2nd SEM B.Sc. ZOOLOGY
CALICUT UNIVERSITY

ANIMAL DIVERSITY: NON-CHORDATA PART – II
2019 - ADMISSION

Prepared by
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SECOND SEMESTER B. Sc. ZOOLOGY PROGRAMME
ZOOLOGY CORE COURSE- II (Theory)
ANIMAL DIVERSITY: NON-CHORDATA PART – II
Code: ZOL2B02T
[DIVERSITY, ADAPTATIONS & FUNCTIONAL ANATOMY OF COELOMATE NON-CHORDATES]
[36 hours] [2 hours per week] [2 Credits]

COELOMATA

MODULE 1. Phylum ANNELIDA (7 hrs)

Classification down to subclasses; salient features of the following classes and subclasses:

1. Class Polychaeta e.g. Arenicola
2. Class Clitellata
   Subclass Oligochaeta e.g. Megascolex
   Subclass Hirudinea e.g. Hirudinaria, Haemadipsa

Type: Neanthes [Nereis]

[Morphology, body wall, digestive system, respiratory system, circulatory system, excretory system, sense organs and reproductive system. Mention Heteronereis stage and Trochophore larva.]

MODULE 2. Phylum ONYCHOPHORA (2 hrs)

Peripatus [distribution, peculiarities and affinities).

MODULE 3. Phylum ARTHROPODA (11 hrs)

Classification down to classes (mention the five subphyla and 16 arthropod classes); salient features of the following classes:

1. Class Trilobita [brief account only]
2. Class Merostomata e.g. Limulus
3. Class Arachnida e.g. Heterometrus (Palamnaeus),Heteropoda (Huntsman spider, Order Araneae).Mention ticks and mites (Subclass Acari).
4. Class Chilopoda e.g. Scolopendra, Scutigera
5. Class Diplopoda e.g. Spirostreptus, Julus
6. Class Crustacea e.g. Sacculina, Eupagurus
7. Class Insecta e.g. Lepisma, Mantis, Tabanus, Troides minos (Southern Birdwing butterfly), Papilio buddha (Malabar Banded Peacock),Apis.

Type: Penaeus indicus [Prawn]

[Morphology, digestive system, respiratory system, blood vascular system, excretory system, nervous system, sense organs (statocyst, compound eye in detail), reproductive system and development] [Details of larval stages not expected].

MODULE 4. Phylum MOLLUSCA (8 hrs)

Classification down to classes; Mention Nudibranchs and Nautilus. Salient features of the following classes:

1. Class Aplacophora e.g. Chaetoderma
2. Class Polyplacophora (=Amphineura) e.g. Chiton

3. Class Monoplacophora e.g. Neopilina
4. Class Gastropoda e.g. Turbinella
5. Class Bivalvia (=Pelecypoda) e.g. Perna
6. Class Scaphopoda e.g. Dentalium
7. Class Cephalopoda (=Siphonopoda) e.g. Sepia

Type: Pila globosa [Apple Snail]

[Morphology, digestive system, respiratory system, blood vascular system, excretory system, nervous system, sense organs (osphradium in detail) and reproductive system].

MODULE 5. Phylum ECHINODERMATA (4 hrs)

Classification down to classes [of extant forms only]; salient features of the following classes and brief account of examples:

1. Class Crinoidea e.g. Antedon
2. Class Asteroidea e.g. Astropecten
3. Class Ophiuroidea e.g. Ophiothrix
4. Class Holothuroidea e.g. Holothuria
5. Class Echinoidea e.g. Echinus

Structural peculiarities of Asterias (star fish); water vascular system in detail.

MODULE 6. Phylum HEMICHORDATA (1 hr)

Balanoglossus: Salient features and affinities.

MODULE 7. COELOMATE MINOR PHYLA (3 hrs)

Salient features of the following coelomate minor phyla; mention examples specified [structure and life history not required).

