



MATS
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MATS CENTRE FOR DISTANCE & ONLINE EDUCATION

Diversity of Invertebrate

**Bachelor of Science (B.Sc.)
Semester - 1**



SELF LEARNING MATERIAL



DSCC002
ZOOLOGY I:
MATS University

DIVERSITY OF INVERTEBRATE
CODE: ODL/MSS/BSCB/102

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MODULE INTRODUCTION

Course has five MODULEs. Under this theme we have covered the following topics:

MODULE 1 Introduction to Invertebrates

MODULE 2 Invertebrate II

MODULE 3 Invertebrate III

MODULE 4 Invertebrate IV

MODULE 5 Invertebrate V

These themes of the Book discuss about Invertebrate biodiversity is incredibly vast, encompassing over 90% of all animal species, with millions yet to be discovered, and plays crucial roles in ecosystems, including pollination, decomposition, and nutrient cycling. This book is designed to help you think about the topic of the particular MODULE. We suggest you do all the activities in the MODULEs, even those which you find relatively easy. This will reinforce your earlier learning

MODULE 1

INTRODUCTION TO INVERTEBRATES



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Objectives

- To understand the diversity and classification of invertebrates
- To study the morphological and functional characteristics of Protozoa and Porifera
- To analyze the role of Protozoa in disease transmission and control methods
- To explore the canal system and skeletal structures in Porifera

UNIT 1.1:

A Short History of Invertebrates — Growing the Tree of Life

1.1 Introduction

The history of life on Earth stretches back more than 3.5 billion years, and invertebrates—animals without a backbone—have been the main players for most of this time. They are not simply “primitive” or less advanced forms of life; in fact, invertebrates have been responsible for shaping entire ecosystems, driving evolutionary innovations, and filling almost every ecological niche on the planet. From microscopic plankton drifting in the oceans to massive reef-building corals and highly specialized insects, invertebrates demonstrate extraordinary adaptability. Understanding their history is like studying the expansion of a huge evolutionary tree, with deep roots in the ancient seas and countless branches that still dominate the biodiversity of our world today.

1.1.1 Origins in Precambrian Seas

The first signs of multicellular animal life appear in the Precambrian period, more than 600 million years ago. Fossils from this era, especially those of the **Ediacaran fauna**, provide important evidence of early animal



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evolution. These organisms, such as *Dickinsonia* and *Charniodiscus*, were soft-bodied creatures that lived flat on the sea floor. They lacked skeletons or shells but displayed unique body patterns, often quilted or leaf-like in appearance. Scientists view them as early experiments in multicellularity and body organization. Although many of these groups eventually went extinct, they set the stage for the evolution of more complex body structures, eventually giving rise to the ancestors of modern invertebrate groups.

The Cambrian Explosion: The Rise of Body Plans

A major turning point in the history of life occurred about 541 million years ago with the **Cambrian Explosion**. Within a relatively short geological period, there was a dramatic increase in the diversity of animal forms. Fossil sites such as the **Burgess Shale** in Canada and the **Chengjiang deposits** in China reveal an incredible array of invertebrates, many with unfamiliar body designs. Early arthropods such as *Anomalocaris* dominated as large predators, while primitive sponges developed intricate silica skeletons, and early mollusks began forming shells.

The Cambrian period was crucial because most of the major **body plans** that we recognize today first appeared during this time:

- **Segmentation** in arthropods gave rise to versatile body structures that could evolve into crustaceans, insects, and arachnids.
- **Radial symmetry** in cnidarians and early echinoderms allowed them to interact with their surroundings from all sides.
- **Bilateral symmetry** in worms, mollusks, and many others provided directionality for movement and more complex organ development.



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These innovations established the fundamental “blueprints” for animal life, which continued to diversify and adapt over hundreds of millions of years.

1.1.2 Ordovician to Devonian: Invertebrates Dominate the Seas

After the Cambrian period, marine ecosystems grew increasingly complex, particularly between the Ordovician and Devonian periods. The oceans were filled with an astonishing range of invertebrates that played important ecological roles.

- **Trilobites**, a group of armored arthropods, became especially abundant and evolved into many forms, from burrowers to active swimmers. They are often used as “index fossils” today to identify the age of ancient rocks.
- **Brachiopods** and the first **bivalve mollusks** flourished as filter feeders, recycling nutrients and maintaining balance in marine ecosystems.
- **Cephalopods**, including straight-shelled orthocones, emerged as intelligent predators with well-developed eyes and the ability to move by jet propulsion, making them among the top hunters of their time.
- **Corals and reef-building organisms** established some of the earliest reefs, creating structured habitats that sheltered fish, crustaceans, and many smaller invertebrates.

These developments marked the beginning of highly interactive ecosystems where predation, burrowing, and filtering activities influenced one another, sparking an evolutionary “arms race” between hunters and prey.

Invertebrates Move onto Land



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Although vertebrates often receive more attention for colonizing land, it was actually the invertebrates that made the first successful steps onto terrestrial environments. By the **Silurian and Devonian periods**, several arthropod groups had begun exploring moist areas on land.

- Fossil trackways show that **early myriapods** (millipede-like creatures) crawled across ancient soils, feeding on decaying plant material.
- **Chelicerates**, the ancestors of spiders and scorpions, adapted specialized respiratory organs known as **book lungs**, which enabled them to extract oxygen from air.

These adaptations allowed invertebrates to access new food sources and niches, from decomposing plant matter to hunting other invertebrates on land. Their movement onto land also set the stage for future ecological developments, as they began interacting with plants and shaping early terrestrial ecosystems.

Invertebrates as Ecosystem Engineers

Throughout the **Mesozoic era**, invertebrates continued to evolve in close connection with plants and vertebrates, often acting as ecosystem engineers.

- **Insects** diversified dramatically during this time, especially alongside the rise of flowering plants. The origin of bees, butterflies, and beetles transformed ecosystems by promoting **pollination**, a process that continues to be vital for modern biodiversity and agriculture.
- **Reef ecosystems** flourished, dominated by corals, sponges, echinoderms, and crustaceans. These organisms created three-dimensional habitats that provided food and shelter for countless other marine species.



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- **Marine bivalves** gradually replaced brachiopods as the dominant filter feeders of the seas, demonstrating how invertebrate groups rise and fall over evolutionary time.

By shaping the environments in which they lived, invertebrates influenced the survival and evolution of many other organisms, including early vertebrates.

1.1.3 Modern Invertebrate Diversity and Roles

Today, invertebrates make up **over 95% of all known animal species**, highlighting their overwhelming importance in the tree of life. Their diversity is almost endless. **Insects** alone account for millions of species, with roles ranging from pollinators to decomposers. **Corals** continue to build reef systems that support thousands of marine species. **Earthworms** enrich soils and recycle nutrients, while other groups act as parasites, controlling population sizes of hosts.

Invertebrates are essential to ecological cycles, balancing energy flow and nutrient recycling across ecosystems. Furthermore, modern molecular studies are revealing hidden evolutionary relationships among different invertebrate groups, often reshaping the way we understand their classification. Far from being relics of the past, they remain active forces in modern ecosystems and scientific research.

The Growing Tree of Life

The history of invertebrates is not just about fossils—it is a **living story** of resilience and adaptation. Each branch of the evolutionary tree, whether leading to jellyfish, worms, beetles, or dragonflies, represents a lineage that has endured mass extinctions, shifting climates, and new environmental challenges. Invertebrates remind us that having a backbone is only one evolutionary solution; countless other successful strategies exist.



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As the tree of life continues to grow, invertebrates remain at its core. They are not simply creatures of the past but essential architects of ecosystems in the present, ensuring that life on Earth continues to thrive in all its diverse forms.

Summary:

- Invertebrates, animals without backbones, have dominated Earth's evolutionary history for more than 3.5 billion years.
- The **Precambrian period** saw the emergence of multicellular life forms like the **Ediacaran fauna**, which were soft-bodied and experimental in body design.
- The **Cambrian Explosion (541 million years ago)** introduced most major invertebrate body plans such as segmentation, bilateral symmetry, and radial symmetry.
- Between the **Ordovician and Devonian periods**, trilobites, brachiopods, cephalopods, and reef-building corals shaped complex marine ecosystems.
- Invertebrates were the **first animals to colonize land**, with arthropods like millipede-like myriapods and chelicerates adapting to terrestrial environments.
- During the **Mesozoic era**, insects co-evolved with flowering plants, while reefs and filter-feeders such as corals and bivalves shaped marine life.
- Today, **over 95% of all animal species are invertebrates**, playing critical roles as pollinators, decomposers, prey, parasites, and ecosystem engineers.
- The history of invertebrates demonstrates resilience, adaptation, and innovation, reminding us that the “tree of life” continues to grow with them at its core.



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A. Multiple Choice Questions (MCQs)

Q1. Which of the following best describes invertebrates?

- a) Primitive animals without organs
- b) Animals without a backbone
- c) Early stages of vertebrate evolution
- d) Exclusively aquatic organisms

Answer: b) Animals without a backbone

Q2. The Ediacaran fauna existed during which period?

- a) Cambrian
- b) Precambrian
- c) Devonian
- d) Silurian

Answer: b) Precambrian

Q3. The Cambrian Explosion is significant because:

- a) First vertebrates appeared
- b) Most invertebrate body plans evolved
- c) Land animals dominated ecosystems
- d) First plants colonized land

Answer: b) Most invertebrate body plans evolved

Q4. Which fossil site is famous for its Cambrian invertebrates?

- a) La Brea Tar Pits
- b) Burgess Shale
- c) Olduvai Gorge
- d) Messel Pit

Answer: b) Burgess Shale

Q5. Which body plan innovation first appeared in early arthropods?

- a) Radial symmetry
- b) Segmentation
- c) Notochord
- d) Book lungs

Answer: b) Segmentation



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Q6. Which group of arthropods dominated marine ecosystems after the Cambrian?

- a) Trilobites
- b) Arachnids
- c) Insects
- d) Crustaceans

Answer: a) Trilobites

Q7. Which invertebrate group first developed book lungs to adapt to terrestrial life?

- a) Mollusks
- b) Chelicerates
- c) Cephalopods
- d) Echinoderms

Answer: b) Chelicerates

Q8. Insects diversified greatly during the Mesozoic due to their association with:

- a) Ferns
- b) Gymnosperms
- c) Flowering plants
- d) Mosses

Answer: c) Flowering plants

Q9. Today, invertebrates make up approximately what percentage of all known animal species?

- a) 50%
- b) 70%
- c) 95%
- d) 20%

Answer: c) 95%

Q10. Which of the following is NOT an ecological role of invertebrates?

- a) Pollinators
- b) Decomposers
- c) Soil enrichers

d) Vertebrate skeleton support

Answer: d) Vertebrate skeleton support



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B.Short Answer Questions

1. Define invertebrates and explain their importance in evolutionary history.
2. What is the significance of the Ediacaran fauna in understanding early life forms?
3. List three major body plan innovations that appeared during the Cambrian Explosion.
4. How did trilobites and cephalopods contribute to early marine ecosystems?
5. Explain how arthropods adapted to life on land during the Silurian and Devonian periods.



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UNIT 1.2:

Protozoa

1.2 Introduction

Protozoa are single-celled, eukaryotic organisms that play an important role in biology and ecology. Even though they consist of just one cell, they display remarkable structural complexity and perform all vital life processes within that single unit. Because of their animal-like mode of nutrition and movement, they are studied under zoology. The branch of science that deals with protozoa is called **protozoology**, and it provides insights into cell biology, ecology, and even human health, since many protozoa are linked to diseases.

1.2.1 General Characteristics and Structure

Protozoa are mostly microscopic, ranging in size from a few micrometres to several hundred micrometres. They thrive in diverse habitats such as freshwater, marine environments, damp soil, and as parasites inside animal bodies.

Each protozoan cell is surrounded by a flexible **plasma membrane** and sometimes a protective **pellicle**, which maintains shape while allowing movement. A well-developed **nucleus** controls all activities. Organelles such as **mitochondria**, **endoplasmic reticulum**, **Golgi bodies**, **contractile vacuoles**, and **food vacuoles** are also present, highlighting their advanced eukaryotic nature.

Locomotion is a key feature. Different protozoa use specialized structures for movement:

- **Flagella** (e.g., *Trypanosoma*) – whip-like movements
- **Cilia** (e.g., *Paramecium*) – coordinated beating for smooth movement
- **Pseudopodia** (e.g., *Amoeba proteus*) – temporary extensions of cytoplasm for creeping movement



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Modes of Nutrition

Protozoa show diverse feeding habits:

- **Holozoic nutrition:** Engulfing food like bacteria or algae through **phagocytosis**, followed by digestion inside food vacuoles.
- **Saprophytic nutrition:** Absorbing dissolved organic matter directly through the membrane.
- **Parasitic nutrition:** Living inside hosts and feeding on tissues or fluids (e.g., *Plasmodium*, *Entamoeba histolytica*).
- **Mixotrophic nutrition:** Some like *Euglena* can photosynthesize in light but feed heterotrophically in the dark.

Reproduction

Most protozoa reproduce **asexually**, usually by **binary fission**, where one cell divides into two. In some cases, **multiple fission (schizogony)** produces many daughter cells simultaneously.

Protozoa also show **sexual processes** to ensure genetic variation. A well-known example is **conjugation in Paramecium**, where two cells exchange genetic material before separating. Parasitic protozoa often produce **spores**, which help them survive harsh conditions and spread to new hosts.

1.2.2 Classification and Diversity

Protozoa were earlier placed under the kingdom *Protista*, but modern classification spreads them across several groups depending on locomotion and life cycle. The main groups are:

- **Rhizopoda (Sarcodina)** – amoeboid forms using pseudopodia (*Amoeba*)
- **Flagellata (Mastigophora)** – flagellated forms (*Trypanosoma*)
- **Ciliata** – ciliated forms (*Paramecium*)



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- **Sporozoa (Apicomplexa)** – spore-forming parasites (*Plasmodium*)

This diversity shows their ability to adapt to varied environments, from ponds to animal bloodstreams.

Ecology and Significance

Protozoa play multiple roles in nature:

- **Ecological role:** They regulate bacterial populations, recycle nutrients, and form part of aquatic food chains.
- **Symbiosis:** Some live harmlessly or beneficially inside other organisms, aiding digestion.
- **Medical significance:** Several protozoa cause serious human diseases –
 - *Plasmodium* → Malaria
 - *Trypanosoma* → Sleeping sickness
 - *Entamoeba histolytica* → Amoebic dysentery

Thus, their study is vital in medical science and disease prevention.

Adaptations and Survival Strategies

Despite being tiny, protozoa have developed strategies to survive in extreme conditions. The most important is **encystment** – forming a protective cyst when conditions are unfavorable (e.g., drought, nutrient shortage). This adaptation also helps in transmission between hosts for parasites.

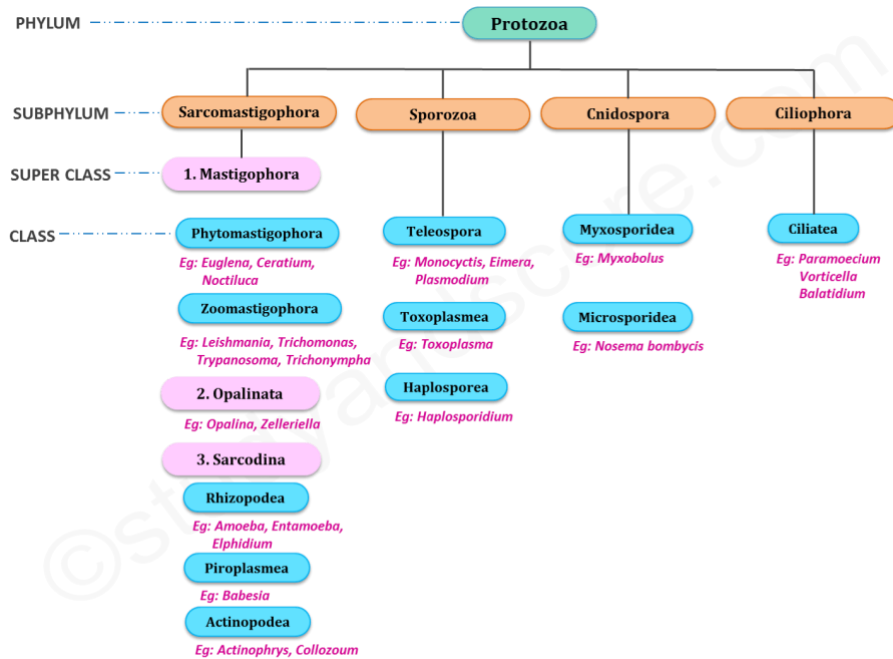


Fig1.1: Classification of Protozoa

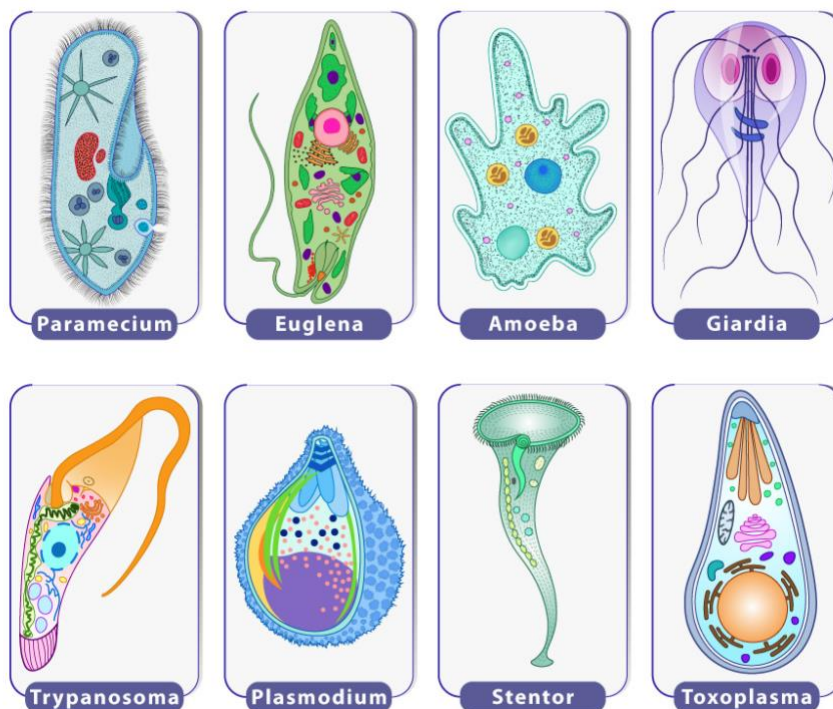


Fig1.2: Protzoa

Protozoan Diseases and Human Health

Protozoa are responsible for some of the world's most dangerous diseases:



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- **Malaria (*Plasmodium falciparum*, etc.)**
Spread by female *Anopheles* mosquitoes. Symptoms include fever, chills, and sweating. Severe cases cause organ failure and cerebral malaria. Control: mosquito nets, spraying, early diagnosis, and artemisinin-based treatments.
- **Sleeping sickness (*Trypanosoma brucei*)**
Transmitted by tsetse flies in Africa. Early symptoms: fever, headaches; later: neurological problems, coma, death. Controlled by vector management and stage-specific drugs.
- **Chagas disease (*Trypanosoma cruzi*)**
Spread by triatomine bugs in Latin America. Chronic stage causes heart and digestive disorders. Controlled by vector control and drug therapy (benznidazole, nifurtimox).
- **Leishmaniasis (*Leishmania* species)**
Spread by sandflies. Forms: cutaneous, mucocutaneous, visceral (kala-azar). Prevented by diagnosis, treatment, and sandfly control.
- **Amoebiasis (*Entamoeba histolytica*)**
Spread through contaminated food/water. Causes dysentery and liver abscesses. Controlled by sanitation and drugs (metronidazole).
- **Giardiasis (*Giardia lamblia*)**
Spread via contaminated water or food. Causes diarrhea and malabsorption. Control: clean water, sanitation, drug treatment.
- **Cryptosporidiosis (*Cryptosporidium*)**
Fecal-oral spread, especially in immunocompromised individuals. Prevention: clean water and hygiene.
- **Trichomoniasis (*Trichomonas vaginalis*)**
A common sexually transmitted infection. Controlled by safe sex practices and drug treatment.



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Summary:

Protozoa, though microscopic, have immense ecological, biological, and medical importance. They regulate ecosystems, serve as indicators of environmental health, and unfortunately, also cause several deadly human diseases. Their ability to adapt through encystment and complex life cycles makes them both fascinating and challenging to control.

For public health, protozoan diseases pose serious threats worldwide, requiring combined efforts in **vector control, sanitation, diagnosis, treatment, and research into new drugs and vaccines.**

A. Multiple Choice Questions (MCQs)

1. The study of protozoa is called:

- a) Bacteriology
- b) Protozoology
- c) Virology
- d) Mycology

Answer: b) Protozoology

2. Locomotion in *Amoeba* occurs by:

- a) Flagella
- b) Cilia
- c) Pseudopodia
- d) None of these

Answer: c) Pseudopodia

3. Which protozoan causes malaria?

- a) Trypanosoma
- b) Plasmodium
- c) Giardia
- d) Entamoeba

Answer: b) Plasmodium

4. Encystment in protozoa helps in:

- a) Photosynthesis
- b) Reproduction



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- c) Survival in adverse conditions
- d) Locomotion

Answer: c) Survival in adverse conditions

5. *Giardia lamblia* spreads mainly through:

- a) Air
- b) Insect bite
- c) Contaminated water
- d) Blood transfusion

Answer: c) Contaminated water

B.Short Answer Questions

1. Define protozoa. Mention two general characteristics.
2. Write two differences between holozoic and saprophytic nutrition in protozoa.
3. Explain conjugation in *Paramecium*.
4. List any four protozoan diseases and their causative organisms.
5. What is encystment? How does it help protozoa survive?

UNIT 1.3:

Porifera



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1.3 Introduction

Sponges, scientifically grouped under the phylum *Porifera*, represent one of the most ancient and primitive forms of multicellular life. Fossil records suggest their presence in the oceans for over 600 million years, making them some of the earliest surviving metazoans. At first glance, sponges may resemble immobile plants, but they are indeed animals with a body organization distinct from other animal groups. The term *Porifera* originates from the Latin words meaning “pore-bearing,” referring to the countless tiny openings that perforate their body wall. These pores form the entry points of a highly specialized canal system through which water continuously flows, carrying food, oxygen, and also removing waste. Sponges are mainly marine, though a few species have adapted to freshwater habitats. Their evolutionary position is significant because they form a connecting stage between unicellular protozoans and more complex multicellular animals.

1.3.1 Classification of Porifera

Taxonomically, the phylum *Porifera* is divided into four major classes: **Calcarea**, **Hexactinellida**, **Demospongiae**, and **Homoscleromorpha**. The key basis of classification lies in the composition and arrangement of their skeletal elements.

- **Calcarea** – possess spicules made of calcium carbonate.
- **Hexactinellida (glass sponges)** – have siliceous spicules arranged in a six-rayed (hexactinal) structure.
- **Demospongiae** – the largest and most diverse class (about 90% of all species), with siliceous but non-hexactinal spicules or spongin fibers.
- **Homoscleromorpha** – once considered a subclass of Demospongiae, now recognized separately due to unique features such as a basement membrane and distinct skeletal traits.

