CLASSIFICATION OF ANIMALS

In our exploration of the vast array of animals surrounding us, a systematic study becomes essential. Animals are not studied arbitrarily; rather, they are categorized into various minor and major groups based on their similarities and differences. Each group is assigned a specific name according to its distinctive characteristics. The levels of classification, in decreasing order of complexity, include

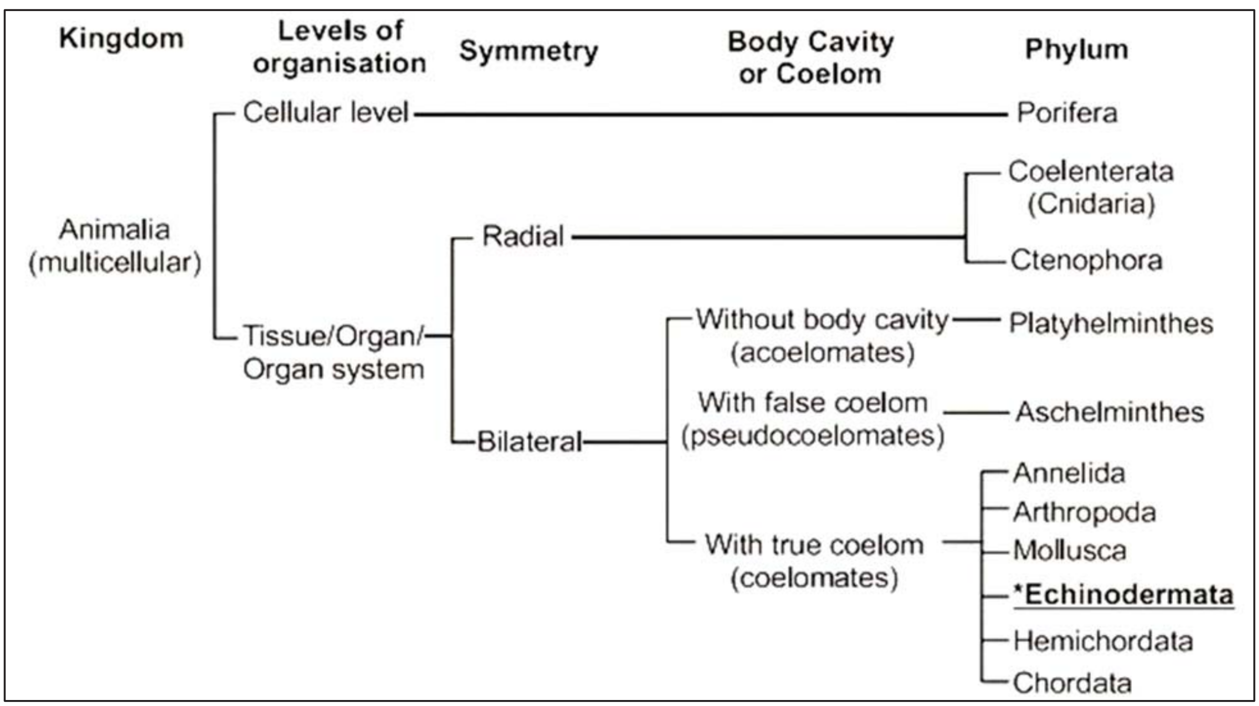
Kingdom → Phylum → Class → Order → Family → Genus → Species

The Kingdom Animalia is further divided into eleven phyla, providing a structured framework for the classification of animals:

- Porifera
- Coelenterata (Cnidaria)
- Ctenophora
- Platyhelminthes
- Aschelminthes
- Annelida
- Arthropoda
- Mollusca
- Echinodermata
- Hemichordata
- Chordata

Animal Classification

The comprehensive classification of the Animalia kingdom, grounded in shared fundamental features, is illustrated in the accompanying figure.



Phylum – Porifera (Sponges)

- Members of this phylum are commonly known as" Sponges". Study of sponges is known as Para zoology.
- All are aquatic and sessile, mostly marine but few are found in fresh water also. They are solitary or colonial. Entire body with pores i.e. numerous small Ostia for entry and one large opening Osculum for exit of water.
- Sponges have various body form and shapes with irregular shape mostly Asymmetrical. (Radial symmetry in Sycon and Leucosolenia)
- Sponges are primitive multicellular acoelomate animals and have cellular level of organization.

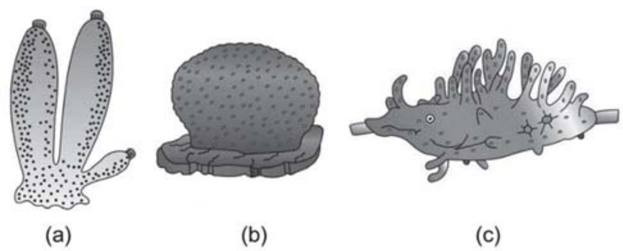


Fig.: Examples of Porifera : **(a)** *Sycon,* **(b)** *Euspongia,* **(c)** *Spongilla*

Body wall consists of-

Outer Pinacoderm - Consists of

- Pinacocytes (Flat cells)
- Porocytes (oval cells)

Inner Choanoderm

Consists of flagellated collar cells or choanocytes (Unique Characteristic of Porifera)

- Between these two layers a gelatinous material Mesenchyme is present which contains certain Amoebocytes cells like -

  Scleroblasts - For formation of skeleton elements

  Archaeocytes - Totipotent cells (Formation of ova & spermatazoa)

