ANIMAL KINGDOM-1

(NON-CHORDATES - PORIFERA TO HEMICHORDATA)

INTRODUCTION

❖ **Taxonomy**

Branch which deals with the study of nomenclature, classification and their principles.

Term “taxonomy" was given by Candolle (Greek word – Taxis – arrangement, Nomos – Law).

❖ **History of taxonomy**

❖ Aristotle –

- Father of Biology and Zoology.
- Father of ancient animal classification.
- Book :- “Historia animalium”.
- He classified animals into two groups:-

(a) Anaima – Animals without RBCs.

(b) Enaima – Animals with RBCs. Divided into two groups -

(i) Viviparous (ii) Oviparous.

❖ Term “species” given by John Ray (also gave “key” for identification of animals).

❖ Modern definition of species given by Mayer.

❖ Binomial system of Nomenclature –

- Devised by Gespard and Bauhin.
- Detailed information about Binomial system given by Linnaeus in 1758 in 10th edition of his book “Systema Naturae”.

❖ Father of Modern Taxonomy – “Carolus Linnaeus”.

❖ Trinomial System of nomenclature –

Given by Huxley and Strickland.

Trinomial nomenclature – Genus species sub-species (e.g. *Homo sapiens sapiens*)

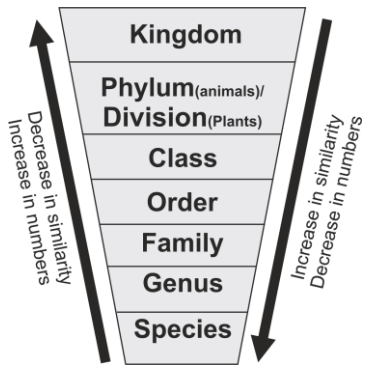
❖ Term “phylum” given by G.L. Cuvier.

❖ Terms “Vertebrate” and “invertebrate” given by Lamarck.

❖ Five Kingdom classification proposed by Robert Whittaker in 1969 –

(a) Monera (b) Protista (c) Fungi (d) Plantae (e) Animalia

- Sequence of Classification:-



Sequence or Hierarchy of classification

Various grouping levels or ranks in classification are known as obligate categories .e.g.

Taxon	Category
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Hominidae
Genus	*Homo*
Species	*sapiens*

BASIS OF CLASSIFICATION

Bases of classification are **arrangement of cells**, **body symmetry**, **and nature of coelom**, **patterns of digestive**, **circulatory** and **reproductive system**.

A. Level of Organization

All members of kingdom **Animalia are multicellular** eukaryotes but all of them do not exhibit the same pattern of organization of cells. Biological organization starts at submicroscopic molecular level.

1. **Cellular level of organization–** The cells are arranged as loose cell aggregates. e.g. **sponges**.
2. **Tissue level of organization–** The arrangement of cells is more complex. Here the cells performing the same function are arranged into tissues. e.g. **coelenterata, Ctenophora**
3. **Organ level of organization** is exhibited by members of **platyhelminthes** and other higher phyla where tissues are grouped together to form organs, each specialized for a particular function.
4. **Organ system of organization** – In animals like annelids, arthropods, molluscs, echinoderms and chordates, organs are associated to form functional systems. Each system concerned with a specific physiological function. This pattern is called organ system level of organization.

B. Digestive Tract

Digestive tract is the passage where food is taken for digestion, absorption and elimination of undigested food. Coelenterates and flat-worms have a digestive tract with a single opening termed mouth that takes food as well as eliminates the undigested food. This type of digestive tract is called incomplete. Digestive tract of many animals has two openings; mouth for intake of food and anus for the elimination of faecal matter. Such a digestive tract is termed complete. It is found from round worms to mammals.

C. Body Plan

Based on structural plan of body can be divided in three categories.

a. **Cell Aggregate -** Cells are loosely arranged as germ layers are absent. Exhibited by parazoans as sponges.

b. **Blind Sac –** Body cavity or alimentary canal has a single opening which serves as mouth & anus: so incomplete digestive system exhibited by Cnidarians & flatworms.

c. **Tube within tube –** Body cavity has two openings, one serving as mouth while other as anus so complete digestive system. Body consists of two tubes outer body wall & inner gut wall. Based on formation of mouth & anus, can be divided in two groups

(i) **Protostomous –** Mouth is formed earlier than anus. Embryonic blastopore forms mouth. Exhibited by Aschelminthes to Mollusca.

(ii) **Deuterostomous –** Anus is formed earlier than mouth. Embryonic blastopore forms anus. Exhibited by Echinodermata to Chordata.

D. Circulatory system

It is a system that takes part in continuous flow of blood in the body. Circulatory system is of two types, closed and open.

1. **Closed circulatory system -** The blood circulates inside the blood vessels without ever coming in direct contact with the body cells, blood capillaries present. It is more efficient system. e.g., Annelids, Chordates.
2. **Open circulatory system -** The blood flows in open spaces like lacunae and sinuses. It bathes the cells directly, blood capillaries absent. It is less efficient system. e.g., Arthropods, Molluscs.

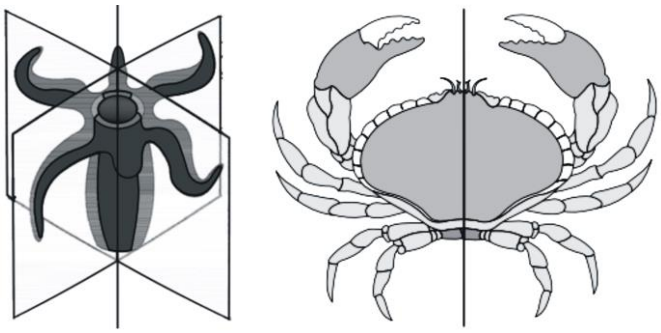
   Blood may be colourless (e.g., insects), bluish due to a respiratory pigment, the haemocyanin (e.g., prawn, *Pila*) or red due to respiratory pigment, the haemoglobin (e.g., earthworm, vertebrates). Circulatory system originates from phylum Annelida.

E. Symmetry

Body symmetry is the similarity of parts in different regions and directions of the body. An animal is said to **be symmetrical if its body is divisible into equal halves by one or more planes.**

1. When the body is not divisible into equal halves by any plane it is called **asymmetrical or asymmetric** as found in amoeba (a protist) and most of sponges (*Spongilla*).
2. **Radial symmetry –** In this type of symmetry, a number of similar parts radiate out from a central axis. The body of the individual can be divided into equal halves by any plane passing through the centre from top to bottom. This type of symmetry is found in some sponges (*Sycon*), Coelenterates (e.g., *Hydra*, jelly fish) and Echinoderms (e.g. star fish).

   When the body can be divided into two similar halves by one vertical plane only, the radial symmetry is called biradial symmetry. It is present in the sea-anemones and ctenophores. The animals which show radial and biradial symmetry have oral and aboral sides. The oral side is that which has mouth, whereas the aboral side is one which is opposite to oral side.
3. **Bilateral symmetry –** In this type of symmetry, the body can be divided into two equal halves by a single plane only because the important body organs are paired and occur on the two sides of a central axis. Bilateral symmetry is found in many invertebrates and all vertebrates. The right and left sides of the body are called the lateral sides. The side of the body which is kept forward during locomotion is termed the anterior side and the opposite one is called posterior side. The back or upper surface is termed dorsal and the under surface (towards the substratum) is called ventral (*L. venter* = *belly*). Bilateral symmetry arose when animals on sea floor become motile. It is strongly associated with cephalization.

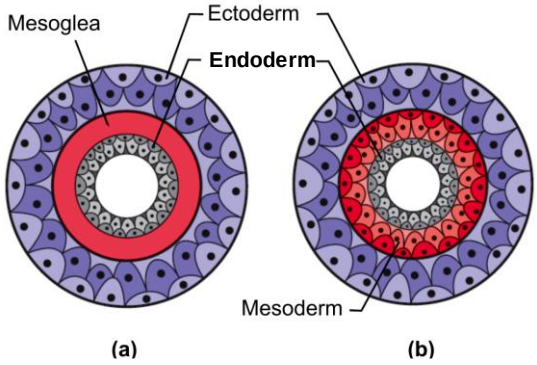


(a) Radial symmetry (b) Bilateral symmetry

F. Germ Layers

They are primary layers of cells which differentiate in the animal embryos at the gastrulation stage. The germ layers give rise to all the tissues/organs of the fully formed individual.

1. The embryos of coelenterates and ctenophores have two germs layers, the ectoderm and endoderm. These animals are called diploblastic.
2. The embryos of all other animals (from phylum platyhelminthes to phylum Chordata) have three layers- the ectoderm, mesoderm and endoderm. These animals are called triploblastic animals.



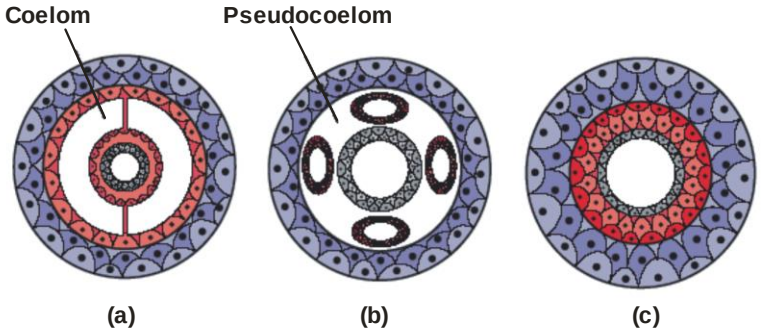
Showing germinal layers (a) Diploblastic (b) Triploblastic

G. Coelom (Body cavity): The body cavity which is lined by mesoderm and filled with coelomic fluid is called coelom.

1. **Acoelomates –** The animals which do not have coelom are called acoelomates e.g., flat worms.
2. **Pseudocoelomates –** The animals which have body cavity, called pseudocoel (false coelom) derived from blastocoel of the embryo are called pseudocoelomates. e.g., Round worms.
3. **Eucoelomates (Coelomates) –** The animals which possess true coelom are called eucoelomates or coelomates. The true coelom is a body cavity which arises as a cavity in embryonic mesoderm. In this case, the mesoderm of the embryo provides a cellular lining, called coelomic epithelium or peritoneum, to the cavity. The coelom is filled with coelomic fluid secreted by the peritoneum. True coelom is found in annelids to chordates. True coelom is of two types; schizocoelom or schizocoel and enterocoelom or enterocoel.
   (a) Schizocoelom – It develops as a split in the mesoderm sheet. It is found in annelids, arthropods and molluscs.
   (b) Enterocoelom – The mesoderm arises from the wall of the embryonic gut or enteron as hollow outgrowths or enterocoelomic pouches which form this type of coelom. It occurs in echinoderms and chordates.

Resonate the Concept

- In the arthropods and molluscs true coelum is reduced. The spaces present in between the viscera grow in size and produce a large cavity. The cavity contains blood and is known as haemocoel.