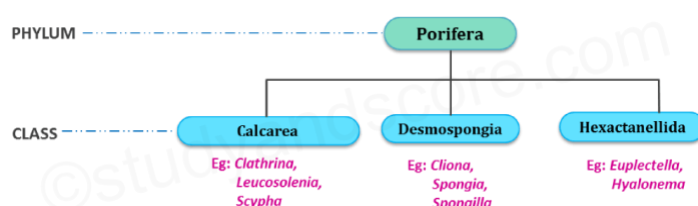


Fig1.3: Classification of Porifera

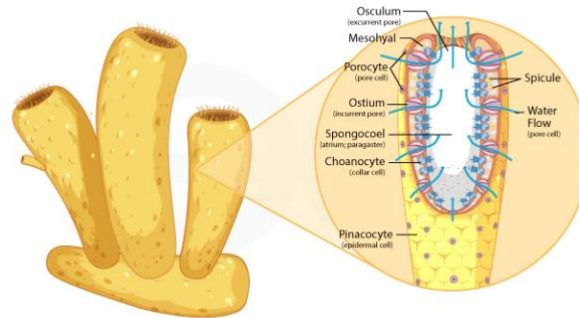


Fig1.4: Sycon

1.3.2 General Characteristics of Sponges

Sponges are **sessile** animals, meaning that once they are attached to a surface, they remain fixed there throughout their adult life. Their body organization is comparatively simple, lacking true tissues, organs, and a nervous system. Despite this, they exhibit a significant degree of **cellular specialization**, with different cell types performing various functions.

The most important feature of sponges is their **water canal system**, which serves in feeding, respiration, excretion, and reproduction. Water carrying microscopic food particles enters through pores (ostia), passes through internal canals lined with choanocytes (collar cells that trap food), and finally exits via a large opening called the osculum.

Their body is supported by a skeleton of **spicules and/or spongin fibers**, which provides structural support and protection against predators.

Regeneration and Reproduction

Sponges have an extraordinary power of **regeneration**. They can restore lost body parts or even regenerate an entirely new sponge from small fragments due to the presence of totipotent cells such as archeocytes, which can transform into different cell types.

Reproduction may occur both **asexually** and **sexually**:

- **Asexual methods** include budding, fragmentation, or the production of gemmules (resistant internal buds).



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- **Sexual reproduction** involves the formation of gametes and fertilization. Most sponges are hermaphrodites, producing both eggs and sperm, but cross-fertilization is common. Fertilized eggs develop into free-swimming larvae, which eventually settle and develop into adult sponges.

Example: *Sycon* (Class Calcarea)

A well-studied example of sponge structure is *Sycon*, belonging to the class Calcarea. *Sycon* has a cylindrical body with a central cavity called the **spongocoel**, opening externally through an **osculum**. Its body wall is complex, made up of:

- **Pinacoderm** – outer layer of flattened pinacocyte cells.
- **Mesohyl** – a jelly-like middle matrix containing free cells and skeletal elements.
- **Choanoderm** – an inner layer of choanocytes that line radial canals.

The **canal system of *Sycon*** is of the **syconoid type**, intermediate between the simple asconoid and the complex leuconoid types. Water enters through dermal pores, passes into radial canals lined with choanocytes, then into the spongocoel, and finally leaves through the osculum. This system provides greater efficiency in feeding and allows for larger sponge size compared to asconoid forms.

1.3.3 Canal System in Sponges

The **canal system** is one of the most distinctive features of sponges. Since sponges do not have specialized organs for digestion, respiration, or circulation, they rely on a continuous flow of water through their body. This water current provides food, oxygen, and also removes metabolic wastes. The movement of water is mainly driven by the beating of **choanocytes** (collar cells), which line different chambers or canals.

The canal system is so fundamental to sponges that it is used to classify them into three major types: **Asconoid, Syconoid, and Leuconoid**.



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A. Asconoid Canal System

- **Simplest type**, found in small sponges like *Leucosolenia*.
- The sponge body is tubular with a large central cavity called the **spongocoel**.
- Water enters through small pores (**ostia**) directly into the spongocoel, which is lined by choanocytes.
- From the spongocoel, water passes out through a large opening, the **osculum**.
- **Limitation:** Due to the direct flow and small filtering surface, sponges with this system remain very small in size.

B. Syconoid Canal System

- Found in *Sycon* and some other calcareous sponges.
- It is more complex than asconoid.
- Water enters through dermal pores into **incurrent canals**.
- From incurrent canals, water passes into **radial canals** (lined with choanocytes) through small openings called **prosopyles**.
- After filtration, water moves from radial canals into the spongocoel through **apopyles** and finally exits via the osculum.
- **Advantage:** The presence of radial canals increases the surface area for choanocytes, making feeding more efficient.

C. Leuconoid Canal System

- The **most advanced and complex type**, seen in the majority of sponges (especially Demospongiae).
- Water enters through ostia into a network of **incurrent canals**.
- From these canals, water passes into numerous small **flagellated chambers** lined with choanocytes.



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- Filtered water then leaves the chambers through **excurrent canals**, which unite and open into the osculum.
- **Advantages:**
 - Greatly increases the filtering surface area.
 - Supports large body sizes.
 - Most efficient system, allowing sponges to colonize diverse habitats.

Functional Importance of Canal System

- **Feeding** – filter feeding by choanocytes.
- **Respiration** – oxygen dissolved in water diffuses into cells.
- **Excretion** – metabolic wastes (like ammonia) diffuse out into the water.
- **Reproduction** – gametes and larvae are released into water currents.

Thus, the canal system serves as a substitute for many organ systems that sponges lack.

Skeleton of Sponges

The body of sponges is supported by a **skeleton**, which gives firmness, protects against predators, and provides attachment sites for soft cells. Unlike higher animals, the sponge skeleton is not made of bones but of microscopic structural elements called **spicules** and/or **spongin fibers**.

The skeleton type varies among classes of Porifera and is an important tool in their classification.

A. Spicules



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Spicules are tiny, rigid, mineralized structures that act like the "bones" of a sponge. They occur in different shapes and sizes and are secreted by special cells called **scleroblasts**.

1. **Calcareous Spicules**

- Found in **Calcarea**.
- Composed of calcium carbonate (CaCO_3).
- May be **monoaxonic** (single axis), **triaxonic** (three axes), or **tetraxonic** (four axes).
- Example: *Sycon*.

2. **Siliceous Spicules**

- Found in **Hexactinellida** and **Demospongiae**.
- Composed of silica (SiO_2).
- In **Hexactinellida**, they are typically **hexactinal** (six-rayed) and often fused into a lattice, giving them the name "glass sponges".
- In **Demospongiae**, siliceous spicules are non-hexactinal and show great variation in form (monaxonic, tetraxonic, or polyaxonic).

B. Spongin Fibers

- Found mainly in **Demospongiae**.
- Made of a protein called **spongin**, which is collagen-like in nature.
- Provides flexibility and elasticity to the sponge body.
- Some commercial bath sponges (e.g., *Euspongia*) consist entirely of spongin fibers and lack spicules.

C. Mixed Skeletons

- Many sponges have skeletons made up of **both spicules and spongin fibers**, combining rigidity with flexibility.
- This variation reflects adaptation to different ecological habitats.

Functions of Skeleton in Sponges

- Provides **structural support** to the body.
- Protects against predators and mechanical damage.
- Determines the **shape and size** of the sponge.
- Helps in **classification** (since spicule composition and arrangement are taxonomically important).

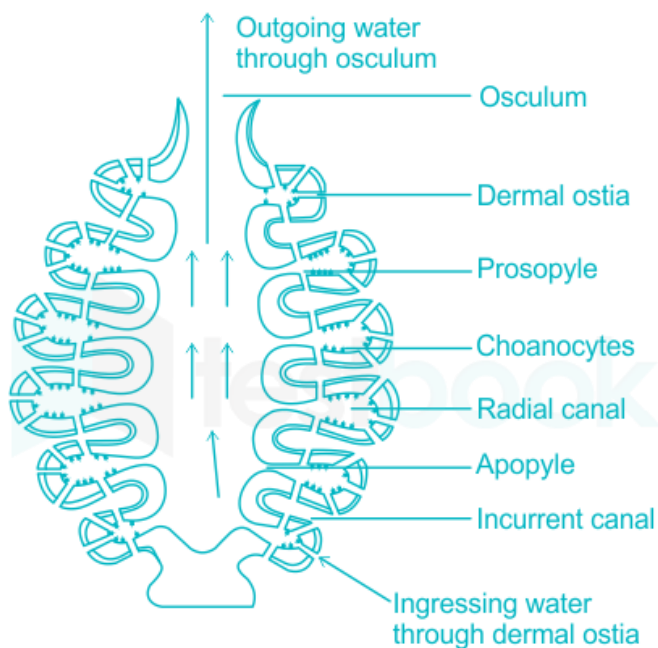


Fig1.4: Canal system



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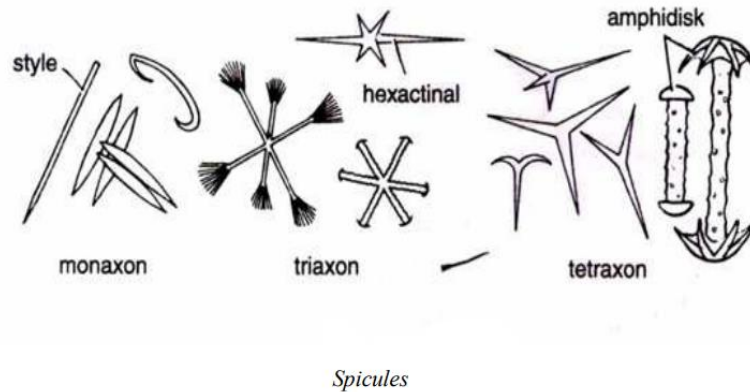


Fig1.5: Spicules

Summary:

Porifera are the most primitive multicellular animals, existing for over **600 million years**. The name means “**pore-bearing**” (Latin), referring to their porous body wall with canals. They are **sessile aquatic animals**, mostly marine, a few freshwater species exist. Lack true tissues, organs, and a nervous system but exhibit **cellular specialization**. The **water canal system** (asconoid, syconoid, leuconoid) is essential for **feeding, respiration, excretion, and reproduction**. Skeleton is made of **spicules (calcium carbonate or silica)** and/or **spongin fibers**. **Reproduction:** Asexual (budding, fragmentation, gemmules) and Sexual (gametes, cross-fertilization, free-swimming larvae). **Regeneration:** High capacity due to **totipotent cells** (archeocytes).

A. Multiple Choice Questions:

Q1. The term *Porifera* means:

- a) Water-bearer
- b) Pore-bearing ☒
- c) Canal-bearer
- d) Spicule-bearing

Q2. Which class of Porifera has calcareous spicules?

- a) Hexactinellida
- b) Demospongiae



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- c) Calcarea ☒
- d) Homoscleromorpha

Q3. The simplest type of canal system in sponges is:

- a) Syconoid
- b) Leuconoid
- c) Rhagon
- d) Asconoid ☒

Q4. The osculum in sponges functions as:

- a) Water entry
- b) Water exit ☒
- c) Food capture
- d) Skeletal support

Q5. Which of the following is NOT a characteristic of Porifera?

- a) Sessile habit
- b) Presence of tissues ☒
- c) Cellular specialization
- d) Filter feeding

Q6. Choanocytes are responsible for:

- a) Skeletal formation
- b) Water circulation and food capture ☒
- c) Reproduction
- d) Waste storage

Q7. Gemmules are produced during:

- a) Reproduction in marine sponges
- b) Reproduction in freshwater sponges ☒
- c) Only during sexual reproduction
- d) Larval stages

Q8. The largest class of sponges is:

- a) Calcarea
- b) Hexactinellida



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- c) Demospongiae ☒
- d) Homoscleromorpha

Q9. Which cells are totipotent in sponges?

- a) Choanocytes
- b) Archeocytes ☒
- c) Pinacocytes
- d) Porocytes

Q10. In *Sycon*, choanocytes are located in:

- a) Spongocoel
- b) Radial canals ☒
- c) Mesohyl
- d) Osculum

B. Short Answer Questions:

1. Describe the general characteristics of Porifera and explain why they are considered the simplest metazoans.
2. Explain the three types of canal systems found in sponges with suitable examples.
3. Write a detailed note on the skeletal system of Porifera, highlighting differences between Calcarea, Hexactinellida, and Demospongiae.
4. Discuss the structure and organization of *Sycon*, with special reference to its syconoid canal system.
5. Explain the process of reproduction in sponges (both asexual and sexual), and mention the significance of regeneration.



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Summary:

Invertebrates are animals that lack a backbone or vertebral column, comprising about 95% of all known animal species. They display immense diversity in form, function, and habitat, ranging from simple organisms like sponges to more complex ones like insects and octopuses. Invertebrates are classified into several major phyla, including Porifera (sponges), Cnidaria (jellyfish and corals), Platyhelminthes (flatworms), Nematoda (roundworms), Annelida (segmented worms), Mollusca (snails, octopuses, clams), Arthropoda (insects, crustaceans, arachnids), and Echinodermata (starfish and sea urchins). These animals inhabit a wide range of environments and play crucial roles in ecosystems, such as pollination, nutrient recycling, and serving as a food source for many other organisms. Their body structures vary from radial to bilateral symmetry, and they exhibit diverse modes of reproduction and adaptation, highlighting their evolutionary success and ecological importance.

A. Multiple Choice Questions (MCQs)

1. What characteristic is unique to invertebrates?

- a. Backbone
- b. Multicellularity
- c. Lack of a vertebral column
- d. Cold-blooded nature

Ans. c. Lack of a vertebral column

2. Which group of Protozoa moves by pseudopodia?

- a. Flagellated Protozoa
- b. Amoeboid Protozoa
- c. Ciliated Protozoa



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- d. Sporozoans

Ans. b. Amoeboid Protozoa

3. The canal system in Porifera helps in:

- a. Respiration
- b. Digestion
- c. Water circulation
- d. Excretion

Ans. c. Water circulation

4. The structure responsible for locomotion in Paramecium is:

- a. Flagella
- b. Cilia
- c. Pseudopodia
- d. Spicules

Ans. b. Cilia

B. Short Answer Questions

1. Define Protozoa and give an example.
2. What is the function of contractile vacuoles in Paramecium?
3. Name two diseases caused by Protozoa.
4. What are spicules in Porifera?
5. Mention the different types of canal systems in Porifera.

C. Long Answer Questions

1. Explain the classification of Protozoa with examples.
2. Describe the structure and reproduction of Paramecium.
3. Discuss the role of Protozoa in disease transmission.
4. What are the major characteristics of Porifera?
5. Explain the canal system in Porifera with diagrams.
6. How do sponges perform respiration and excretion?
7. Discuss the economic importance of Protozoa.
8. Describe the different skeletal structures in Porifera.

9. Compare and contrast Asconoid, Syconoid, and Leuconoid canal systems.
10. Explain the classification of Porifera with examples.



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MODULE-2

INVERTEBRATE II

Objectives

- To study the classification and general characteristics of Coelenterates and Platyhelminths.
- To analyze the structure and morphology of Obelia and Fasciola.
- To understand polymorphism in Hydrozoa and its biological significance.
- To examine the process of coral reef formation and the ecological role of corals.
- To investigate the life cycle and pathogenicity of Fasciola hepatica.
- To compare the adaptations of Coelenterates and Platyhelminths to their habitats

UNIT 2.1

Coelenterate

2.1 Introduction

The phylum Cnidaria, earlier known as *Coelenterata*, represents one of the oldest and simplest groups of multicellular animals. Although their body organization is relatively primitive when compared with higher animals, they display fascinating adaptations that allow them to survive in a wide variety of aquatic environments. From the delicate sea anemones that inhabit rocky shorelines to the massive coral reefs that support immense biodiversity, cnidarians have established themselves as an essential component of marine ecosystems worldwide.

The name of the phylum is derived from two Greek words: “*koilos*” meaning hollow and “*enteron*” meaning gut, referring to the presence of a central hollow cavity that functions as both the digestive tract and hydrostatic skeleton. Despite their simplicity, cnidarians offer valuable insights into the early evolution of multicellularity, the organization of tissues, and the origins of nervous systems in animals.

2.1.1 Classification of Cnidaria



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Cnidaria is divided into four major classes based on structural, developmental, and evolutionary features:

1. Class Hydrozoa – Includes hydroids, hydromedusae, and siphonophores.
2. Class Scyphozoa – The true jellyfishes.
3. Class Cubozoa – Known as box jellyfishes, often highly venomous.
4. Class Anthozoa – Comprising sea anemones, corals, and sea pens.

All these classes share the fundamental characteristics of cnidarians but also display distinct traits suited to their ecological lifestyles. Being among the earliest branches of the animal kingdom (*Metazoa*), cnidarians occupy a key position in animal phylogeny.

Body Symmetry and Tissue Organization

Unlike most higher animals which show bilateral symmetry, cnidarians are radially symmetrical. This arrangement, where body parts radiate from a central axis, is advantageous for their mostly sessile (fixed) or slow-moving lifestyle, enabling them to sense and interact with the environment equally from all directions.

Cnidarians are diploblastic animals, meaning their body wall is composed of two primary cell layers:

- Epidermis (ectodermal origin) – forms the outer covering.
- Gastrodermis (endodermal origin) – lines the internal cavity and aids in digestion.

Between these two layers lies a jelly-like non-cellular matrix called mesoglea. This is in contrast to triploblastic animals (with three germ layers), which possess more complex tissues and organ systems.

The central body cavity is called the coelenteron or gastrovascular cavity, which serves multiple functions such as digestion, distribution of nutrients, circulation, and providing hydrostatic support.

Cnidocytes and Nematocysts

The most unique and defining feature of cnidarians is the presence of cnidocytes (stinging cells). Each cnidocyte contains a highly specialized organelle called the nematocyst, capable of discharging explosively. These organelles contain a coiled thread that can rapidly evert and inject toxins into prey or potential threats.



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Functions of cnidocytes include:

- Capturing and immobilizing prey.
- Defense against predators.
- Aiding in locomotion and attachment in some species.

The nematocyst mechanism is one of the fastest cellular processes in the animal kingdom, allowing these simple organisms to overpower prey much larger than themselves.

Polymorphism: Polyp and Medusa Forms

A remarkable feature of cnidarian biology is the alternation between two morphological forms:

1. Polyp – A cylindrical, sessile form attached to a surface, with tentacles surrounding the mouth at the upper end.
2. Medusa – A free-swimming, umbrella-shaped form adapted for dispersal and sexual reproduction.

This phenomenon, termed metagenesis or alternation of generations, allows cnidarians to exploit different ecological niches during their life cycle. While classes like Scyphozoa alternate between both forms, anthozoans exist only as polyps.

Nervous System and Sense Organs

Cnidarians possess one of the earliest forms of a nervous system in the animal kingdom. Instead of a brain or centralized ganglia, they have a diffuse nerve net that coordinates muscular contractions and sensory responses.

Some medusae also have specialized sensory structures called rhopalia, which may contain:

- Statocysts – for balance and orientation.
- Ocelli – simple eyes that detect light intensity.

This primitive neural network allows cnidarians to respond effectively to environmental stimuli such as light, touch, water currents, and chemical signals.

Reproduction

Cnidarians exhibit both asexual and sexual reproduction:

- Asexual reproduction occurs by budding, fragmentation, or formation of reproductive polyps.

- Sexual reproduction usually involves external fertilization in water, although in some species fertilization occurs internally. The fertilized zygote develops into a free-swimming planula larva, which eventually settles and grows into a polyp.

This combination of reproductive strategies ensures both genetic diversity (through sexual reproduction) and rapid colonization (through asexual reproduction).

Ecological Significance of Cnidarians

Cnidarians play crucial ecological roles:

- **Coral Reefs** – Reef-building corals (Anthozoa) form massive calcium carbonate structures that host thousands of marine species, serving as biodiversity hotspots.
- **Symbiosis** – Many corals harbor symbiotic algae (zooxanthellae), which perform photosynthesis and provide essential nutrients to their host. In return, the algae gain protection and access to waste nutrients.
- **Food Web Role** – Cnidarians act as predators (feeding on plankton), prey (to turtles and fish), and habitat providers (especially corals).

Coral reefs also provide services to humans, such as coastal protection, fisheries, and sources of bioactive compounds for medicines.

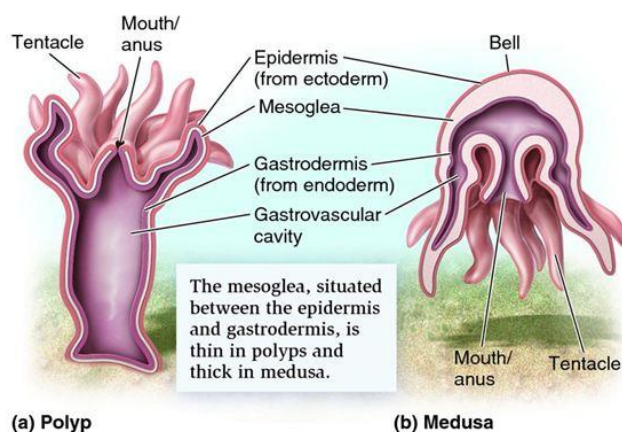


Fig2.1: Polyp and Medusa

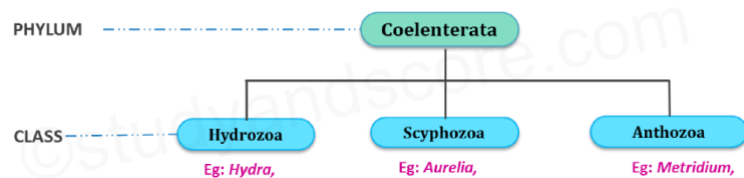
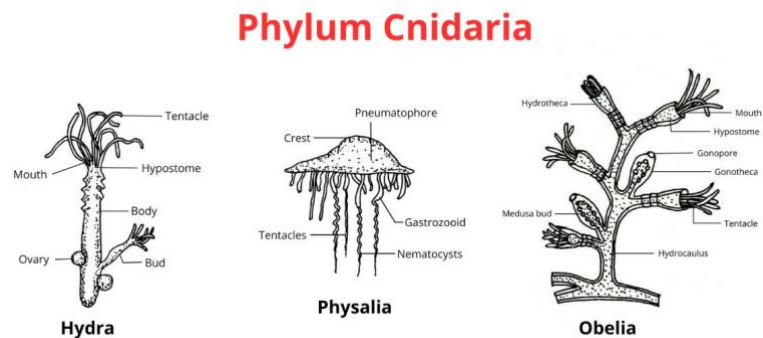


Fig2.2: Examples and Classification in Coelenterate

2.1.2 Obelia: Structure and Morphology, Hydrozoa Polymorphism, and Coral Reefs

General Features

Obelia is a colonial hydrozoan commonly found attached to submerged surfaces in marine environments. Its colony resembles a delicate, branching plant-like structure, although it is entirely animal in nature. The colony consists of a **hydrorhiza** (root-like base for attachment) and a branching **hydrocaulus** (stem) covered by a protective chitinous covering known as the **perisarc**.

The colony exhibits **polymorphism**, with specialized polyps performing different functions:



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- **Hydranths (gastrozooids)** – feeding polyps equipped with tentacles and nematocysts.
- **Gonangia (gonozooids)** – reproductive polyps enclosed in protective gonothecae, producing medusa buds.

This division of labor improves efficiency, with each type of zooid performing its role within the colony.

Feeding and Reproduction in Obelia

The **hydranths** capture prey with their tentacles, paralyze it using nematocysts, and ingest it through the central cavity where digestion occurs. Nutrients are distributed throughout the colony via the interconnected gastrovascular cavity.

Reproduction in Obelia follows a characteristic life cycle:

1. The **gonangia** produce small **medusae** by budding.
2. These medusae detach and become free-swimming, representing the sexual stage.
3. Medusae develop gonads and release gametes into water.
4. Fertilization produces a **zygote**, which develops into a **planula larva**.
5. The larva settles, grows into a polyp, and forms a new colony.