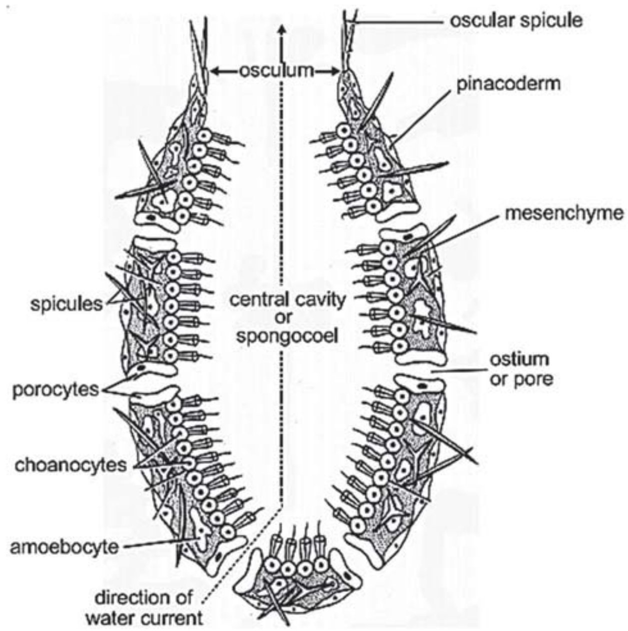
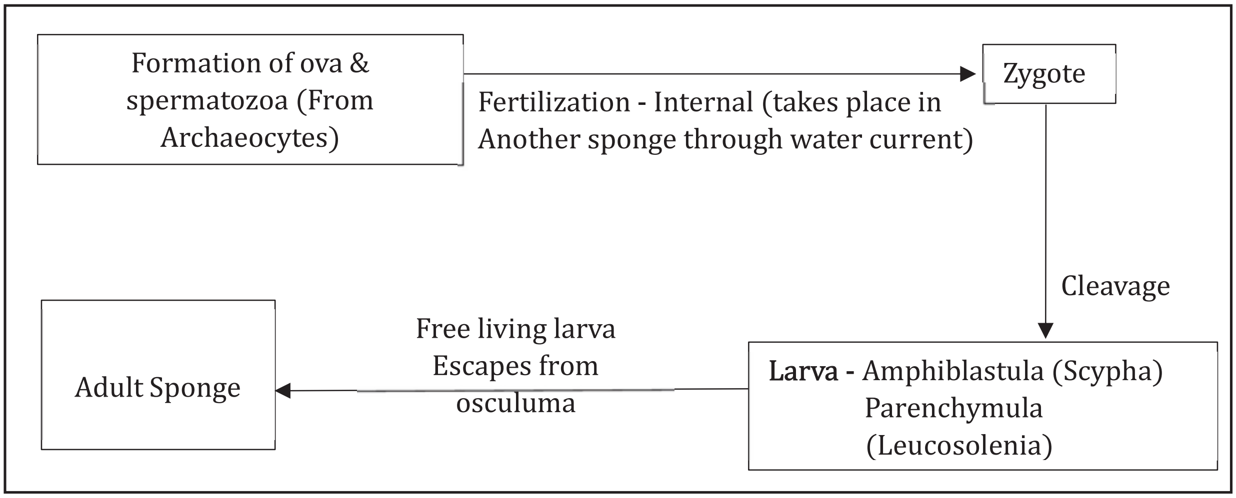


Fig.: Longitudinal section of a sponge with water canal system

- Body wall encloses a large central cavity the spongocoel or paragastric cavity with small hollow canals.
- **Canal system or water transport system: -** It is unique feature of sponges, water enters through ostia in the body wall into spongocoel and goes out through osculum. This pathway of water transport is helpful in food gathering (Nutrition), respiratory exchange and removal of Wastes (excretion).
- **Choanocytes** forms lining of Spongocoel and canals. Ceaseless beating of flagella helps in maintaining flow of water current.
- **Nutrition is holozoic: -** Digestion is intracellular and occurs in food vacuoles of choanocytes.
- Skeleton is internal, consist of tiny calcareous spicules or siliceous spicules or fine spongin fibre located in mesenchyme. Scleroblast secretes spicules and spongioblast secretes spongin fibres.
- Respiration and Excretion takes place by diffusion of gases through body surface. Excretory matter is Ammonia.

Reproduction takes place by means of:-

- **Asexual: -** By Budding or Fragmentation or by Spedal cell mass Gemmules containing Archaeocytes.
- Endogenous buds of asexual reproduction in sponge are known as Gemmules (In unfavourable condition).
- **Sexual: -** Sponges are Hermaphrodite, fertilization is internal and cross due to Protogynous condition and development is indirect having a larval stage which is morphologically distinct from adult.



Porifera (3 Classes – On The Basis of Skeleton)

	Calcarea	Hexactinellida	Demospongia
Skeleton	Calcareous spicules	6-rayed siliceous spicules (Glass sponge)	1 or 4 rayed siliceous spicules or sponging fibre or both
Habitat	All marine and found in shallow water	All marine and found in deep sea water	Marine or fresh water sponges
e.g.	1. Leucosolenia-smallest sponge 2. **Scypha (Sycon)** - Urn sponge	1. Euplectella - Venus flower basket, Bridal gift in japan, Shrimps (Spongicola) crustacean, shows commensalism with it 2. Hyalonema - Glass rope sponge	**1. Euspongia** - Bath sponge **2. Spongilla** - Fresh water sponge **3. Cliona** - Boring sponge (harmful to Oyster)

Phylum – Coelenterata

- Leuckart named Coelenterata. Hatschek named Cnidaria on the basis of stinging cells.
- Mostly marine, few fresh-water (Hydra.) Carnivorous, some are fixed or free floating.
- Coelenterates have two types of forms (Dimorphic)
- Either or both zooids may occur in a species.
- If both are found in a species, two form alternate in life cycle. (Alternation of generation or Metagenesis)
- Polyps produce medusae as exully and medusae form the polyps sexually eg :- Obelia
- Group of different types of zooids in polyp or medusa shows polymorphism.
- Coelenterates are usually having radial symmetry, Some Anthozoans have Biradial symmetry.
- Coelenterates have two Germs layers (1) Ectoderm (2) Endoderm i.e. They are Diploblastic (Mesogloea between two layers)
- Coelenterates have Tissue level of organisation.
- Cnidoblast or Chidocyte (contain stinging capsule as Nematocyst) present on the tentacles and body, which are used for anchorage, defence and for the capture of Prey.

- Body of coelenterates may be supported by horny or calcareous exoskeleton. E.g. Corals
- Cavity of the Coelenteron is having single aperture. Mouth serve both purpose i.e. incomplete digestion tract (Blind sac).
- Digestion is intercellular/extracellular as well as Intracellular i.e. takes place in Coelenteron as well as in food vacuole.
- Coelenteron is also responsible for distribution of food besides partly digesting it. This dual role named coelenteron as Gastro vascular cavity.
- Respiration and Excretion takes place by diffusion of gases through body surface.
  Excretory matter is Ammonia.
- Nervous system consist of non-polar neurons & sensory cell.
  Cleavage is Holoblastic. Development includes larva (Indirect).
  Larva of Obelia - Planula (free living).
  Larva of Aurelia - Ephyra.

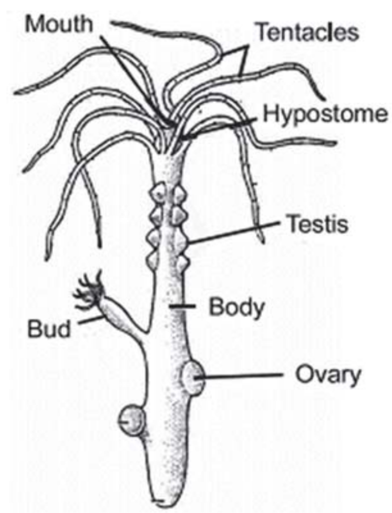


Fig.: *Hydra*

Classification: 3 classes (On the basis of dominance of polyp and medusa)

Hydrozoa	- Polyp & medusa often show metagenesis e.g. 1. Hydra – Frest water polyp (medusa absent) 2. Obleia – Sea fur 3. Physalia – Portuguese man-of-war. (Neurotoxic, gas gland present)
Scyphozoa	- Medusa form is more common, polyp may be reduced or absent e.g. 1. Aurelia – jelly fish, Moon jelly.
Anthozoa	- Only polyp form dominant, medusa may be reduced or absent. - This class has two types of animals (A) Sea Anemones (Skeleton absent) e.g. 1. Adamsia 2. Metridium - Sea anemones show commensalism with Hermit

	crab (B) Corals ($CaCO_3$ Skeleton) 3. Pennatula - Sea) pen 4. Gorgonia - Sea fan 5.Meandrina-Brain coral 6. Tubipora- Organ pipe coral 7. Alcyonium -Dead man's finger (Soft coral) 8. Corallium - Red coral (Moonga)

Unique Features

- Tissue level of organisaton of the body.
- Special stinging cells, the cnidoblats, for defence and offence.
- Incomplete digestive tract bounded by body wall.
- A simple nervous system in the form of a network of nerve cells and fibres.
- Simple gonands without gonoducts.