1. Phylum Phoronida e.g. Phoronis
2. Phylum Ectoprocta [Bryozoa] e.g. Bugula
3. Phylum Echiura e.g. Bonellia

MODULE 1

PHYLUM ANNELIDA

- The Annelids are coelomate and triploblastic.
- They exhibit organ system level organization.
- Their body is segmented.
- They respire through their body surface.
- Nephridia are the excretory organs.
- They have a well-developed circulatory and digestive system.
- Their body contains haemoglobin, which gives them a red colour.
- Regeneration is a very common characteristic of the Annelids.
- Setae help them in movement.
- Most of the Annelids are hermaphrodite, i.e., male and female organs are present in the same body. They reproduce both sexually and asexually.
- Eg., ***Earthworms, leeches***

Classification

Classified into three,

- Polychaeta
- Oligochaeta
- Hirudinea

Class Polychaeta

- The body is elongated and divided into segments.
- They are found in the marine environment.
- These are true coelomates, bilaterally symmetrical worms.
- They excrete through metanephridia and protonephridia.
- Fertilization is external.
- They have a well-developed nervous system.
- The circulatory system is closed type.
- They are hermaphrodites.
- They might possess fin-like appendages called ***parapodia.***

- The organisms belonging to this group ***lack clitellum*** and are dioecious.
- Larva – Trochophore
- Eg:- ***Nereis***

Class Oligochaeta

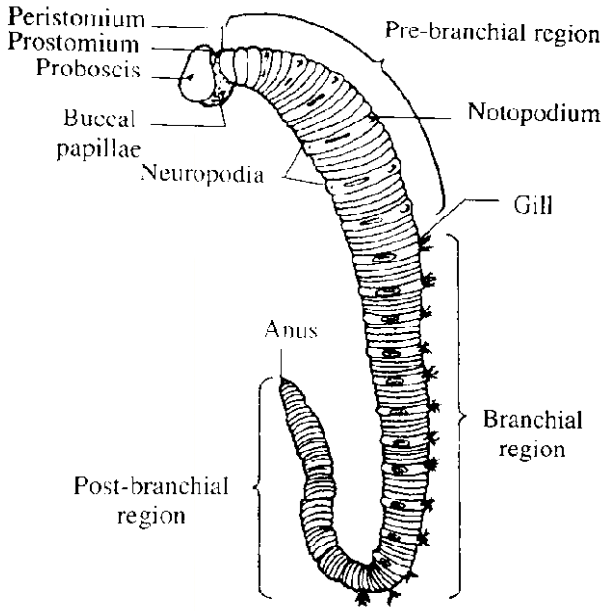
- They are mostly freshwater and terrestrial organisms.
- The body is segmented metamerically.
- Head, eyes and tentacles are not distinct.
- They are hermaphrodites, but cross-fertilization takes place.
- Fertilization is external.
- Cocoon formation occurs.
- Setae are segmented.
- They ***do not possess parapodia but clitellum is present***.
- The organisms belonging to this class are monoecious.
- They exhibit no free larval stage and the development takes place inside the cocoons.
- Eg:- ***Megascolex***

Class Hirudinea

- Most commonly found in freshwater. Some are marine, terrestrial, and parasitic.
- Fixed number of body segments
- The ***tentacles, parapodia, and setae are not present***.
- The animals are monoecious.
- The body is dorsoventrally or cylindrically flattened.
- They have an ***anterior and posterior sucker*** on the ventral side.
- There is no larval stage during the development of the organism.
- The mouth is located ventrally in the anterior sucker, while the anus is present dorsally in the posterior sucker.
- Fertilization is internal.
- They are hermaphrodites.
- Eg:- ***Hirudinaria***

Arenicola

- Popularly known as ***"lugworm or "lobeworm***
- Tubiculous marine annelid
- Body is long, soft, cylindrical and brownish green.
- It is divisible into three regions, anterior pre-branchial, middle branchial and posterior post-branchial regions.