Daigrammatic sectional view of: (a) Coelomatic (b) Pseudocoelomate (c) Acoelomate

H. Segmentation

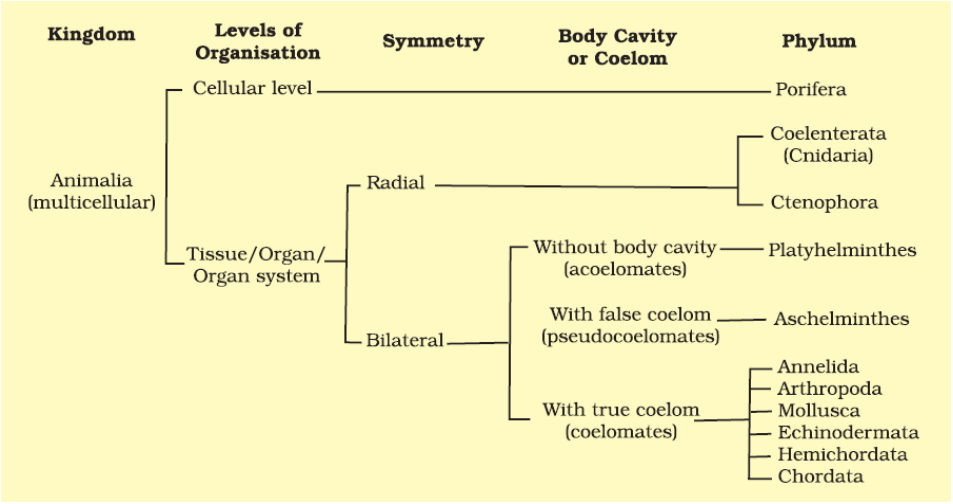
Segmentation is a type of body form having a linear sequence of units or segments possessing a similar or modified structure. It occurs in three animal phyla – Annelida, Arthropoda and Chordata.

1. **Metameric segmentation** (True metamerism or True segmentation). It is a type of segmentation where external divisions correspond to internal divisions. The body is often divided both externally and internally into a number of segments (metameres) e.g., annelids. Segmentation is mostly external in arthropods and mainly internal in man and other chordates (vertebrates' body muscles, some blood vessels and nerves).
2. **Pseudometamerism** (False segmentation) – It is found in tapeworms. In tapeworms, the proglottids (segments of tapeworms) are budded off from the neck; hence, this segmentation is called pseudometamerism (pseudosegmentation). It differs from true segmentation of embryonic origin as found in annelids, arthropods and chordates.

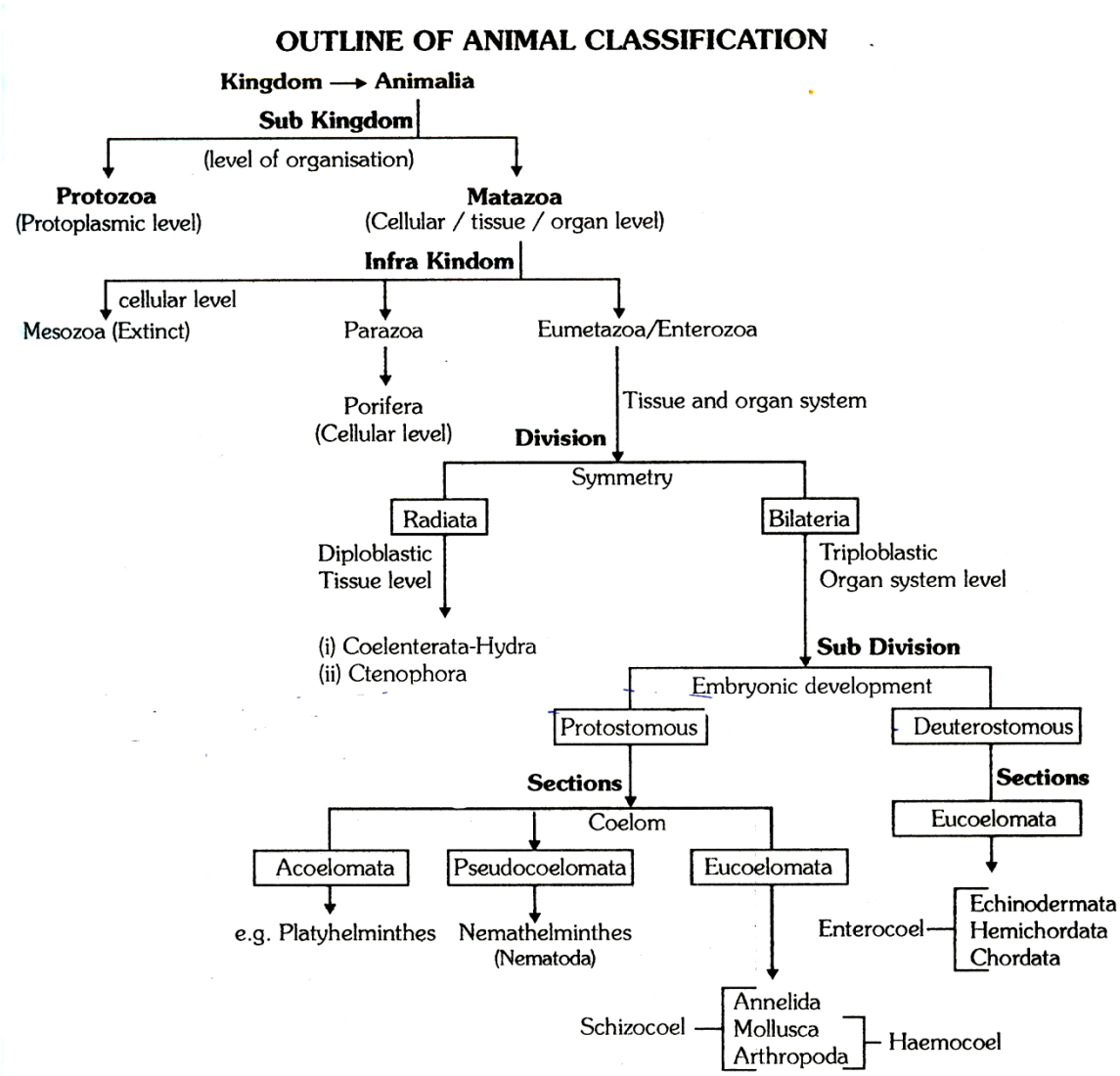
I. Notochord

Animals with notochord are called chordates. Notochord is a mesodermally derived rod-like structure present above alimentary canal and below nerve cord. Those animals which do not form this structure are called non-chordates, e.g., Porifera to Hemichordata.

Non chordates are dissected from dorsal side, whereas Chordates from ventral side.



Broad classification of Kingdom Animalia based on common fundamental features



Phylum Porifera (Sponges)

(Gk. Porus = Pore ; ferre = to bear)

- Study of sponges is called Parazoology.
- Phylogenetically evolved from choano flagellates (Protero spongia)
- **General characters**

1. **Habitat –** All are aquatic (mostly marine and some are fresh water). They are sessile (immotile), solitary or colonial in nature.
2. **Body form –** Entire body contains pores i.e. numerous mouthlets called ostia and one opening for exit called osculum.
3. **Water canal system –** Also called aquiferous system. Characteristic feature of sponges that helps in :-
   a. Nutrition (food gathering)
   b. Respiration (gaseous exchange)
   c. Excretion (removal of wastes)
   d. Transfer of gametes.
   - Canals are formed by folding of inner wall.
   - There are 3 types of canal systems -

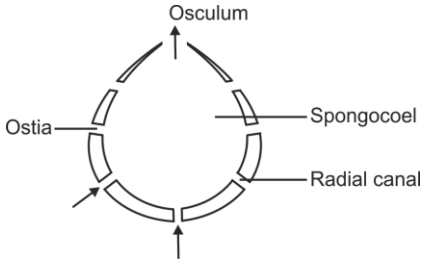
i. Asconoid (Simplest canal) e.g. *Leucosolenia, Olynthus.*
ii. Syconoid e.g. *Scypha*
iii. Leuconoid e.g. *Euspongia, Spongilla, Rhagon* larva of class Demospongiae.

4. **Level of organization** – They have cellular level of organization. Division of labour present between cells.
5. **Symmetry** – They are asymmetrical but some have radial symmetry.(*Leucosolenia*)
6. **Germ layers** – Sponges are the first multicellular diploblastic animals *i.e.* derived only from two embryonic germ layers, ectoderm and endoderm.
7. **Body wall** – It consists of –
   a. Outer Pinacoderm made up of -
      i. Pinacocytes (flat cells)
      ii. Porocytes (oval cells)
   b. Inner choanocytic layer or choanoderm made up of collar cells or **choanocytes** (flagellated cells). It is the characteristic feature of porifera.
   c. Between these two layers gelatinous material mesohyl is there which consists of amoebocytes.

Amoebocytes	**Function**
Scleroblast & spongioblast	form skeleton
Thesocytes	food storage (Glycogen)
Phagocytes	phagocytosis
Trophocytes	distribution of food
Archaeocytes	formation of ova and sperm (totipotent cells)
Collencytes	connective tissue cells
Chromocytes	pigmented cells
Myocytes	highly contractile (at osculum)

- Body wall encloses a large cavity, the spongocoel or paragastric cavity with small ostia.

  Choanocytes with flagella line the spongocoel and beating of flagella is responsible for unidirectional flow of water i.e. from ostia towards osculum.

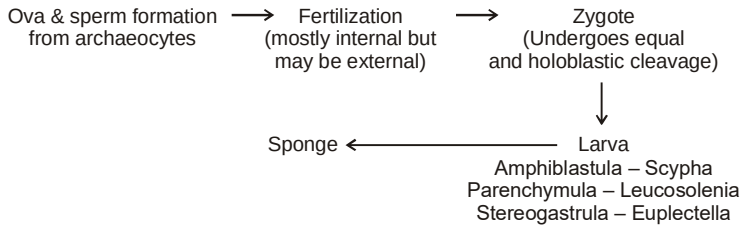


8. **Skeleton –** Endoskeleton consists of spicules (Calcareous spicules formed by calcoblasts by $CaCO_3$ secretion and siliceous spicules by silicoblasts by silica secretion) or spongin fibres (formed from spongioblast by secretion of spongin protein). Scleroblasts (Calcoblasts and silicoblasts) secrete spicules and spongioblasts secrete spongin fibres.

9. **Digestion –** Nutrition is holozoic. Sponges are filter feeder.
   - Intra cellular digestion occurs in food vacuoles of choanocytes.
   - The digested food is then stored in thesocytes in the mesohyl.
   - Distribution of stored food occurs through trophocytes to various cells of the body.

10. **Respiration and excretion –** Respiration is by diffusion of gases through body surface. Excretory matter is ammonia.
11. **Nervous system –** absent
12. **Reproduction –** takes place by -
    a. Asexual method
       - By internal or endogenous budding called gemmulation.
       - By external budding and fragmentation.
    b. Sexual method
       - Sponges are hermaphrodite.
       - Fertilization:- Mostly internal & cross fertilization. In protandrous condition testis gets matured before ovary and in protogynous condition ovary gets matured before testis. Any of the two conditions may be found in sponges.

13. **Development –** Indirect development present i.e. free swimming larval stage present.



14. **Classification –** On the basis of skeleton, divided into three classes-

S.No.		Calcarea	Hexactinellida	Demospongia
1.	Skeleton	Calcareous spicules	6 rayed siliceous spicules	1 or 4 rayed siliceous spicules or spongin fibres
2.	Choanocytes	Large	small	small
3.	Habitat	Marine, Shallow water	Marine, deep water	Marine or fresh water (shallow/deep)
4.	Canal system	Ascon or Sycon	Leucon	Leucon / Rhagon
5.	e.g.	***Leucosolenia*** ***Scypha*** *Grantia* *Leucilla* *Clathrina*	***Euplectella*** *Hyalonema* *Pheronema*	***Spongia* (*Euspongia*)** ***Spongilla*** ***Ephydatia*** ***Cliona*** ***Hippospongia*** ***Chalina*** *Poterion* *Oscarella* *Chondrosina* *Halichondria* *Haliclona*

❖ **Common names and special points**

1. ***Scypha* –** Sycon/urn sponge
2. ***Euplectella* –** Venous flower basket, bridal gift in Japan. Commensal with male and female shrimps of genus *Spongicola*.
3. ***Hyalonema* –** Glass rope sponge. Symbiosis with Anaemone.
4. ***Pheronema* –** Bowl sponge
5. ***Spongia* (*Euspongia*) –** Bath sponge. Spongin fibres are present.
6. ***Spongilla* – Fresh water sponge**
7. ***Ephydatia* – Sulphur sponge**
8. ***Cliona* – Boring sponge (harmful to oyster therefore detrimental to pearl industry)**
9. ***Halichondria* –** Bread sponge
10. ***Haliclona* –** Finger sponge
11. ***Hippospongia* – Horse sponge or horny sponge.**
12. ***Chalina* – Mermaid's gloves**
13. ***Poterion* –** Neptun's cup
14. ***Oscarella & Chondrosina* –** Skeleton absent
15. **Largest sponge – *Spheciospongia* (Demospongiae)**
16. **Smallest sponge – *Leucosolenia***

❖ **Unique features**

1. Many ostia and single osculum present.
2. Cellular level of organization.
3. Presence of water canal system
4. Presence of choanocytes
5.. Central body cavity spongocoel.