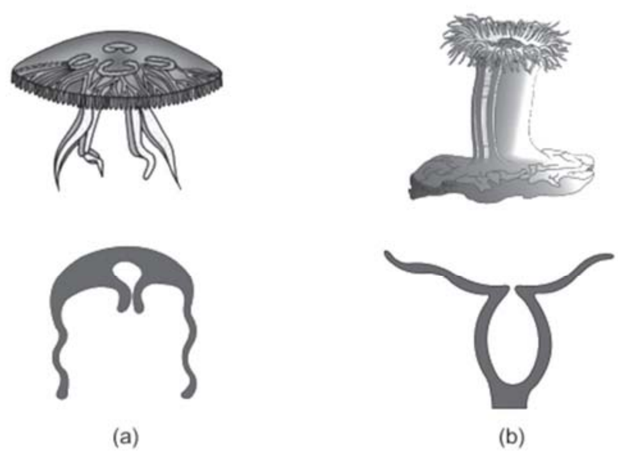


Fig.: Examples of Coelenterata indicating outline of their body form:
(a) *Aurelia* (Medusa), **(b)** *Adamsia* (Polyp)

Phylum – Ctenophora

- Ctenophores, also known as comb-bearers, comb-jellies, or sea walnuts, are marine organisms primarily inhabiting oceans and characterized by their free-swimming nature. The following are the general features of ctenophores:
- Habitat: Ctenophores exclusively reside in marine environments, specifically in oceans, where they navigate as free-swimming creatures.
- Body Symmetry: These organisms exhibit radial symmetry, where their body parts are arranged around a central axis.
- Level of Organization: Similar to cnidarians, ctenophores display a tissue level of organization, marking an intermediate complexity in their biological structure.
- Germ Layers: Ctenophores are diploblastic animals with embryonic layers comprising an outer ectoderm, an inner endoderm, and a distinct layer known as mesoglea. Unlike cnidarians, ctenophore mesoglea contains amoebocytes and smooth muscle cells, providing a jelly-like appearance.

- Body Form: Featuring a transparent body, ctenophores can have flat to oval shapes. Eight median comb plates on the external surface bear fused cilia, aiding in locomotion. Unlike cnidarians, they lack cnidoblasts.
- Tentacles: Tentacles, when present, number two and are solid with adhesive cells called colloblasts or lasso cells.
- Bioluminescence: Ctenophores exhibit well-marked bioluminescence, the ability to emit light.
- Digestion: Digestion is both extracellular and intracellular. Tentacles capture food and direct it to the gastro-vascular cavity, where extracellular digestion occurs before intracellular digestion within food vacuoles. The branched gastro vascular cavity opens to the exterior through the mouth.
- Special Sense Organ: A distinctive sense organ called the 'Statocyst' is located at the aboral end, opposite the mouth.

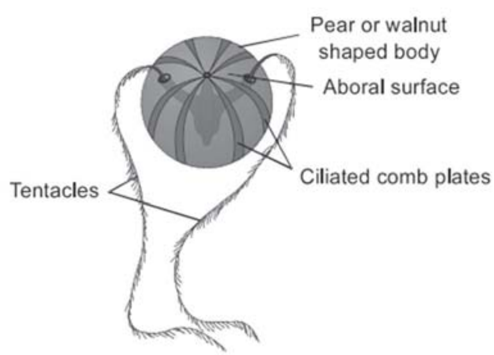


Fig.: *Pleurobrachia*

- Skeletal, Circulatory, Respiratory, and Excretory Systems: These systems are absent in ctenophores.
- Nervous System: Ctenophores have a diffuse type of nervous system.
- Reproduction: Ctenophores are hermaphrodites, and reproduction occurs exclusively through sexual means. Asexual reproduction is absent.
- Fertilization: Fertilization is external, taking place in the water.
- Development: After fertilization, the zygote develops into a free-swimming larva known as a cydippid larva, which eventually matures into the adult form. This indirect development is a characteristic feature of ctenophores.
- Examples of ctenophores include Pleurobrachia (sea gooseberry), Ctenoplana, Hormiphora (sea walnut), Cestum (Venus girdle), and Beröe.

Phylum Platyhelminthes

The organisms belonging to this phylum exhibit a body structure that is flattened in the dorso-ventral plane. This means that their upper (dorsal) and lower (ventral) body surfaces are compressed and lie in a flat configuration. Consequently, these creatures are commonly referred to as flatworms due to the characteristic flatness of their body shape.

Key Features of Platyhelminthes:

- Habit and Habitat: Platyhelminthes exhibit diverse lifestyles, with the majority functioning as endoparasites, residing inside the bodies of other animals known as hosts. However, some flatworms are free-living, particularly in aquatic environments, encompassing both marine and freshwater habitats. Certain species also adapt to terrestrial life. For instance, Dugesia (Planaria), a freshwater flatworm, thrives in ponds, lakes, and streams.

- Body Symmetry: These organisms display bilateral symmetry, meaning their bodies can be symmetrically divided into identical left and right halves by a vertical plane passing through the central axis.
- Level of Organization: Platyhelminthes represent a significant advancement in the evolutionary ladder, being among the first animals to achieve the organ level of organization. Their body structure involves cells grouping together to form tissues, and these tissues organize into organs. Additionally, certain organ systems are present in these organisms.
- Germ Layers: Platyhelminthes are classified as triploblastic animals, signifying that their body structures originate from three embryonic germ layers—ectoderm, mesoderm, and endoderm. This triploblastic nature contributes to the complexity of their physiological and structural characteristics.
- Coelom: Despite being triploblastic with a mesodermal layer, flatworms lack a coelom, which refers to a mesoderm-lined body cavity. Consequently, flatworms are categorized as acoelomate animals, as this cavity is notably absent.
- Body Form: The physical structure of flatworms is characterized by a dorso-ventrally flattened body, contributing to their distinctive appearance.
- Exoskeleton and Endoskeleton: Flatworms do not possess exoskeletons or endoskeletons. However, they may exhibit various adhesive structures such as hooks, spines, suckers (in parasitic forms), teeth, or thorns. These specialized organs aid in attachment to surfaces.
- Parenchyma: The region between the body wall, alimentary canal, and other internal organs is filled with a unique connective tissue known as parenchyma. This tissue plays a crucial role in facilitating the transport of food materials within the organism.
- Respiratory and Circulatory Systems: Flatworms lack respiratory and circulatory systems, distinguishing them from more complex organisms. The absence of these systems implies that they rely on alternative means for gas exchange and nutrient distribution.
- Digestive Tract: The digestive system in platyhelminthes features a single opening that serves both as a mouth and anus, rendering it incomplete. Notably, tapeworms lack a digestive tract altogether.
- Parasitic Flatworms: Specialized adaptations are observed in the bodies of parasitic flatworms to acquire nutrition from their hosts. Further details on these adaptations are explored in subsequent discussions.

