristome and having Aristotle's lantern with teeth..

Subclass 1. Bothriocidaroida

Every ambulacral is one row of plates with lanteen absent with the preence of radial madreporite.

- Example: *Bothriocidaris*.

Subclass 2. Regularia

- The structure of the body is globular, circular form i common and sometimes oval with symmetry , the interior part is located on the surface with central and anus is also found centrally .

Order 1. Lepidocentroida

- The twisted test found with superimposing plates in which plates are found to be associated with mouth .
- Example: *Palaeodiscus*.

Second Order . Cidaroidea

- Five bushy Stewart's organs are located in the turgid area, which has rows of forms of narrow, ambulacral plates and, for the most part, two rows of inter-ambulacral plates. Examples of these organs include Cidaris.

Order 3: The globular, two-row ambulacral with inter-ambulacral plates body.Gillsa are not present.

Examples are Astropyga and Diadema.

Order 4 Camarodonta: The inflexible examination, which is infrequently oval. and the lantern's massive epiphyses meet above pyramids.There are all the types that include pedicellariae, such as Echinus and Strongylocentrotus.

Subclass 3. Irregularia

- The structure o the body are oval to circular, flattened oral-aborally. The body symmetry is bilateral with Mouth centrally located or anteriorly displaced on the oral portion.. The Podia or tube feet are generally are absent.

Order 1. Clypeastroida

The body is mostly covered with small spines and conspicuous pedicellariae (pincerlike organs). In various species show hollow, elongated test (in internal skeleton), which incorporates the water-vascular system, with notching the symmetry near the edge with small perforationsThe anterior surface of the test has an radial, like flower arrangement of five porous spaces, called petaloids; are found, these pores permit the extension of tube feet which is modified for respiration. Tube feet found on the underside of the body which are commonly used for consuming food particles.

- Examples like sand dollars: *Echinarachinus*, *Echinocyamus*.

Order 2. Spatangoida

The oval or heart-shaped incorporated associated with mouth and posterior part with no gills .Examples: *Spatangus*, *Echinocardium*, *Lovenia*.

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

- Most called starfishes or sea stars with flattened like body showing star shape creature comprises of distinct oral and aboral in which oral directed towards the lower part and aboral in the upper surface.
- The 5 Arms are not sharply marked off. The anterior part is placed encircled with memberanous peristome.
- The posterior portion is small which is located in center following the surface. Tube feet in like orally placed ambulacral grooves like structure ; with suckers with extended periostome on the top of the arms
- The Endoskeleton is twistible with separated ossicles is reported with respitation done by papulae

- The reproduction is done with separate sexes which are present radially with bipinnaria larvae

Order 1. Phanerozonia

- The Body like structure comprises of marginal like plates which are preent in the arboreal surfacewith arms having two conspicuous marginal plates which not crossed pedicellariae
- The anterior part is prominent and they urvive at lowest point

- Examples like *Luidia*, *Astropecten* **etc.**

Order 2 . Spinulosa

- The arms are not having marginal plates with arboreal skeleton like structures comprises of single spine with pedicellariiae in tube feet mostly in two rows
- The anterior part of the framework of mouth is of adambulactral type with low spines
- Examples
- *Aesterina*,
- *Echinaster*
- *Hymenaster*
- *Solaste*

Order 3. Forcipulata

- The skeleton with aborael is mostly reticulate endorse with spines with pedicellariae like a base .
- The Podia like and tube feest are mostly arranged in the four rows which is provided with the suckers. Both the surfaces is having papulaecand ambulactal type
- Examples: like *Brisingaster*,
- *Heliaster*, etc.

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

- Thee are known as brittle-stars
- The body structure is like flattened comprises with five star shaped or central disc.with distinct oral and aboral
- The Body is star-like with arms sharply marked off from the central disc.

- The Pedicellariaeand Ambulacral grooves is not present which is covered by ossicles.
- The posterior part called anus is absent with stomach sac-like
- The modified tube feet are not present without suckers. madreporite is present on the oral surface.
- The Sexual forms are separate in originating with gonad pentamerous have developmental structure incorporating a free-swimming pluteus larva.

Order 1 : Ophiurae

- The broken with serpent stars are found with arms are simple, moving chiefly in the transverse plane.
- Discs with arms are comprises particular shields or scale like bodies
- Spines on arms are laterally arranged and are located towards the arm points ,with one madreporite is found
- Examples:
- *Ophioscolex*, etc,

Order 2 . Euryalae

- The Arms are, long with flexible , which is able of coiling in the vertical plane.
- The Ossicles of arms with a linear manner mostly are shaded by soft skin with the . spines are mostly towards lower direction with spiny clubs and madreporite interradially arranged

13.4 Introduction to Water Vascular System:

Originating from the left hydrocoel, the water vascular system, sometimes referred to as the ambulacral system, has an enterocoelic origin. It is symmetric around the radii from the start.