This alternation between polyp and medusa stages is a classic example of cnidarian **metagenesis**.

Hydrozoan Polymorphism

Hydrozoans like Obelia exhibit **polymorphism**, where multiple specialized zooids exist within the same colony:

- **Feeding zooids (gastrozooids).**
- **Reproductive zooids (gonozooids).**



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- **Defensive zooids (dactylozooids)** – heavily armed with nematocysts for protection.

This division of labor functions like the organ systems of higher animals, with different parts of the colony performing feeding, reproduction, and defense.

Corals and Coral Reefs

Coral Morphology and Growth Forms

Corals occur in various structural forms, such as:

- **Massive/Boulder corals** – solid dome-shaped.
- **Branching corals** – tree-like forms creating complex habitats.
- **Plate-like corals** – horizontal sheets forming layered structures.
- **Encrusting corals** – thin layers covering rocks or other surfaces.

This morphological diversity contributes to reef complexity, providing numerous microhabitats for marine organisms.

Coral-Zooxanthellae Symbiosis

Reef-building corals form a mutualistic relationship with photosynthetic dinoflagellates called **zooxanthellae**. These algae reside within the coral's gastrodermal cells, producing carbohydrates through photosynthesis and supplying up to 90% of the coral's energy requirements. In return, corals provide the algae with a safe environment and access to waste nutrients.

This symbiosis explains why coral reefs thrive in clear, shallow waters where sunlight is abundant.

Formation of Coral Reefs

Coral reefs develop over long geological timescales. The process begins when coral larvae (planulae) settle on a hard surface and metamorphose into polyps. These polyps secrete calcium carbonate and reproduce

asexually to form colonies. Over many generations, the colonies grow, die, and are replaced by new ones, creating massive reef structures.

Reefs act as **ecosystem engineers**, shaping marine biodiversity, protecting coastlines, and supporting human economies.



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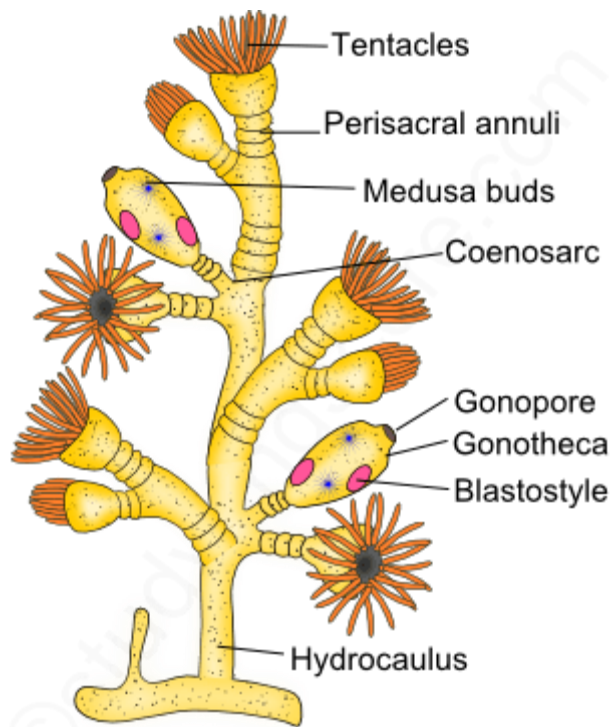
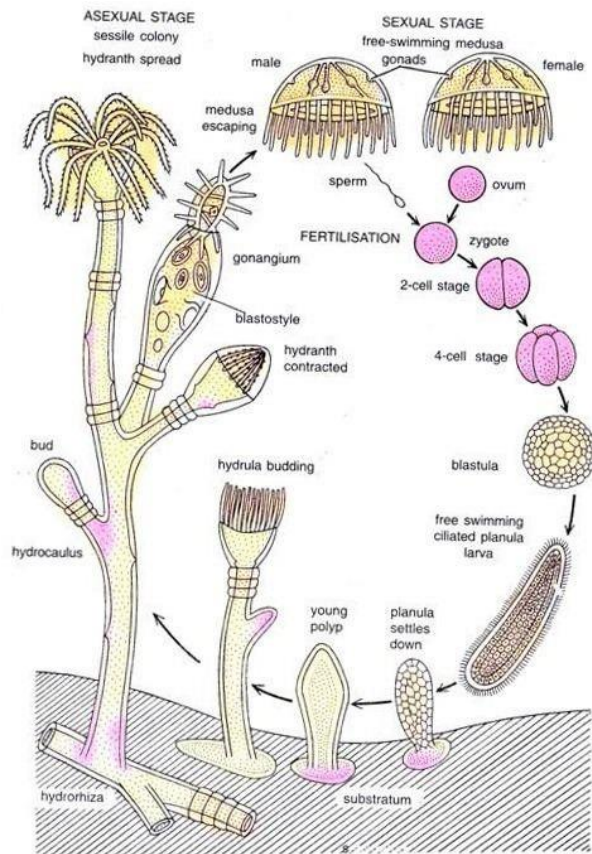


Fig2.3 Obelia Colony



Summary:

Obelia, a hydrozoan, shows colonial organization, polymorphism (specialized zooids), and alternation of generations. Hydrozoans exhibit division of labor among feeding, reproductive, and defensive polyps. Corals (Anthozoa) form reefs with various growth forms (branching, massive, plate-like, encrusting). Reef-building corals live in mutualistic symbiosis with zooxanthellae (photosynthetic algae), crucial for reef

productivity. Coral reefs are ecologically and economically vital, providing biodiversity hotspots, fish habitats, and coastal protection.



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A. Multiple Choice Questions (MCQs)

1. The unique stinging cells in cnidarians are called:
 - a) Nephridia
 - b) Nematocysts
 - c) Flame cells
 - d) Cnidophores

Answer: b) Nematocysts

2. The central body cavity in cnidarians is known as:
 - a) Coelom
 - b) Coelenteron
 - c) Pseudocoel
 - d) Blastocoel

Answer: b) Coelenteron

3. Obelia belongs to which class of cnidarians?
 - a) Hydrozoa
 - b) Scyphozoa
 - c) Cubozoa
 - d) Anthozoa

Answer: a) Hydrozoa

4. Which cnidarian group forms coral reefs?
 - a) Hydrozoa
 - b) Anthozoa
 - c) Scyphozoa
 - d) Cubozoa

Answer: b) Anthozoa

5. The free-swimming larva of cnidarians is:
 - a) Trochophore
 - b) Nauplius
 - c) Planula
 - d) Veliger

Answer: c) Planula

6. The body wall of cnidarians is made of:
 - a) One layer
 - b) Two layers and mesoglea
 - c) Three layers
 - d) Four layers

Answer: b) Two layers and mesoglea

7. Coral polyps get most of their nutrition from:
 - a) Small fishes
 - b) Seaweeds



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- c) Zooxanthellae
- d) Filter feeding

Answer: c) Zooxanthellae

8. Division of labor among polyps in Obelia is an example of:
- a) Polymorphism
 - b) Metamorphosis
 - c) Symbiosis
 - d) Parasitism

Answer: a) Polymorphism

9. Radial symmetry in cnidarians is an adaptation for:
- a) Burrowing
 - b) Sessile or slow-moving life
 - c) Fast swimming
 - d) Bilateral movement

Answer: b) Sessile or slow-moving life

10. The class of cnidarians that includes highly venomous box jellyfish is:
- a) Hydrozoa
 - b) Cubozoa
 - c) Anthozoa
 - d) Scyphozoa

Answer: b) Cubozoa

B. Short Answer Questions:

1. Define cnidocytes and mention their functions.
2. What is the role of mesoglea in cnidarians?
3. Differentiate between polyp and medusa forms.
4. Explain metagenesis with an example.
5. Describe the nervous system of cnidarians.
6. What is polymorphism in Hydrozoa?
7. Write a short note on planula larva.
8. Explain the ecological importance of coral reefs.

UNIT 2.2:

Platyhelminths



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2.2 Introduction to Helminths

Helminths are a diverse group of parasitic worms that have been affecting humans and animals for thousands of years. Unlike bacteria and protozoa, helminths are multicellular eukaryotic organisms belonging to the animal kingdom. They are invertebrates and have developed complex life cycles and specialized survival adaptations that allow them to live inside their hosts. These adaptations include nutrient absorption from the host, immune evasion strategies, and highly efficient reproductive systems.

The word *helminth* originates from the Greek term “helmins” meaning *worm*. Interestingly, “helminths” is not a formal taxonomic unit but rather a practical grouping of several unrelated worm-like parasites that share similar lifestyles. Helminths generally include:

- Nematodes (roundworms)
- Platyhelminthes (flatworms)
- Acanthocephalans (thorny-headed worms)

In this unit, we focus on the phylum Platyhelminthes (flatworms), one of the most important groups of helminths in medical, veterinary, and ecological contexts.

Phylum Platyhelminthes (Flatworms)

The Platyhelminthes are soft-bodied invertebrates with a dorsoventrally flattened body (flattened top to bottom). This unique structure allows gases and nutrients to diffuse directly across their body surface, since they lack circulatory and respiratory systems. Their simple body plan, though primitive, is highly successful in parasitism.

General Characteristics of Platyhelminthes



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- Bilaterally symmetrical, triploblastic animals
- Acoelomates (without a true body cavity)
- Dorsoventrally flattened body (increases surface area for diffusion)
- Possess a primitive nervous system with ganglia and nerve cords
- Excretion via flame cells (protonephridia) – important for osmoregulation
- Digestive system incomplete (no anus) in most; nutrients/waste expelled through the mouth
- High reproductive capacity; many are hermaphroditic
- In parasitic forms, tegument (outer covering) is modified for protection, nutrient absorption, and immune evasion

2.2.1 Classification of Platyhelminthes

Traditionally, the phylum is divided into four main classes:

1. Turbellaria – Mostly free-living flatworms such as planarians.
 - Habitat: Marine, freshwater, moist soil
 - Have ciliated epidermis for movement
 - Carnivorous, scavenging, and sometimes parasitic
 - About 4,500 species described
2. Monogenea – Ectoparasitic worms.
 - About 1,100 species
 - Found on gills, skin, and fins of fish; some infect amphibians and reptiles
 - Equipped with opisthaptor (posterior attachment organ) containing hooks/clamps



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- Usually have a direct life cycle (single host)
 - Cause problems in fish farming (aquaculture)
3. Trematoda (Flukes) – Endoparasitic worms.
- About 18,000 species
 - Require two or more hosts (complex life cycle)
 - Have oral and ventral suckers for attachment
 - Subclasses:
 - *Digenea* (medically important e.g., Schistosomes, Fasciola)
 - *Aspidogastrea* (less common)
4. Cestoda (Tapeworms) – Internal parasites of vertebrate intestines.
- About 5,000 species
 - Specialized body with scolex (head with hooks/suckers) and proglottids (segments)
 - No digestive system; absorb nutrients directly from host intestine
 - Examples: *Taenia solium*, *Taenia saginata*, *Echinococcus*

Modern Viewpoint: Molecular studies suggest that Monogenea, Trematoda, and Cestoda form a clade called Neodermata, united by their tegumental adaptations for parasitism. Meanwhile, Turbellaria is likely paraphyletic (not a true clade).



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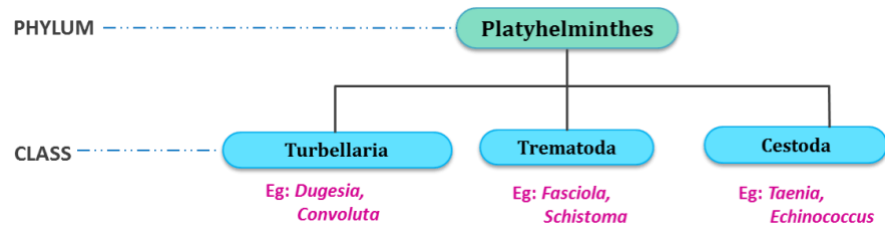


Fig2.5: Classification of Platyhelminths

2.2.2 General Features, Structure, Morphology, Life Cycle and Virulence of *Fasciola hepatica*

Among trematodes, *Fasciola hepatica* is one of the most important parasites, affecting both animals and humans.

Taxonomy

- Phylum: Platyhelminthes
- Class: Trematoda
- Subclass: Digenea
- Family: Fasciolidae

Distribution and Importance

- Found worldwide, especially in Europe, South America, Africa, and Asia
- Requires freshwater snails (family Lymnaeidae) as intermediate hosts
- Causes liver fluke disease (fascioliasis) in humans and livestock
- Major economic losses: reduced milk production, lower fertility, liver condemnation, and death in severe cases
- Estimated billions of dollars lost annually in livestock industries

Morphology of *Fasciola hepatica*



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- Shape: Leaf-like, dorsoventrally flattened
- Size: 2–3 cm long, 1–1.5 cm wide
- Anterior end: Oral cone with oral sucker for attachment and feeding
- Ventral sucker (acetabulum): Secondary attachment organ
- Tegument: Syncytial covering with spines and microvilli → immune evasion, nutrient absorption
- Digestive system: Mouth → muscular pharynx → short esophagus → branched intestine (blind-ending caeca, no anus)
- Excretion: Flame cells connected to excretory ducts and posterior pore
- Nervous system: Cerebral ganglia, nerve cords, and sensory papillae around suckers
- Reproductive system: Hermaphroditic, highly prolific – a single worm can lay up to 25,000 eggs per day

Life Cycle of Fasciola hepatica

The life cycle is digenetic (two hosts) and highly complex:

1. Egg stage: Released in feces of definitive host (sheep, cattle, humans). Eggs embryonate in freshwater.
2. Miracidium: Free-swimming ciliated larva infects a snail host.
3. Sporocyst: Sac-like stage inside snail, develops into rediae.
4. Rediae: Produce multiple cercariae (asexual multiplication).
5. Cercariae: Free-swimming larvae leave snail, encyst on aquatic vegetation.
6. Metacercariae: Encysted, infective stage; survive long periods on plants (e.g., watercress).



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7. Definitive host infection: Ingested with vegetation → excyst in duodenum → juvenile flukes migrate through liver tissue → mature in bile ducts → produce eggs → cycle repeats.

Prepatent period (egg to egg production): ~8–12 weeks.

Pathogenesis and Disease (Fascioliasis)

Fascioliasis has two clinical phases:

1. Acute phase (migratory stage):
 - Juvenile flukes burrow through the liver parenchyma
 - Cause tissue necrosis, hemorrhage, fever, abdominal pain
2. Chronic phase (biliary stage):
 - Adults live in bile ducts for years
 - Cause bile duct hyperplasia, cholangitis, fibrosis, anemia
 - In humans: weight loss, jaundice, digestive problems

Control and Treatment

- Drug of choice: Triclabendazole (TCBZ)
- Problem: Emerging drug resistance
- Other measures:
 - Control snail population (intermediate host)
 - Avoid eating raw aquatic plants (e.g., watercress)
 - Improve livestock management and drainage systems in pastures

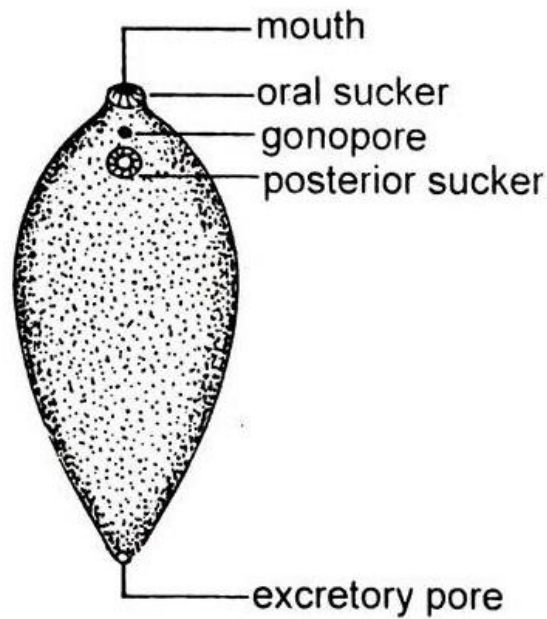


Fig2.6: Fasciola hepatica

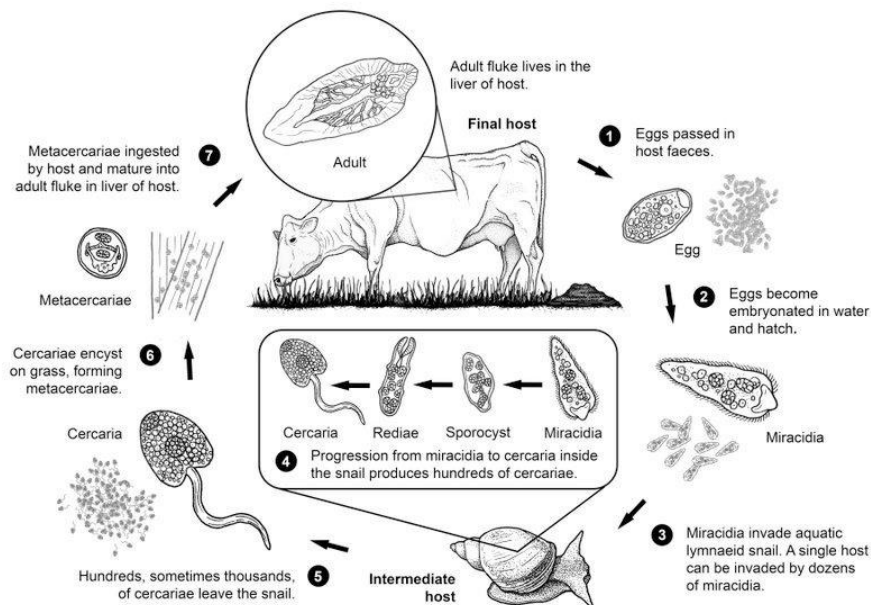


Fig2.7: life cycle of Fasciola



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Summary:

- Helminths are parasitic worms with high medical and veterinary importance.
- Platyhelminthes include free-living and parasitic flatworms.
- Major parasitic classes: Monogenea, Trematoda, Cestoda.
- Fasciola hepatica is a trematode responsible for fascioliasis.
- Its complex life cycle involves snails (intermediate host) and mammals (definitive host).
- Causes serious health and economic impacts.
- Control requires both chemotherapy and preventive strategies.

A. Multiple Choice Questions:

1. The term “helminth” is derived from the Greek word meaning:

- a) Flat
- b) Worm
- c) Parasite
- d) Snail

Answer: b) Worm

2. Which of the following classes of Platyhelminthes is mainly free-living?

- a) Trematoda
- b) Cestoda
- c) Monogenea
- d) Turbellaria

Answer: d) Turbellaria

3. The posterior attachment organ of Monogeneans is called:

- a) Scolex
- b) Acetabulum
- c) Opisthaptor



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d) Proglottid

Answer: c) Opisthaptor

4. Fasciola hepatica belongs to which subclass?

a) Digenea

b) Aspidogastrea

c) Turbellaria

d) Monogenea

Answer: a) Digenea

5. The infective stage of Fasciola hepatica for the definitive host is:

a) Miracidium

b) Sporocyst

c) Cercaria

d) Metacercaria

Answer: d) Metacercaria

6. In Fasciola hepatica, the organ used for attachment and feeding at the anterior end is:

a) Pharynx

b) Oral sucker

c) Flame cell

d) Ventral sucker

Answer: b) Oral sucker

7. Which freshwater snail genus commonly serves as an intermediate host for F. hepatica in Europe?

a) Planorbis

b) Galba (Lymnaea)

c) Biomphalaria

d) Bulinus

Answer: b) Galba (Lymnaea)

8. The excretory structures of Platyhelminthes are called:

a) Nephridia



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- b) Malpighian tubules
- c) Flame cells (protonephridia)
- d) Green glands

Answer: c) Flame cells (protonephridia)

9. A single adult Fasciola hepatica can produce approximately how many eggs per day?

- a) 1,000
- b) 5,000
- c) 25,000
- d) 100,000

Answer: c) 25,000

10. The main drug used against Fasciola hepatica infections is:

- a) Albendazole
- b) Praziquantel
- c) Triclabendazole
- d) Ivermectin

Answer: c) Triclabendazole

B. Short Answer Questions:

1. Define helminths. Mention the three major groups included under the term.
2. State three general features of Platyhelminthes.
3. Differentiate between Monogenea and Trematoda.
4. Name the intermediate and definitive hosts of Fasciola hepatica.
5. What is the function of flame cells in flatworms?



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Summary:

Coelenterata (Cnidaria):

Diploblastic, radially symmetrical, tissue-level organization, gastrovascular cavity with single opening, special cnidoblasts for defense & prey capture, body forms polyp & medusa, mostly aquatic. Examples: *Hydra*, *Jellyfish*, *Corals*.

Platyhelminthes (Flatworms):

Triploblastic, bilaterally symmetrical, acoelomate, dorsoventrally flattened, organ-level organization, excretion by flame cells, incomplete/absent digestive system, mostly hermaphroditic, many parasitic. Examples: *Planaria*, *Fasciola*, *Taenia*.

A. Multiple-Choice Questions (MCQs)

1. Which of the following is a characteristic feature of Coelenterates?

- a. Segmented body
- b. Radial symmetry
- c. Pseudocoelomate body
- d. Bilateral symmetry

Ans. b. Radial symmetry

2. Obelia belongs to which class of Coelenterates?

- a. Scyphozoa
- b. Anthozoa
- c. Hydrozoa
- d. Cubozoa

Ans. c. Hydrozoa

3. Which of the following is responsible for coral reef formation?

- a. Hydrozoa
- b. Anthozoa
- c. Ctenophora
- d. Platyhelminths



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Ans. b. Anthozoa

4. What is the primary mode of reproduction in Obelia?

- a. Binary fission
- b. Budding
- c. Parthenogenesis
- d. Sporulation

Ans. b. Budding

5. Fasciola hepatica belongs to which class?

- a. Cestoda
- b. Turbellaria
- c. Monogenea
- d. Trematoda

Ans. d. Trematoda

6. Which stage of Fasciola hepatica infects the intermediate host?

- a. Miracidium
- b. Cercaria
- c. Sporocyst
- d. Metacercaria

Ans. a. Miracidium

7. Which is the definitive host of Fasciola hepatica?

- a. Snail
- b. Fish
- c. Sheep
- d. Insect

Ans. c. Sheep

8. What type of symmetry do Platyhelminths exhibit?

- a. Radial symmetry
- b. Bilateral symmetry



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- c. Asymmetry
- d. None of the above

Ans. b. Bilateral symmetry

9. The excretory organ of Platyhelminths is:

- a. Nephridia
- b. Malpighian tubules
- c. Flame cells
- d. Kidneys

Ans. c. Flame cells

10. Coral reefs are mainly composed of:

- a. Silica
- b. Calcium carbonate
- c. Chitin
- d. Magnesium

Ans. b. Calcium carbonate

B.Short Answer Questions (SAQs)

1. Define Coelenterates with an example.
2. What are the key characteristics of Obelia?
3. Explain polymorphism in Hydrozoa.
4. What are the major components of a coral reef?
5. Differentiate between medusa and polyp forms in Coelenterates.
6. Name the intermediate and definitive hosts of Fasciola hepatica.
7. What are flame cells, and what is their function?
8. Explain the role of Fasciola hepatica in causing disease.
9. What is the significance of radial symmetry in Coelenterates?
10. Describe the structure of a planarian.