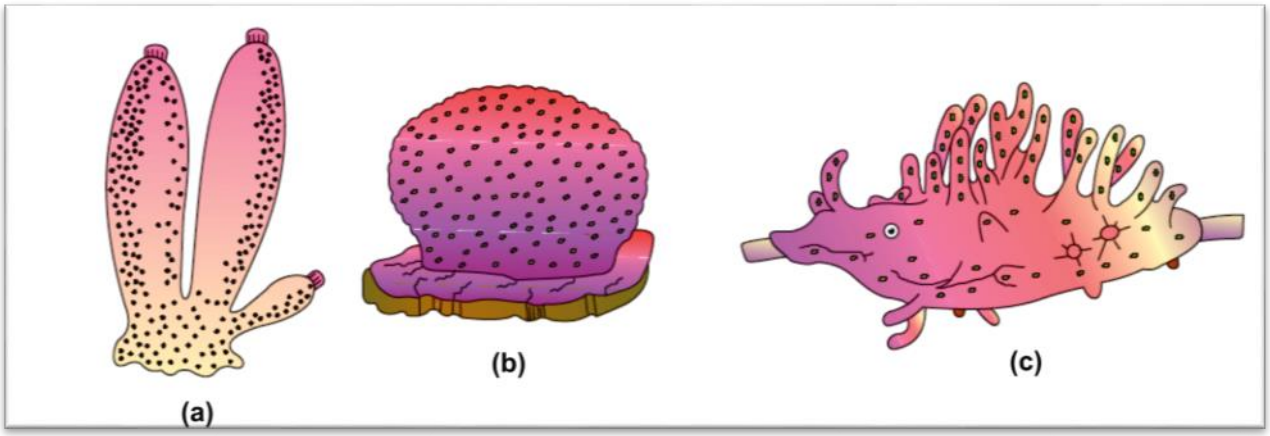


Figure: Examples for Porifera: (a) *Sycon* (b) *Euspongia* (c) *Spongilla*

Important Examples of Porifera: ***Sycon*** (Scypha), ***Spongilla*** (Fresh water sponge) and ***Euspongia*** (Bath sponge).

Test your Resonance with concept

1. Most important characteristic of all sponges is presence of
(1) Coelenteron (2) Herbivorous nutrition
(3) Choanocytes (4) Only sexual reproduction

2. In sponges, there is
(1) radial symmetry (2) A true coelom
(3) single exit and a number of moutlets (4) A single mouth and a number of outlets

3. Which of the following are "cellular grade" organisms?
(1) Sponges (2) Coelenterates (3) Prokaryotes (4) Vertebrates

4. Type of fertilization present in sponges is –
(1) Self and external (2) Self and internal
(3) Cross and external (4) Cross and internal

Answers
1. (3) **2.** (3) **3.** (1) **4.** (3)

Phylum – Coelenterata (Cnidaria)

(Gk. Knide = nettle or sting cells)

❖ General characters

1. **Habit and habitat –** All are aquatic, mostly marine and some are fresh water (*Hydra*). Both sessile (sedentary and fixed in a place) or free swimming forms are found.
2. **Body form –** Body form varies considerably.
   - Coelenterates have mainly two types of forms or zooids (dimorphism/polymorphism) :-

Polyp	Medusa
• Cylindrical shape	• Umbrella shape
• Mostly sessile, but some times motile	• Free swimming
• May be solitary or colonial	• Always solitary
• e.g. ***Hydra*,*Adamsia***	• e.g, ***Aurelia* (Jelly fish)**

   - If both forms are found in a group, it is called cormidia.
   - Metagenesis – When both forms found in a species, the two forms alternate in life cycle called as alternation of generation or metagenesis. Polyp (asexual form) produces medusa asexually and medusa (sexual form) produces polyp sexually. e.g. *Obelia*, but absent in *Aurelia*.
3. **Level of organization –** Tissue level of organization.
4. **Symmetry –** Radial (Some anthozoans like sea anemones have biradial symmetry)
5. **Germ layers –** Diploblastic animals.
6. **Body wall –** Consists of two layers of cells -

a. Outer epidermis (Ectodermal)

Consists of 2 types of cells :-

i. Cnidocytes or nematocytes or stinging cells– Highly specialized stinging cells that contain stinging capsule filled with hypnotoxic chemical for –

1. Anchorage
2. Defence
3. Prey capturing

- Cnidocytes are present on tentacles and body surface except basal disc. They can not be used again so new cnidocytes are developed from interstitial cells.
- Cnidoblasts have stinging capsule (nematocyst) which contain hypnotoxin.
- Cnidoblasts are of 4 types –
  (i) Penetrant (Stenotele) – Largest
  (ii) Stereoline glutinant
  (iii) Streptoline glutinant
  (iv) Volvent (desmoneme) - Smallest

ii. Interstitial cells – Totipotent cells.

b. Inner gastrodermis (endodermal) :-

Consists of 2 types of cells :-

i. Nutritive cells (with food vacuole)

ii. Interstitial cells

- There is a gelatinous layer, called mesogloea between the epidermis and the gastrodermis

7. Skeleton – Some members of phylum coelenterata and mainly the members of class Anthozoa have exoskeleton of $CaCO_3$. (Great barrier reef along north east coast of Australia).

8. Digestive tract – The body cavity known as coelenteron or central gastro vascular cavity, contains only one opening, which acts as mouth as well as anus. Thus there is present incomplete digestive tract.

- Both extra and intra cellular digestion is present.

9. Respiration and excretion – Occurs through body surface by diffusion.

- Ammonia is chief excretory waste.

10. Nervous system – Primitive nervous system consisting of a network of nerve cells and their processes.

- Sensory cells also present.
- Medusa have sense organs rhopalia or statocyst or tentaculocyst.

11. Reproduction – Mostly hermaphrodite but some are unisexual like *Hydra viridisma*.

- Fertilization may be external or internal.
- Zygote undergoes unequal, holoblastic cleavage.
- Development may be direct or indirect.
- Larvae of *Obelia*– Planula (free living) and Scyphistoma (fixed polyp like)
- Larva of *Aurelia* – Ephyra

12. Classification – One the basis of the dominance of medusoid or polypoid phase in the life cycle, the phylum coelenterate is divided into three classes.

i. Hydrozoa ii. Scyphoza iii. Anthozoa

		Hydrozoa	Scyphozoa	Anthozoa
1.	**Polymorphism**	Polyp & medusa	Polyp may be present	Only polyp form.

	& metagenesis	Present. It oftens show metagenesis	but medusa form more common.	
2.	**Habitat**	Marine or fresh water	Marine	Marine
	e.g.	***Hydra*** ***Obelia*** ***Physalia*** *Porpita* *Vellela* *Millipora*	***Aurelia*** *Rhizostoma* *Cyanea*	**2 types of animals -** **(a) Anemones :-Skeleton absent** **e.g. *Adamsia*, *Metridium*** **(b) Corals : $CaCO_3$ skeleton** e.g. *Fungia* ***Meandrina*** *Corallium* *Heliopora* *Oculina* ***Pennatula*** *Alcyonium* *Tubipora* ***Gorgonia*** *Madrepora*

❖ **Common names and special points :-**

1. ***Hydra*** - **Fresh water polyp/water devil**
2. ***Obelia*** - **Sea fur**
3. ***Vellela*** - Little snail
4. ***Millipora*** - Sting coral
5. ***Aurelia*** - **Jelly fish, Moon jelly**
6. ***Rhizostoma*** - Many mouths are present.
7. ***Cyanea*** - Sun Jelly
8. ***Adamsia & Metridium*** - Sea anemone
9. ***Pennatula*** - **Sea pen**
10. ***Gorgonia*** - **Sea Fan**
11. ***Tubipora*** - Organ pipe coral
12. ***Alcyonium*** - Dead man's finger (soft coral)
13. ***Corallium*** - Red coral
14. ***Heliopora*** - Blue coral
15. ***Oculina*** - Eye coral
16. ***Meandrina*** - **Brain coral**
17. ***Madrepora*** - Stag horn coral
18. ***Fungia*** - Mushroom coral
19. ***Physalia*** - **Portuguese man of war**

❖ **Unique features -**

1. Tissue level of organization.
2. Incomplete digestive tract.

3. Special stinging cells, the nematocytes / cnidocytes for defence and offence.
4. Gonads without gonoducts.
5. Network of nerve cells forming primitive nervous system.

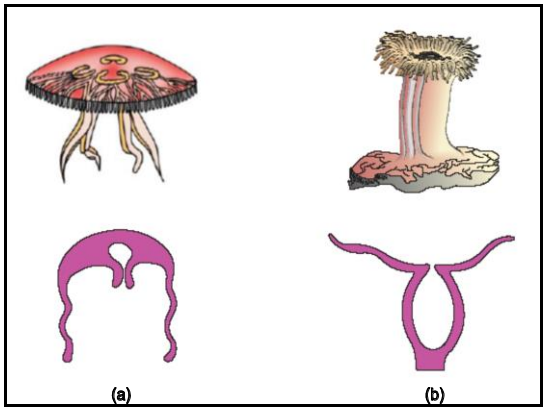


Figure : Examples of Coelenterata indicating outline of their body form :
(a) *Aurelia* (Medusa) (b) *Adamsia* (Polyp)

Figure : Diagrammatic view of Cnidoblast

Important Examples of Coelenterata: ***Physalia*** (Portuguese man-of-war), ***Adamsia*** (Sea anemone), ***Pennatula*** (Sea-pen), ***Gorgonia*** (Sea-fan) and ***Meandrina*** (Brain coral).

Corals (have a skeleton composed of calcium carbonate).

Polyp: Hydra, *Adamsia* ; **Medusa:** *Aurelia* or jelly fish; **Metagenesis:** *Obelia* (Polyp + Medusa)

Phylum - Ctenophora

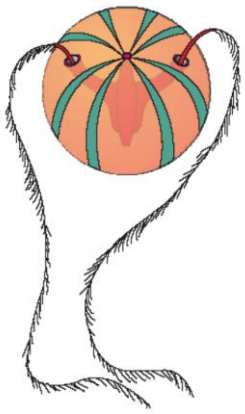
(Gk. Cteno = comb, ferre = to bear)

- Animals of this phylum are known as "Sea gooseberries" or "comb jellies" or "sea- walnuts" or acnidaria.
- Body bears eight external rows of ciliated comb plates that help in locomotion.
- **General characters :-**

1. **Habitat and Habit -** All are exclusively marine, free living and feed upon zooplankton. They are pelagic (float on sea surface).
2. **Body form –** May be spherical, cylindrical or pear - shaped.
   - Body is soft, transparent and jelly like.
3. **Level of organization –** Tissue level.
4. **Symmetry –** Radial or biradial symmetry.
5. **Germ layers**– Diploblastic animals.
6. **Body wall –** Consists of outer ectoderm, middle cellular mesenchyme/mesogloea and inner endoderm.
7. **Skeleton –** absent
8. **Bioluminescence –** Members of ctenophore emit light and this property is called bioluminescence.
   - In sunlight, their comb plates give the effect of a rainbow.
9. **Digestion –** They are carnivorous.
   - Feed on the eggs and larvae of Molluscs, fishes and crustaceans.
   - Digestion is firstly extracellular and then intracellular.
   - A pair of long solid, rectractile tentacles are present.