Directly above the hematopoietic system is the water vascular system. This system's principal purpose is to move. In certain animals, it also facilitates breathing. Although it is still unclear, some scientists have proposed that this system has an excretory function.

The histological image shows that the canals are composed of an inner lining of flat ciliated epithelium, a layer of connective tissue, a layer of longitudinal muscles, and an outermost layer of flat ciliated cells..

13.4.1 Water Vascular System components

Main parts of the water vascular system are:

- **Madreporite:** This upper surface plate resembles a sieve and lets seawater enter the system.
- **The stone canal** is a brief calcareous tube that serves as a filter for seawater entering the system.
  Ring canal: The radial canals are connected to the stone canal by a circular canal that encircles the mouth.
- **Radial Canals:** These five canals are branched out from the ring canal and extended along each of the echinoderms.
- **Tube feet:** Several hollow sac like projections are extended from the radial canals and ambulacral grooves. Suckers are present at the tip of tube feets which are powered by water pressure to help echinoderms move, feed and sense their environment.
- **Ampullac:** At the base of each tube foot ampulac sacks are present. They act as the reservoirs of water.
- Muscles which surround the ampulac contract to force water into the tube feet, causing them to extend.
- **Polian Vesicles:** They are sack like structures. Their function is to remove waste and sometimes p[lay a role inthe immune system also.

- **Tiedemamm's Bodies:** These are small sack like structures which helps in pressure regulation within the water vascular system.

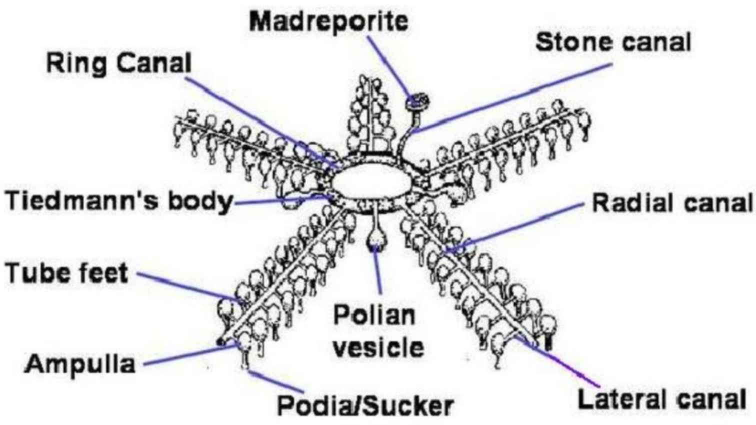


Fig. 13.1 **Tiedemamm's Bodies**

Image Source: https://images.app.goo.gl/krSz213Tf9ixoan59

13.4.2 Water Vascular System modifications in Different Classes:

The water vascular system is found in the same way in all Echinoderms and has almost the similar structural plan. There are some differences in the system in different classes according to their adaptations in different living environments.

- **Sea Stars (Asteroidea)**
- In sea starts more water intake points (multiple Madriporites) and simpler tube feet that is stretched with water sacks are present instead of special pumps.
- **Brittle Stars (Ophiuroidea):** In Brittle stars tiny tube feet are present just on their arms and the pumps (ampullae) are present right intothe arms for faster movement of water.
- **Sea Urchins (Echinoidea):**
- They have a single madriporite and their tube feet can be specialized for different functions. Some may be short and pointed for gripping and some may be long for feeding all sensory purposes.
- **Sea Cucumbers (Holothuroidea):** They have long stretched out bodies so the water vascular system has a reduced number of radial canals. They have internal madriporite present inside their bodies hanging freely in their coelom.
- **Sea Lillies (Crinoidea):** As they are stationary and attached to the sea floor via a stalk. Their tube feet are modified for capturing food particles from water currents and not for the locomotion.

These modifications show how the water vascular systems is adapted to suit the organism according to its habitats.