Parasitic Adaptations:

Hooks: Hooks serve as adhesive structures facilitating the attachment of the worm to the internal layers of the host's body. In organisms such as Taenia, these hooks function as specialized organs of attachment, ensuring a secure connection.

Suckers: Suckers play a dual role in parasitic organisms, aiding in both adhesion and the ingestion of food. Functioning as suctorial organs, they assist in extracting nutrients by suction from the host's body. This adaptation is observed in parasites like Taenia and Fasciola.

Direct Absorption of Nutrients through Body Surface: Due to their flattened body structure, certain parasites have the ability to absorb nutrients directly through the surface of their bodies. This adaptation is particularly evident in endoparasites, such as Taenia, which reside within the bodies of other living organisms. Soluble nutrients can diffuse directly through the parasite's body surface.

Thick Tegument: Parasitic worms are externally covered by a substantial tegument, forming a protective layer that shields them from the host's digestive juices. This thick tegument is a crucial adaptation, safeguarding the parasites from the potentially hostile environment within the digestive system of the host.

- Excretion and Osmoregulation: Platyhelminthes employ specialized cells known as flame cells to perform the dual functions of excretion and osmoregulation. These flame cells play a crucial role in maintaining the balance of salts and water within the organism.

- Nervous System: The nervous system of platyhelminthes is considered primitive. It primarily consists of a pair of cerebral ganglia or a brain, along with one to three pairs of longitudinal nerve cords. These nerve cords are interconnected by transverse commissures, resulting in a nervous system referred to as a ladder-like nervous system. This basic nervous arrangement facilitates communication and coordination within the organism.

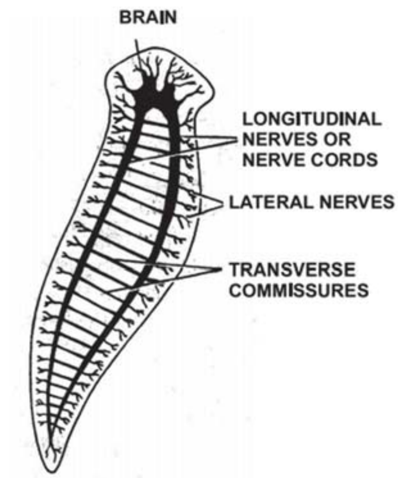


Fig.: Nervous system of *Planaria*

- Reproduction: Flatworms, with the exception of Schistosoma, are hermaphrodites, meaning they possess both male and female reproductive organs (monoecious). Predominantly, these organisms engage in sexual reproduction, producing both sperm and eggs. However, certain flatworms, such as Planaria, exhibit asexual reproduction through transverse binary fission.
- Fertilization: Fertilization in flatworms is an internal process, occurring within the organism's body.
- Development: Typically, the development of flatworms follows an indirect pattern, involving a complex life cycle characterized by multiple larval stages and the involvement of more than one host organism.
- Regeneration: Regeneration, defined as the ability of an organism to replace lost or damaged body parts, is a notable feature of some flatworms. Remarkably, certain species, like Planaria, demonstrate a remarkable power of regeneration. If these animals are divided into two or more parts, each segment has the capability to regenerate into a complete and fully functional individual. This exceptional regenerative ability is a distinctive characteristic of Planaria.

Example Organisms: Taenia (Tapeworm), Fasciola (Liver Fluke), Planaria/Dugesia

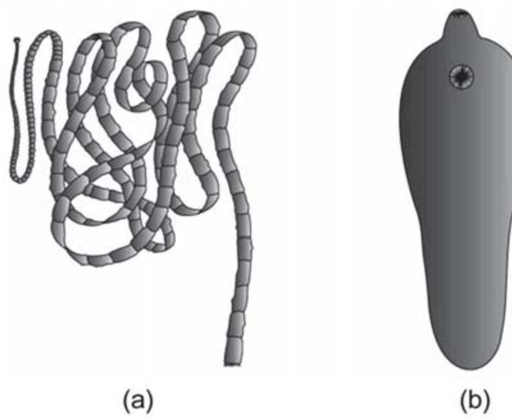


Fig.: (a) Tape worm, **(b)** Liver fluke

Phylum - Aschelminthes/Nemathelminthes

Aschelminthes, commonly referred to as roundworms, derive their name from the circular appearance of their body in transverse cross-sections. This phylum encompasses a vast array, boasting approximately 15,000 species of roundworms.

General Features:

- Habit and Habitat: Roundworms display versatility in their lifestyles, existing as either free-living or parasitic organisms. They can inhabit aquatic or terrestrial environments. For instance, Rhabditis, a terrestrial aschelminth, thrives freely in soil enriched with organic matter. Parasitic roundworms, on the other hand, dwell in plants and animals as endoparasites. Notable examples include Ascaris and Wuchereria, common animal endoparasites.
- Body Symmetry: Roundworms exhibit bilateral symmetry, where their bodies can be divided into two identical halves along a central axis.
- Level of Organization: Aschelminthes achieve the organ-system level of organization. Their organs collaborate to form distinct systems, each dedicated to specific physiological functions such as digestion, respiration, circulation, excretion, and reproduction.
- Germ Layers: Roundworms are classified as triploblastic animals, indicating that their bodies develop from three embryonic germ layers. This triploblastic nature contributes to the complexity of their structure and function.
- Coelom: Aschelminthes possess a pseudocoelom, categorizing them as pseudo coelomates. Unlike a true coelom, the pseudo coelom's body cavity is not lined by mesoderm. Instead, mesodermal tissue is scattered in pouches between the ectoderm and endoderm.
- Body Form: Roundworms exhibit an elongated, cylindrical body shape that tapers towards both ends, contributing to their characteristic morphology.
- Digestive System: The digestive system in roundworms is complete, featuring two separate openings, namely the mouth and anus. These organisms possess a well-developed muscular pharynx. In parasitic roundworms, the rhythmic pumping action of the muscular pharynx facilitates the ingestion of a diet comprising blood, lymph, and partially or fully digested food particles.
- Excretory System: Roundworms house an excretory tube within their bodies, accompanied by Renette cells responsible for eliminating waste through an excretory pore.
- Reproductive System: Aschelminthes are dioecious (unisexual), exhibiting distinct external characteristics for males and females. Females are often longer than males. Sexual reproduction is the exclusive mode, with different individuals producing sperm and eggs.
- Fertilization: Fertilization occurs internally within the reproductive system of roundworms.