C. Long Answer Questions (LAQs)

1. Explain the classification, general characteristics, and structure of Coelenterates.



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2. Describe the morphology and life cycle of Obelia with a well-labeled diagram.
3. Discuss the phenomenon of polymorphism in Hydrozoa with suitable examples.
4. Explain the process of coral reef formation and its ecological importance.
5. Give a detailed account of the classification and general characteristics of Platyhelminths.
6. Describe the structure and life cycle of Fasciola hepatica with diagrams.
7. Explain the adaptations of parasitic Platyhelminths to their lifestyle.
8. Compare and contrast Coelenterates and Platyhelminths based on their body organization.
9. Discuss the economic and medical significance of Fasciola hepatica.

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MODULE 3

INVERTEBRATES III



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Objectives

1. To study the general characteristics and classification of Nematelminths and Annelida.
2. To analyze the morphology, life cycle, and pathogenicity of *Dracunculus medinensis*.
3. To understand parasitic adaptations in helminths and their impact on host organisms.
4. To examine the general characteristics and classification of Annelida with examples.
5. To study the structure, physiology, and adaptations of *Hirudinaria granulosa*.
6. To explore the evolutionary significance of the coelom and coelom ducts in Annelida.

UNIT 3.1:

Nematelminths

3.1 Introduction

Phylum Nematelminthes (commonly called roundworms) is one of the largest and most diverse groups of invertebrates. These worms are named after their thread-like, cylindrical bodies, which gave rise to the Greek-derived name:

- *nema* = thread
- *helmins* = worm

Roundworms are pseudocoelomates, meaning they have a body cavity (pseudocoel) not completely lined by mesoderm. They are found in nearly every ecosystem on Earth—from oceans and rivers to deserts, polar regions, and tropical forests. Many live freely in soil or water, while others are parasitic in plants and animals, including humans.



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This group is ecologically and economically important:

- Free-living nematodes participate in nutrient recycling.
- Parasitic nematodes cause human diseases (ascariasis, filariasis, trichinosis), animal diseases (in livestock and pets), and crop losses in agriculture.

3.1.1 General Characteristics

Roundworms share a basic body plan with several distinctive features:

1. Body Shape – Long, thin, cylindrical, and unsegmented. Body tapers at both ends.
2. Symmetry – Bilateral (left and right halves are mirror images).
3. Body Cavity – Pseudocoelom, which acts as a hydrostatic skeleton and helps in circulation, locomotion, and waste removal.
4. Body Size – Ranges from microscopic (< 1 mm) to giant forms like *Placentonema gigantissima* (> 8 m long).
5. Body Wall – Composed of:
 - Cuticle – Thick, non-living, flexible layer made of collagen. Protects against host's immune response in parasites; shed during molting.
 - Hypodermis – Secretes cuticle; contains longitudinal nerve cords and excretory canals.
 - Muscles – Only longitudinal muscles (unlike annelids which also have circular muscles). Movement is whip-like, not smooth.
6. Segmentation – Absent (unlike annelids).
7. Circulatory & Respiratory Systems – Absent. Exchange of gases and transport of nutrients occurs by diffusion.



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Digestive System

Roundworms have a complete digestive tract, meaning food enters through a mouth and exits through an anus.

- Mouth – Located anteriorly, often surrounded by lips or papillae (sensory structures). Some have teeth, stylets (needle-like organs), or spears to pierce tissues.
- Pharynx – Muscular, pumps food into the intestine. Acts like a suction pump.
- Intestine – Straight tube lined by columnar epithelial cells; absorbs nutrients.
- Anus – Located ventrally near the posterior end.

This complete digestive system allows continuous food intake, unlike flatworms which have an incomplete gut.

Excretory System

- Roundworms show great variety in their excretory structures.
- Most species have lateral canals that open to an excretory pore near the anterior end.
- In some, renette cells or an H-shaped canal system are present.
- Functions: Removal of nitrogenous waste (ammonia or urea) and osmoregulation

Nervous System and Sense Organs

The nervous system is simple but effective:

- Circumpharyngeal nerve ring around the pharynx acts like a primitive brain.
- Longitudinal nerve cords (dorsal, ventral, lateral) run through the body.

Sense organs include:



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- Papillae – Small tactile receptors near mouth and tail.
- Amphids – Chemoreceptors at the head region (important for finding host in parasites).
- Phasmids – Chemoreceptors at the tail (present in some species, absent in others).

These allow nematodes to detect chemicals, heat, and host signals.

Reproductive System

Reproduction in nematodes is highly developed.

- Sexes – Usually dioecious (separate male and female).
- Sexual Dimorphism – Males smaller than females, with curved tails and copulatory structures.
- Female Reproductive System – One or two ovaries → oviducts → uterus → vulva (genital pore).
- Male Reproductive System – Single testis → vas deferens → seminal vesicle → cloaca. Males have spicules (needle-like structures) for mating.
- Fertilization – Internal.
- Development – Mostly direct (without larval stage). Growth occurs through molting (ecdysis).

Nematodes show determinate cleavage (fate of each embryonic cell is fixed early).

The nematode *Caenorhabditis elegans* is a famous model organism used in genetics, developmental biology, and neuroscience research.

3.1.2 Classification of Nemathelminthes

Traditionally divided into two main classes: Adenophorea (Aphasmidia) and Secernentea (Phasmidia).



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A. Class Adenophorea (Aphasmidia)

- Mostly free-living (marine, freshwater, soil). Some parasitic.
- Key Features:
 - No phasmids.
 - Amphids complex and spiral-shaped.
 - Excretory system simple (ventral gland cell).
- Examples:
 - *Trichinella spiralis* – causes trichinosis.
 - *Mermis nigrescens* – insect parasite.
 - *Dorylaimus stagnalis* – free-living aquatic nematode.

Important Orders:

1. Enoplida – Marine predators with teeth and mandibles.
2. Mermithida – Insect parasites; adults are free-living, non-feeding.
3. Trichocephalida – Includes whipworm (*Trichuris trichiura*).

B. Class Secernentea (Phasmidia)

- Largest class; includes many important parasites.
- Key Features:
 - Phasmids present.
 - Amphids simple pore-like.
 - Well-developed H-shaped excretory system.
 - Esophagus with muscular bulb.
- Examples:
 - *Ascaris lumbricoides* – human roundworm.



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- *Wuchereria bancrofti* – causes filariasis (elephantiasis).
- *Meloidogyne incognita* – plant parasite (root-knot nematode).
- *Caenorhabditis elegans* – model organism.

Important Orders:

1. Rhabditida – Free-living & parasitic; includes *C. elegans*.
2. Strongylida – Blood-sucking parasites in vertebrates (*Haemonchus contortus*).
3. Ascaridida – Large intestinal parasites (*Ascaris*).
4. Spirurida – Tissue parasites; many transmitted by arthropod vectors (*Wuchereria*).
5. Tylenchida – Plant parasites with stylets (root-knot & cyst nematodes).

Economic and Ecological Importance

A. Beneficial Roles

- Soil health – Free-living nematodes recycle organic matter, release nutrients, and regulate microbial populations.
- Food chains – Serve as prey for small invertebrates and play a role in aquatic ecosystems.
- Model organisms – *C. elegans* is widely studied in science.

B. Harmful Roles

1. Human diseases:
 - Ascariasis (*Ascaris lumbricoides*).
 - Filariasis/elephantiasis (*Wuchereria bancrofti*).
 - Trichinosis (*Trichinella spiralis*).
 - Whipworm infection (*Trichuris trichiura*).



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2. Animal parasites:

- Blood parasites in cattle and sheep (*Haemonchus contortus*).
- Parasites in poultry, pets, and wild animals.

3. Plant parasites:

- Root-knot nematodes (*Meloidogyne*).
- Cyst nematodes (*Heterodera*, *Globodera*).
- Cause billions of dollars of crop losses annually.

Modern Classification (Molecular Approach)

Recent genetic studies suggest that the old division into Adenophorea and Secernentea does not reflect true evolutionary relationships. Instead, nematodes may be grouped into five major clades:

1. Dorylaimia
2. Enoplia
3. Spirurina
4. Tylenchina
5. Rhabditina

This classification is based on molecular data but is still under debate.

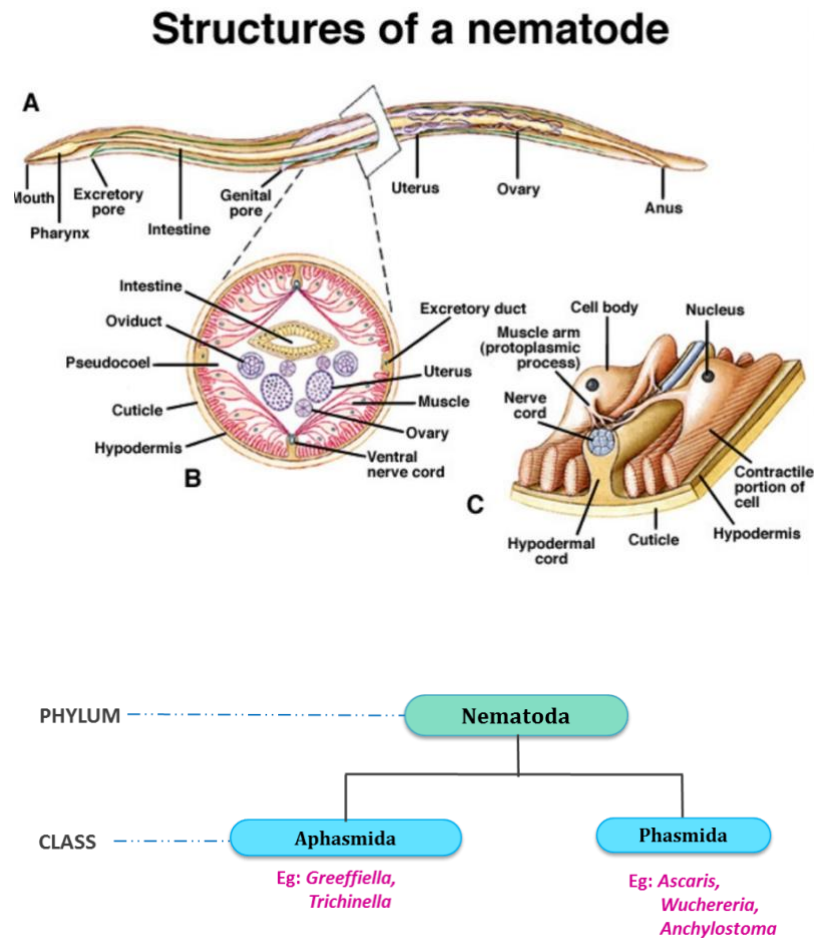


Fig3.1: structure and classification of nematode

Summary

- Nematelminthes (roundworms) are thread-like, unsegmented, bilaterally symmetrical worms.
- They are pseudocoelomates with a complete digestive system and only longitudinal muscles.
- Nervous system is simple, with amphids and phasmids as sensory structures.
- Most are dioecious, with internal fertilization and direct development.
- Classification: Adenophorea (aphasmdia) and Secernentea (phasmdia).



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- They are ecologically important but many are serious parasites of humans, animals, and plants.
- Modern molecular research proposes five clades for classification.

A. Multiple Choice Questions (MCQs)

1. The body cavity of nematodes is:

- a) A true coelom
- b) Pseudocoelom
- c) Hemocoel
- d) Absent

Answer: b) Pseudocoelom

2. The outer covering of nematodes is called:

- a) Cuticle
- b) Peritoneum
- c) Chitin
- d) Epidermis

Answer: a) Cuticle

3. Movement in nematodes is whip-like because they have:

- a) Only circular muscles
- b) Only longitudinal muscles
- c) Both circular and longitudinal muscles
- d) No muscles

Answer: b) Only longitudinal muscles

4. The excretory organs of nematodes are usually:

- a) Malpighian tubules
- b) Green glands
- c) Lateral canals and renette cells
- d) Flame cells

Answer: c) Lateral canals and renette cells

5. Amphids are present in the:

- a) Tail region
- b) Anterior (head) region
- c) Mid-body region
- d) Posterior gut

Answer: b) Anterior (head) region

6. The largest roundworm parasite in humans is:

- a) Wuchereria bancrofti
- b) Trichinella spiralis
- c) Ascaris lumbricoides
- d) Enterobius vermicularis

Answer: c) Ascaris lumbricoides



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7. Which nematode causes lymphatic filariasis (elephantiasis)?

- a) *Haemonchus contortus*
- b) *Trichuris trichiura*
- c) *Wuchereria bancrofti*
- d) *Ancylostoma duodenale*

Answer: c) *Wuchereria bancrofti*

8. Which nematode is widely used as a model organism in genetics and developmental biology?

- a) *Ascaris lumbricoides*
- b) *Trichinella spiralis*
- c) *Caenorhabditis elegans*
- d) *Enterobius vermicularis*

Answer: c) *Caenorhabditis elegans*

9. Plant-parasitic nematodes that use a stylet to feed are found in the order:

- a) Spirurida
- b) Tylenchida
- c) Rhabditida
- d) Ascaridida

Answer: b) Tylenchida

10. The whipworm (*Trichuris trichiura*) belongs to which order?

- a) Mermithida
- b) Strongylida
- c) Trichocephalida
- d) Enoplida

Answer: c) Trichocephalida

B. Short Answer Question:

1. Mention four general characteristics of phylum Nematelminthes.
2. Differentiate between Adenophorea and Secernentea.
3. What is the function of the cuticle in nematodes?
4. What is the role of amphids and phasmids in nematodes?
5. Write short notes on the reproductive system of nematodes.
6. Give two examples of human parasitic nematodes and the diseases they cause.

UNIT 3.2:

A Unique Perspective on *Dracunculus medinensis*: Helminth Adaptations



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3.2 Introduction

One of the most fascinating examples of parasitic helminths is *Dracunculus medinensis*, commonly known as the Guinea worm. This parasite has been infecting humans for thousands of years, even earning references in historical texts and possibly inspiring the medical symbol of the Rod of Asclepius. Female worms can grow more than one metre in length, making them among the largest tissue-dwelling nematodes in humans. The study of *D. medinensis* provides valuable insight into the clever biological adaptations that allow helminths to survive, reproduce, and spread in hostile host environments.

Taxonomy and Historical Relevance

D. medinensis belongs to the phylum Nematoda, a diverse group of roundworms found across nearly every habitat on Earth. Unlike many nematodes, this species has evolved as an obligatory parasite with a complex life cycle involving both humans (definitive host) and copepods (intermediate host). Its name is derived from Latin, where *dracunculus* means “little dragon” and *medinensis* refers to Medina, a historical hotspot of infection. While cases have dropped dramatically from about 3.5 million in the 1980s to very few in recent years, this worm remains an important case study due to its remarkable parasitic adaptations.

Life Cycle and Host Transmission

The life cycle of *D. medinensis* begins when humans drink water containing copepods infected with its larvae. Once inside the digestive system, the copepods are destroyed, releasing the larvae, which migrate through the intestinal wall into connective tissues. Over the course of a year, they mature into adult worms. After mating, the male dies and is absorbed by the host, while the female migrates towards the skin, usually in the lower limbs.

To ensure transmission, the female worm causes blister formation that bursts painfully when exposed to water. At this point, she releases hundreds of thousands of larvae into the water, which are then consumed by copepods. The larvae develop into infective stages inside these tiny crustaceans, thus completing the cycle. This process is an extraordinary example of host behavioral manipulation, as the worm essentially “forces” its human host to enter water to relieve pain, enabling parasite transmission.



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Morphological Adaptations

The body of *D. medinensis* shows extreme specialization for reproduction. In females, most of the internal cavity is occupied by the uterus, which can hold millions of embryos. The worm's cuticle (outer covering) is highly resistant to the human immune system, allowing survival for years inside tissues. It also possesses sensory structures at its tail end that detect contact with water, triggering the release of larvae. These features highlight how morphology has been shaped by evolutionary pressures to maximize survival and reproduction.

Immunological and Biochemical Adaptations

The Guinea worm is also adapted to evade the host's immune system. By releasing specific molecules, it can suppress or divert immune responses, creating a protective environment for its development. Additionally, it produces enzymes that help digest host tissues during migration, making movement easier. The parasite has even developed unique biochemical pathways suited for low-oxygen conditions deep within human tissues. Furthermore, blister formation is chemically induced by the worm, showing how it uses pharmacological "tricks" to manipulate host physiology.

Reproductive Strategies

Sexual dimorphism is highly pronounced in this species: females are much larger than males, reflecting their heavy investment in egg production. This is an example of an *r-selected strategy*, where organisms produce vast numbers of offspring to ensure that at least some survive the difficult transmission cycle. The timing of larval release is also adapted to seasonal patterns, maximizing chances of continuation. Such strategies illustrate how natural selection has shaped the reproductive biology of parasitic helminths.

3.2.1 Broader Helminth Adaptations

Although *D. medinensis* is a unique example, similar adaptations can be found across other helminth groups such as tapeworms (cestodes), flukes (trematodes), and thorny-headed worms (acanthocephalans). These groups have independently evolved parasitism, often developing specialized structures for attachment (hooks, suckers, proboscides), protective body coverings (teguments or cuticles), and simplified or altered digestive systems. Some absorb nutrients directly from the host's body fluids, while others retain specialized mouthparts for feeding. Across all helminths, reproductive adaptations are striking—ranging from hermaphroditism to high fecundity—ensuring survival despite harsh transmission challenges.

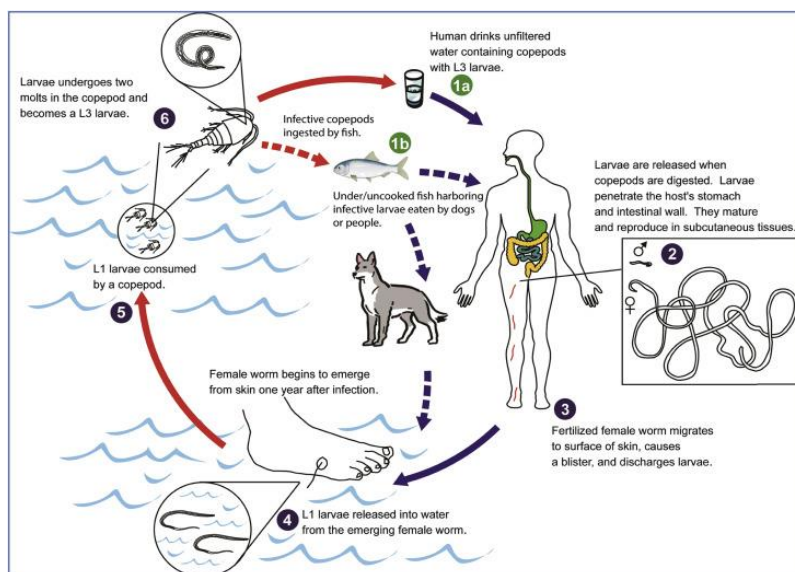


Fig3.2: Life cycle of *D. medinensis*

Conclusion

The study of *Dracunculus medinensis* highlights the incredible evolutionary creativity of helminths. Its life cycle, morphology, immunological tricks, and reproductive strategies all reveal how parasitic organisms adapt to survive within hosts. Beyond this single species, helminths as a group demonstrate convergent solutions to the fundamental challenges of parasitism: entering a host, avoiding immune attack, reproducing successfully, and ensuring transmission to the next host. Understanding these adaptations not only deepens our knowledge of parasitology but also sheds light on the long history of coevolution between parasites and their human hosts.

A. Multiple Choice Questions (MCQs)

- The common name of *Dracunculus medinensis* is:
 - Pinworm
 - Hookworm
 - Guinea worm
 - Threadworm
- The intermediate host of *D. medinensis* is:
 - Mosquito
 - Copepod
 - Freshwater snail
 - Blackfly
- What is the primary adaptation of the female Guinea worm that ensures transmission?



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- a) Formation of resistant cysts
 - b) Causing a painful blister that bursts in water
 - c) Production of anticoagulants in blood
 - d) Hermaphroditic reproduction
4. The cuticle of *D. medinensis* primarily helps in:
- a) Oxygen absorption
 - b) Evading host immune response
 - c) Breaking down host tissues
 - d) Nutrient storage
5. The extreme difference in size between male and female Guinea worms is an example of:
- a) Asexual reproduction
 - b) Sexual dimorphism
 - c) Hermaphroditism
 - d) Metamorphosis
6. Which term best describes the reproductive strategy of *D. medinensis* (producing millions of offspring to ensure survival)?
- a) K-selection
 - b) r-selection
 - c) Opportunistic reproduction
 - d) Iteroparity
7. Which specialized structure helps the female worm detect water and release larvae?
- a) Oral suckers
 - b) Mechanoreceptors in the tail
 - c) Proboscis spines
 - d) Tegumental pores

Answer Key for MCQs

- 1. c) Guinea worm
- 2. b) Copepod
- 3. b) Causing a painful blister that bursts in water
- 4. b) Evading host immune response
- 5. b) Sexual dimorphism
- 6. b) r-selection
- 7. b) Mechanoreceptors in the tail

Short Answer Questions:

1. Explain the significance of the name *Dracunculus medinensis*.
2. How does *D. medinensis* manipulate host behavior to complete its life cycle?
3. What role do copepods play in the transmission of Guinea worm disease?
4. Describe the immunological adaptations of *D. medinensis*.
5. State one morphological adaptation in female worms and explain its importance.



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UNIT 3.3

Annelida

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3.3 Introduction

The term *Annelida* comes from the Latin word *annellus*, meaning “little ring.” This name refers to the ring-like body segments that make annelids unique. Segmentation, also called *metamerism*, is a key evolutionary feature of annelids. It gives them many advantages such as better movement, more surface area for gas exchange, and the possibility of having specialized body regions.

Annelids are found in many environments and play an important role in ecosystems. They help in soil formation, nutrient recycling, and are a part of food chains in both land and water habitats. Their body cavity is a true *coelom*—a fluid-filled space lined with mesoderm—that works as a *hydrostatic skeleton*. With the help of circular and longitudinal muscles, this structure allows smooth and efficient movement. The coelomic fluid also helps in transporting nutrients, removing wastes, and providing a safe environment for gametes (sex cells) to mature.

Body Structure and Segmentation

The annelid body is made of repeating segments (metameres). This is called *homonomous segmentation*, where each segment contains similar organs such as parts of the nervous system, excretory system, and reproductive structures.

Externally, the segmentation is visible as rings called *annuli*. Internally, thin walls called *septa* divide the coelom into compartments. However, in some annelids, septa are reduced or absent.

At the front end, annelids have a distinct head region (*prostomium*), a mouth-bearing segment (*peristomium*), and at the rear, a terminal segment (*pygidium*). Segments are added one by one from a growth zone during development.



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The body wall has several layers: a thin epidermis covered by a protective cuticle, circular and longitudinal muscles, and the inner peritoneum lining the coelom. Terrestrial forms produce mucus that keeps their body moist, which helps in both movement and respiration.

Chaetae and Locomotion

Most annelids have bristle-like structures called *chaetae* or *setae* made of chitin-like proteins. These are important for anchoring the body during movement. Chaetae vary in number, shape, and arrangement, and are used for classification.

In polychaetes (marine annelids), chaetae are found on lateral extensions called *parapodia*. These help in locomotion and sometimes in respiration. Different annelids show different movement styles like crawling, burrowing, or swimming, depending on their habitat.

Digestive System

Annelids have a complete digestive system with a mouth and anus. The alimentary canal is a straight tube with specialized regions: mouth, pharynx, esophagus, crop, gizzard, intestine, and anus.

- The *pharynx* may act like a proboscis in predatory worms.
- The *gizzard* grinds food with the help of mineral particles.
- The intestine often has a fold called a *typhlosole* that increases the surface area for absorption.

Feeding behavior varies widely: earthworms are detritivores, some polychaetes filter food from water, while others are active predators.