Arenicola

- *Pre branchial* region is 7-segmented.
- The first segment, or ***peristomium***, is the oral segment.
- Just in front of it, is a fleshy lobe, called ***prostomium.***
- Prostomium is trilobed and bears small eyes.
- Through the mouth, buccal mass can be everted out as the ***proboscis*** for feeding and locomotion.
- The six segments that follow bear biramous parapodia, armed with setae.
- Each parapodium has a small dorsal lobe, called ***notopodium*** and large and swollen ventral lobe, called ***neuropodium.***
- Notopodium bears long, unjointed and needle-like setae.
- Neuropodium bears curved and hook-like setae, called uncini or crochets.
- *Branchial region* is 13-segmented, with 13 pairs of parapodia and 13 pairs of ***arborescent gills (branched).***
- Parapodia are provided with setae.
- Gills are the modified dorsal cirri of the parapodia.
- *Post-branchial* region is many-segmented.
- It has no parapodia, setae and gills, but has irregularly scattered epidermal papillae.

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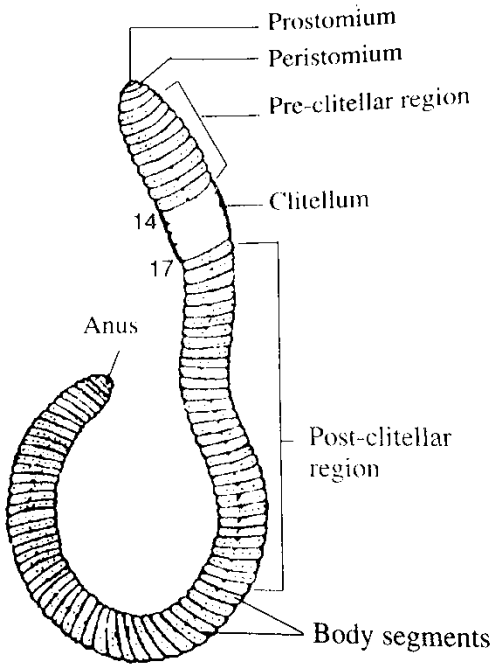
- The last body segment is the anal segment.
- Arenicola has a statocyst.
- lt consists of a fluid-filled capsule of ciliated cells

Megascolex

- Earthworms are subterraneous
- Nocturnal in habit.
- While digging burrows, earthworms eat large quantities of moist soil.
- After digesting the organic matter contained in it, earth is passed out as small pellets.
- These form small heaps of faeces, known as worm casts
- Very important in agriculture - engage in digging burrows and raking the soil – “nature’s plough-men" and farmers friends.
- They form an important link in the detritus food chain and play a vital role in the recycling of nutrients.
- The body of earthworm is long, cylindrical and segmented.
- A distinct head region is absent.
- Adjacent body segments of earthworm are separated externally by intersegmental grooves, and internally by partitions, called intersegmental septa.
- The first segment is known as peristomium or ‘buccal segment'.
- Overhanging the mouth is a fleshy lobe, the prostomium.
- The last segment is the anal segment.
- At its tip is the anus.
- In mature worms, segments from 14 to 17 fuse together, forming a swollen circular and glandular girdle, known as ***clitellum or cingulum***.
- Clitellum secretes the cocoon or egg case during sexual reproduction.
- Clitellum marks out the body into three regions, namely pre-clitellar, clitellar and post-clitellar regions.