- Development: Roundworms display both direct and indirect modes of development, showcasing versatility in their life cycles.

Examples: Notable examples of roundworms include Ascaris (Roundworm), Wuchereria (Filaria worm), Ancylostoma (Hookworm), Enterobius (Oxyuris), Dracunculus medinensis (Guinea worm), and Rhabditis (Free living).

Fig.: Aschelminthes-Roundworm

Phylum – Annelida

The phylum Annelida comprises over 9,000 species of metamerically segmented animals characterized by a true coelom.

General Features:

- Habits and Habitats: Annelids display diverse habits and habitats, with some being aquatic (in marine and freshwater environments) and others terrestrial. For example, Nereis is a marine annelid, the Earthworm is a terrestrial species, and Hirudinaria is a freshwater annelid. While the majority of annelids are free-living, certain species exhibit parasitic tendencies. An illustration of this is Hirudinaria, a blood-sucking leech serving as a common ectoparasite, feeding on the blood of fishes, frogs, cattle, and other animals.
- Common Name: Annelids are commonly known as segmental worms, a nomenclature derived from the distinct segments present in their body structure.
- Body Symmetry: Members of the phylum Annelida exhibit bilateral symmetry, where their bodies can be divided into two mirror-image halves along a central axis.
- Level of Organization: Annelids showcase the organ-system level of organization, signifying a structured arrangement where organs collaborate to form systems dedicated to specific physiological functions. This level of organization reflects a higher complexity in their biological structure.
- Germ Layers: Annelids are categorized as triploblastic animals, indicating that their bodies are composed of three embryonic germ layers—ectoderm, mesoderm, and endoderm. This triploblastic nature contributes to the structural complexity of these organisms.
- Segmentation: The bodies of annelids are characterized by metameric segmentation, representing a distinctive feature where the external segments correspond directly to internal ones. Annelids are notably the first animals to exhibit true body segmentation. This segmentation is evident not only internally but also on the external surface, where the body is visibly marked into distinct units. These units are referred to as metameres, and the segmentation process itself is termed metameric segmentation. This unique form of segmentation is a key defining characteristic of annelids.


(a) (b)

Fig.: Examples of Annelida :
(a) *Nereis*, **(b)** *Hirudinaria*

The nomenclature of the phylum Annelida is rooted in the characteristic presence of segmentation in the bodies of its members. The term "Annelida" is derived from the Latin word "annulus," meaning little ring.

- Locomotion: Annelids, whether dwelling in terrestrial or aquatic environments, possess the ability to move. Their muscular body walls are equipped with muscles that facilitate body motion. The body wall houses two types of muscles based on the arrangement of muscle fibers—circular and longitudinal muscles. Certain aquatic annelids exhibit locomotory appendages known as parapodia, which are fleshy, flattened structures projecting laterally (observed in Nereis). Parapodia, in conjunction with body muscles, play a crucial role in the swimming locomotion of aquatic annelids. It's noteworthy that Hirudinaria lacks parapodia, and earthworms feature chitinous setae for movement.
- Digestive System: Annelids have a complete digestive system, comprising a distinct mouth and anus. The digestion of food is entirely extracellular, occurring in specialized digestive compartments.
- Circulatory System: Annelids typically possess a closed blood vascular system. Respiratory pigments, such as hemoglobin or erythrocruorin, are dissolved in the blood plasma. While free amoeboid blood corpuscles are present, red blood cells (RBCs) are absent. Leeches, however, deviate with an open blood vascular system.
- Excretory System: Coiled tubes, referred to as nephridia (singular: nephridium), are situated in the body of annelids. Nephridia play a dual role in excretion and osmoregulation, aiding in the removal of metabolic waste from the body.
- Nervous System: The nervous system in annelids facilitates body control and coordination. It comprises paired ganglia (singular: ganglion) connected to a double ventral nerve cord. This arrangement ensures communication and coordination within the body.
- Reproductive System: Earthworms and leeches exhibit a monoecious reproductive system, signifying that they are hermaphrodites with both male and female reproductive organs. In contrast, Nereis displays a dioecious reproductive system, where distinct individuals are either male or female. Nereis undergoes indirect development through a trochophore larva. Annelids exclusively engage in sexual reproduction.

Examples: Notable examples of annelids include Nereis (Sandworm), Pheretima (Earthworm), and Hirudinaria (Blood-sucking leech). These examples showcase the diversity within the phylum Annelida in terms of reproductive strategies and ecological roles.

Phylum – Arthropoda

The phylum Arthropoda stands as the largest and most diverse group within the animal kingdom, boasting an astonishing count of approximately 900,000 species. Impressively, over two-thirds, accounting for about 60 to 70%, of all formally classified species on Earth fall under the umbrella of arthropods. This phylum comprises a heterogeneous assembly, encompassing a multitude of animals that vary significantly in terms of structure, habitat, feeding habits, and other distinguishing characteristics. Within the diverse array of arthropods, familiar members include the cockroach, butterfly, crab, prawn, spider, centipede, millipede, mosquito, honey bee, and many more. The sheer abundance and diversity of arthropods underscore their ecological importance and their ubiquity in various ecosystems around the globe.

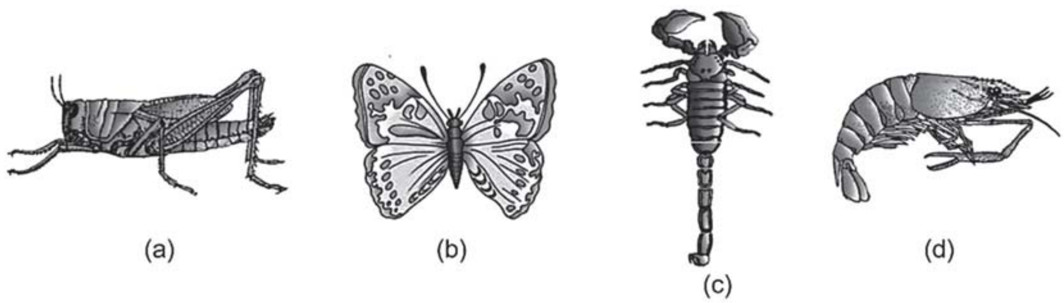


Fig.: Examples of Arthropoda :
(a) *Locust*, **(b)** Butterfly, **(c)** Scorpion, **(d)** *Prawn*

General Characteristic Features:

- Habit and Habitat: Arthropods exhibit a remarkable diversity in habitats, occupying environments such as oceans (e.g., Limulus), freshwater (e.g., Daphnia), land (e.g., cockroach, locust), and even air (housefly, mosquito).
- Body Symmetry: Arthropods are characterized by bilateral symmetry, where their bodies can be divided into two mirror-image halves along a central axis.
- Level of Organization: These animals display the organ-system level of organization, reflecting a structured arrangement where organs collaborate to form systems dedicated to specific physiological functions.
- Germ Layers: Arthropods belong to the category of triploblastic animals, indicating that their bodies develop from three embryonic germ layers—ectoderm, mesoderm, and endoderm.
- Segmentation: The bodies of arthropods are distinctly segmented, showcasing a notable feature of segmentation.
- Coelom: Arthropods are classified as coelomates, possessing a true coelom that accommodates visceral organs within the body cavity.
- Body Form: The bodies of arthropods are encased in a robust, water-resistant exoskeleton composed of chitin. This exoskeleton provides essential protection, support, and prevents water loss through evaporation, enabling arthropods to thrive in diverse and sometimes dry environments. The body is distinctly divided into three well-defined regions: the anterior head, middle thorax, and posterior abdomen. Each of these regions is further divided into segments, contributing to the segmented nature of their bodies. Notably, arthropods possess jointed appendages, a defining feature reflected in the phylum's name (arthros-joint, poda-appendages).
- Digestive System: Arthropods feature a complete digestive tract equipped with glands that release enzymes, facilitating the extracellular digestion of food. This digestive system is a vital component of their efficient nutrient processing.