Circulatory and Respiratory System



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Annelids have a closed circulatory system, meaning blood stays within vessels. There are dorsal and ventral vessels connected by lateral branches in each segment. The dorsal vessel acts like a pumping heart, moving blood forward. Blood often contains respiratory pigments like hemoglobin that carry oxygen efficiently.

Respiration takes place through the skin, parapodia, or specialized gills, depending on the species.

Excretory System

Excretion and osmoregulation are carried out by *metanephridia*, which occur in most body segments. Each metanephridium has:

- A ciliated funnel (*nephrostome*) opening into the coelom.
- A coiled tubule for reabsorption.
- An external pore (*nephridiopore*) that releases wastes.

This system works much like kidneys in higher animals. Some aquatic annelids also have *protonephridia* with flame cells during larval stages.

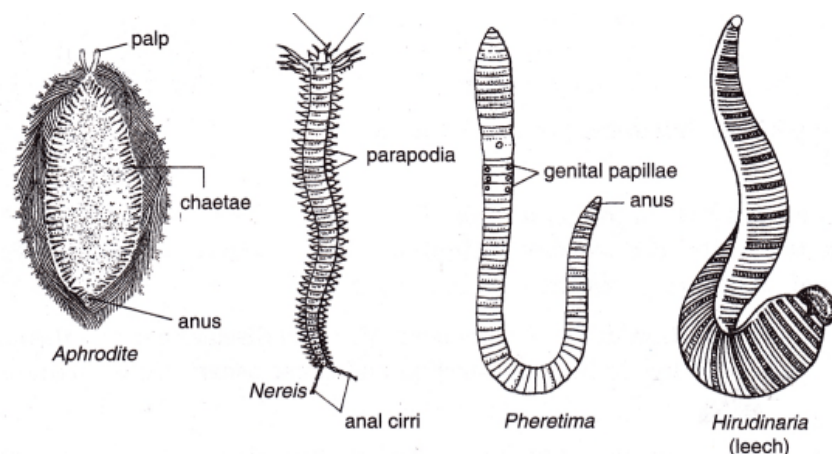


Fig3.3: Some examples of Annelida

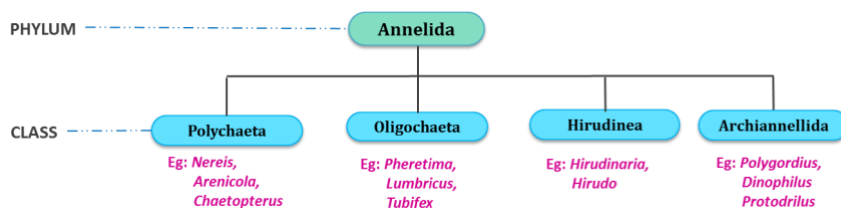


Fig3.4: Classification of Annelida

Nervous System and Sense Organs

The nervous system includes:

- A dorsal brain or *cerebral ganglion*.
- Connectives that loop around the pharynx.
- A ventral nerve cord with ganglia in each segment.

This arrangement allows coordination of the whole body while giving some independence to individual segments.

Sense organs include touch receptors, light-sensitive eyespots or eyes, chemical sensors, and balance organs (statocysts). Many polychaetes have well-developed sensory appendages like palps, antennae, and tentacles.

Reproduction and Development

Annelids reproduce both sexually and asexually.

- **Asexual reproduction** occurs by fragmentation or budding.
- **Sexual reproduction** varies: polychaetes usually have separate sexes, while oligochaetes (earthworms) and leeches are mostly hermaphrodites.

Aquatic species often release gametes into water, while terrestrial forms usually have internal fertilization. Development may involve a free-swimming *trochophore larva*, a feature that links annelids with other related phyla.



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Annelids also have great regenerative ability, being able to regrow lost segments.

3.3.1 Classes of Annelida

1. **Polychaeta** – Mostly marine worms with many chaetae and parapodia. They often have a well-developed head with eyes and tentacles. Examples: *Nereis* (clamworm), *Arenicola* (lugworm), *Sabella* (feather duster worm).
2. **Oligochaeta** – Includes earthworms and freshwater worms. They have fewer chaetae, no parapodia, and a simple head. They play a key role in soil fertility. Example: *Lumbricus terrestris* (earthworm).
3. **Hirudinea (Leeches)** – Mostly freshwater or terrestrial. They are flattened, have suckers for attachment, reduced chaetae, and are often parasitic or predatory.

Ecological and Evolutionary Significance

Annelids are vital to ecosystems. Earthworms improve soil structure and fertility. Marine polychaetes play a role in nutrient cycling and sediment turnover. Leeches, though parasitic, are important in regulating host populations and have medical applications (e.g., in blood circulation therapies).

Overall, the segmented body plan, coelom, and adaptive features make annelids an evolutionary success and one of the most important animal groups in both aquatic and terrestrial ecosystems.

Summary:

Annelids are segmented worms whose name comes from *annellus* (little ring). Their bodies show *metamerism* (segmentation), which gives advantages in movement, respiration, and specialization of organs. They



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have a true coelom acting as a hydrostatic skeleton, a closed circulatory system, paired nephridia for excretion, and a ventral nerve cord for coordination.

Most annelids have *chaetae* (bristles) for locomotion; in polychaetes, these are carried on *parapodia*. They have a complete digestive system with specialized parts like pharynx, crop, gizzard, and typhlosole. Respiration happens through skin, parapodia, or gills.

Reproduction is both sexual and asexual, with trochophore larvae in many marine species. The three main classes are:

- **Polychaeta** (marine worms with many chaetae and parapodia)
- **Oligochaeta** (earthworms with few chaetae and no parapodia)
- **Hirudinea** (leeches, mostly parasitic with suckers).

Annelids play crucial ecological roles in soil fertility, nutrient cycling, and aquatic food chains, making them an evolutionary success.

A. Multiple Choice Questions (MCQs)

1. The term *Annelida* is derived from the Latin word meaning:

- a) Little worm
- b) Little ring
- c) Jointed legs
- d) Soft body

Answer: b) Little ring

2. The body cavity of annelids is:

- a) Acoelomate
- b) Pseudocoelomate
- c) True coelomate
- d) Haemocoel

Answer: c) True coelomate



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3. The hydrostatic skeleton in annelids works by the action of:

- a) Circular and longitudinal muscles
- b) Exoskeleton and appendages
- c) Bones and muscles
- d) Muscles and chitinous cuticle

Answer: a) Circular and longitudinal muscles

4. Chaetae or setae in annelids are made of:

- a) Chitin
- b) Cellulose
- c) Keratin
- d) Collagen fibers

Answer: a) Chitin

5. The larval form common in polychaetes is called:

- a) Nauplius
- b) Planula
- c) Trochophore
- d) Miracidium

Answer: c) Trochophore

B. Short Answer Question:

1. Explain the evolutionary importance of segmentation (metamerism) in annelids.
2. Describe the structure and function of the hydrostatic skeleton in annelids.
3. Compare the morphological features of Polychaeta, Oligochaeta, and Hirudinea with suitable examples.
4. Discuss the role of chaetae (setae) in locomotion and classification of annelids.
5. Give an account of the digestive system of annelids with special reference to adaptations in earthworms.



Unit 3.4:

Type study: *Hirudinaria granulosa*

3.4 Introduction

Hirudinaria granulosa, commonly called the Indian cattle leech, belongs to the phylum **Annelida** and the class **Hirudinea**. It is an important freshwater species found in India, known for both its ecological role and its use in traditional medicine. This leech shows adaptations for a parasitic lifestyle, yet it still retains some basic annelid features that help us understand evolutionary changes in the group. Because of its importance in medicine, ecology, and anatomy, *H. granulosa* has been studied widely.

External Structure and Adaptations

The body of *H. granulosa* is soft, flattened from top to bottom (dorsoventrally flattened), and usually **5–10 cm long** when relaxed. It can stretch much longer while feeding. The body is divided into six regions: anterior sucker, head region, clitellar region, middle region, posterior region, and posterior sucker.

- The **anterior sucker** surrounds the mouth and has three jaws with many tiny teeth. These jaws cut the skin of the host and make a **Y-shaped wound** for blood feeding.
- The **posterior sucker** is larger and stronger, mainly used for attachment while moving or resting.
- The body surface is covered with many small rings (annuli). Although there are about 100 external rings, the leech has only 33 true internal segments.
- The dorsal side is olive-green to brown with stripes and spots, while the ventral side is yellowish or reddish-orange. This **countershading** acts as camouflage.



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The body wall has four layers: a thin cuticle, mucus-secreting epidermis, pigmented connective tissue, and strong muscles. These muscles (circular, diagonal, and longitudinal) help in both **swimming and crawling** movements.

Digestive System

The leech is a **blood-sucking parasite**. Its digestive system is highly adapted for this:

- The **mouth** leads into a muscular pharynx with salivary glands that produce **hirudin**, a natural anticoagulant that prevents the host's blood from clotting.
- The pharynx opens into a short esophagus that leads to the **crop**, the largest storage organ. The crop has 11 pairs of side pouches (caeca) that can hold large amounts of blood. A single meal can last for months.
- After the crop, blood passes into a small stomach and then into the intestine where actual digestion occurs.
- The process is helped by **symbiotic bacteria (Aeromonas hydrophila)**, which break down blood proteins and provide vitamins.

Circulatory and Respiratory Systems

Unlike other annelids with a true closed circulatory system, *H. granulosa* has a modified system made of **blood vessels and body sinuses**. The blood contains **hemoglobin dissolved in plasma**, which helps the leech survive even in low-oxygen water.

There are no special respiratory organs. Instead, **gas exchange occurs through the moist skin**, which is richly supplied with blood vessels. The leech can also switch to **anaerobic respiration** when oxygen is scarce.



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Excretory System

Excretion is carried out by **17 pairs of metanephridia** located in body segments 7–23. These structures remove nitrogenous waste (mainly ammonia, partly urea) and help maintain the **water and salt balance**. This is especially important because the leech lives in freshwater, where water continuously enters its body by osmosis.

Nervous and Sensory System

The nervous system is well-developed and consists of:

- A **brain (suprapharyngeal ganglia)** above the pharynx.
- A **ventral nerve cord** with 21 ganglia that control different segments.
- Sensory structures such as tactile receptors, chemical sensors, temperature sensors, and **10 pairs of simple eyes (ocelli)** that can detect light intensity.

These adaptations help the leech locate warm-blooded hosts, respond to threats, and move effectively.

Reproductive System

H. granulosa is a **hermaphrodite**, meaning each individual has both male and female organs.

- The **male system** has nine pairs of testes connected to ducts leading to a penis, which opens through a male gonopore.
- The **female system** has a pair of ovaries, each with an oviduct opening into a vagina, which exits through a female gonopore just behind the male opening.



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- Reproduction occurs by **cross-fertilization**. Two leeches exchange sperm through spermatophores.
- Fertilized eggs are enclosed in a **cocoon** secreted by the clitellum. Development is direct, meaning young leeches hatch as miniature adults with no larval stage.

Behaviour and Locomotion

Leeches show two main types of movement:

- **Swimming**, by producing wave-like contractions.
- **Crawling**, using their anterior and posterior suckers alternately like an inchworm.

They respond strongly to **chemical and thermal signals** from hosts. Feeding is regulated by signals from the expanding crop, which prevents overfeeding. When threatened, leeches contract quickly, secrete excess mucus, or detach and swim away. They also show simple learning behaviours such as **habituation** (ignoring harmless repeated stimuli) and **sensitization** (increased response to repeated harmful stimuli).

3.4.1 Ecological and Economic Importance

H. granulosa plays an important role in freshwater ecosystems:

- As a **parasite**, it feeds on the blood of cattle, buffalo, amphibians, fish, and sometimes humans.
- It also serves as **prey** for fish, birds, and amphibians, helping in the food chain.
- In **traditional medicine (Ayurveda and Unani)**, leeches have been used for centuries in blood-letting and treatment of diseases. Modern research has focused on **hirudin** and other saliva compounds for their medical potential as anticoagulants and anti-inflammatory agents.

However, leeches may also spread blood-borne diseases and cause severe blood loss in livestock. Over-collection for medical use and destruction of habitats are causing declines in their populations, though they are still fairly common in suitable freshwater habitats.

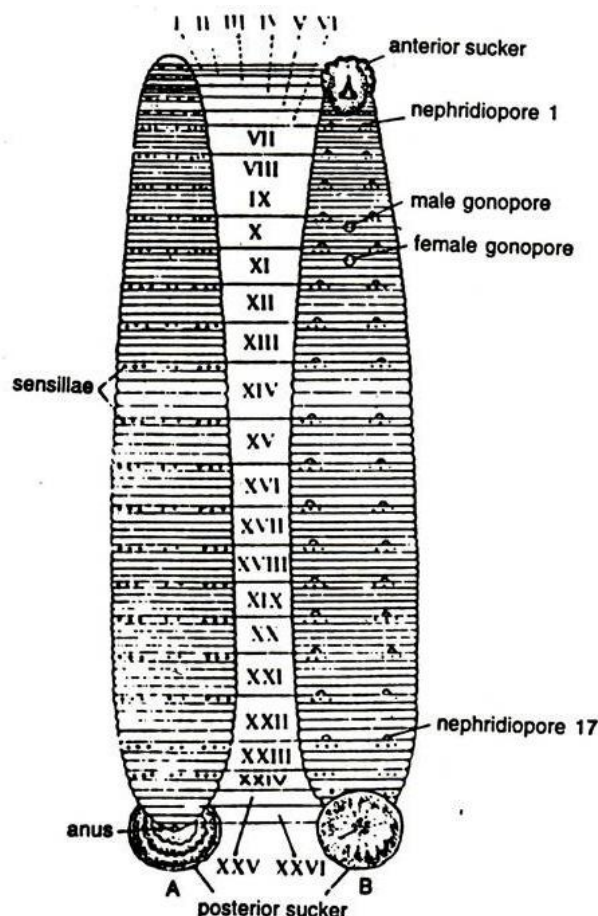


Fig3.5: Leech

Summary

Hirudinaria granulosa (Indian cattle leech) is a freshwater parasite of the class **Hirudinea**. Its body is flat, segmented externally into ~100 rings, with **anterior and posterior suckers** for feeding and attachment. The anterior sucker has **three jaws with teeth** that make a Y-shaped wound.

The digestive system is adapted for **blood-sucking**, with a large **crop** for storage, salivary glands secreting **hirudin** (anticoagulant), and **symbiotic**



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bacteria aiding digestion. Circulation occurs through blood sinuses with hemoglobin in plasma, and **respiration takes place through the moist skin**.

Excretion is by **17 pairs of nephridia**. The nervous system includes a brain, ventral nerve cord, and sensory organs such as **ocelli and thermoreceptors**. Reproduction is **hermaphroditic with cross-fertilization**, and eggs develop in a **cocoon secreted by the clitellum**.

Ecologically, the leech is both a **parasite and prey**, while economically, it is used in **traditional medicine (hirudotherapy)** and modern pharmacology but can also cause harm to livestock.

A. Multiple Choice Questions:

1. *Hirudinaria granulosa* belongs to the class:

- a) Polychaeta
- b) Hirudinea
- c) Oligochaeta
- d) Crustacea

Answer: b) Hirudinea

2. The anticoagulant secreted by the salivary glands of leeches is:

- a) Heparin
- b) Hirudin
- c) Hemoglobin
- d) Histamine

Answer: b) Hirudin

3. The anterior sucker of *H. granulosa* bears:

- a) One jaw
- b) Two jaws
- c) Three jaws
- d) No jaws

Answer: c) Three jaws

4. The number of true segments in *H. granulosa* is:

- a) 50



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- b) 33
- c) 100
- d) 17

Answer: b) 33

5. Symbiotic bacteria in the gut of *H. granulosa* mainly help in:

- a) Respiration
- b) Excretion
- c) Digestion of blood proteins
- d) Reproduction

Answer: c) Digestion of blood proteins

6. The excretory organs of leeches are:

- a) Malpighian tubules
- b) Nephridia
- c) Flame cells
- d) Green glands

Answer: b) Nephridia

7. The cocoon in leeches is secreted by:

- a) Epidermis
- b) Clitellum
- c) Crop
- d) Botryoidal tissue

Answer: b) Clitellum

8. The locomotion in leeches occurs by:

- a) Pseudopodia
- b) Cilia
- c) Suckers and muscles
- d) Flagella

Answer: c) Suckers and muscles

B. Short Answer Questions

1. Describe the external features of *Hirudinaria granulosa*.
2. What is the role of hirudin in leeches?



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3. How does respiration occur in leeches?
4. Explain the function of the crop in the digestive system.
5. Write a short note on the nervous system of *H. granulosa*.

SUMMARY:

Nemathelminthes (Nematoda) are unsegmented, cylindrical worms with a pseudocoelom. Their body is covered by a cuticle, has only longitudinal muscles, and shows thrashing movement. They have a complete digestive tract but lack circulatory and respiratory systems, relying on diffusion. Excretion occurs through renette cells or canals. They are mostly dioecious, with internal fertilization and direct development. Many are parasitic, e.g., *Ascaris* and *Wuchereria*.

Annelida, in contrast, are true coelomates with a segmented body (metamerism). They have a body wall with muscles and sometimes setae/parapodia for locomotion. Digestive system is complete and specialized. They possess a closed circulatory system, with respiration through skin or gills. Excretion occurs via nephridia. The nervous system has a brain and ventral nerve cord. Most are hermaphroditic (earthworms), while some are dioecious (polychaetes). They play key roles in soil fertility, medicine (leeches), and aquatic ecosystems.

A. Multiple-Choice Questions (MCQs)

1. What is the body symmetry of Nemathelminths?

- a. Radial symmetry
- b. Bilateral symmetry
- c. Asymmetry
- d. None of the above

Ans. b. Bilateral symmetry



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2. Which of the following is an example of a parasitic nematode?

- a. *Ascaris lumbricoides*
- b. *Hirudinaria granulosa*
- c. *Nereis*
- d. *Amoeba proteus*

Ans. a. *Ascaris lumbricoides*

3. *Dracunculus medinensis* is commonly known as:

- a. Guinea worm
- b. Hookworm
- c. Liver fluke
- d. Tapeworm

Ans. a. Guinea worm

4. Which characteristic is unique to Annelida?

- a. Pseudocoelom
- b. Segmentation
- c. Chitinous exoskeleton
- d. Radial symmetry

Ans. b. Segmentation

5. *Hirudinaria granulosa* belongs to which class of Annelida?

- a. Polychaeta
- b. Oligochaeta
- c. Hirudinea
- d. Turbellaria

Ans. c. Hirudinea

6. What is the function of the coelom in Annelida?

- a. Digestion
- b. Circulation and locomotion
- c. Photosynthesis



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- d. None of the above

Ans. b. Circulation and locomotion

7. The mode of transmission of *Dracunculus medinensis* occurs through:

- a. Contaminated soil
- b. Mosquito bite
- c. Contaminated water containing copepods
- d. Airborne particles

Ans. c. Contaminated water containing copepods

8. Which of the following is a feature of parasitic helminths?

- a. Presence of a complete digestive system
- b. High reproductive capacity
- c. Well-developed sense organs
- d. Free-living nature

Ans. b. High reproductive capacity

9. The anticoagulant secreted by *Hirudinaria granulosa* is called:

- a. Heparin
- b. Hirudin
- c. Fibrinogen
- d. Thrombin

Ans. b. Hirudin

10. What type of circulatory system is present in Annelida?

- a. Open circulatory system
- b. Closed circulatory system
- c. No circulatory system
- d. Water vascular system

Ans. b. Closed circulatory system



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B. Short Answer Questions (SAQs)

1. Define Nematelminths and give an example.
2. What are the general characteristics of *Dracunculus medinensis*?
3. How do parasitic nematodes adapt to their environment?
4. What are the distinguishing features of Annelida?
5. Classify Annelida up to classes with suitable examples.
6. Explain the role of *Hirudinaria granulosa* in medicine.
7. What is the significance of the coelom in annelids?
8. Differentiate between free-living and parasitic nematodes.
9. How does *Dracunculus medinensis* infect humans?
10. What are the functions of the coelomic fluid in Annelida?

C. Long Answer Questions (LAQs)

1. Describe the classification, general characteristics, and adaptations of Nematelminths.
2. Explain the morphology, life cycle, and pathogenicity of *Dracunculus medinensis*.
3. Discuss the different types of parasitic adaptations in helminths with examples.
4. Explain the classification and general features of Annelida with representative examples.
5. Describe the structure, physiology, and ecological significance of *Hirudinaria granulosa*.
6. Discuss the evolutionary significance of the coelom and coelom ducts in annelids.
7. Compare and contrast Nematelminths and Annelida based on structural and functional features.
8. Explain the role of segmentation in the movement and function of Annelida.
9. Describe the economic importance of annelids with reference to soil fertility and medicine.

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MODULE 4

INVERTEBRATE IV

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Objectives

1. To study the general characteristics and classification of Arthropoda and Mollusca.
2. To analyze the morphology, structure, and adaptations of prawn (type study).
3. To understand the structure and function of mouthparts in different insect groups.
4. To examine the structural features and affinities of Peripatus and its evolutionary significance.
5. To study the morphology and structure of Pila (type study).
6. To explore the process of pearl formation in mollusks.
7. To understand the concepts of torsion and detorsion in gastropods and their evolutionary importance.

UNIT 4.1

Arthropoda

4.1 Introduction

More than 80 percent of all known animal species are arthropods, making them the largest and most diverse phylum in the animal kingdom. They inhabit nearly every environment on Earth, ranging from the ocean depths and polar regions to mountain summits and dense rainforests. Their evolutionary success is linked to a unique body design featuring segmentation, jointed appendages, and a chitinous exoskeleton.

Origin of the Name and Body Segmentation

The term *Arthropoda* comes from the Greek words *arthron* (joint) and *podos* (foot), highlighting their jointed limbs. Arthropods show metameric segmentation, often arranged into functional regions called tagmata—for



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example, the head, thorax, and abdomen of insects, or the cephalothorax and abdomen of arachnids. This regional specialization allowed the group to undergo vast adaptive radiation. Their coelom is reduced in adults and replaced by a hemocoel, which supports an open circulatory system where hemolymph directly bathes internal organs.

Exoskeleton and Molting

The most distinctive feature of arthropods is the exoskeleton or cuticle, mainly composed of chitin and, in crustaceans, reinforced with calcium salts. It protects the body, prevents water loss, and acts as a point of muscle attachment. However, since the rigid skeleton restricts growth, arthropods undergo molting (ecdysis)—a hormone-regulated process of shedding the old cuticle and secreting a larger one. While essential for growth, this phase leaves them vulnerable and requires significant energy investment. Jointed appendages evolved alongside this adaptation, serving functions such as locomotion, feeding, sensing, reproduction, and defense.

Nervous and Sensory Systems

Arthropods possess a highly developed nervous system, allowing advanced behaviors and sensory responses. Their organs include compound eyes, simple eyes (ocelli), statocysts, chemoreceptors, and mechanoreceptors that detect vibrations, touch, and fluid movement. Many arthropods, especially insects, communicate through chemical, visual, and sound signals.

Respiration, Digestion, and Excretion

Respiratory structures vary across groups: insects use tracheae, arachnids possess book lungs, horseshoe crabs have book gills, and crustaceans use specialized gills. The digestive system is complete, with mouth, foregut, midgut, hindgut, and anus. Feeding involves specialized appendages such as mandibles, maxillae, or chelicerae, depending on diet type (predatory, detritivorous, or filter-feeding). Excretion is managed by Malpighian tubules in terrestrial forms and antennal/maxillary glands in aquatic crustaceans, helping maintain water balance and eliminate nitrogenous



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wastes. The circulatory system is open, with a dorsal heart pumping hemolymph, which carries hemocytes involved in defense, repair, and nutrient transport.