- In place of nematoblast, on the tentacles a special type of cells are present called lasso cells (Colloblast) which help in catching the prey.
- Anus is absent.

10. **Nervous system –** It is like Cnidaria. Statocyst is balance organ present at aboral end.
11. **Reproduction –**
    - They are hermaphrodite (bisexual).
    - Only sexual reproduction occurs.
    - Fertilization is external.
    - Spiral cleavage and indirect development with cydippid larva.
    - Only medusa form present polyp absent.
12. Regeneration and paedogenesis is present.



Example of Ctenophora (*Pleurobranchia*)

13. **Classification –** divided into 2 classes on the basis of tentacles :-
    i. **Tentaculata**
    e.g. *Pleurobranchia*
    Cestum – Venus's girdle
    Ctenoplana – Commensal with *Alcyonium.*
    Velamen
    Euchlora rubra – with cnidocyte (exception)
    ii. **Nuda**
    e.g. *Beroe* – Swimming eye of cat

Important Examples of Ctenophora: *Pleurobrachia* and ***Ctenoplana***.

Test your Resonance with concept

1. Explain metagenesis in Cnidaria.
2. Write down three similarities and three dissimlarities between Cnidaria and Ctenophora.

Phylum - Platyhelminthes (Flatworms)

(Gk. Platys = Broad or flat ; Helmin = worm)

❖ **General characters :**

1. **Habitat –** Mostly **endo parasites.** Some are free living (terrestrial, fresh water or marine).
2. **Body form –** Body is dorso ventrally flattened and is without true segments.
3. **Level of organization –** Organ level / Organ system level of organization.
4. **Symmetry –** bilateral symmetry.
5. **Germ layers –** Triploblastic animals i.e. consisting of 3 germ layers – ectoderm, mesoderm and endoderm.
6. **Body wall –** Body covering is soft and ciliated. On the body wall of parasitic animals, a thick cuticle is present i.e. tegument which protects the parasite from the digestive enzymes of the host. It is secreted by epidermis.
   - Muscles in the body wall are mesodermal. Below the epidermis longitudinal muscles are present.
7. **Body cavity –** The space between the body wall, alimentary canal and other organs is filled with a solid, loose mesodermal tissue called mesenchyme or parenchyma. The flatworms do not contain coelom, thus they are acoelomates.
8. **Digestive tract –** In Turbellaria and Trematoda class an incomplete digestive tract (blind sac body plan) is present without anus while in class Cestoda, digestive tract is completely absent.
9. **Skeleton system –** It is absent. The fluid in the parenchymal network maintains the body shape called hydroskeleton.
10. **Respiratory system –** Gaseous exchange occurs through body surface. Anaerobic respiration occurs in internal parasites like *Taenia*.
11. **Circulatory system –** Absent (parenchymal fluid transports materials).
12. **Excretory system –** Excretory organs are flame cells or solenocytes or protonephridia. They also help in osmoregulation.
    - Ammonia is the chief excretory product.
13. **Nervous system –** The nervous system is ladder like. It consists of the brain ring and two main longitudinal nerve cords joined at intervals by transverse commissures.
14. **Reproduction –** These animals are hermaphrodite (bisexual).
    - Fertilization is always internal.
    - Fertilization can be cross or self fertilization.
    - Asexual reproduction by fission occurs in some flatworms.
15. **Development –** Cleavage is spiral and determinate.
    - Development may be direct or indirect.
    - In indirect development, larva may be one or of more types.
    - In these animals, Yolk / Vitelline glands are present which provide nutrition to the eggs.
16. **Regeneration –**Well marked in some flatworms like Planaria.
17. **Classification –** Divided into 3 classes.

		Turbellaria	**Trematoda**	**Cestoda**
1.	**Habitat**	Free living (fresh water or marine), known as planarians or Eddy worm.	Endoparasites known as flukes.	Intestinal endopasites known as tapeworms.
	e.g.	***Dugesia* (Planaria)** ***Microstomum*** – enemy	***Fasciola* (sheep liver fluke)** ***Schistosoma* (blood fluke)**	***Taenia solium* (Pork tapeworm)**

		of *Hydra* ***Ichthyophaga***–Parasite on fishes.	***Paragonimus*** (lung fluke) ***Diplozoon*** (ectoparasite on gills of fishes i.e. Gill fluke) ***Opisthorchis*** (human liver fluke or Chinese liver fluke.	***Taenia saginata*** **(Beef tapworm)** ***Echinococcus granulosus*** **(Dog tapeworm)** ***Hymenolepis*** **[smallest tapeworm in man's intestine - 10 cm and 200proglottids (Monogenetic)]**

❖ ***Dugesia*** **(Planaria) –**
- Inhabits fresh water.
- Both sexual and asexual reproduction (transverse binary fission) present.
- Highest power of regeneration.

❖ ***Fasciola hepatica*** **–** Liver fluke (sheep)
- Found in the bile ducts of liver of sheep and goat (Digenetic endoparasite i.e. two hosts– sheep & goat/garden snail)
- Causes liver rot or cirrhosis.
- Anaerobic respiration.
- Temporary copulatory canal called Laurer's canal is found.
- Life history involves two hosts :
  i. Primary host - sheep and goat
  ii. Secondary host - Garden snail (*Planorbis, Lymnea, Bulinus*).
- Larvae – Miracidium, sprorocyst, redia, cercaria and metacercaria.
- Infective stage of primary host (sheep/Goat) – Metacercaria.
- Infective stage stage of secondary host (snail) – Miracidium (free swimming).
- Possess both alternation of generation and alternation of host.

❖ ***Schistosoma*** **(Blood fluke)**
- Found in veins of human bladder and intestine.
- Aerobic respiration and feeds on blood.
- Unisexual (sexual dimorphism present).
- Large male carries female in a groove called gynaecophoric canal on ventral side.
- Life history involves two hosts (digenetic) :
  (i) Primary host - man
  (ii) Secondary host – Garden snail (*Planorbis, Lymnaea, Bulinus*).

❖ Larvae - Miracidium, sporocyst & cercaria.
- Infective statge of primary host (Man) – Cercaria
- Infective stage of secondary host (Snail) – Miracidium (free swimming)
- Larva (Cercaria) enters the human body by boring in skin while bathing in ponds.
- It damages the liver and causes intestinal disorder called as Schistosomiasis or Bilharzia.

❖ Differences between *Taenia solium* and *Taenia saginata*

		Taenia solium	***Taenia saginata***
1.	**Common Name**	Pork tapeworm	Beef tapeworm

2.	**Mode of transmission**	Ingestion of undercooked pork or by auto infection.	Ingestion of under cooked beef.
3.	**Location**	Small intestine, muscle,brain	Small intestine.
4.	**Infective stage**	Cysticercus cellulosae	Cysticercus bovi
5.	**Definitive host**	Man	Man
6.	**Intermediate host**	Pigs, man if autoinfection	Cattle
7.	**No. of proglottids**	1000	2000
8.	**Scolex**	Rostellum with 2 rows of hooks and 4 suckers	Rostellum & hooks absent, 4 suckers present.

- Larvae of *Taenia* – Hexacanth and Cysticercus or bladder worm.

❖ **Unique Features -**

1. Triploblastic.
2. Organ system level of organization.
3. Better developed nervous system.
4. Well organized excretory system.

❖ **Parasitic adaptations in flatworms**

(i) Hooks – Adhesive structures, present in *Taenia*.

(ii) Suckers – Adhesion as well as ingestion of food in *Taenia* & *Fasciola*.

(iii) Direct absorption of food by body surface in *Taenia.*

(iv) Body covered by thick tegument which protect it form digestive enzymes of host.

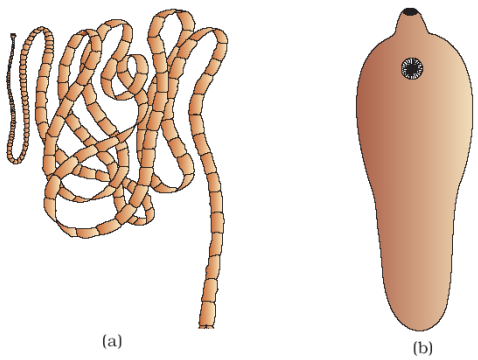


Fig. Examples of Platyhelminthes: (a) Tape worm (b) Liver fluke

Important Examples of Platyhelminthes: *Taenia* (Tapeworm), ***Fasciola*** (Liver fluke), ***Planaria*** (possess high regeneration capacity)

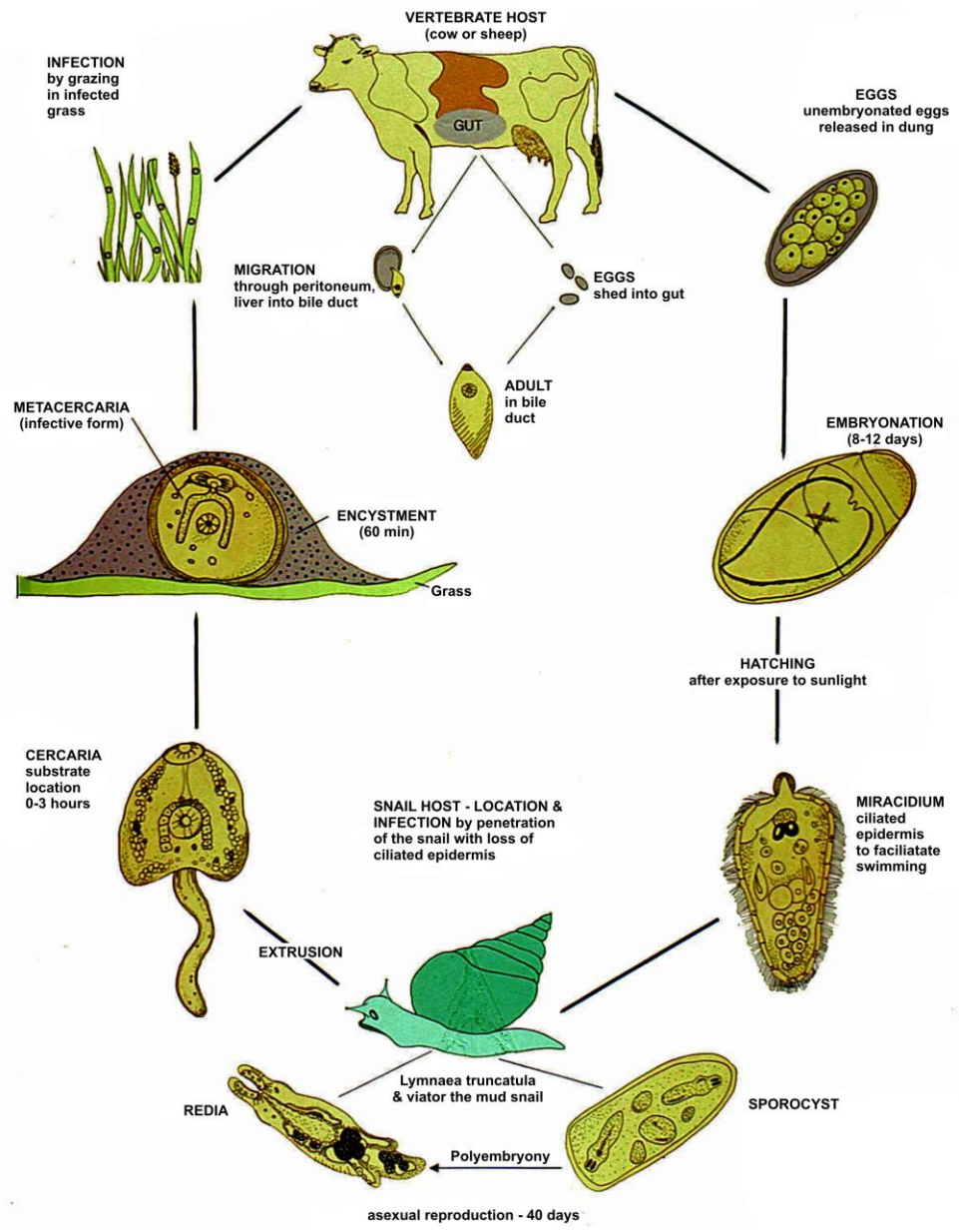


Figure: Life cycle of *Fasciola hepatica*

Phylum Aschelminthes/Nemathelminthes/Nematoda (roundworm)

(Gk. Nema = Thread ; Helmin = worm)

❖ **General characters :**

1. **Habitat –** Many roundworms live as parasites in plants and animals. A large number of nematodes are free living and occur in fresh water, sea water and soil.
2. **Body from –** The body of round worms in cylindrical, tapering at both ends without segmentation (unsegmented).
3. **Level of organization –** They have organ system level of organization.
4. **Symmetry –** Bilateral symmetry.