- Respiratory Structures: Arthropods showcase a variety of respiratory structures tailored to facilitate the exchange of oxygen or air across their body surfaces. These adaptations differ across arthropod groups:
  Gills: Aquatic arthropods such as prawns and crabs utilize gills as their respiratory structures to extract oxygen from water.
  Book-gills: Limulus, a notable arthropod, possesses book-gills characterized by plate-like structures known as lamellae. These lamellae are arranged parallel to each other, resembling the pages of a book.
  Book-lungs: Found in arachnids like scorpions and spiders, book-lungs are modified versions of book-gills adapted for aerial respiration.
  Tracheal System: Insects, including butterflies, cockroaches, and mosquitoes, rely on a tracheal system as their primary respiratory organ. This elaborate system comprises branching elastic air tubes called tracheae, which open directly to the external environment through pores known as spiracles.

- Circulatory System: Arthropods possess an open circulatory system, wherein colorless blood flows freely within the body cavity. Despite the simplicity of the circulatory system, arthropods compensate with a well-developed respiratory system to efficiently facilitate gas exchange. This adaptation ensures that oxygen is adequately supplied to tissues throughout the arthropod's body.
- Sensory System: Arthropods boast a comprehensive sensory system, encompassing major senses such as touch, smell, hearing, and sight. Various types of sensory organs equipped with receptors for detecting external stimuli contribute to the sensory prowess of arthropods. The distinctive sensory organs include:
  Antennae (singular: Antenna): Positioned on the anterior end of the body, antennae are whip-like, slender, jointed appendages. Comprising smaller segments, antennae possess joints and function as crucial sensory organs. They house receptors for touch and smell, with olfactory receptors facilitating the sense of smell and tactile receptors enabling the sensation of touch.
  Eyes (Simple and Compound): Arthropods exhibit both simple and compound eyes. Simple eyes, referred to as ocelli (singular: ocellus), provide basic vision capabilities. Compound eyes are composed of numerous smaller units, enhancing the arthropod's ability to perceive light. While their vision is not as highly developed as that of more complex animals, arthropods can discern both dim and bright light. This perceptual capacity aids in avoiding threats and serves various other purposes.
  Statocyst: The statocyst is a sensory structure that relays information about changes in the animal's position to its brain. This information is crucial for maintaining the animal's balance, demonstrating the role of the statocyst in the sensory integration and coordination of arthropods.

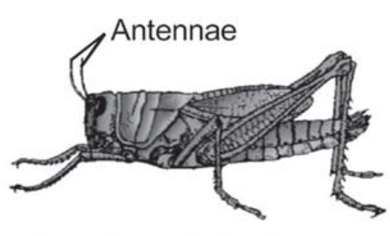


Fig.: An arthropod showing antennae

- Excretory System: Arthropods possess an excretory system comprising elongated, fine blind tubules known as Malpighian tubules. These tubules are intricately connected to the alimentary canal and play a vital role in removing waste from the body fluids. The nitrogenous waste is expelled along with feces through the anus, contributing to the efficient elimination of metabolic byproducts.

- Reproductive System: Arthropods typically exhibit a dioecious reproductive system, where male and female sexes are distinct. The majority of females in this phylum are oviparous, meaning they lay eggs as part of their reproductive process.
- Fertilization: Fertilization in arthropods is commonly an internal process, particularly observed in terrestrial arthropods. This internal mode of fertilization is a notable feature of the reproductive strategy within the arthropod phylum.
- Development: Arthropods showcase diverse developmental patterns, with some undergoing direct development while others exhibit an indirect approach. Noteworthy examples of arthropods with indirect development include Culex, Anopheles (both mosquito species), and Bombyx (silk moth). These arthropods undergo a series of larval stages before reaching maturity, illustrating the variety in their developmental life cycles.

Examples of Arthropods:

- **Economically Useful Insects:** Many insects play a crucial economic role, providing various valuable products to humanity. Some noteworthy examples include:
  Apis (Honey Bee): Honey bees contribute the essential product of honey, widely used as both food and in medicinal applications. Additionally, beeswax produced by honey bees finds applications in cosmetics and paint industries.
  Bombyx (Silkworm): Silkworms are significant for the silk they produce, a material extensively used in the creation of sarees, shawls, and other garments.
  Laccifer (Lac Insect): The lac insect secretes a substance known as lac, which serves as a sealing wax. This material is utilized in the production of bangles, toys, and various other products.
- **Vectors:** Certain insects act as vectors, transmitting dangerous diseases. Examples of such vectors include:
  Anopheles: The Anopheles mosquito serves as a vector for malaria.
  Culex: Culex mosquitoes act as vectors for filariasis (elephantiasis), a disease caused by the parasite Wuchereria.
  Aedes: Aedes mosquitoes are responsible for spreading dengue fever and chikungunya.
  Xenopsylla/Rat Flea: Rat fleas, known as Xenopsylla, are vectors that transmit plague.
  Glossina (Tse-Tse Fly): Tse-Tse flies, belonging to the genus Glossina, are vectors for sleeping sickness.
  Phlebotomus (Sand Fly): Sand flies of the genus Phlebotomus act as transmitters of kala-azar.
- **Gregarious Pest:** Locusta, commonly known as the locust, is an example of a gregarious pest. This pest poses a significant threat to crops, causing substantial damage to vegetation. Despite living in groups, these individuals do not cooperate with one another, earning them the classification of "gregarious."
- **Living Fossil:** Limulus, also known as the king crab, stands as an example of a living fossil. This species showcases characteristics that have remained relatively unchanged over an extended period, providing insights into the evolutionary history of arthropods.

Phylum – Mollusca

Mollusca, the second-largest phylum within the animal kingdom, is home to a diverse array of soft-bodied creatures. The name "Mollusca" is derived from the Latin word "mollis," signifying their characteristic soft-bodied nature.

General Characteristic Features:

- Habitat: Mollusks exhibit a broad distribution across various habitats, spanning oceans, coral reefs, deserts, forests, rivers, lakes, and even subterranean environments. This adaptability makes them equally at home in terrestrial and aquatic ecosystems, encompassing both marine and freshwater domains.