Reproduction and Development

Most arthropods are dioecious with internal fertilization, though parthenogenesis is present in some groups. Courtship and parental care behaviors can be complex. Development may be direct or indirect, with metamorphosis producing distinct larval and adult forms. This developmental flexibility enables arthropods to occupy diverse ecological niches during their life cycle.

Diversity and Social Organization

Arthropods vary enormously in size, from microscopic mites less than 0.1 mm long to giant Japanese spider crabs with a leg span of 4 meters. Social organization ranges from solitary lifestyles to the highly complex eusocial systems of ants, bees, termites, and certain wasps. These societies exhibit division of labor, caste systems, communication networks, and cooperative behaviors, serving as models for scientific and technological studies.

Ecological and Evolutionary Importance

Arthropods are vital to ecosystems, contributing to pollination, seed dispersal, soil aeration, nutrient cycling, and population control of other organisms. They dominate biodiversity, accounting for about 85% of described animal species. Fossils reveal their presence since the Cambrian period, over 500 million years ago, and their survival through multiple mass extinctions highlights their resilience and adaptability.

ARTHROPODS

PHYLUM: **ARTHROPODA**

Four subphyla and some of their representative members

Subphylum : Chelicerata



Sea Spiders



Horseshoe Crabs



Harvestmen



Mites



Scorpions



Spiders

Subphylum : Hexapoda



Insects



Springtails

Subphylum : Crustacea



Seed Shrimps



Mystacocaridans



Fish Lice



Barnacles



Calanoids



Cyclopoids



Mantis Shrimps



Crabs



Lobsters



Horseshoe Shrimps



Water Fleas



Remipedes

Subphylum : Myriapoda



Pseudoscorpion



Bristle millipedes



Hexameroceratans



Pill millipedes



Scutigermorphs



Scolopendromorphs

Fig4.1 : Examples of Arthropoda



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4.1.1 Phylum Arthropoda – Classification up to Classes with Examples

The phylum **Arthropoda** is the largest and most diverse group in the animal kingdom, making up over 80% of all known animal species. They are found in almost every habitat on Earth, from the deepest oceans to the highest mountains. Arthropods share some common features such as a segmented body, jointed legs, and a hard exoskeleton made of chitin. Scientists have studied their evolutionary relationships for many decades, and with the help of modern molecular biology, the classification of arthropods has been revised. Below is a simplified explanation of their main subphyla and classes with examples.

Subphylum Chelicerata

Chelicerates are unique because they do not have antennae or mandibles. Instead, they possess **chelicerae**, which are claw-like or fang-like appendages used for feeding. Their bodies are divided into two main regions: the **prosoma** (or cephalothorax) and the **opisthosoma** (abdomen). The prosoma usually carries six pairs of appendages, including walking legs, pedipalps, and chelicerae. Members of this group are mostly terrestrial but also include marine forms.

Class Merostomata (Horseshoe Crabs)

Horseshoe crabs are often called “**living fossils**” because they have changed very little over millions of years. They have a hard, horseshoe-shaped shell, a long tail spine called a **telson**, and breathe with book gills. They are marine animals found in shallow seas and are ecologically and medically important. For example, the species **Limulus polyphemus** has blood that is used in medical testing for bacterial contamination.

Class Arachnida (Spiders, Scorpions, Ticks, and Mites)

Arachnids are mostly land-dwelling animals with four pairs of legs and no antennae. Their bodies are divided into a cephalothorax and abdomen. They are usually predators, using their fangs or claws to inject venom or digestive enzymes into prey. This class includes:

- **Scorpions** such as *Androctonus* and *Pandinus*, which have venomous stingers.
- **Spiders** like *Latrodectus* (black widow) and *Araneus* (orb-weaver), which spin silk for webs.
- **Harvestmen** (*Phalangium*) that have long legs and a fused body.
- **Ticks and mites** (*Sarcoptes*, *Dermacentor*) that are small, parasitic, or free-living.



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Other lesser-known arachnids include pseudoscorpions, whip spiders, and sun spiders.

Class Pycnogonida (Sea Spiders)

Sea spiders are marine chelicerates with long legs and very small bodies. They feed on soft-bodied invertebrates such as sponges and cnidarians. Males have special legs called **ovigers** for carrying eggs. Examples include *Nymphon* and *Colossendeis*.

Subphylum Crustacea

Crustaceans are mostly aquatic arthropods and are easily recognized by their **two pairs of antennae** and **biramous (two-branched) legs**. They usually have a hard shell strengthened with calcium carbonate and breathe through gills. Their body is divided into a **cephalothorax** (often covered by a carapace) and an abdomen.

Class Branchiopoda (Fairy Shrimps, Water Fleas)

Branchiopods are freshwater animals with flattened leaf-like appendages used for swimming and breathing. Some produce resting eggs that can survive harsh conditions. Examples are *Daphnia* (water flea), *Artemia* (brine shrimp), and *Triops* (tadpole shrimp).

Class Maxillopoda (Barnacles and Copepods)

This class contains very diverse animals. Barnacles are sessile (fixed to surfaces) and enclosed in a calcareous shell, while copepods are tiny free-swimming creatures that are extremely abundant in oceans. Examples include *Balanus* (acorn barnacle), *Lepas* (goose barnacle), and *Calanus* (copepod).

Class Ostracoda (Seed Shrimps)

Ostracods are very small crustaceans with a body enclosed in a bivalve-like shell. They are found in both freshwater and marine environments and have a rich fossil record. Examples include *Cypridopsis* and *Gigantocypris*.

Class Malacostraca (Crabs, Lobsters, Shrimps, Krill)

This is the largest class of crustaceans, including familiar animals such as crabs, prawns, and lobsters. They typically have 19–20 body segments, often with the head and thorax fused into a cephalothorax. Examples include:

- **Decapods** (*Homarus* – lobster, *Penaeus* – prawn, crabs).
- **Isopods** (*Armadillidium* – pill bug).
- **Amphipods** (*Gammarus* – scuds).
- **Krill** (*Euphausia superba*).



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Subphylum Myriapoda

Myriapods are land-dwelling arthropods with elongated bodies made of many similar segments, each bearing one or two pairs of legs. They have one pair of antennae and breathe through tracheae.

Class Chilopoda (Centipedes)

Centipedes are fast-moving predators with a flattened body. Each body segment has one pair of legs, and the first pair is modified into poison claws called **forcipules** for capturing prey. Examples include *Scolopendra* and *Lithobius*.

Subphylum Hexapoda (Insects and Allies)

This subphylum includes insects, the most diverse and successful group of arthropods. They have three main body regions: **head, thorax, and abdomen**. The thorax usually bears three pairs of legs and (in most species) two pairs of wings. Insects have adapted to almost every ecological niche.

Insect Mouthparts – A Key Adaptation

The mouthparts of insects are highly modified to suit their feeding habits. They are made of several components such as mandibles, maxillae, labium, labrum, and hypopharynx.

- **Chewing type:** Seen in grasshoppers and beetles, where strong mandibles cut and grind food.
- **Piercing-sucking type:** Found in mosquitoes and true bugs, with needle-like stylets to suck blood or plant sap.
- **Siphoning type:** Butterflies and moths have a long coiled proboscis to suck nectar.
- **Chewing-lapping type:** Bees use mandibles for cutting and a tongue-like structure for collecting nectar.

These adaptations have made insects the most successful arthropods, able to exploit a wide variety of food sources.



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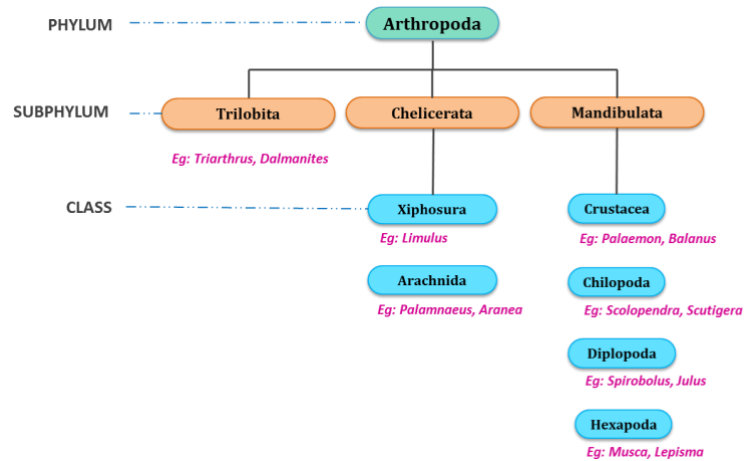


Fig4.2: Classification of Arthropoda

SUMMARY:

Phylum **Arthropoda** is the largest and most diverse animal phylum, with jointed appendages, segmented bodies, and a chitinous exoskeleton. Arthropods are classified into major subphyla:

- **Chelicerata** – no antennae, first pair of appendages are chelicerae. Classes include *Merostomata* (horseshoe crabs), *Arachnida* (spiders, scorpions, ticks, mites), and *Pycnogonida* (sea spiders).
- **Crustacea** – mostly aquatic, with two pairs of antennae and biramous appendages. Classes include *Branchiopoda*, *Maxillopoda*, *Ostracoda*, and *Malacostraca* (crabs, prawns, lobsters).
- **Myriapoda** – terrestrial, many body segments with one or two pairs of legs per segment. Example class: *Chilopoda* (centipedes).
- **Hexapoda (Insects)** – body divided into head, thorax, and abdomen with three pairs of legs and (usually) wings. Their mouthparts are highly adapted for chewing, sucking, piercing, lapping, or siphoning.

A. Multiple Choice Questions:

1. Which of the following is NOT a characteristic of Arthropoda?

- a) Jointed appendages
- b) Exoskeleton made of chitin
- c) Notochord
- d) Segmented body

Answer: c) Notochord



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2. Horseshoe crabs belong to which class?

- a) Arachnida
- b) Merostomata
- c) Maxillopoda
- d) Malacostraca

Answer: b) Merostomata

3. The respiratory structures in spiders are called:

- a) Book lungs
- b) Book gills
- c) Tracheoles
- d) Malpighian tubules

Answer: a) Book lungs

4. Which class of Crustacea includes crabs, lobsters, and prawns?

- a) Ostracoda
- b) Maxillopoda
- c) Malacostraca
- d) Branchiopoda

Answer: c) Malacostraca

5. The first pair of appendages in centipedes (Chilopoda) is modified into:

- a) Mandibles
- b) Antennae
- c) Poison claws (forcipules)
- d) Palps

Answer: c) Poison claws (forcipules)

6. Which insect has siphoning type mouthparts?

- a) Mosquito
- b) Butterfly
- c) Grasshopper
- d) Honeybee

Answer: b) Butterfly

B.Short Answer Questions

1. Write two general characteristics of Arthropoda.
2. Name two differences between Chelicerata and Crustacea.
3. Give examples of organisms belonging to Class Arachnida.
4. What are the functions of insect mouthparts?
5. Why are horseshoe crabs called “living fossils”?



UNIT 4.2

Peripatus: An Intriguing Link Between Two Major Branches of Evolution

4.2 Introduction

Peripatus, commonly called **velvet worms**, are among the most interesting but less understood animals in evolutionary biology. They live mostly in tropical and subtropical regions. Their body shows a **mixture of traits from both annelids (segmented worms) and arthropods (insects, spiders, crabs)**. Because of this, Peripatus is often considered a “**living link**” that helps us understand how different groups of animals evolved.

Body Structure

Peripatus has a **soft, elongated body** that is usually 15 to 150 mm long. Its skin looks velvety because it is covered with small bumps called **papillae**. These papillae help in sensing the environment and also in breathing. Unlike arthropods, they do not have a hard exoskeleton. Their body structure resembles what early ancestors of arthropods might have looked like, making them an important model for studying evolution.

Locomotion (Movement)

Unlike arthropods, Peripatus does not have **jointed legs**. Instead, it moves with the help of a **hydrostatic mechanism**, which means its body muscles and internal fluid work together to produce movement. The legs are **short, stubby, and paired**, with sticky pads at their ends. These pads help the animal crawl on different surfaces in the forest floor. This style of walking is considered an **intermediate stage** between simple crawling worms and advanced walking arthropods.



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Respiration

Peripatus does not have specialized organs like gills or lungs. Instead, it breathes through a **network of small tubes** (tracheae-like structures) spread across the body. These tubes directly carry oxygen to body tissues. This is a **transitional type of respiration**, which shows an evolutionary step between simpler and more advanced systems.

Reproduction

Most species of Peripatus are **viviparous**, which means the young ones are born alive instead of hatching from eggs. The mother provides nutrients to the developing embryo through structures similar to a **placenta**. This advanced reproductive strategy is rare among invertebrates and indicates a higher level of evolutionary adaptation.

Feeding and Predatory Behavior

Peripatus are predators. They have a unique way of catching prey: they **squirt a sticky fluid** from special papillae near their mouth to trap small insects and other arthropods. Once the prey is immobilized, Peripatus feeds on it. This combination of **chemical and mechanical capture** is an effective hunting method and shows how early animals developed specialized feeding strategies.

Sensory Organs

Even though Peripatus looks simple, it has surprisingly **well-developed sensory abilities**. Its skin papillae contain sensory structures that detect touch, chemicals, and possibly even weak environmental signals. This helps Peripatus locate prey and respond to changes in its surroundings.

Habitat and Ecology



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Peripatus is found mainly in **damp, shady areas** like forest floors, soil, rotting wood, or leaf litter. They require **moist habitats** because their body can dry out easily. This ecological preference reflects both their evolutionary past and their physiological needs.

Evolutionary Importance

Peripatus belongs to the phylum **Onychophora**. Traditionally, it was seen as a “missing link” between annelids and arthropods. Modern molecular studies show that while it is related to arthropods, it also has many unique features that place it in a **separate evolutionary line**. Its genetic makeup helps scientists understand how early animals evolved complex traits like locomotion, respiration, and reproduction.

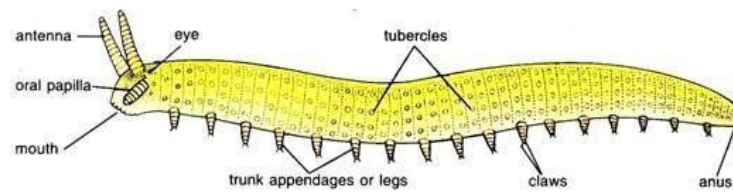


Fig4.3: Peripatus

Summary

Peripatus is not just a taxonomic curiosity. It represents a **living evolutionary museum**, showing features that lie between two major groups of animals. By studying Peripatus, scientists gain important insights into the **transition from simple worms to advanced arthropods**. For students of biology, Peripatus is a perfect example of how living organisms preserve the story of evolution within their bodies.

A. Multiple Choice Questions:

1. Peripatus belongs to which phylum?
 - a) Annelida
 - b) Onychophora
 - c) Arthropoda



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d) Mollusca

Answer: b) Onychophora

2. The body of Peripatus is covered with:

a) Scales

b) Chitinous plates

c) Papillae

d) Feathers

Answer: c) Papillae

3. Peripatus moves by:

a) Jointed legs

b) Hydrostatic mechanism and unjointed legs

c) Flagella

d) Cilia

Answer: b) Hydrostatic mechanism and unjointed legs

4. Most Peripatus species reproduce by:

a) Oviparity (egg laying)

b) Budding

c) Viviparity (live birth)

d) External fertilization

Answer: c) Viviparity (live birth)

5. Peripatus captures its prey by:

a) Poisonous bite

b) Sticky slime secretion

c) Crushing with jaws

d) Swallowing whole

Answer: b) Sticky slime secretion

B. Short Answer Questions:

1. Why is Peripatus considered a “living link” between annelids and arthropods?



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2. Describe the habitat preferences of Peripatus.
3. Write a short note on the locomotion of Peripatus.
4. Explain how Peripatus reproduces.
5. Mention two features of Peripatus that resemble annelids and two that resemble arthropods.

UNIT 4.3:

Mollusca



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4.3 Introduction

Mollusca is one of the most successful and diverse phyla in the animal kingdom, second only to Arthropoda in terms of species number. Scientists have described nearly **85,000–100,000 living species**, along with around **70,000 fossil species**. The word *Mollusca* comes from the Latin *molluscus*, meaning “soft,” referring to their soft, unsegmented body. Molluscs have adapted to **a wide range of habitats**. Most are marine, but many live in **freshwater** and some have colonized **terrestrial ecosystems**. They can be found everywhere—from **deep-sea trenches** to **high mountain streams**, and even intertidal zones where they survive harsh environmental conditions. This ability to live in such varied habitats makes them one of the most successful animal groups.

General Body Plan and Mantle

Despite their diversity, all molluscs share a common **body plan**, which has three main parts:

1. **Visceral Mass** – contains most of the internal organs such as heart, digestive organs, kidneys, and gonads.
2. **Muscular Foot** – used for movement, burrowing, attachment, or modified into arms and tentacles (as in cephalopods).
3. **Mantle** – a special tissue layer that covers the visceral mass and often secretes the shell.

The **mantle cavity** is a major evolutionary innovation in molluscs. It houses respiratory organs (gills or lungs) and also plays a role in **excretion and reproduction**. Essentially, it connects the external environment with the body, providing a protected chamber for important physiological functions.



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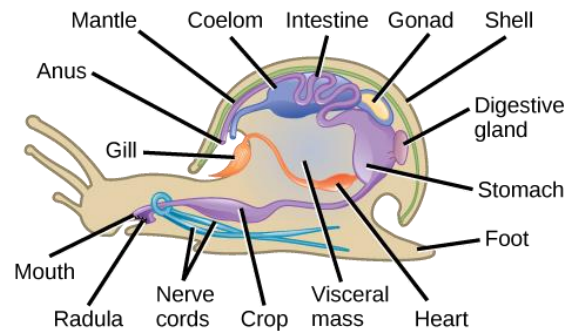


Fig4.4: Body plan of Mollusca

Shell Structure and Locomotion

The **shell** is a well-known feature of molluscs, although in some groups (slugs, octopuses) it is reduced or absent. When present, it is secreted by the mantle and is made of **calcium carbonate crystals and conchiolin** (a protein matrix). Molluscan shells are usually built in three layers:

- **Periostracum** – the thin outer organic layer that resists acids and prevents shell dissolution.
- **Prismatic layer** – made of calcium carbonate crystals arranged vertically.
- **Nacreous layer** – smooth inner “mother-of-pearl” layer, often iridescent.

Shells serve as **protection against predators, mechanical support, and prevention of water loss**. Their shapes vary greatly, from simple caps to coiled spirals and chambered structures, reflecting ecological adaptations.

The **foot** shows evolutionary diversity. In chitons and gastropods, it is a flat surface used for crawling. In bivalves, it is adapted for digging into sediments. In cephalopods, the foot is transformed into **arms, tentacles, and a funnel** for jet propulsion. This demonstrates how a single basic organ has been modified for different lifestyles.



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Digestive System and Feeding

Molluscs have a **complete digestive system**, with specialization according to diet.

- A unique feeding organ, the **radula**, is present in most classes. It is a chitinous ribbon-like structure with rows of teeth used for scraping algae, cutting plant matter, or tearing flesh. The radula rests on a **cartilaginous support (odontophore)** and is operated by strong protractor and retractor muscles.
- The **shape and arrangement of radular teeth** vary between herbivores, carnivores, and parasites. For example, cone snails have a modified radula that works as a venomous harpoon to capture prey.
- Bivalves, which are filter-feeders, have completely lost the radula. They use **gills (ctenidia)** lined with cilia to trap and transport food particles.

The digestive tract usually consists of a **buccal cavity, esophagus, stomach, digestive gland (hepatopancreas), intestine, and rectum**. The hepatopancreas functions in **enzyme secretion, nutrient absorption, and storage of food reserves**.

Circulatory and Excretory Systems

Most molluscs possess an **open circulatory system**, in which blood (called hemolymph) is not confined to vessels but flows into open spaces called **hemocoel**. The **heart**, usually located in the pericardial cavity, has **one ventricle and one or more atria**.

- Primitive molluscs generally have two atria, but some advanced groups have only one.



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- The respiratory pigment is usually **hemocyanin** (copper-based, giving blood a bluish color), though a few species possess **hemoglobin**.

Cephalopods are an exception—they have a **closed circulatory system**, where blood is entirely contained within vessels. This provides efficient oxygen delivery needed for their **active predatory lifestyle**.

Excretion is carried out by **metanephridia (kidneys)**. These are paired tubular structures that filter wastes from hemolymph and release them into the mantle cavity. In species living in varying salinity conditions, metanephridia also help with **osmoregulation** (regulating salt and water balance).

Nervous System and Sense Organs

The nervous system of molluscs varies widely among classes:

- In primitive forms like chitons, it consists of a **nerve ring** with simple ganglia and nerve cords.
- In gastropods, there is greater **cephalization** (concentration of nerve cells in the head).
- In cephalopods, the nervous system is **highly advanced**, with a complex brain divided into lobes, enclosed in a cartilaginous cranium. Their intelligence is comparable to some vertebrates, with abilities such as learning, memory, and problem-solving.

Sensory organs include:

- **Statocysts** – balance organs that detect orientation.
- **Osphradia** – chemosensory structures that test water quality.
- **Eyes** – range from simple light-sensitive pits to advanced **camera-type eyes** in cephalopods, which evolved independently but resemble vertebrate eyes.



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- **Chromatophores** in cephalopods allow them to change skin color for camouflage, communication, or signaling.

Reproduction and Development

Molluscs show a wide range of reproductive strategies:

- Most are **dioecious** (separate sexes), though many gastropods are hermaphroditic.
- Fertilization may be **external** (common in marine species) or **internal** (common in terrestrial and some freshwater species).
- Some species show simple spawning, while others display **complex courtship behaviors** and parental care.

Development may be **direct** (juveniles resemble adults) or involve **larval stages**. The most typical larva is the **trochophore**, which is shared with some other invertebrates, suggesting evolutionary relationships. In many molluscs, the trochophore develops into a **veliger larva**, which bears ciliated lobes for swimming and initial shell formation. These larvae are important for dispersal and colonization of new habitats.

4.3.1 Major Classes of Mollusca

1. **Monoplacophora** – Deep-sea molluscs with simple cap-like shells and repeated organs, once thought extinct.
2. **Polyplacophora (Chitons)** – Marine animals with eight dorsal plates, clinging tightly to rocks in intertidal zones.
3. **Gastropoda** – Largest class (snails, slugs). Characterized by **torsion**, where the body twists during development. Show diverse feeding habits from herbivory to predation.



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4. **Bivalvia** – Clams, oysters, mussels, scallops. Possess two hinged shells, lack radula, and feed by filtering water. Some form reefs and others burrow into sand.
5. **Scaphopoda (Tusk Shells)** – Tubular, burrowing molluscs with tentacle-like **captacula** for capturing small prey.
6. **Cephalopoda** – Octopuses, squids, cuttlefish, nautilus. Possess closed circulation, advanced brain, camera-type eyes, and highly modified foot into tentacles and funnel. Known for intelligence and complex behavior.
7. **Aplacophora** – Worm-like, deep-sea molluscs lacking shells, covered in spicules. Thought to represent primitive or simplified forms.

Ecological Importance

Molluscs are **ecologically vital organisms**.

- **Bivalves** such as oysters and mussels form reefs that provide habitat, filter water, and stabilize ecosystems.
- **Gastropods** act as grazers, controlling algae and plant growth, shaping the structure of ecosystems.
- **Cephalopods** are active predators, feeding on fish and crustaceans, while also serving as prey for whales, seals, and large fishes—making them central to marine food webs.
- The shells and burrowing activities of molluscs modify physical environments, making them **ecosystem engineers**.
- Their **larval stages** are important in plankton communities, influencing nutrient cycling and energy transfer in oceans.