5. **Germ layers –** Triploblastic.
6. **Body wall –** Consists of :-
   i. Cuticle – Firm, non - living, resistant to digesive enzymes of host.
   ii. Epidermis – Without cilia, and syncytial *i.e.* a continuous layer of cytoplasm having scattered nuclei.
   iii. Muscle layer –Longitudinal muscle fibres.
7. **Body cavity –** Body cavity is present between body wall and digestive tract.
   • Body cavity is not lined by mesothelium i.e. Pseudocoel (developed from blastocoel) and contains pseudocoelomic fluid.
8. **Skeleton system –** Absent (High fluid pressure in the pseudocoelom maintains body shape called hydroskeleton).
9. **Digestive tract –** Digestive tract is complete (tube within tube plan).
   Differentiated into mouth, pharynx, intestine and anus.
   • Mouth is surrounded by 3 lips having sensory papillae and amphids.
   • Pharynx is muscular.
   • Intestine is non- muscular.
10. **Respiratory system –** Respiration occurs by diffusion through body surface.
11. **Circulatory system –** Circulatory system is absent.
    • The pseudo coelomic fluid transports materials.
12. **Excretory system –** It is H - shaped consisting of gland cells or intracellular canals or both.
    • In some marine nematodes, Renette gland cells are found.
    • Ammonia is main excretory matter.
    • Ascaris excretes both ammonia and urea.
13. **Nervous system –** It is comprises of **circum pharyngeal ring (Brain)**. Sense organs like **Papillae**. (Tangoreceptors), **Amphids** (Chemoreceptor) are present on lip. Paired unicellular **phasmids** (chemoreceptor) are found near hind end of body.
14. **Reproduction –** Are usually unisexual. Sexual dimorphism is present.
    • Male is smaller than female and curved at its caudal end. Male has chitinous spicules or penial setae for copulation. Genital tract joins digestive tract to form cloaca which opens outside through cloacal operture.
    • Female is larger than male and straight. Genital tract opens independently. Female lays numerous eggs with chitinous shell.
    • Fertilization is internal.
15. **Development –** Cleavage is holoblastic, spiral and determinate type. Development is mostly direct.
    • Number of cells are fixed from larva to adult known as eutely.
16. **Classification –** Nematoda has been classified into two classes on the basis of specialized sense organs, caudal receptors & excretory system -
    A. Phasmidia
    e.g, *Ascaris* – Intestinal round worm (in small intestine)
    larva – Rhabditiform/Rhabditoid.
    Ancylostoma – Hookworm (in small intestine)
    Trichuris –Whip worm (in large intestine)
    Trichinella – First in intestine, then in stripped/skeletal muscle, viviparous
    Enterobius – Pin worm or seat worm (in large intestine)
    Wuchereria – Filarial worm
    – In lymph vessels/gland
    – Vector – female Culex mosquito
    – Viviparous, digenetic.
    Loa loa – African eye worm

Dracunculus – Guinea worm/ Nadina worm /fiery serpent.

– Digenetic – Cyclops are intermediate host and man is primary host.

– Oldest discovered nematode.

– Causes Naru disease (Dracunculasis)

Rhabditis – Free living.

B. Aphasmidia – **e.g.*Demoscolex***

❖ **Unique features**

1. Syncytial epidermis.
2. Body wall musculature of longitudinal fibres only.
3. Pseudo coelom.
4. Complete digestive tract
5. Unisexual condition.

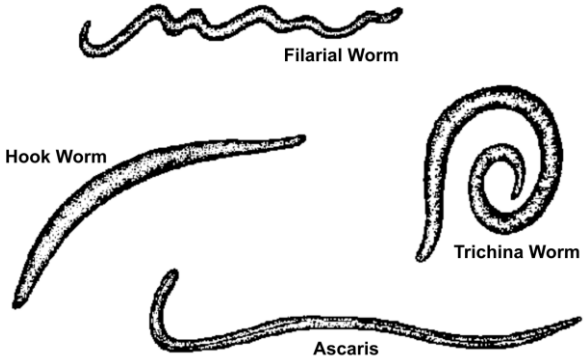


Figure: Roundworms (Phylum Nematoda)

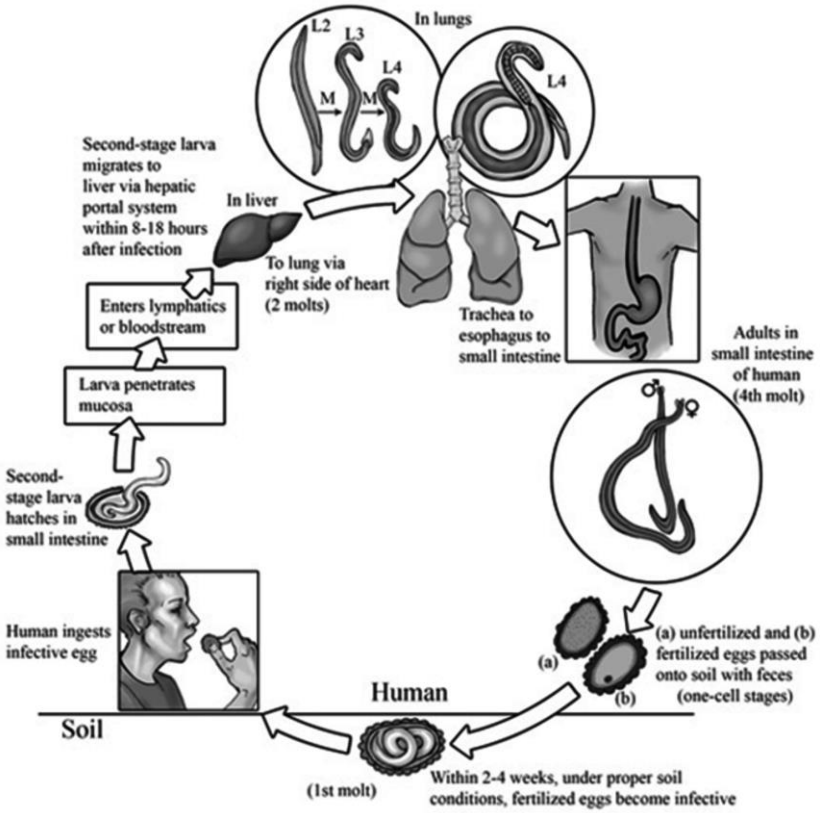


Figure : Life cycle of *Ascaris*

Important Examples of Aschelminthes: ***Ascaris*** (Round Worm), ***Wuchereria*** (Filaria worm), ***Ancylostoma*** (Hookworm).

Test your Resonance with concept

1. Flame cells are excretory organs of
(1) Coelenterates (2) Platyhelminthes (3) Annelida (4) Echinodermata

2. Stage of the life history of liver fluke, when it infects the intermediate host is
(1) Metacercaria (2) Cysticercus (3) Rhabditiform (4) Miracidium

3. Shedding of proglottids in tapeworm is called
(1) histolysis (2) topolysis (3) apolysis (4) detachment

4. The secondary host of *Taenia* is
(1) Dog (2) Man (3) Pig (4) Snail

5. Most dangerous nematode parasite of human and plant is-
(1) *Ancylostoma* and *Ascaris* respectively (2) *Melodigynae* and *Anclyostoma* respectively
(3) *Ancylostoma* and *Melodigynae* respectively (4) *Ascaris* and *Melodigynae* respectively

Answers

1. (2) **2.** (4) **3.** (3) **4.** (3) **5.** (3)

Phylum – Annelida (The segmented animals)

(Gk. Annules = ring ; lidos = form)

❖ **General characters**

1. **Habitat –** Annelids occur in fresh water, sea water or moist soil. Some are free living, some are burrowing and a few are parasitic.
2. **Body form –** The annelids are characterized by metameric segmentation i.e. the body is divided externally by ring like grooves called annuli and internally by transverse septa. The segments are called metameres.
3. **Level of organization –** Organ system level of organization having tube within tube plan.
4. **Symmetry –** Bilateral symmetry.
5. **Germ layers –** Triploblastic.
6. Body wall – consists of :-
   i. Cuticle – Thin, moist.
   ii. Epidermis – Single layered epidermis.
   iii. Muscle layer – Both circular and longitudinal muscle layers present.
   - Appendages are simple, without joints and locomotory having chitinous setae and parapodia.
7. **Body cavity –** First protostome eucoelomate animals.
   - Body cavity is true coelom lined by mesodermal coelomic epithelium – schizocoel.
   - It is divided by transverse septa into compartments.
   - Filled with coelomic fluid that contains cells.
8. **Skeleton system –** Absent (fluid filled coelom serves as a hydrostatic skeleton).
9. **Digestive system –** Digestive tract is complete.

- The gut has both longitudinal and circular muscles.
- Few annelids are sanguivorous.(eg. leech)
- Digestive glands are developed for the first time in Annelids.