- Body Symmetry: Bilateral symmetry is a defining feature of molluscan anatomy. However, certain mollusks, such as Pila, may undergo torsion or twisting during growth, leading to asymmetry in adults as a secondary characteristic.
- Level of Organization: Mollusks operate at the organ-system level of organization, showcasing a sophisticated arrangement where specialized organs collaborate to perform distinct physiological functions.
- Germ Layers: Mollusks belong to the category of triploblastic animals, indicating that their body structures derive from three embryonic germ layers—ectoderm, mesoderm, and endoderm.
- Segmentation: Unlike some other organisms, mollusks lack body segmentation, resulting in a distinctly unsegmented body plan.
- Coelom: Possessing a true body cavity or coelom lined by the mesoderm, mollusks are categorized as coelomates. This internal structure contributes to their overall body organization.
- Body Form: The molluscan body is characterized by a calcareous shell covering it, providing protection and support. The body is unsegmented and features a distinct head, visceral hump (containing internal organs), and a muscular foot. This structural arrangement is key to their overall body plan and functionality

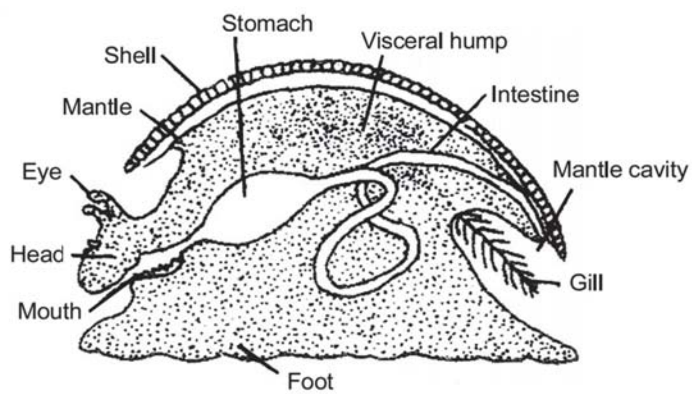


Fig.: Body plan of a Mollusc (Hypothetical)

- Anatomical Structures: The head, positioned at the anterior part of the body, serves as a region that accommodates essential structures such as the mouth, tentacles, and eyes in certain mollusks. The visceral hump, situated centrally, encompasses the digestive tract and various visceral organs. The foot, a robust and muscular component, primarily functions as a locomotory organ.
- Mantle (Pallium): The mantle, a soft and spongy layer of skin, delicately covers the visceral hump or pallial complex in mollusks. This distinctive feature plays a multifaceted role, serving functions such as:
  Providing anterior protection to the head by acting as a shielding hood.
  Secreting a calcareous shell that envelops the body, offering protection and functioning akin to an exoskeleton (except in Octopus). The mantle cavity encloses feather-like gills, contributing to both respiration and excretion.
- Digestive System: Mollusks possess a complete digestive system featuring separate openings for food entry and waste exit. Digestive glands are present, and digestion occurs extracellularly. Molluscan diets vary and may include microorganisms, vegetation (notably in snails), and decomposed plant

and animal tissues. The mouth is equipped with a radula, a file-like rasping organ armed with transverse rows of chitinous teeth, although absent in certain members like Pinctada.

- Respiratory System: In aquatic mollusks, respiratory organs take the form of gills within the mantle cavity, while terrestrial forms utilize lungs. The gills, referred to as ctenidia, exhibit a comb-like or feather-like structure, facilitating the oxygenation of blood by extracting oxygen from the surrounding water.
- Circulatory System: Mollusks feature an open circulatory system where the heart propels blood through large vessels into open spaces or body cavities called sinuses. The respiratory pigment involved is haemocyanin. Cephalopods, a subgroup of mollusks, distinguish themselves with a closed circulatory system.
- Excretory System: The gills in mollusks serve a dual function by facilitating both excretion and respiration. These respiratory organs effectively separate nitrogenous waste products from the blood due to their rich blood supply. Excretion is further carried out by the paired Organ of Bojanus, while an additional excretory organ, known as Keber's organ (Pericardial gland), deposits waste into the pericardium. Subsequently, the waste is transported to the Organ of Bojanus for elimination.
- Sensory System: In the anterior head region, mollusks may feature sensory tentacles highly responsive to touch. Beyond tentacles, various other sensory organs contribute to their awareness of the surroundings, including eyes for light detection, statocysts for balance, and receptors for smell and taste. An essential sensory structure called the Osphradium evaluates the chemical nature of water.
- Nervous System: Mollusks possess a nervous system comprised of paired ganglia, which are clusters of nerve cells, along with several nerves that provide nervous supply throughout the body.
- Reproductive System: Mollusks typically exhibit dioecious characteristics, with separate sexes, as observed in species like Pila, Sepia, Loligo, Octopus, among others. However, monoecious forms, where both male and female reproductive organs are present in the same individual, are exemplified by Aplysia and Doris. Mollusks are primarily oviparous, laying eggs.
- Fertilization: Mollusks employ both external and internal fertilization methods, with internal fertilization being more prevalent.
- Development: Mollusks undergo both direct and indirect development, with the latter being more common. Indirect development involves a free-swimming larval stage, such as trochophore, Veliger (observed in Pila), glochidium (seen in Unio), and ectoparasitic forms on fishes, as seen in Pila and Aplysia. Examples of mollusks with direct development include Loligo, Sepia, and Octopus.

Example Mollusks: Some representative examples of mollusks include Pila (Apple snail), Pinctada (Pearl oyster), Sepia (Cuttlefish), Loligo (Squid), Octopus (Devil fish), Aplysia (Sea hare), Dentalium (Tusk shell), and Chaetopleura (Chiton).

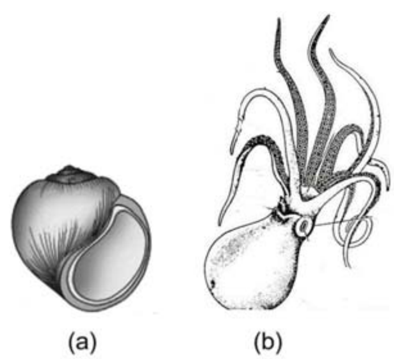


Fig.: Examples of Mollusca : **(a)** *Pila*, **(b)** *Octopus*

Phylum – Echinodermata

The term Echinodermata, derived from the Greek words "echinos" meaning spiny and "derma" meaning skin, literally translates to "spiny or prickly-skinned." These marine organisms are characterized by an endoskeleton, an internal framework composed of calcareous ossicles, or small bones, embedded within their skin.

Similarities with Chordates:

- Tube within Tube Body Plan: Echinoderms share a tube-within-tube body plan, an evolutionary adaptation along the deuterostomic lineage.
- True Coelom: They possess a true coelom known as the enter coelom.
- Mesodermal Skeleton: The presence of a mesodermal skeleton composed of calcareous plates or ossicles is another shared characteristic with chordates.