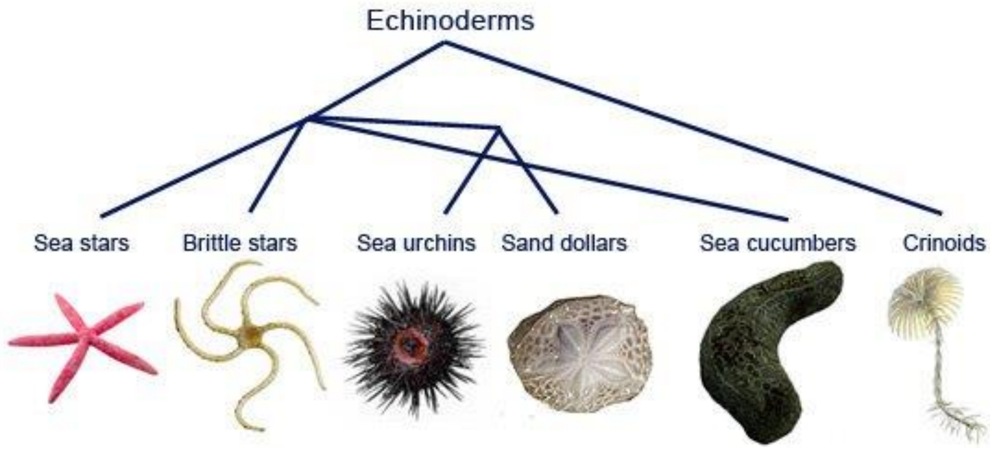


Fig 13.4 Echinodermates

(Image Source: https://images.app.goo.gl/gb5MicYAPpxvmHyi9)

13.4.3 Functions of the Water Vascular System :

The vascular system of water is a unique character of echinodermates. The main function of this system are:

1. Locomotion:

Tube feet and ampullae (sack like reservoirs at the base of tube feet) both help echinodermates to move freely in water. Tube feets are powered by water pressure and muscles surrounding the ampullae relax and contract enable the organism to crawl, borrow and grip objects.

2. Feeding: Tube feet help in capturing prey such as small molluscs and bring them to the mouth. Tubely feeted are also used to filter food particles from the water in some echinoderms.

3. Respiration: As tube feet have thin walls in some species which allow the organism to absorb oxygen and release carbon dioxide from the surrounding water.

4. Sensory Perception: In some echinoderms tube feet have sensory receptors that help them sense their environment. These receptors can detect touch, light and chemicals in water helping them to navigate, find food and avoid predators.

The water vascular system primarily focuses on locomotion, feeding respiration and sesnsory perception in few echinoderms nitrogen containing wastes are discarded through the thin walls of tube feet.

MCQS:

Q1. Which of the following classes of echinoderms have the ability of regeneration.

(a) Sea Stars (Asteroidea)
(b) Brittle Stars (Ophiuroidea)
(c) Sea Urchins (Echinoidea)
(d) Sea Cucumbers (Holothuroidea)

Q2. The nervous system of echinoderms have a nerve ring around the: _____

(a) Mouth
(b) Oesophagus
(c) Anus
(d) Central Body

Q3. The number of peltate in elasipodians is:

(a) 10-20
(b) 20-30
(c) 5-10
(d) 30-35

Q4. Water vascular system is also known as:

(a) Ambulacral system
(b) Radial System
(c) Excretrory System
(d) Respiratory System

Q5. Which of the following is a component of water vascular system:

(a) Tube feet

(b)Stone canal

(c)Ring canal

(d)All of the above

Q6. **Number of Madreporite in Sea Urchins :**

(a) Single

(b) Double

(c) Several

(d) Not defined

Q7. Which of the following is not the defined function of water vascular system:

(a) Locomotion

(b) Feeding

(c) Excretion

(d) Respiration

(Answers: Q1 – D, Q2 – D, Q3 –A, Q4 –A, Q5 – D, Q6 – A, Q7 – C)

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GLOSSARY

Abdomen: The body region farthest from the mouth. In insects, it's the third segment, located behind the head and thorax.

Ambulacra: A row of tube feet in echinoderms.

Anapsid: A vertebrate characterized by a skull with no openings behind the eyes, such as turtles.

Anus: The end of the digestive tract through which waste is expelled, distinct from the mouth.

Biramous: Refers to arthropod appendages with two branches. In crustaceans, for example, one branch is used for walking, while the other might function as a gill. Opposite of uniramous.

Blood: A fluid circulating through an animal's body, distributing nutrients and often oxygen.

Book Lung: Overlapping, plate-like structures covered by an abdominal plate, used for gas exchange in many terrestrial arachnids like spiders and scorpions.

Brain: A nerve cell collection typically located at the anterior end of an animal, coordinating sensory information, movement, and internal functions.

Chordate: An animal with a notochord, dorsal hollow nerve cord, pharyngeal slits, and a tail at some stage of its life.

Clitellum: A swollen section of an annelid's body near the head where the gonads are located, present in oligochaetes and leeches.