10. **Respiratory system –** Respiration is through skin i.e. cutaneous respiration.
    - Some have gills (branchial respiration).
11. **Circulatory system –** It is usually closed type.
    - Blood is red due to the presence of respiratory pigment haemoglobin or erythrocruorin found dissolved in the plasma.
    - Free amoeboid blood corpuscles are present but there are not red blood corpuscles.
    - Few annelids like *Sabella* have chlorocruorin as a respiratory pigment.
    - In leech (*Hirudinaria)*, there is no true closed blood vascular system. It is called haemocoelomic system and red coelomic fluid is called haemocoelomic fluid.
12. **Excretory system –** Consists of coiled tubular structures called Nephridia which also help in osmoregulation. Chloragogen cell are analogous to vertebrate liver.
    - Excretory matter
        i. Ammonia in aquatic forms.
        ii. Urea in land forms.
13. **Nervous system –** Consists of a circumenteric nerve ring and a solid, double, mid ventral nerve cord with ganglia.
14. **Reproduction –** Both unisexual (e.g. *Nereis*) and bisexual (e.g.- Earthworm, leech) forms are found.
    - Sexual reproduction is present.
    - Cleavage – Spiral, holoblastic, unequal and determinate.
    - Development is mostly direct. If there is indirect development (e.g. *Nereis*), It includes a trochophore larva.
15. **Classification –** On the basis of number and presence or absence of setae, phylum Annelida is divided into three classes–

    i. Polychaeta –
        a. Mainly found in sea water.
        b. Cephalisation is more distinct. Head with well developed eyes, tentacles and olfactory palps.
        c. Setae are numerous and are present in parapodia, parapodia help in locomotion and also in respiration. Suckers are absent.
        d. Clitellum is absent.
        f. Unisexual and gonads are formed only during breeding season.
        g. Development is indirect. Larval stage is called Trochophore.

        e.g. *Nereis* – Sand worm or clam worm or rag worm.
        Aphrodite – Sea mouse.
        Chaetopterus – Paddle worm (shows biofluorescence, great power of regeneration).
        Arenicola – Lug worm (branchial respiration)
        Sabella – Peacock worm
        Terebella – Branchial respiration.
        Polynoe – Scale worm (biofluosescence present)

    ii. Oligochaeta –
        a. Mostly terrestrial, some are aquatic.

b. Cephalisation absent. No distinct head, eyes, tentacles and olfactory palps.
c. Setae for locomotion and are less in number. Parapodia and suckers are absent.
d. Clitellum is present permanently for cocoon formation. Fertilization is external and is held in cocoon.
e. Bisexual or hermaphrodite. Cross fertilization and external fertilization occurs.
f. Development is direct (no larva).

e.g. *Pheretima* – Indian earthworm
Lumbricus – European earthworm
Megascolex – Largest earthworm (South India)
Tubifex – Blood worm (fresh water) – indicator of organic loading.
Dravida

iii. Hirudinea –

a. Aquatic or terrestrial, ectoparasite and sanguivorous.
b. Cephalisation is absent.
c. Parapodia and setae are absent. Suckers are present at both the ends.
d. Clitellum (9-11 segments) develops only in breeding season.
e. Bisexual.
f. Fertilization is internal.
g. Development is direct (no larva).
h. Special features:-

- Number of segments are fixed i.e. 33 segments.
- Hirudin present in the saliva.
- Saw like chitinous teeth present in buccal cavity.
- Haemocoelomic system is present.
- A special mesodermal tissue Botryoidal tissue made up of adipose tissue for fat storage is present.

e.g. *Hirudinaria* – Fresh water leech.
Hirudo – Medicinal leech.
Pontobdella – Skate sucker
Acanthobdella –Ectoparasite with setae (connecting link b/w oligochaeta and Hirudinea).
Bonellia – Sea leech
Some authors include two more classes in phylum Annelida.

iv. Archiannelida – It includes small marine annelids related to polychaeta but some forms are without parapodia and setae. Development is indirect with trochophore larva.

e.g. ***Polygordius*** – **Connecting link between Annelida and Mollusca (living fossil), its larva is known as Loven's larva.**

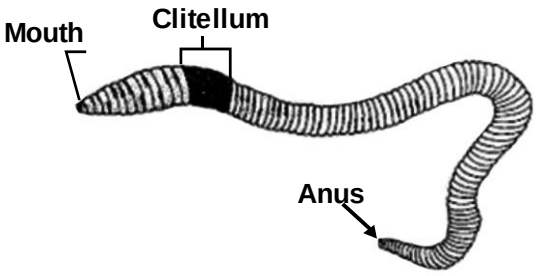
e.g. *Dinophillus*

v. Echiurida – These annelids are without external and internal segmentation. Setae are rare. They usually have long prostomium.

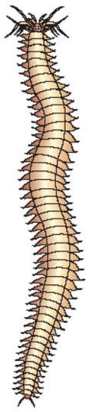
e.g, ***Bonellia*** (included in Hirudinea in 3 class system)

❖ **Unique Features**

1. Metameric segmentation.
2. Closed circulatory system with haemoglobin (erythrocruorin) dissolved in plasma.
3. Nephridia for excretion and osmoregulation.
4. Circular and longitudinal muscles in both body wall and gut wall.
5. To suck impure blood by leech is called phlebotomy.



(a) Earthwrom



(b) Nereis

(c) Hirudinaria

Important Examples of Annelida *Nereis*, ***Pheretima*** (Earthworm) and ***Hirudinaria*** (Blood sucking leech).

Test your Resonance with concept

1. Metamerism is characteristic of phylum
(1) Porifera (2) Platyhelminthes (3) Annelida (4) Mollusca

2. A postanal tail is absent in
(1) Snake (2) Earthworm (3) Rabbit (4) Lizard

3. Which of the following belongs to phylum Annelida?
(1) *Nereis* (2) *Octopus* (3) Crab (4) Ant

4. Haemoglobin is found dissolved in blood plasma of
(1) Earthworm (2) Cockroach (3) Rabbit (4) Frog

Answers

1. (3) **2.** (2) **3.** (1) **4.** (1)

Phylum – Arthropoda (Animals with jointed legs)

(Gk. Arthro =
Joints ; Podos = foot)

❖ It is the biggest phylum (comprising 2/3 of all animal species present today). About 9,00,000 species are there. It is most successful and most heterogeneous group of animals.

❖ **General characters**

1. **Habitat –** They occur on land, in the soil, in sea water, in fresh water and in the bodies of animals and plants as parasites.
2. **Body form –** Arthropoda have various shapes with externally segmented body. Segmentation is either into -
   - **i.** two regions with head and trunk or cephalothorax and abdomen.
   - ii. three regions with head, thorax and abdomen.
     - Head is distinct (high degree of cephalization), consists well developed sense organs such as simple eyes, compound eyes and antennae.
     - Some or all segments bear jointed appendages, hence name arthropoda (arthro – Joints, poda – foot).
3. **Level of organization –** Organs system level of organization.
4. **Symmetry –** bilateral.
5. **Germ layers –** Triploblastic.
6. **Body wall –** Consists of –
   - **i. Thick chitinous cuticle –** Cuticle composed of protein and polysaccharide **chitin** which is further strengthened by deposition of minerals (Calcium phosphate and carbonate).
     - Cuticle periodically changes during growth known as moulting or ecdysis (regulated by ecdysone secreted by prothoracic gland).
     - Flexible part of cuticle is called suture.
     - Wings of insects also made of chitin.
     - Chitinous plates which form exoskeleton are known as sclerites.
   - ii. Epidemis –Single layered epidermis.
   - iii. Muscles – Arranged in bundles.
     - Muscles are striped / striated – voluntary (first time developed in Arthropods).
7. **Body cavity –** Body cavity is a haemocoel i.e. body cavity around viscera is filled with blood.
8. **Digestive tract –** Digestive tract is complete.

Resonate the Concept
Types of Mouth-parts in insects: Labrum-1, Hypopharynx-1, Mandible-2, Maxilla-2, Labium-1, a. Biting and chewing type – Cockroach, Grasshopper b. Piercing and sucking type – Mosquitoes (Proboscis is a modification of labium) c. Sponging type – Housefly (Mandibles are absent) d. Siphoning type – Butterflies (Proboscis is a modification of maxilla) e. Chewing & lapping type – Honey-bee

9. **Respiratory system –**The respiratory organs are gills (prawn) or book gills (King crab) in aquatic forms and tracheae (insects) or book lungs (scorpion) in terrestrial forms.
10. **Circulatory system –** It is open type i.e. blood flows in haemocoel instead of blood vessels. Haemocoel has lacunae/sinuses.
    - Blood – It contains white corpuscles and is colourless called as haemolymph in insects.
    - Contains copper containing pigment hemocyanin in some arthropods (e.g, Prawns)
    - Heart – A dorsal, pulsatile, one to many chambered tubular structure.
11. **Excretory system –** Excretory organs are–
    i. Green glands or antennary glands or maxillary glands, opening directly to the exterior. e.g, Crustaceans.
    ii. Malpighian tubules opening into the gut. *e.g,* insects.
    iii. Coxal glands e.g. Arachnids.
    - Excretory matter–
      i. Ammonia in aquatic forms ii. Uric acid in terrestrial forms.
12. **Nervous system –** The annelidian type of nervous system is present *i.e.* It consists of a circumenteric ring and a double, solid, ganglionated midventral nerve cord.
    - Sense organs – In many arthropods compound eyes are present consisting of many similar units ommatidia each having lens and capable of forming image thus mosaic vision is developed. Some forms also have statocysts (balancing organs). Antenna is for detection of touch and chemicals.
13. **Endocrine glands –** Endocrine glands are present which secrete hormones.
    - Insects communicate by pheromones i.e, chemicals released into the environment. Pheromones also act as sex attractants.
14. **Reproduction –** Sexes are separate and sexual dimorphism is observed in many forms.
    - Fertilization is mostly internal but some aquatic forms have external fertilization.
    - Gonads have ducts.
    - Mostly oviparous, few viviparous (Scorpion).
    - The development of the larva may involve metamorphosis.
    - Parental care is often seen in many arthropods.

Resonate the Concept

Types of Insects, based on mode of development

1. Ametabolous development- No Metamorphosis, direct development.
   Three stages in life : Egg → Young → Imago(adult)
   Ex. Silver fish (Primitive & Wingless)
2. Paurometabolus development- Gradual metamorphosis, direct development.
   Three stages in life : Egg → Nymph (young) → Imago(adult)
   Nymph is similar to adult in mode of life. But is wingless
   Ex. Cockroach,Locust
3. Hemimetabolus development- Incomplete metamorphosis, direct development.
   Three stages in life : Egg → Naiad (young) → Imago(adult)
   Naiad difer from adult in both mode of life & structure.
   Ex. Mayfly, Dragonfly.
4. Holometabolus development- Complete metamorphosis, Indirect development.
   Three stages in life : Egg → Larva → Pupa → Imago(adult)
   Ex. Butterfly(Larva-Caterpillar), Housefly(Larva-Maggot), Mosquito (Larva-Wriggler)

15. Parthenogenesis – Occurs in certain forms. Development of an egg (ovum) into a complete individual without fertilization by a sperm is called parthenogenesis.

16. Animals of arthropoda are most successful invaders of terrestrial environment in invertebrates due to presence of

i. Chitinous cuticle ii. Joint appendages iii. Chitinous wings.

17. Classification – The phylum arthropoda is divided into 6 classes –

(i) Crustacea – Cephalothorax present (head and thorax fused)

- 2 pairs of antennae, 1 pair of jaws, 2 pairs of maxillae.
- aquatic, respire by gills.
- *e.g.*, *Palaemon* (Prawn)
  Palineurus (Lobster)
  Astacus (Cray fish)
  Cancer (Crab)
  Eupagarus (Hermit crab)
  Daphnia (Water flea)

(ii) Chilopoda – e.g, *Scolopendra* (Centipede)

(iii) Diplopoda – e.g. *Julus* (Millipede)

Resonate the Concept

- Chilopoda & Diplopoda together included in Myriapoda having long cylindrical body.
- These are terrestrial arthropods.

(iv) Insecta (Hexapoda) – Body divisible into head, throax and abdomen.

- one pair of antennae, 3 pairs of legs, 2 pairs of wings present or absent, predominantly terrestrial.
- e.g. Silver fish, cockroach, bedbug, locust, termites, butter flies, rat flea, beetle, wasp.

(v) Arachnida – Cephalothorax present, antennae absent

- 1 pair chelicerae, 1 pair pedipalp & 4 pairs of legs.
- e.g. Scorpion (*Palamnaeus*), spider (*Aranea*), tick, mite.