General Features:

- Habitat: Echinoderms exclusively inhabit marine environments, residing predominantly at the ocean floor, making them bottom-dwelling organisms.
- Habit: These animals are exclusively free-living, lacking any parasitic forms.
- Body Symmetry: While adult echinoderms exhibit radial symmetry, their larvae display bilateral symmetry.
- Level of Organization: Echinoderms demonstrate an organ-system level of organization.
- Germ Layers: They are triploblastic animals, possessing three germ layers.
- Segmentation: The body of echinoderms is unsegmented.
- Coelom: Echinoderms are categorized as coelomate animals, featuring a body cavity.
- Body Form: Adult echinoderms showcase pentamerous radial symmetry, with their body parts arranged along five axes. The distinctive characteristics of Echinodermata, such as their marine habitat, free-living nature, and unique radial symmetry, set them apart in the animal kingdom.

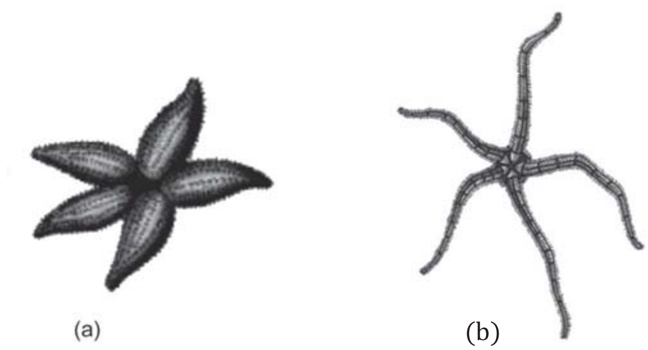


Fig.: Examples for Echinodermata : **(a)** *Asterias*, **(b)** *Ophiura*

- Body shape varies from star-like (star fish) to globular or globe-like (sea urchin) to cylindrical (sea cucumber). An endoskeleton of calcareous ossicles with overlying skin gives a spiny appearance to echinoderms.
- Pedicellariae and Spines: Located between the spines of echinoderms, there exist specialized structures known as pedicellariae, which play a vital role in maintaining the cleanliness of the organism's surface. These pedicellariae are composed of three calcareous plates, forming a configuration with two jaw-like valve structures positioned over a basal calcareous plate. The presence of these pincer-like pedicellariae contributes to the hygiene and protection of the echinoderm's integument.

- Water Vascular System: One of the distinctive features defining echinoderms is the water vascular system, a modified component of the coelom that comprises a network of canals filled with watery fluid. This intricate system includes various canals, namely the madreporite (sieve plate), stone canal, ring canal, radial canals, and tube feet.
  Functions of the Water Vascular System:
  The designation as the water vascular system is apt, given its resemblance to the circulatory system, as it ensures a continuous flow of water in and out of the echinoderm's body. The system serves several essential functions:
  Locomotion: A particularly intriguing aspect of the water vascular system is its role in locomotion. The movement of the body is orchestrated by the coordinated stepping action of tube feet, which alternately adhere to and release from the substratum. This dynamic process is facilitated by the entry and exit of water.
  Capture and Transport of Food: In the capture and transportation of food, the arms and tube feet play a pivotal role. Prey is seized and secured by these appendages, allowing for the intake and subsequent transport of food within the organism's body.
  Respiration: Furthermore, the tube feet contribute to respiration by acting as respiratory organs akin to gills. The thin walls of these tube feet facilitate the exchange of gases, supporting the respiratory needs of the echinoderm.
- Haemal and Perihaemal Systems: Instead of blood vascular system, there are present haemal and perihaemal systems which are of coelomic origin. Thus the so called circulatory system is open type. The so called blood is often without a respiratory pigment. There is no heart.
- Digestive system: Digestive system is complete with two separate openings. It lies along the dorso-ventral axis of body. Mouth lies on the lower (ventral) side and anus on the upper (dorsal) side of body.
- Excretory system: Specialised excretory system is absent. The excretory products diffuse out from the body tissues into the coelomic fluid from where they are finally eliminated out.
- Reproductive system: The echinoderms are usually dioecious (sexes are separate). The reproduction is sexual.
- Fertilisation: Fertilisation is usually external, takes place in the sea water.
- Development: Development is indirect with free-swimming bilaterally symmetrical larva such as Dipleurula, Bipinnaria, Brachiolaria, Doliolaria, and Auricularia.

Example: Asterias (Star fish), Echinus (Sea urchin), Antedon (Sea lily), Cucumaria (Sea cucumber) and Ophiura (Brittle star).

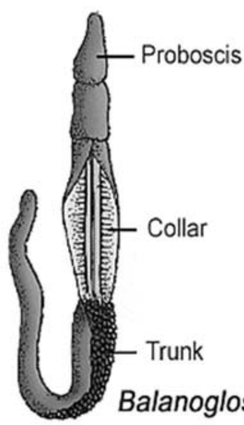
Phylum - Hemichordata/Stomochordata

Originally categorized as a sub-phylum within the chordate phylum, Hemichordata has undergone a reclassification and is now recognized as an independent phylum within the realm of non-chordates. The nomenclature Hemichordata, derived from the Greek words "hemi" meaning 'half' and "Chorde" meaning 'cord,' alludes to the initial assumption that these organisms were 'half' chordates. Despite being named for a structure once thought to be their notochord, subsequent evidence has led to their reclassification as non-chordates. This phylum encompasses a small group of worm-like marine animals.

General Characteristics:

- Habitat: Hemichordates are exclusively found in marine environments.
- Body Symmetry: These organisms exhibit bilateral symmetry.
- Level of Organization: They display the organ-system level of organization.
- Germ Layers: Hemichordates are triploblastic animals, possessing three germ layers.
- Segmentation: Unlike segmented organisms, hemichordates lack segmentation, featuring an unsegmented body.
- Coelom: Hemichordates are coelomate animals, characterized by a mesoderm-lined body cavity.

- Body Form: The physical characteristics of hemichordates include a soft, fragile, and worm-like appearance. The body is cylindrical and can be divided into three distinct regions:
  Anterior Proboscis: This section is short and conical in shape.
  Middle Collar: Represented by a short and cylindrical part.
  Long Posterior Trunk: This elongated portion is flat and further differentiated into various segments.
- Digestive System: The digestive system of hemichordates features a complete digestive tract.
- Circulatory System: Hemichordates possess an open circulatory system.
- Respiratory System: Given their aquatic nature, these organisms carry out respiration through gills.
- Excretory System: The elimination of nitrogenous waste occurs through the proboscis gland. The proboscis pore is situated at the anterior region of the proboscis.
- Reproductive System: Hemichordates are dioecious, exhibiting separate sexes. Reproduction is predominantly sexual.
- Fertilisation: Fertilization in hemichordates is external, taking place in the sea water.



Balanoglossus

- Development: The developmental process in hemichordates is primarily indirect, involving a free-swimming larva known as the Tornaria larva.

Examples: Prominent examples of hemichordates include Balanoglossus (Tongue worm) and Saccoglossus (Tongue worm).