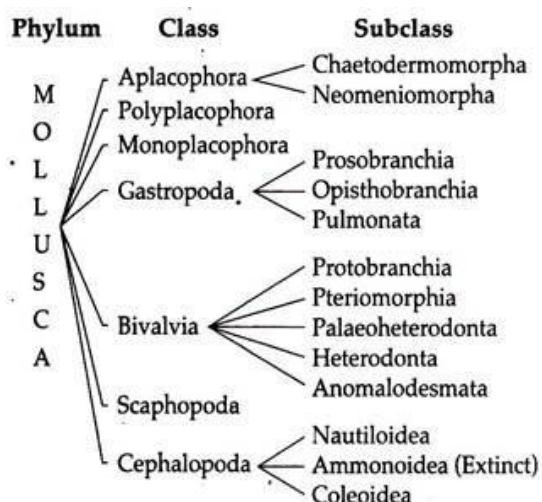


Fig 4.5: Classification of Mollusca

4.3.2 Mollusca: *Pila* as an Example

Introduction to Mollusca and *Pila*

The phylum **Mollusca** is one of the most diverse groups in the animal kingdom, second only to Arthropoda in terms of species richness. Mollusks include familiar animals such as snails, slugs, clams, mussels, oysters, octopuses, and squids. They are soft-bodied, bilaterally symmetrical, triploblastic coelomates that usually possess a calcareous shell. Among mollusks, the class **Gastropoda** is the largest and most diverse, comprising over 60,000 described species. Gastropods are characterized by the presence of a coiled shell, torsion during development, and the use of a radula as a feeding organ.

Pila, commonly called the **apple snail**, is an important example of a freshwater gastropod. It belongs to the family **Ampullariidae** and is widely distributed in tropical and subtropical regions of Asia, Africa, and the Americas. These snails thrive in rivers, ponds, lakes, rice fields, and even irrigation canals. The ability of *Pila* to survive both in water and on land for short periods makes it an excellent example of amphibious adaptation among mollusks. Because of its wide distribution and unique structural features, *Pila* is often chosen for detailed study in zoology courses.



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Taxonomic Position of *Pila*

The scientific classification of *Pila* is as follows:

- **Kingdom:** Animalia
- **Phylum:** Mollusca
- **Class:** Gastropoda
- **Order:** Architaenioglossa
- **Family:** Ampullariidae
- **Genus:** *Pila*

This classification places *Pila* in the phylum Mollusca, which is known for its soft body, mantle, radula, and muscular foot. Within gastropods, *Pila* is part of a primitive order (Architaenioglossa) that retains both **gills and lungs** for dual respiration. This feature highlights its evolutionary significance as a bridge between aquatic and terrestrial adaptations in mollusks.

External Morphology

The **external structure** of *Pila* reflects its adaptation to freshwater life. The most prominent feature is its **spirally coiled shell**, which is thick, strong, and globular in shape. This shell acts as a protective covering for the soft body. The shell has several distinct regions:

- **Apex:** The pointed tip of the shell, representing the earliest growth.
- **Whorls:** The coiled spirals of the shell, increasing in size as the animal grows.
- **Body Whorl:** The largest and last whorl, which houses most of the soft body.
- **Aperture:** The large opening through which the animal protrudes its head and foot.

- **Operculum:** A horny or calcareous disc attached to the foot, which closes the aperture when the animal withdraws, protecting it from desiccation and predators.

Shell coloration varies from olive green to brown, often with wavy or mottled patterns that provide **camouflage in aquatic vegetation**. Growth lines or ridges on the shell surface indicate stages of shell deposition. Adult shells may reach 10–15 cm in diameter, making *Pila* one of the larger freshwater snails.

The soft body of *Pila* is bilaterally symmetrical but appears asymmetrical externally due to **torsion**. It consists of three main regions:

1. **Head-foot:** Contains the mouth, tentacles, eyes, and muscular foot used for locomotion.
2. **Visceral mass:** Located inside the shell, housing digestive, excretory, and reproductive organs.
3. **Mantle:** A thin fold of tissue covering the visceral mass, responsible for secreting shell material and forming respiratory structures.

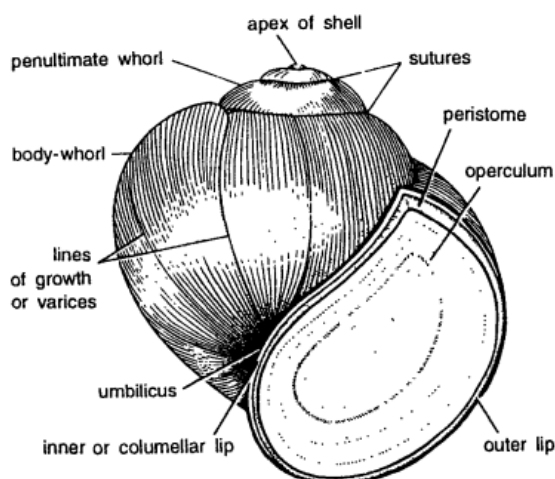


Fig 4.6: Structure of Pila



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Internal Anatomy and Physiological Systems

Digestive System

The digestive system of *Pila* is well adapted for a **herbivorous diet**, mainly consisting of aquatic vegetation and algae.

- **Mouth:** Contains the radula, a ribbon-like chitinous structure with rows of minute teeth used for scraping plant matter.
- **Buccal cavity and salivary glands:** Begin mechanical and chemical digestion.
- **Esophagus:** Transfers food to the stomach.
- **Stomach and Intestine:** Complete digestion and absorption of food.
- **Hepatopancreas:** A large gland functioning both as a liver (storing nutrients) and a pancreas (secreting digestive enzymes).

The radula is one of the most important feeding adaptations of mollusks. It acts like a **rasping file**, scraping algae off stones and aquatic plants, enabling *Pila* to utilize resources in freshwater ecosystems effectively.

Respiratory System

The respiratory system of *Pila* demonstrates its **dual ability to respire in water and air**.

- In water, *Pila* uses a **ctenidium (gill)** located in the mantle cavity to extract oxygen from water.
- In air, a **pulmonary sac (lung)** functions as a vascularized chamber, absorbing oxygen directly from the atmosphere.

This adaptation allows *Pila* to survive in oxygen-deficient waters and even make temporary excursions on land. When water becomes stagnant and oxygen-poor, the snail rises to the surface and extends a **siphon-like tube** to inhale air into the lung.



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Circulatory System

Pila possesses an **open circulatory system**, typical of most mollusks.

- A **two-chambered heart** (one auricle and one ventricle) pumps hemolymph into open spaces (sinuses) within the body.
- Hemolymph bathes tissues directly before returning to the heart through venous channels.
- Instead of hemoglobin, *Pila* has **hemocyanin**, a copper-based respiratory pigment that gives its blood a bluish color and transports oxygen efficiently.

This relatively simple circulatory design is sufficient for the low metabolic demands of the snail.

Nervous System

The nervous system of *Pila* is moderately developed compared to other gastropods. It consists of **interconnected ganglia**:

- **Cerebral ganglia**: Control sensory organs and coordination.
- **Pedal ganglia**: Regulate foot movement and locomotion.
- **Visceral ganglia**: Manage internal organs such as the heart, kidney, and gonads.

These ganglia are linked by nerve connectives and commissures, ensuring communication between different body parts. The nervous system enables the snail to perform activities such as crawling, feeding, and responding to stimuli like light, touch, and chemical signals.

Reproductive Biology

Pila exhibits fascinating reproductive adaptations. Many species are **dioecious** (separate sexes), while some may show **hermaphroditism**. Cross-fertilization is common, enhancing genetic variation. During reproduction:



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- The male transfers sperm to the female using specialized copulatory structures.
- Fertilized eggs are laid in **jelly-like masses**, often above the water surface on vegetation.
- This behavior prevents aquatic predators from consuming the eggs and ensures better survival.
- The egg masses contain multiple embryos, ensuring high reproductive success.

Development is usually direct, with the young hatching as miniature versions of adults, bypassing a free-swimming larval stage.

Pearls and Gastropod Morphology

Pearls are remarkable biological products formed by mollusks as a **defense mechanism**. When a foreign particle (such as a parasite or sand grain) enters the soft tissue, the **mantle secretes nacre (mother-of-pearl)** in concentric layers around it. Over time, this forms a pearl.

Natural pearls are rare, and their beauty made them highly valuable historically. Today, most pearls are produced artificially through **cultured pearl farming**, where a nucleus is deliberately inserted into the mollusk. Different species produce pearls of varied size, color, and luster, e.g., Akoya pearls (Japan), South Sea pearls (Australia), and Tahitian pearls (French Polynesia).

Gastropods also demonstrate unique morphological processes like **torsion**, which drastically alter their anatomy during development.

4.3.3 Torsion and Detorsion in Gastropods

One of the most significant evolutionary features of gastropods is **torsion**. During early larval development, the visceral mass rotates **180°**, shifting

the mantle cavity, gills, and anus to the anterior side of the body. This rearrangement produces a highly asymmetrical body plan.

The adaptive advantages of torsion include:

- Protection of the head region (as the shell opening faces forward).
- Improved coordination of sensory organs.
- Better efficiency of respiration and excretion.

However, torsion also results in anatomical complications, such as the crossing of digestive and excretory tracts. In some gastropod groups, a process called **detorsion** occurs later in development, partially reversing the body back to a symmetrical form. This is seen in nudibranchs and some advanced gastropods, allowing them to adapt to open marine environments.

The study of torsion and detorsion provides valuable insights into **evolutionary developmental biology (evo-devo)**, showing how relatively small changes in embryonic processes can lead to dramatic changes in adult body plans.

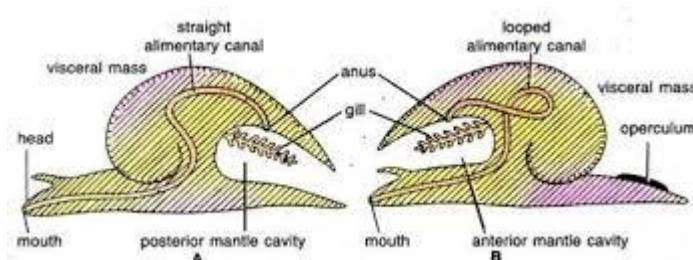


Fig 4.7: A- Torsion B- Detorsion

SUMMARY:

The phylum **Mollusca** is a large and diverse group of soft-bodied animals that are bilaterally symmetrical, triploblastic, and coelomate. They usually possess a **calcareous shell**, a **muscular foot** for locomotion, a **mantle** that secretes shell material, and a specialized feeding organ called the **radula**



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(absent in bivalves). Mollusks have an **open circulatory system** (except cephalopods), a **complete digestive system**, and a nervous system that ranges from simple to highly complex depending on the class. Reproduction is usually sexual, with both dioecious and hermaphroditic members.

Among mollusks, the class **Gastropoda** is the largest, including snails and slugs. A unique evolutionary feature of gastropods is **torsion**, a 180° rotation of the visceral mass during larval development, which results in asymmetry of internal organs. Some groups later undergo **detorsion** to regain partial symmetry.

Pila, commonly known as the **apple snail**, is a representative freshwater gastropod belonging to the family **Ampullariidae**. It is widely distributed in Asia, Africa, and the Americas and is adapted to both aquatic and amphibious life. The **external morphology** includes a coiled, globular shell with a large aperture and an **operculum** that seals the opening when the snail withdraws. Shell colors usually range from greenish to brown, with growth lines and patterns providing camouflage.

A. Multiple Choice Questions (MCQs)

1. *Pila* belongs to which class of Mollusca?
 - a) Bivalvia
 - b) Cephalopoda
 - c) Gastropoda
 - d) Scaphopoda

Answer: c) Gastropoda

2. The operculum in *Pila* functions to:
 - a) Aid in respiration
 - b) Close the shell aperture
 - c) Help in locomotion
 - d) Secrete shell material

Answer: b) Close the shell aperture



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3. The respiratory pigment in the hemolymph of *Pila* is:

- a) Hemoglobin
- b) Hemocyanin
- c) Myoglobin
- d) Chlorocruorin

Answer: b) Hemocyanin

4. The radula of *Pila* is used for:

- a) Reproduction
- b) Excretion
- c) Scraping food
- d) Locomotion

Answer: c) Scraping food

5. In *Pila*, aerial respiration is carried out by:

- a) Ctenidium
- b) Nephridium
- c) Pulmonary sac (lung)
- d) Mantle gland

Answer: c) Pulmonary sac (lung)

6. Torsion in gastropods refers to:

- a) Coiling of shell
- b) 180° rotation of visceral mass
- c) Detorsion of internal organs
- d) Segmentation of body

Answer: b) 180° rotation of visceral mass

7. Pearl formation occurs due to the secretion of:

- a) Conchiolin
- b) Nacre (mother-of-pearl)
- c) Calcium oxalate
- d) Hemocyanin

Answer: b) Nacre (mother-of-pearl)



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8. The circulatory system of *Pila* is:

- a) Closed, with hemoglobin
- b) Open, with hemoglobin
- c) Open, with hemocyanin
- d) Closed, with hemocyanin

Answer: c) Open, with hemocyanin

B. Short Answer Questions

1. Write a note on the taxonomic position of *Pila*.
2. What is the function of the operculum in *Pila*?
3. Define torsion. Why is it significant in gastropods?
4. Differentiate between gill respiration and lung respiration in *Pila*.
5. What role does the hepatopancreas play in digestion?
6. Describe pearl formation in mollusks.
7. Explain the role of the radula in the feeding mechanism of *Pila*.

SUMMARY

Arthropoda is the largest animal phylum, including insects, crustaceans, and arachnids, characterized by a segmented body, jointed appendages, and a chitinous exoskeleton that undergoes molting. They have an open circulatory system with hemolymph, respiration through gills, tracheae, or book lungs, and excretion by Malpighian tubules or green glands. The nervous system is advanced with a ventral nerve cord, compound eyes, and antennae. Reproduction is sexual, mostly dioecious, with direct or indirect development involving metamorphosis. Mollusca, the second-largest phylum, includes snails, clams, squids, and octopuses, with a soft, unsegmented body divided into head-foot, visceral mass, and mantle which secretes a calcareous shell. Most possess a radula for feeding (except bivalves), have open circulation (closed in cephalopods),



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respiration by gills or pulmonary sac, and excretion by nephridia. The nervous system ranges from simple in bivalves to highly developed in cephalopods. Reproduction is sexual, mostly dioecious, with trochophore and veliger larval stages. Arthropods are important as pollinators, decomposers, vectors, and sources of silk, honey, and food, while mollusks provide food, pearls, shells, lime, and serve as bioindicators.

A. Multiple-Choice Questions (MCQs)

1. Which of the following is a characteristic feature of Arthropoda?

- a. Radial symmetry
- b. Chitinous exoskeleton
- c. Pseudocoelomate body
- d. Water vascular system

Ans. b. Chitinous exoskeleton

2. Which class does the prawn belong to?

- a. Arachnida
- b. Crustacea
- c. Myriapoda
- d. Insecta

Ans. b. Crustacea

3. Peripatus is considered a connecting link between:

- a. Arthropoda and Mollusca
- b. Arthropoda and Annelida
- c. Mollusca and Echinodermata
- d. Annelida and Nematoda

Ans. b. Arthropoda and Annelida

4. Which type of mouthpart is found in butterflies?

- a. Chewing



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- b. Piercing and sucking
- c. Siphoning
- d. Sponging

Ans. c. Siphoning

5. Which of the following classes belongs to Mollusca?

- a. Crustacea
- b. Cephalopoda
- c. Arachnida
- d. Myriapoda

Ans. b. Cephalopoda

6. The main component of a mollusk shell is:

- a. Chitin
- b. Calcium carbonate
- c. Silica
- d. Keratin

Ans. b. Calcium carbonate

7. The function of the radula in mollusks is:

- a. Locomotion
- b. Digestion
- c. Respiration
- d. Feeding

Ans. d. Feeding

8. What is the main reason for torsion in gastropods?

- a. Protection of the head
- b. Development of gills
- c. Better locomotion
- d. Reduction of weight

Ans. a. Protection of the head



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9. Which organ is responsible for pearl formation?

- a. Gills
- b. Radula
- c. Mantle
- d. Foot

Ans. c. Mantle

10. Which of the following mollusks is known for its ability to produce pearls?

- a. Pila
- b. Octopus
- c. Unio
- d. Loligo

Ans. c. Unio

B.Short Answer Questions (SAQs)

1. Define Arthropoda and mention its key characteristics.
2. Classify Arthropoda up to classes with examples.
3. Describe the morphological features of prawn.
4. Differentiate between chewing and siphoning mouthparts in insects.
5. What are the structural affinities of Peripatus with annelids and arthropods?
6. List the general characteristics of Mollusca.
7. Explain the process of pearl formation in mollusks.
8. What is the significance of torsion in gastropods?
9. Describe the structure of Pila with a labeled diagram.
10. How does the exoskeleton of arthropods help in protection and locomotion?



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C.Long Answer Questions (LAQs)

1. Discuss the general characteristics and classification of Arthropoda with examples.
2. Explain the morphology and structure of prawn in detail.
3. Describe the various types of insect mouthparts with examples and diagrams.
4. Explain the structure and affinities of Peripatus and its evolutionary significance.
5. Describe the classification and general characteristics of Mollusca with examples.
6. Explain the morphology and structure of Pila with a well-labeled diagram.
7. Discuss the process of pearl formation and its significance in the pearl industry.
8. Explain torsion and detorsion in gastropods with suitable examples.
9. Compare and contrast Arthropoda and Mollusca based on their structural adaptations.
10. Explain the economic importance of Arthropods and Mollusks in human life.

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MODULE 5

INVERTEBRATE V

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Objectives

1. To study the general characteristics and classification of Echinodermata and Hemichordata.
2. To analyze the structure and morphology of Asterias (starfish) and Balanoglossus (acorn worm).
3. To understand the water vascular system in starfish and its role in locomotion and feeding.
4. To examine different types of echinoderm larvae and their evolutionary significance.
5. To explore the classification and anatomical adaptations of Balanoglossus as a hemichordate.
6. To evaluate the phylogenetic position of hemichordates in relation to chordates and non-chordates.

UNIT 5.1:

Echinodermata

5.1 Introduction

The phylum **Echinodermata** is one of the most fascinating groups of marine animals. These invertebrates have lived in the oceans for more than **500 million years**, and today about **7,000 living species** are known, along with many fossil forms. The word *Echinodermata* comes from the Greek words *echinos* (spiny) and *derma* (skin), referring to their **spiny, calcite-based skeleton**. Unlike many other invertebrates that adapted to land or freshwater, echinoderms are found **only in the sea**, ranging from shallow coastal waters to the deep ocean floor.

One of their most unique features is their **pentaradial symmetry** (five-part body plan). Although their larvae are **bilateral** (two-sided like humans), the adults develop into a star-like or pentagon shape with five body parts arranged around a central axis. This allows them to sense and move in any direction — a great advantage for bottom-dwelling animals.



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Water Vascular System – A Unique Feature

Perhaps the most special feature of echinoderms is their **water vascular system**. This is a hydraulic system made of canals filled with seawater, which ends in small structures called **tube feet**. Tube feet are used for **movement, feeding, respiration, and sensing**.

The system works like this:

- Water enters through a sieve-like plate called the **madreporite**.
- It passes through the **stone canal** into a circular **ring canal** around the mouth.
- From here, **five radial canals** extend into each arm.
- Tiny **lateral canals** connect the radial canals to the tube feet.
- Each tube foot has an internal bulb (**ampulla**) and an external extension (**podium**) ending with a sucker.

When the ampulla contracts, water is pushed into the podium, making it extend. The sucker attaches to surfaces using suction and adhesive secretions. This allows starfish to pull open shells of bivalves (like clams). The tube feet also help with gas exchange and detecting touch, light, and chemicals in the environment.

Endoskeleton and Body Features

Echinoderms have an **internal skeleton** made of **calcium carbonate plates** called **ossicles**. These ossicles may form:

- Flexible plates (as in sea stars and brittle stars), or
- A rigid shell/test with spines (as in sea urchins).

Some species have special defensive features such as:

- **Spines** for protection.



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- **Pedicellariae** (tiny pincer-like structures).
- **Papulae** (skin gills used for respiration).

This skeleton provides support, protection for internal organs, and attachment points for muscles.

Regeneration Ability

Echinoderms are famous for their **remarkable regenerative ability**. For example:

- Many sea stars can regrow lost arms.
- Some can even regenerate a whole body from just one arm with part of the central disc.
- Sea cucumbers can expel internal organs (evisceration) and regenerate them later.

This regeneration is an important research area, as it may help scientists develop new ideas for **human tissue repair and wound healing**.

Feeding Strategies

Echinoderms have a wide variety of feeding methods depending on their class:

- **Sea stars:** Use *extraoral digestion* – they evert (push out) their stomachs onto prey like clams, digest food outside the body, and then pull the stomach back inside.
- **Sea urchins:** Use a special chewing organ called **Aristotle's lantern**, which has five teeth for scraping algae from surfaces.
- **Crinoids and brittle stars:** Use their arms and tube feet to capture suspended food particles from the water.



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- **Sea cucumbers:** Use modified tube feet around the mouth as feeding tentacles.

This diversity allows echinoderms to play different roles in marine ecosystems.

Circulation, Respiration, and Nervous System

- Echinoderms **do not have a heart**. Instead, they use **coelomic fluid** and a system of open channels for circulation.
- Gas exchange occurs through **skin gills, tube feet, or specialized structures** (like respiratory trees in sea cucumbers).
- They have **no central brain**, but instead a **nerve ring** around the mouth with radial nerves extending into each arm. Despite this, they can sense light, chemicals, and touch effectively. Some brittle stars even have light-sensitive organs in their arms.

Reproduction and Development

- Most echinoderms reproduce **sexually**, releasing eggs and sperm into the water where fertilization takes place.
- Fertilized eggs develop into **bilateral larvae** (like *pluteus* in sea urchins or *auricularia* in sea cucumbers).
- The larvae undergo a dramatic **metamorphosis** into the pentaradial adult form.
- Some species reproduce **asexually** by fission or budding.
- Others may **brood larvae** inside the body instead of releasing them into the ocean.

The planktonic larval stage helps in **long-distance dispersal** and is an important part of marine food webs.



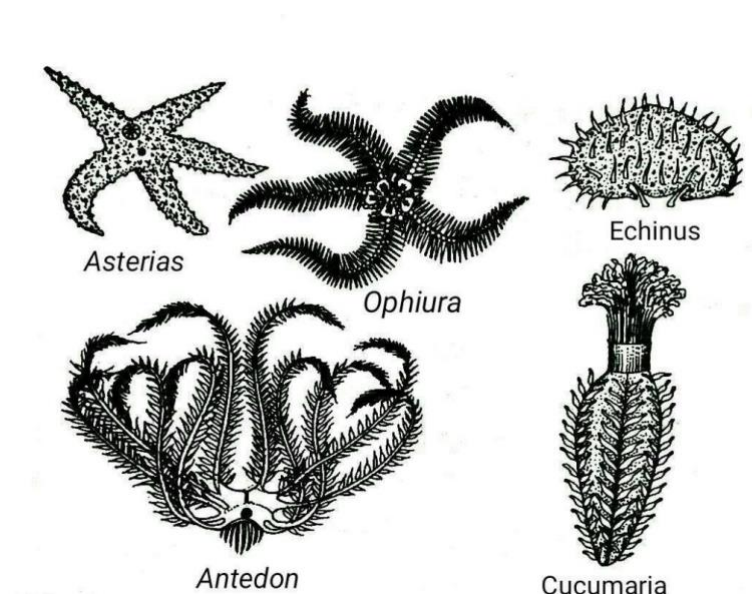
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Ecological and Evolutionary Importance

Echinoderms are **keystone species**, meaning they play a very important role in maintaining ecosystem balance. For example:

- Sea urchins control algal growth.
- Sea stars regulate populations of bivalves.
- Crinoids and brittle stars contribute to nutrient cycles.