(vi) Merostomata – Include living fossils. 5-6 pair abdominal appendage with book gills. e.g. ***Limulus***

(King crab)

Resonate the Concept

Some important Arthropodas-

1. **Apis (Honey-bee)** : Social ,Polymorphic, Colonial insect.
   Three types of individuals-
   (a) Queen–Single, diploid, fertile female. Copulation once in life.
   (b) Worker– Many, diploid, sterile females.
   (c) Dones– Many,haploiad males.(Produced by Parthenogenesis)
   → Prof. Karl von frisch, decoded bee dance. Round dance for food closer then 75 m. and tail wagging dance for food far than 75 m.
   → Two Producers–
   (i) Honey– Nectar converted to honey in crop of worker-bee.
   (ii) Bees Wax– Produced by abdominal glands of worker-bee. It is true product.
   → Most commonly used species in Apiculture is *Apis mellifera*.
   → Sting of worker- bee is modified ovipositor.
2. Silk-Worm : ***Bombyx*** *mori*, reared on Mulberry tree *(Morus alba)*
   → Silk is produced by salivary glands of larva.
   → Silk is composed of fibroin & Serricin Proteins (80:20)
   → *Nosema* (Protozoan) causes pebrine disease.
3. Lac insect – ***Laccifer*** *lacca* & *Tachardia lacca*.
   → Lac is produced by females.
4. Mosquito– ***Anopheles*****,** ***Culex, Aedes***.
   → Males suck juce of flower & fruit
   → Johnston's organ in antenna is sound receptor.
5. Scolopendra – Commonly called centipede
   → Included in class Chilopoda.
   → Body divided to head & trunk, each trunk segmentation bear 1 pair of legs, first pair of legs modified to Poision Claws.
6. Julus– Commonly called millipede.
   → Included in class diplopoda.
   → Body diveded to head, thorax and abdomen. Thoracic segments except first bear two pair of limbs, abdominal segments bear one pair of limbs.

❖ **Unique features**

1. Jointed appendages
2. Thick exoskeleton of chitinous plates.
3. Compound eyes
4. Antennary glands, malpighian tubules and coxal glands for excretion and osmoregulation.
5. Tracheae, gills and book lungs as respiratory organs.

Resonate the Concept

- Trilobites are fossil arthropods which are over 600 million years old and extinct.

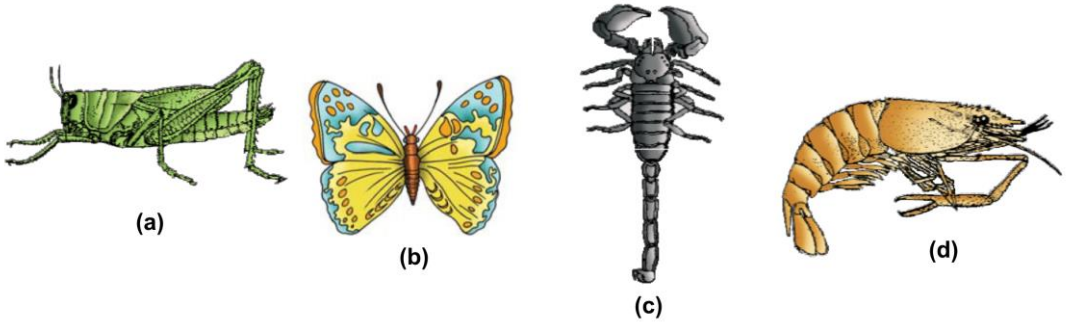


Figure : Examples of Arthropoda : (a) Locusta (Gregareous pest) (b) Butterfly (c) Scorpion (d) Prawn

Important Examples of Arthropoda

Economically important insects –

Apis (Honey bee), ***Bombyx*** (Silkworm), ***Laccifer*** (Lac insect)

Vectors – ***Anopheles, Culex* and *Aedes*** (Mosquitoes)

Gregarious pest – ***Locusta*** (Locust)

Living fossil – ***Limulus*** (King crab).

Test your Resonance with concept

1. Which is not a member of class insecta?
(1) Louse (2) Cockroach (3) Spider (4) *Musca*

2. The first animals to fly were
(1) Birds (2) Insects (3) Mammals (4) Lizards

3. Which one of the following is a connecting link?
(1) *Pila* (2) *Limulus* (3) *Periplaneta* (4) *Peripatus*

4. Which one of the following is non-poisonous?
(1) Crab (2) Centipede (3) Spider (4) Scorpion

5. Which one is a tracheate group?
(1) Spider – *Peripatus* – Mosquito (2) Crab – Centipede – Cockroach
(3) Silk worm – Bed bug – Sand fly (4) House fly – King crab – Scorpion

Answers

1. (3) **2.** (2) **3.** (4) **4.** (1) **5.** (3)

Phylum - Mollusca (The soft bodied animals)

(L.Molluscs = Soft)

- ❖ It is the second largest phylum (60,000 species).
- ❖ The study of molluscs is known as malacology and study of shells of molluscs is called as conchology.

General characters –

1. **Habitat –** They are mostly marine. Some, however, occur in fresh water or may be terrestrial.
2. **Body form –** Body is unsegmented with variety of shapes. *Neopilina* is a segmented mollusc (exception).
3. **Level of organization –** Organ system level.
4. **Symmetry –** Bilateral symmetry. In some molluscs like *Pila*, due to torsion (twisting) during growth, the adults become asymmetrical.
5. **Germ layers –** Triploblastic
6. **Body wall –** Consists of single layered epidermis (usually ciliated) with unstriped muscles found in bundles.
7. **Body parts–** Consists of
   - i. Head with sense organs. Head is absent in pelecypoda and scaphopoda.
   - ii. Dorsal visceral mass /Hump containing organ system.
   - iii. Ventral muscular foot for locomotion.
   - iv. Thin fleshy fold or outgrowth of dorsal body wall covers the body. This fold is called mantle or pallium. The space between hump and mantle is called mantle cavity.
   - v. Shell – The mantle usually secretes an external limy shell. Shell is made up of calcium carbonate and concheolin protein.
   - Shell may be external (in most molluscs), internal (e.g. slug, cuttle fish, squid) or absent (e.g. *Octopus*).
8. **Body cavity –** Coelom is greatly reduced. It is represented by cavities in the pericardium, kidneys and gonads. Space amongst the viscera contains blood and forms haemocoel.
9. **Digestive tract –** It is complete.
   - In some molluscus like *Pila*, the buccal cavity contains a rasping organ, the radula, with transverse rows of teeth.
   - Anus opens into the mantle cavity.
   - Digestive glands are known as hepatopancrease.
10. **Respiratory system –** Usually takes place through feather like gills called Ctenidia (ctenidia are present in the mantle cavity) which also assists in excretion but may take place through body surface also.
    - Dentalium respires by Mantle.
    - Semi – terrestrial forms like Pila respire by pulmonary sac (lung) on land and by gills in water.
11. **Circulatory system –** It is of open type.
    - It includes dorsal pulsatile heart and arteries that open into sinuses (spaces).
    - Blood is usually blue due to the presence of a copper containing blue respiratory pigment called haemocyanin.
    - Class Cephalopoda has closed type of circulatory system.
12. **Excretory system –** Includes 1 or 2 pairs of sac like kidneys, which open into the mantle cavity. Kidney of molluscs are metanephridia known as Kaber's organs or Organs of Bojanus.
13. **Nervous system**

    It comprises three paired ganglia

    (1) Cerebral (above the mouth) (2) Pedal (in the foot) (3) Visceral (in visceral mass)
14. **Sense organs**

(i) In many molluscs, eyes (photoreceptors) and tentacles (tactile receptors) are present on the head.
(ii) Statocyst/Lithocysts – For equilibrium (in foot).
(iii) Osphradia – Chemoreceptor/ olfactory as well as for testing chemical and physical nature of water.

15. Reproduction – The sexes are generally separate but some are hermaphrodite (snail has ovotestis)

- Gonads have ducts.
- Fertilization may be external or internal.
- Cleavage is spiral, determinate, unequal and holoblastic.
- Development in direct or indirect. When indirect, metamorphosis is present.
- Larvae – Trochophore larva (most common larva of phylum Mollusca).
  – Glochidium larva (Fresh water mussel)
  – Veliger larva (Pila)

❖ **Unique features and special points**

1. Three body regions - head, visceral mass and foot.
2. A glandular fold mantle covers the body.
3. Calcareous shell around the mantle in most forms.
4. Mantle cavity has anal, excretory and genital apertures in it.
5. Buccal cavity has rasping organ, radula in most of the forms.
6. Better developed sense organs like eyes, statocysts, osphradia etc.
7. Trochophore larva found in molluscs suggests that molluscs have descended form annelid like ancestors.
8. Precious pearl of the size of tennis ball is made by a mollusc*Tridekna*.
9. "Nacre layer" is called "Mother of Pearl"
10. Father of pearl industry – Kokichi Mikimoto

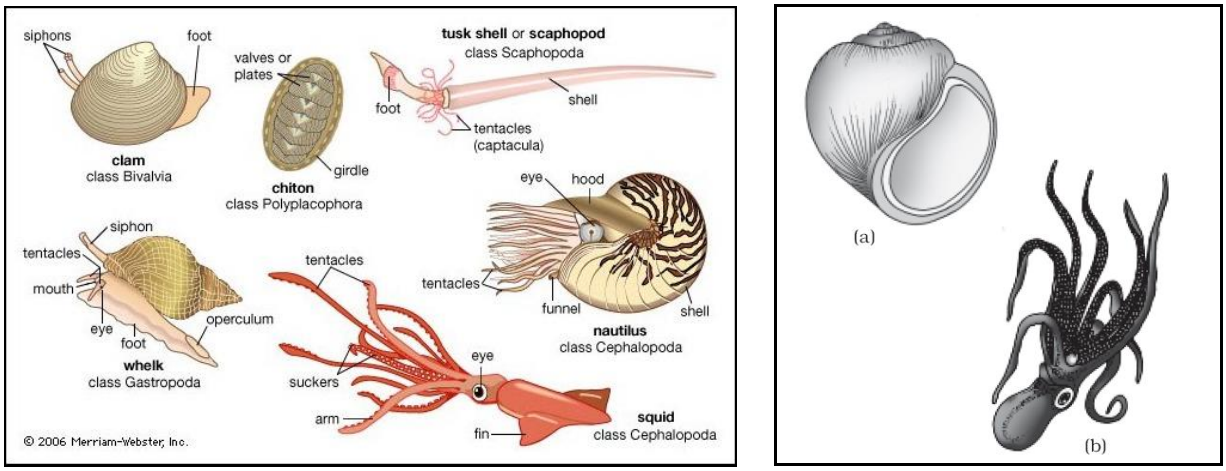


Figure: Examples of Mollusca

Test your Resonance with concept

1. The branch of science dealing with the study of molluscs is
(1) Conchology (2) Malacology (3) Entomology (4) Parasitology

2. Haemocyanin, the blue coloured respiratory pigment of molluscan blood contains
(1) Iron (2) Magnesium (3) Copper (4) Manganese

3. Closed circulatory system does not occur in
(1) Cockroach (2) Cuttle fish (3) Earthworm (4) All of the above

4. Molluscan blood contains
(1) Haemoglobin (2) Haemocyanin (3) Haemozoin (4) All of the above

Answers

1. (2) **2.** (3) **3.** (1) **4.** (2)

		Monoplacophora	Aplacophora	Polyplacophora / Amphineura	Scaphopoda	Gastropoda	Pelecypoda/ Bivalvia/ Lamellibranchia	Cephalopoda
1.	**Habitat**	**Marine**	**Marine, Worm like**		**Marine**	**Marine/ Fresh water/ Moist soli**	**Marine/ Fresh water**	**Marine**
2.	**Shell**	dome shaped	Absent	Present / Absent, 8 dorsal plates present (multivalved)	Tubular, open at both ends	Spirally coiled	Consists of two movable plates / valves	Internal & reduced/ external (*Nautilus*) / absent (*Octopus*)
3.	Special point			Term 'Amphineura' given by Vonlhering				Exhalant siphon Closed blood circulation – Ink gland for defense – Hectocotyle for sperm transfer
	e.g.	***Neopilina*** – Living fossil Connecting link between Annelida & Mollusca only segmental Mollusc **nephridia present**	***Neomenia***	***Chiton*** (the coat of mail shell) *Chaetopleura*	***Dentalium*** (the elephant's tusk shell)	***Pila*** (Apple snail) ***Limax*** (slug)–shell less ***cypraea*** (Cowrie) – old currency *Turbinella* (Shankh) *Doris* (sea lemon) *Aplysia* (sea hare)– Internal shell *Planorbis* (land snail) *Lymnaea* (pond snail)	***Unio*** (Fresh water mussel),***Mytilus*** (sea mussel),***Teredo*** (ship worm) *Solen* (blade fish) ***Pinctada*** (Pearl oyester) *Pteria* (Indian pearl oyester) ***Tridekha***– highest economic value *Pecten* (Scallop) ***Spondilus*** (edible oyester)	***Sepia*** (cuttle fish) – 10 arms ***Octopus*** (Devil fish) – 8 arms ***Loligo*** (Squid) – Radula absent ***Nautilus*** ***Architeuthis*** (Giant squid) – Largest invertebrate

Important Examples of Mollusca: ***Pila*** (Apple snail), ***Pinctada*** (Pearl oyster), ***Sepia*** (Cuttlefish), ***Loligo*** (Squid), ***Octopus*** (Devil fish), ***Aplysia*** (Seahare), ***Dentalium*** (Tusk shell) and ***Chaetopleura*** (Chiton).