Earthwom-entire

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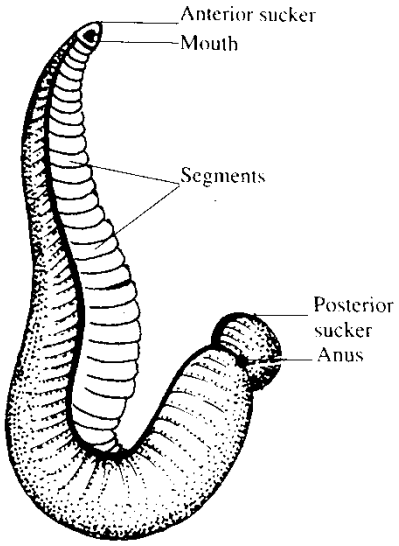
- ***Dorsal pores*** – series of openings on the dorsal side - external openings of coelom – oozes out coelomic fluid – keeps body surface moist
- ***Spermathecal openings*** – in between segments 6 &7, 7 & 8, 8 & 9
- A pair of ***oviducal openings*** – ventral side of 14th segment
- A pair of ***spermiducal openings*** – ventral side of 18t segment
- In all segments, behind the first one, there are numerous chitinous rods or bristles, known as chaetae or setae.
- The circular arrangement of setae around the body is called ***perichaetine arrangement.*** The basal portion of the setae is lodged in an epidermal pit, called ***setal or setigerous sac***.
- The terminal part projects to the body surface.
- Setae are slightly curved and cylindrical rods.
- It has three portions
  1. Root or base – basal part, lodged in the setal sac
  2. Shaft or neck – terminal part
  3. Nodulus – swollen middle portion
- Setae are operated by special muscles during locomotion – protractor & retractor muscles

Hirudinaria

- ***Indian cattle leach***
- It is a ***sanguivorous or haematophagous*** (blood feeding) ectoparasite on fishes, frogs, cattle, man and some other mammals.
- Body of leach is soft and dorso ventrally flattened.
- The body surface is moist and slimy due to mucus secretion.
- The body consists of 33 true segments or metameres.
- Body has three major divisions, namely head, trunk and posterior sucker.
- Though a clitellum is absent, trunk is divisible into four regions, namely pre clitellar, clitellar, post-clitellar and caudal regions.
- Pre-clitellar, clitellar and post-clitellar regions bear segmentally paired nephridiopores (17 pairs) on the ventral side.
- Male gonopore is located mid-ventrally in the 10th segment and female gonopore in the 11th segment.
- The external receptors include the annular receptors, segmental sensory receptors or sensillae and the pigmented eyes.

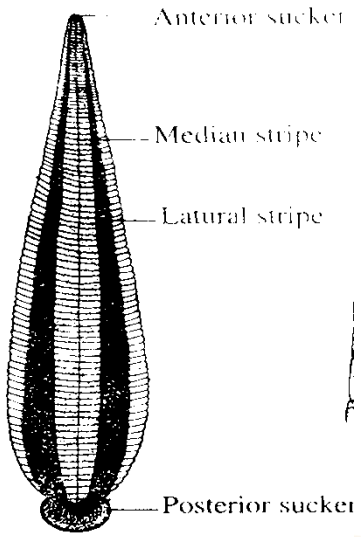


Hirudinaria

- The interior of the body is filled with a characteristic connective. tissue, called ***botryoidal tissue.***
- The digestive system of leech is characteristic in that buccal cavity is armed with toothed jaws or cutting plates, pharynx is a muscular pump, and crop 1s a large blood storing chamber.
- For storing blood, crop has paired lateral pouches, called ***caeca or diverticula***.
- The salivary glands of leech produce an anti-coagulant enzyme, called ***hirudin.***
- Leech is a hermaphrodite.
- Cross fertilization is the rule.
- Their blood feeding adaptations are
  (1) Toothed cutting plates for making wounds on the host
  (2) Suctorial pharynx to suck biood
  (3) The salivary enzayme hirudin to prevent blood- clotting at wounds
  (4) Paired lateral pouches of the crop, known as caecae or diverticula for storing blood
  (5) Suckers for attachment to host' s body.