Their larval development also provides clues about the **evolutionary history of deuterostomes** (a group that includes chordates and humans).



Phylum	Subphylum	Class	Sub-class	Examples
E		Helicoplacoidea (Extinct)		
C		Holothuroidea	Dendrochiroacea	Placothuria, Cucumaria
H			Aspidochiroacea	Stichopus, Elpidia
			Apodacea	Molpadia, Leptosynapta
I	Echinozoa	Edrioasteroidea (Extinct)		
N		Echinoidea	Perischoechinoidea	Goniocidaris, Ogmocidaris
O			Euechinoidea	Echinus, Mespilia
D		Ophiocistoidea (Extinct)		
E	Homalozoa (Extinct)			
R				
M	Crinozoa	Crinoidea	Inadunata (Extinct)	
			Camerata (Extinct)	
A			Flexibilia (Extinct)	
			Articulata	Metacrinus, Antedon
T	Asterozoa	Stelleroidea	Somasteroidea	Platasterias
			Asteroidea	Asterias, Asterina
A			Ophiuroidea	Astrophyton, Ophiura

Box. 1.8: Scheme of classifications of Phylum Echinodermata as in 'Text book of Zoology — Invertebrates' by Parker and Haswell (eds. Marshall and Williams, 1972).

Fig5.1: classification and Examples of Echinodermata



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5.1.1 Water Vascular System in Echinodermata

The water vascular system is the most distinctive and unique feature of the phylum Echinodermata. It is a complex hydraulic system of canals filled with seawater that plays an essential role in locomotion, feeding, respiration, excretion, and sensory reception. This system is not found in any other group of animals and hence serves as a key characteristic of echinoderms. Developmentally, the water vascular system arises from the left hydrocoel of the larva during metamorphosis, while the right hydrocoel usually degenerates. This origin from the coelomic cavities links echinoderms with other deuterostomes and reflects their evolutionary position.

The system begins with the **madreporite**, a sieve-like calcareous plate situated on the aboral surface of the animal. It acts as the main gateway for seawater, filtering particles and preventing entry of sediments or microorganisms. The madreporite connects internally to a narrow tube known as the **stone canal**, which is often reinforced with calcareous deposits and extends down to join the **ring canal**. The ring canal is a circular structure surrounding the esophagus and serves as the central hub of the entire system. Attached to the ring canal are several special structures. The **Tiedemann's bodies** are small glandular outpocketings that produce coelomocytes, which play a role in immune functions, while the **Polian vesicles** are sac-like reservoirs that act as storage chambers and help in regulating internal pressure within the system.

From the ring canal arise five or more **radial canals**, one running into each arm in star-shaped echinoderms, following the typical pentaradial body plan. These radial canals extend along the ambulacral grooves and give off numerous short branches known as **lateral canals**. Each lateral canal connects to a single **tube foot**, also called podium, and is provided with a valve to prevent backward flow of fluid. The tube foot is the most important functional unit of the water vascular system. It consists of two main regions: an internal muscular sac called the **ampulla** and an external extensible portion, the **podium**, which often ends in a sucker.

The working of the tube feet is based on the principle of hydraulics. When the ampulla contracts, fluid is forced into the podium, causing it to extend outward. The sucker of the podium attaches firmly to the substrate either by suction or by adhesive secretions. To pull the body forward, longitudinal muscles of the podium contract, driving the fluid back into the ampulla and shortening the tube foot. By repeating this cycle in coordination, tube feet achieve slow but effective locomotion. Thus, the mechanism works in accordance with Pascal's law, where pressure applied to fluid is transmitted equally in all directions.



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The water vascular system performs multiple vital functions. The most obvious is **locomotion**, as seen in starfish slowly crawling over rocks or substrates. It also plays a major role in **feeding**: for example, sea stars use their tube feet to pry open the shells of bivalve mollusks, while in sea cucumbers the tube feet around the mouth are modified into feeding tentacles. The thin-walled podia additionally function in **respiration**, allowing gaseous exchange of oxygen and carbon dioxide by diffusion. Similarly, nitrogenous wastes, mainly in the form of ammonia, diffuse out through the tube feet, making them organs of **excretion** as well. Another important role is **sensory reception**, since tube feet are sensitive to touch, light, and certain chemical stimuli. In some echinoderms, especially crinoids and brittle stars, certain tube feet are modified as sensory tentacles. Moreover, the hydraulic pressure of the system maintains turgidity in the tube feet, thereby providing **support and rigidity** to the animal's body.

Although the general plan of the water vascular system is similar, it exhibits certain modifications in different classes of echinoderms. In **Asteroidea** (sea stars), the system is well-developed, and tube feet in the ambulacral grooves serve for locomotion and prey capture. In **Ophiuroidea** (brittle stars), tube feet are reduced and mainly act as sensory and feeding organs, while locomotion is achieved chiefly by arm movements. In **Echinoidea** (sea urchins), the tube feet emerge through pores in the rigid test and function along with movable spines in locomotion and handling of food particles. In **Holothuroidea** (sea cucumbers), the tube feet around the mouth are modified into tentacles for collecting food, whereas the rest of the tube feet may be reduced or specialized for creeping movements. In **Crinoidea** (feather stars and sea lilies), the tube feet are primarily used for attachment and food collection rather than locomotion.

From an evolutionary standpoint, the water vascular system is a remarkable adaptation that allowed echinoderms to thrive as benthic marine animals. Its uniqueness provides insight into their evolutionary history and ecological specialization. In modern science, the study of the water vascular system has inspired the field of biomimetics, particularly in the design of soft robotics and underwater attachment devices, which mimic the functioning of echinoderm tube feet. Additionally, since echinoderms possess remarkable regenerative abilities, the regeneration of arms in starfish includes the redevelopment of a functioning water vascular system, making it an area of considerable biological interest.

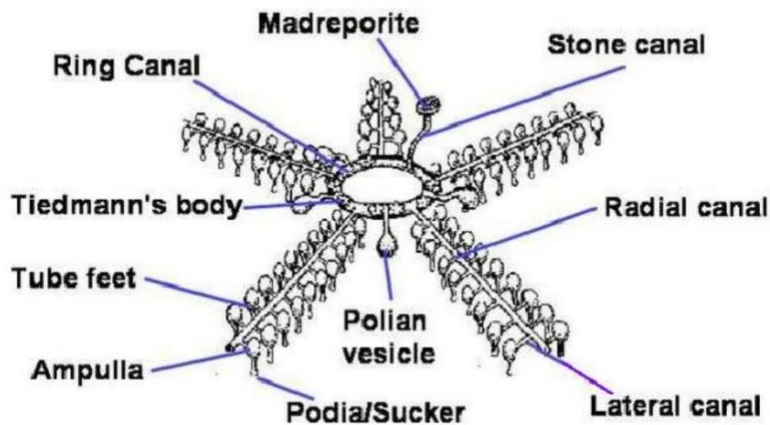


Fig5.2: water vascular system

SUMMARY:

Echinodermata is an exclusively marine phylum characterized by **radial symmetry in adults** (pentamerous) and **bilateral symmetry in larvae**, showing a remarkable case of secondary radial symmetry. The body is **triploblastic, coelomate, unsegmented**, and covered with a calcareous endoskeleton made of ossicles and spines. They possess a unique **water vascular system**, which functions in locomotion, feeding, respiration, excretion, and sensory reception.

A. MULTIPLE CHOICE QUESTIONS

1. The water vascular system of echinoderms originates from:
 - a) Mesoderm
 - b) Endoderm
 - c) Left hydrocoel
 - d) Right hydrocoel

Answer: c) Left hydrocoel

2. Which of the following is the larva of Asteroidea?
 - a) Auricularia
 - b) Bipinnaria
 - c) Ophiopluteus
 - d) Doliolaria

Answer: b) Bipinnaria



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3. Aristotle's lantern is found in:

- a) Starfish
- b) Sea cucumber
- c) Sea urchin
- d) Brittle star

Answer: c) Sea urchin

4. The symmetry shown by adult echinoderms is:

- a) Bilateral symmetry
- b) Radial symmetry
- c) Biradial symmetry
- d) Asymmetry

Answer: b) Radial symmetry

5. In which class of echinoderms is evisceration commonly observed?

- a) Asteroidea
- b) Holothuroidea
- c) Echinoidea
- d) Crinoidea

Answer: b) Holothuroidea

B. Short Answer Type

1. List the general characteristics of Echinodermata.
2. What is the role of tube feet in echinoderms?
3. Differentiate between Asteroidea and Ophiuroidea.
4. Explain the significance of the larval forms of echinoderms.
5. Why are echinoderms considered deuterostomes?
6. Describe the structure and functions of the water vascular system in Echinodermata.

Unit 5.2:

Hemichordata: type study *Balanoglossus*



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5.2 Introduction

Hemichordates are a fascinating group of **marine invertebrates** that are evolutionarily significant because they share several features with chordates, such as **gill slits** and a **dorsal nerve cord**, but also possess unique traits that set them apart. The name Hemichordata comes from the Greek words *hemi* (half) and *chorda* (cord), referring to the presence of the **stomochord**, a structure resembling the notochord of chordates. These organisms are widely distributed in the oceans, from shallow coastal areas to deep-sea habitats, and they play important ecological roles by processing sediments, recycling nutrients, and creating habitats for other marine life.

General Characteristics

Hemichordates are **bilaterally symmetrical**, **triploblastic**, and coelomate animals. They possess a **tripartite body plan** divided into the **proboscis (prosoma)**, **collar (mesosome)**, and **trunk (metasoma)**. The body wall consists of an outer **epidermis**, a thin cuticle, and muscle layers arranged circularly and longitudinally. Hemichordates are mostly soft-bodied, worm-like, and burrowing or tube-dwelling. Their **digestive system is complete**, with a mouth, pharynx with gill-slits, esophagus, stomach/intestine, and anus. The **circulatory system is open**, usually without respiratory pigments, and includes the unique **heart–glomerulus complex**. Respiration is mainly through **pharyngeal gill-slits** and the body surface. Their **nervous system** is simple, comprising a nerve net and paired dorsal and ventral nerve cords, with a hollow dorsal cord in some species, reminiscent of the chordate neural tube.

Classification



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The phylum Hemichordata is divided into three main classes:

1. **Enteropneusta (Acorn worms):** Solitary, burrowing hemichordates with a tripartite body and pharyngeal gill-slits. They are usually large, some growing up to 2 meters. Examples: *Balanoglossus*, *Saccoglossus*.
2. **Pterobranchia:** Small, colonial or pseudocolonial hemichordates that live in secreted tubes. They have tentaculated arms for filter feeding. Examples: *Rhabdopleura*, *Cephalodiscus*.
3. **Graptolithina (Extinct graptolites):** Colonial forms important as fossils, closely related to pterobranchs, used in geological stratigraphy.

Morphology and Body Organization

The **proboscis** is muscular, aids in burrowing, locomotion, and feeding, and contains the **stomochord**. The **collar** lies behind the proboscis and contains the mouth, cilia for locomotion and feeding, and a collar coelom that acts as a hydrostatic structure. The **trunk** is the largest part of the body and houses most organs, including the pharynx with gill-slits, a straight or U-shaped digestive tract, gonads, and excretory structures. The gill-slits are used for respiration and feeding and are an important link to chordates.

Reproduction and Development

Hemichordates mainly reproduce **sexually**. Fertilization is **external**, with gametes released into seawater. The resulting zygotes develop into **tornaria larvae**, which are planktonic and free-swimming. These larvae exhibit ciliated bands for movement and feeding and eventually metamorphose into juvenile worms with a tripartite body. Some species may also reproduce **asexually** by fragmentation or budding, especially in pterobranchs.

Feeding and Ecology

Hemichordates are mostly **deposit feeders** or **filter feeders**, depending on the group. Enteropneusts ingest organic matter from sediment, while pterobranchs filter particles from water using tentacles. By burrowing and feeding, hemichordates **bioturbate sediments**, oxygenate substrates, and help recycle nutrients, creating microhabitats for other marine species. Their ecological role as **ecosystem engineers** is critical for maintaining the health and diversity of marine ecosystems.

Evolutionary and Phylogenetic Significance

Hemichordates belong to the superphylum **Deuterostomia** and are closely related to **echinoderms**, forming the clade **Ambulacraria**. Molecular studies suggest that hemichordates share a common ancestor with chordates, explaining their chordate-like features such as gill-slits and a dorsal nerve cord. Their developmental genes, including **Hox genes** and neural patterning genes, are highly conserved, offering insights into the evolution of complex body plans and vertebrate ancestry.

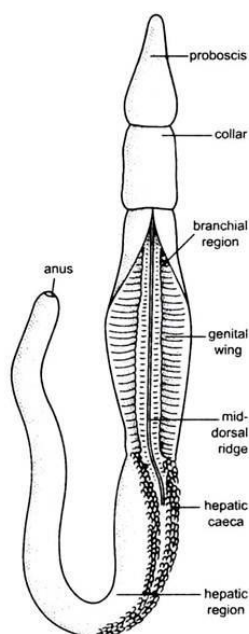


Fig 5.3: Balanoglossus



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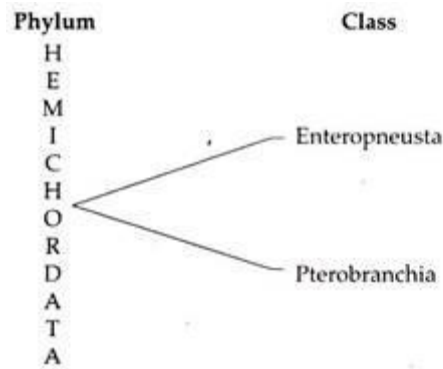


Fig5.4: Classification of Hemichordata

5.2.1 Hemichordata – Type Study: *Balanoglossus*

Introduction

Hemichordata is an interesting group of marine invertebrates that holds great evolutionary importance. These animals share some features with chordates (like pharyngeal gill-slits and a dorsal nerve cord), but also have their own unique traits, which place them in a separate phylum. They give scientists valuable clues about how early animal body plans evolved. The best-known example of this group is ***Balanoglossus***, commonly called the *acorn worm* or *tongue worm*. This worm-shaped marine animal lives in burrows in sand or mud, mostly along seashores, and plays an important role in marine ecosystems.

Morphology (Body Structure)

The body of ***Balanoglossus*** is soft, elongated, and divided into three distinct regions:

1. **Proboscis (prosoma)** – A muscular, conical part at the front, used for burrowing, movement, and collecting food. It also helps in respiration and has a structure called the **stomochord**, once thought to be like the notochord of chordates.
2. **Collar (mesosome)** – Lies just behind the proboscis. It contains the mouth on its ventral side and has cilia (tiny hair-like structures) that help in creating water currents for feeding and respiration.



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3. **Trunk (metasome)** – The largest region, containing the pharynx with gill-slits, the digestive tract, gonads, and excretory organs. The gill-slits are very important because they represent an early evolutionary stage leading to the more complex respiratory systems of chordates.

Digestive and Other Systems

The digestive canal of *Balanoglossus* is straight, running from mouth to anus. Food particles from mud or organic matter are ingested, broken down, and absorbed as the animal burrows. Respiration occurs mainly through the **gill-slits**, which allow water to pass through and facilitate gas exchange. The circulatory system is open, with blood moving through sinuses and a special **heart–glomerulus complex** in the proboscis that helps in circulation and excretion. The nervous system is quite simple, consisting of a **nerve net** and two nerve cords, with the dorsal cord sometimes becoming hollow – a condition similar to that of chordates.

Reproduction and Life Cycle

Balanoglossus reproduces sexually, with separate sexes. Fertilization is external – gametes are released into seawater. Development includes a special **tornaria larva**, which is free-swimming and resembles the bipinnaria larva of echinoderms. This similarity shows a close evolutionary link between hemichordates and echinoderms. Some species may also reproduce asexually by fragmentation, but this is less common.

Ecological Importance

Balanoglossus is an important **deposit feeder**. By burrowing and feeding on organic material in sediments, it helps in nutrient cycling, oxygenation of soil, and maintaining marine biodiversity. Their burrows create



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microhabitats for other organisms. Thus, they act as **ecosystem engineers**, improving the quality of marine sediments.

SUMMARY:

Hemichordates, represented by species like *Balanoglossus*, are key **evolutionary and ecological models**. Their simple but well-organized body plan, diverse reproductive strategies, and important roles in sediment processing make them a crucial link in understanding **early chordate evolution** and marine ecology. Studying these organisms provides insights into how body plans, organs, and developmental pathways evolved in more complex animals.

Hemichordates like *Balanoglossus* are a key evolutionary link between invertebrates and chordates. Their simple body structure, gill-slits, and larval forms provide strong evidence about how chordate features may have evolved. They are also ecologically important in maintaining healthy marine environments.

A. Multiple Choice Questions:

1. Hemichordates belong to which superphylum?
 - a) Protostomia
 - b) Deuterostomia
 - c) Lophotrochozoa
 - d) Ecdysozoa

Answer: b) Deuterostomia

2. The tripartite body of *Balanoglossus* consists of:
 - a) Head, thorax, abdomen
 - b) Proboscis, collar, trunk
 - c) Cephalon, thorax, pygidium
 - d) Proboscis, trunk, tail

Answer: b) Proboscis, collar, trunk

3. The structure in Hemichordates that resembles the notochord is called:
 - a) Nerve cord



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- b) Stomochord
- c) Gill slit
- d) Coelom

Answer: b) Stomochord

4. Which class of Hemichordata is colonial and builds tube-like habitats?
- a) Enteropneusta
 - b) Pterobranchia
 - c) Graptolithina
 - d) Chordata

Answer: b) Pterobranchia

5. Tornaria larva of Balanoglossus is similar to which larva of echinoderms?
- a) Planula
 - b) Bipinnaria
 - c) Nauplius
 - d) Trochophore

Answer: b) Bipinnaria

6. The circulatory system of Balanoglossus is:
- a) Closed
 - b) Open
 - c) Single-chambered
 - d) Absent

Answer: b) Open

7. Hemichordates are important in ecosystems because they:
- a) Pollinate flowers
 - b) Bioturbate sediments and recycle nutrients
 - c) Produce oxygen
 - d) Feed on plankton only

Answer: b) Bioturbate sediments and recycle nutrients



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B.Short Answer Questions

1. Define Hemichordata and mention its evolutionary significance.
2. Describe the **tripartite body plan** of Balanoglossus.
3. Explain the **digestive and respiratory systems** of Hemichordates.
4. What is the **stomochord**, and how is it different from the notochord of chordates?
5. Describe the **reproductive cycle** of Balanoglossus, including the tornaria larva.

Summary:

Together, echinoderms and hemichordates highlight the **evolutionary diversity of deuterostomes**. While echinoderms are highly specialized marine animals with a unique body organization, hemichordates provide a link to the chordates, bridging the evolutionary gap and giving insights into the early origins of vertebrate characteristics.

Echinodermata and Hemichordata are two important deuterostome phyla that help us understand the evolution of higher animals. **Echinodermata** is a diverse phylum of exclusively marine invertebrates such as starfish, sea urchins, sea cucumbers, and brittle stars. They are characterized by **radial symmetry in adults, a calcareous endoskeleton, a unique water vascular system, and tube feet** used for locomotion, feeding, and respiration. Their development is indirect, with characteristic larval forms (like bipinnaria and auricularia). They play key ecological roles in marine ecosystems, including bioerosion, nutrient cycling, and maintaining coral reef balance.

Hemichordata, on the other hand, is a small but evolutionarily significant phylum that includes organisms like *Balanoglossus* (acorn worms) and pterobranchs. They show a **tripartite body division** (proboscis, collar,



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trunk), possess **pharyngeal gill slits**, and have an organ called the **stomochord**, once thought to be a true notochord. They exhibit features that are intermediate between echinoderms and chordates, making them crucial for studying the **origin of chordates**. Hemichordates are mostly benthic, burrowing organisms that contribute to **bioturbation and nutrient recycling** in marine environments.

A. Multiple-Choice Questions

1. Which of the following features is unique to Echinodermata?

- a. Radial symmetry in adults
- b. Segmentation
- c. Exoskeleton of chitin
- d. Closed circulatory system

Ans. a. Radial symmetry in adults

2. What is the function of the water vascular system in echinoderms?

- a. Respiration
- b. Locomotion and feeding
- c. Excretion
- d. Reproduction

Ans. b. Locomotion and feeding

3. Asterias belongs to which class of Echinodermata?

- a. Echinoidea
- b. Asteroidea
- c. Ophiuroidea
- d. Holothuroidea

Ans. b. Asteroidea

4. Which of the following is a larval form of Echinodermata?



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- a. Trochophore
- b. Bipinnaria
- c. Planula
- d. Veliger

Ans. b. Bipinnaria

5. The larval forms of echinoderms exhibit which type of symmetry?

- a. Radial
- b. Bilateral
- c. Asymmetry
- d. Pentaradial

Ans. b. Bilateral

6. Hemichordates are considered a connecting link between:

- a. Chordates and Arthropods
- b. Non-chordates and Chordates
- c. Annelids and Mollusks
- d. Cnidarians and Echinoderms

Ans. b. Non-chordates and Chordates

7. Which structure in Balanoglossus resembles the notochord?

- a. Proboscis
- b. Buccal diverticulum
- c. Collar
- d. Gill slits

Ans. b. Buccal diverticulum

8. The excretory organ in hemichordates is called:

- a. Nephridia
- b. Malpighian tubules
- c. Proboscis gland
- d. Green gland

Ans. c. Proboscis gland



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9. Which class does Balanoglossus belong to?

- a. Enteropneusta
- b. Pterobranchia
- c. Asteroidea
- d. Holothuroidea

Ans. a. Enteropneusta

10. The circulatory system in Balanoglossus is:

- a. Open
- b. Closed
- c. Absent
- d. Both open and closed

Ans. d. Both open and closed

B.Short Answer Questions

1. Define Echinodermata and give an example.
2. What are the key characteristics of Asterias?
3. Explain the function of the water vascular system in starfish.
4. Name the different larval forms of echinoderms and their significance.
5. Differentiate between radial and bilateral symmetry in echinoderms.
6. Classify Hemichordata up to classes with suitable examples.
7. Describe the structure and function of the proboscis in Balanoglossus.
8. What are the characteristics of the buccal diverticulum in hemichordates?
9. Discuss the significance of echinoderm larvae in evolutionary studies.
10. How do echinoderms exhibit regeneration?

C.Long Answer Questions



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1. Discuss the classification and general characteristics of Echinodermata with examples.
2. Explain the structure, morphology, and adaptations of Asterias with a labeled diagram.
3. Describe the water vascular system of echinoderms and its role in locomotion.
4. Explain the different types of larval forms in Echinodermata and their significance.
5. Discuss the classification and general features of Hemichordata with representative examples.
6. Describe the structure, morphology, and significance of Balanoglossus.
7. Explain the evolutionary relationship of Hemichordata with chordates and non-chordates.
8. Compare and contrast Echinodermata and Hemichordata based on their structural organization.
9. Discuss the excretory and circulatory system of Balanoglossus.
10. Explain the significance of radial symmetry in adult echinoderms and its adaptive advantages.

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