Cnidocyst: The stinging cell found in cnidarians.

Coelom: A fluid-filled body cavity lined with tissue, where the gut is suspended, crucial for identifying major animal groups.

Compound Eye: An eye composed of many small, closely packed simple eyes (ommatidia), each with its own lens and nerve receptors, found in many arthropods.

Cuticle: In animals, an external, multilayered body covering, often composed of chitin or collagen, sometimes reinforced with minerals. In plants, a waxy layer that helps retain moisture.

Diapsid: A vertebrate with a skull featuring two pairs of openings behind the eyes, such as lizards, snakes, and crocodiles.

Ectoderm: The outermost layer of tissue in animals with true tissues, giving rise to the skin and nervous system in vertebrates.

Endoderm: The innermost tissue layer in animals with true tissues, forming the gut and its derivatives, including the liver, trachea, and lungs in vertebrates.

Epidermis: The outermost skin or cell layer, often containing specialized cells for protection, gas exchange, or secretion.

Epithelium: A cell layer lining body cavities, which may be ciliated or unciliated and vary in shape (squamous, cuboidal, or columnar), lining structures like the stomach and cheeks.

Esophagus: The part of the digestive tract that connects the pharynx to the stomach.

Exoskeleton: An external covering that provides support and protection, commonly found in many invertebrates.

Gastrodermis: In cnidarians, the inner tissue layer lining the gut cavity, often referred to as endodermis.

Genus: A taxonomic category ranking between species and family.

Gill: Tissue structures with large surface areas in aquatic animals, used for gas exchange with the surrounding water.

Gill Arches: Support structures for gill slits in chordates; in most vertebrates, the first gill arches form the jaw, and in tetrapods, the inner ear bones.

Gill Slit: Openings connecting the pharynx to the outside in chordates, used for gas exchange in fish and for filter-feeding or modified in land vertebrates.

Gnathobase: The hardened base of an arthropod appendage used to macerate food.

Gut (Enteron): The digestive tract cavity running from the mouth to the anus, including the mouth, pharynx, esophagus, stomach, intestine, and anus.

Librigenae: The detachable "free cheeks" of the trilobite cephalon.

Mesoderm: The middle tissue layer in animals with three tissue layers, forming structures like the skeleton, muscles, heart, and spleen in vertebrates.

Mesoglea: The jellylike layer between the ectoderm and endoderm in cnidarians.

Mouth: The opening of the digestive tract where food intake occurs. In flatworms, it is the sole digestive cavity opening, located on the ventral side.

Mucus: A sticky secretion used for various purposes like locomotion, lubrication, or protection.

Nematocyst: An older term for cnidocyst.

Nerve: A bundle of neurons, specifically axons, transmitting impulses.

Nerve Cord: The main nerve bundle in chordates, connecting the brain to major muscles and organs.

Neuron: A specialized cell that transmits impulses, consisting of a body with a nucleus, dendrites receiving impulses, and an axon sending impulses away.

Notochord: A stiff rod of tissue along the back, characteristic of chordates, around which the vertebral column forms in vertebrates.

Organ System: A collection of organs with related functions, such as the nervous, vascular, and muscular systems.

Osculum: The main opening in sponges through which filtered water is expelled.

Papilla(e): Cellular projections resembling bumps or fingers on cell surfaces.

Parapodia: Extensions of the body cavity functioning like "false feet," aiding locomotion in polychaetes and some insect larvae.

Pedipalps: The second pair of appendages in cheliceromorphs, often enlarged in male arachnids for copulation.

Pharyngeal Slits: Openings characteristic of chordates, involved in feeding and respiration, and present only in embryos in most terrestrial vertebrates.

Pharynx: The digestive cavity behind the mouth, often muscular for sucking or swallowing.

Phylum: A taxonomic category between class and kingdom.

Placenta: In mammals, a tissue in the uterus for nutrient and waste exchange between mother and developing young.

Pleurae: Flat outgrowths from body segments in trilobites and other arthropods, protecting the appendages.

Spicule: Crystalline or mineral deposits found in sponges, sea cucumbers, or urochordates.

Tentacles: Flexible appendages without a rigid skeleton, found in cnidarians and mollusks.

Tetrapod: A vertebrate with four limbs with digits, or closely related to such animals.

Thorax: In insects, the body region between the head and abdomen, where legs and wings are attached.

Tracheae: Internal air tubes for respiration. In vertebrates, a single trachea carries air to the lungs, while insects have a complex network of tracheae.

Tube Feet: Extensions of echinoderms' water-vascular system, often ending in suckers for movement or grip.

Tubercle: A small rounded protrusion

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