Phylum – Echinodermata (Spiny skinned animals)

(Gk. Echinos = spines ; Derma = skin/covering)

❖ **General characters**

1. **Habitat –** All are marine except *Synapta similis*.
   - They generally live at sea bottom and are slow moving.
   - Some are pelagic (free swimming in open water) and a few are sessile.
2. **Body form –** Body shape varies considerably (star shaped, spherical, cylindrical etc.).
   - Body is unsegmented and lacks head.
3. **Level of organization –** Organ system level of organization.
4. **Symmetry –** Symmetry is bilateral in larvae but penta-merous radial in adults i.e. body parts are arranged in fives or multiples of five.
5. **Germ layers –** Triploblastic.
6. **Body wall –** Consists of
   i. Epidermis – Single layered and ciliated.
   ii. Dermis– Below the epidermis,there is thick dermis having mesodermal endoskeleton of calcareous plate (Ossicles). It has spines and pedicellariae.
   iii. Muscles – Smooth and lie below dermis.
   iv. Spines and pedicellariae – Many echinoderms bear spines and pincer like pedicellariae. The spines are protective in function and arise from the dermis. The pedicellariae keep the body surface clear of debris and minute organisms.
7. **Body cavity –** There is a true enterocoelic coelom surrounded by ciliated mesothelium. Enterocoelous contains fluid with free amoeboid cells called coelomocytes.
   - Coelom is divided into many tubes and sinuses, which together form 3 systems
   i. Ambulacral system or water vascular system – It is a characteristic feature of Echinodermata. A perforated plate called madreporite is present in this system that allows entry of water into the system which helps in transport of food & gases. Tube feet of this system help in locomotion.
   ii. Haemal system
   iii. Perihaemal system
8. **Respiratory system –** Gaseous exchange occurs by gills called dermal branchae or papulae in most of the Echinoderms like star fishes, Peristomial gills in sea urchins, genital bursae in brittle stars and cloacal respiratory trees in holothurians.
   - Tube feet also help in gaseous exchange.
9. **Digestive tract –** It is complete (exception – incomplete in Brittle stars)
10. **Circulatory system –** It is of open type. It consists of haemal and perihaemal system
    - The so called blood is often without a respiratory pigment.
    - There is no heart or pumping vessel.
11. **Excretory system –** Specialized excretory organs are absent. Nitrogenous wastes are diffused out through gills. Ammonia is chief excretory matter.
12. **Nervous system–** Primitive and simple type of nervous system consisting of a nerve ring and radial nerve cords.
    - Brain is absent.
13. **Sense organs –** Poorly developed.
14. **Reproduction** –

- Have separate sexes
- Fertilization is usually external
- Life history includes ciliated, bilaterally symmetrical larva that undergoes metamorphosis and changes into an adult.
- Larvae – Star fish – Bipinnaria, Brachiolaria.
  Sea urchin – Echinopluteus
  Brittle star – Ophiopluteus
  Feather star – Doliolaria
  Sea cucumber – Auricularia

15. **Regeneration and autotomy –** Few echinoderms have great power of regeneration.
    - They break off their arms for defence purpose. This phenomenon is known as autotomy.

16. **Evisceration –** Echinoderms in angry or frightened state vomit out viscera (internal organs). This phenomenon is known as evisceration.

❖ **Unique features**

1. Presence of spines and pedicellariae.
2. Ambulacral system for locomotion and transport of food & gases.
3. Endoskeleton of calcareous plates.
4. Bilateral symmetry in larva and radial symmetry in the adult.
5. Echinoderms occur only in sea water.

		Asteroidea	**Ophiuroidea**	**Echinoidea**	**Holothuroidea**	**Crinoidea**
(1)	**Body form**	Flat & star like	Flat & star like	Globular/disc like	Long and cylindrical	Plant like fixed with cirri
(2)	**Spines**	Present	Present	Present	Absent	Absent
(3)	**Pedicellariae**	Present	Absent	Present	Absent	Absent
(4)	**e.g.**	***Asterias*** (Star fish)	***Ophiothrix*** (Brittle star) ***Ophiura***	***Echinus*** (Sea urchin)	***Cucumaria*** **(**Sea Cucumber) ***Holothuria*** ***Synapta***	**Antedon** (Sea lilly) –most primitive
(5)	**Special points**			Mouth with biting & chewing apparatus called as**Aristotles lantern** (Masticating apparatus with 5 teeth)		

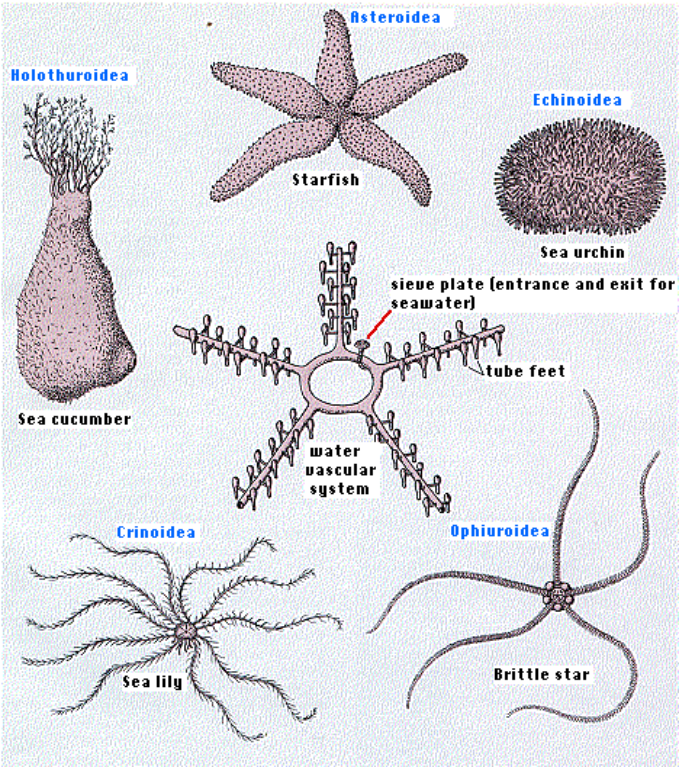


Figure: Examples of Echinodermata

Important Examples of Echinodermata: ***Asterias*** (Star fish), ***Echinus*** (Sea urchin), ***Antedon*** (Sea lily), ***Cucumaria*** (Sea cucumber) and ***Ophiura*** (Brittle star).

Test your Resonance with concept

1. Which one of the following groups of animals lives, only in marine habitat?
(1) Porifera (2) Cnidaria (3) Echinodermata (4) Mollusca

2. Which one of the following hase a radially symmertical body?
(1) Star fish (2) Frog (3) Pigeon (4) Apple snail

3. Water vascular system is found in
(1) Sponges (2) Cnidarians (3) Echinoderms (4) Arthropods

4. Echinoderms show following characteristics:
(1) Spiny skin and radial symmetry (2) Smooth skin and radial symmetry
(3) Spiny skin and bilateral symmetry (4) Spiny skin and symmetry

5. An animal having unsegmented coelom, superficial radial symmetry in adult but bilateral symmetry in larva is a member of
(1) Echinodermata (2) Mollusca (3) Annelida (4) Arthropoda

Answers

1. (3) **2.** (1) **3.** (3) **4.** (1) **5.** (1)

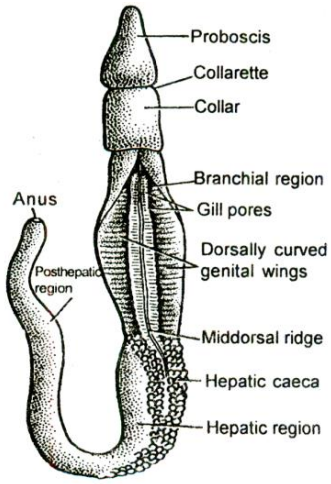
Phylum - Hemichordata

(Gk. hemi = half, chordata = notochord)

❖ Hemichordata was earlier considered as a subphylum under phylum chordata. But now it is placed as a separate phylum under non chordates or invertebrates.

General characters

1. **Habitat –** Animals of this phylum are all fossorial.
   - They are exclusively marine.
2. **Body form–** Body is soft, worm like and is divisible into proboscis, collar and trunk.
3. **Level of organization–**Organ system level of organization.
4. **Symmetry –** Bilateral symmetry.
5. **Germ layers –** Triploblastic.
6. **Body wall –** Body wall consists of Single layered epidermis.
7. **Body cavity –** Body cavity is enterocoelous divided into protocoel, mesocoel and metacoel.
8. **Stomochord –**True notochord is absent.
   - A notochord like structure is found in their buccal cavity that is called "Buccal diverticulum" or "Stomochord"(outgrowth structure from gut). It is present in proboscis.
9. **Digestive tract –** It is complete and is straight or U-shaped.
10. **Respiratory system –** Respire by gill slits or body surface.
11. **Circulatory system –** It is of open type.
    - Heart is situated dorsally.
    - Blood is colourless and contains respiratory pigment vanadium.
12. **Excretory system –** Excretion is by a single glomerulus situated in the proboscis known as Proboscis gland.
13. **Nervous system –** Central nervous system is just like Non chordates. Brain is present in the form of nerve-ring.
14. **Sense organs –** Sensory cells of the epidermis act a sense organs.
15. **Reproduction –** Most animals are unisexual.
    - Reproduction is sexual.
    - Fertilization is external.
    - Cleavage is holoblastic.
    - Development is direct or indirect.
    - In indirect development, a free living tornaria larva, just like bipinnaria larva of Echinodermata is present.
16. **Classification –** 2 classes
    A. Enteropneusta
       e.g.*Balanoglossus* – Tongue worm or Acorn worm
       Saccoglossus
       Protoglossus
    B. Pterobranchia
       e.g. *Rhabdopleura* ,*Cephalodiscus*
17. Hemichordata is the connecting link between Non-chordata & chordata.



Balanoglossus :
External features in dorsal view

Important Examples of Hemichordata: *Balanoglossus* and ***Saccoglossus.***

Test your Resonance with concept

1. *Balanoglossus* belongs to
(1) Annelida (2) Hemichordata (3) Platyhelminthes (4) Cephalochordata

2. *Balanoglossus* is also called
(a) silk worm (2) ship worm (3) tongue worm (4) hook worm

3. Acorn worms are included in
(1) Cestoda (2) Trematoda (3) Hemichordata (4) Echinodermata

4. Which type of coelom is found in Hemichordata?
(1) Haemocoel (2) Enterocoel (3) Schizocoel (4) Pseudocoel

Answers

1. (2) **2.** (3) **3.** (3) **4.** (2)