Haemadispa

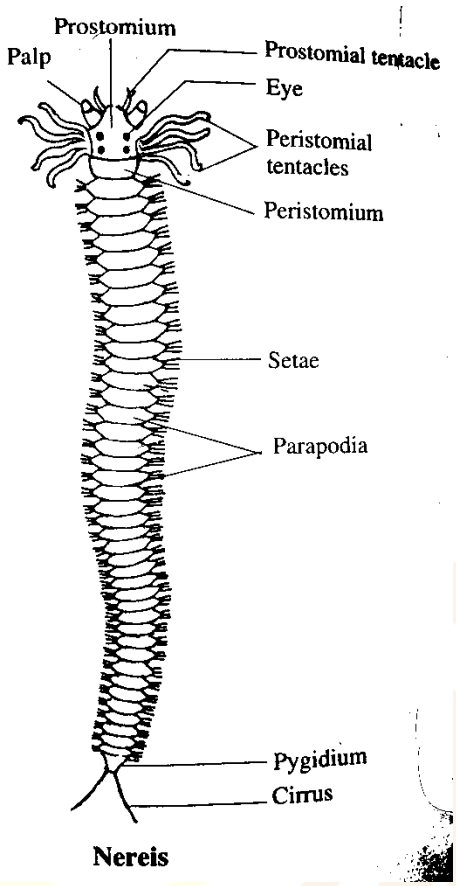
- ***Land leech***
- ***Sanguivorous***
- It remains attached to trees, bushes, waiting for a passing of man or beast
- Its body is compact, sub cylindrical & slender
- Tapering from behind forwards
- Olive green in colour, mottled with black
- Skin is thick to prevent dehydration & numerous mucous glands to keep it moist



- A mid dorsal narrow stripe & two lateral stripes
- Clitellum is indicated by greyish or yellowish band
- Anterior & posterior suckers are prehensile – used to hold on branches
- Mouth is armed with toothed, saw like & movable chitinous jaws
- 17 pairs of nephridiophores
- Testes – 10 pairs
- Ovisac – a pair
- Male gonopore – 11^{th} segment
- Female gonopore – 12^{th} segment
- Voracious blood feeder
- Ingest large quantity of blood, nearly ten times of its weight
- Undergo aestivation

Type : Neanthes (Nereis)

- Popularly known as the ***"sandworm", "ragworm" or "clamworm***"
- Predaceous marine annelid
- Nocturnal animal



Nereis

Morphology

- The body of Nereis is long, slender, metamerically segmented
- Bilaterally symmetrical and dorso-ventrally flattened.
- The body colour varies with species, age and sexual maturity.
- The body is roughly divisible into three regions, ***"head", trunk and tail or pygidium***.
- Head has two divisions, namely ***prostomium*** and ***peristomium***.
- Prostomium is not a true segment, but only a lobular extension of prostomium
- Peristomium represents the fused first and second segments
- Peristomium bears
  Two pairs of pigmented dorsal eyes
  A pair of peristomial tentacles
  A pair of peristomial palps
  A pair of ciliated lateral pits, known as nuchal organs.
- Trunk is the longest part or the body, formed of numerous segments
- Each trunk segment bears a pair of lateral processes, known as ***parapodia.***
- Tne last body segment is the anal segment and it represents the tail.
- It bears the anus and a pair of filamentar processes, known as ***anal cirri.***
- ***Parapodia***, or 'side feet', are the fleshy, lobular and muscular lateral processes or appendages of the body wall.
- Each trunk segment, behind the peristomium, has a pair of them.
- They are provided with bundles of chitinous bristles, called***setae***& several sensory filaments known as ***cirri***.

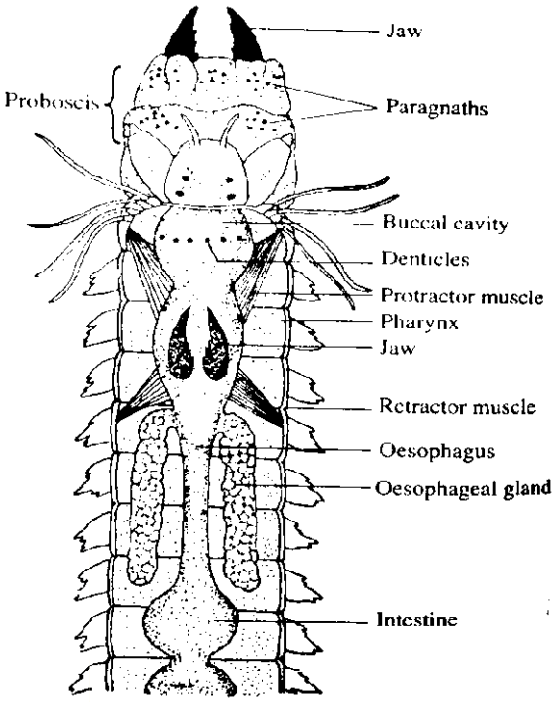
- Parapodium is a biramous organ - upper ***notopodium*** and lower ***neuropodium.***
- Each lobe, in turn, has two lobules or ligules.
- Notopodium and neuropodium have bundles of setae, known respectively as ***notopodial setae and neuropodial setae.***
- Basally, setae are lodged in a sac, known as ***setigerous sac.***
- Embedded somewhere in the middle of notopodium and neuropodium is a large and strong bristle, known as ***aciculum*** - serves as an internal supporting skeleton and also provides a surface for the attachment of setal muscles.

Body wall

- Very thick
- Consist of four parts
- Cuticle, epidermis muscular layer & the parietal peritoneum
- ***Cuticle*** is a thin, transparent and elastic chitinous envelope over the entire body surface, including the parapodia.
- It is secreted by the underlying epidermis.
- It is perforated by the minute pores of epidermal gland cells.
- ***Epidermis*** is single-layered.
- It consists of sensory cells, mucus-secreting gland cells and supporting columnar cells.
- Gland cells perforate the cuticle to discharge mucus over the body surface.
- ***Muscular layer*** consists of outer circular and inner longitudinal muscles.
- Circular muscles are arranged in a continuous layer, whereas longitudinal muscles are arranged in four separate blocks, two dorso-lateral and two ventro-lateral.
- The contraction of the circular muscles lengthens the body, while the contraction of the longitudinal muscles causes the side-to-side bending of the body.
- ***Parietal peritoneum*** – coelom is lined externally

Digestive system

- Digestive system consists of the alimentary canal and a few digestive glands.
- Alimentary canal is a long, straight and muscular tube, with mouth and anus at opposite ends. It has three major divisions, namely stomodaeum (fore-gut), mesodaeum (mid-gut) and proctodaeum (hind-gut).
- Stomodaeum consists of mouth, buccal cavity and pharynx
- Mesodaeum consists of oesophagus and intestine
- Proctodaeum consists of rectum and anus.
- Buccal cavity occupies the peristomium, ana pharynx occupies the next four segments.
- Both these regions have the same muscular coats so, called bucco-pharyngeal region.
- The cuticular lining of this region is raised into tooth-like structures, called denticles or paragnaths.
- In the posterior part of the pharynx, the cuticular lining is produced into two movable jaws, embedded in the muscular wall.
- Jaws are used for seizing and tearing the prey.



Nereis - Digestive system

- During active feeding, the bucco-pharyngeal region may be thrown to the outside as a complex mass, called proboscis or introvert.
- Pharynx is followed by the oesophagus, which occupies five segments in most species.
- Opening to it is a pair of saccular oesophageal glands - secrete digestive enzymes.
- Intestine is long and segmentally sacculated.
- At the junction between oesophagus and intestne, is a muscular sphincter, which regulates the passage of food from esophagus to intestine.
- Rectum is the terminal part of the intestine and it occupies the last segment.
- The passage of food along the digestive tract is due to the peristaltic movements of the gut wall
- Nereis is a predaceous carnivore, feeding on small worms, crustaceans, larval forms,..
- The prey is seized and swallowed with the help of the heavily armed introvert.
- The prey gets caught in between the jaws.
- The introvert is withdrawn, ingesting the prey.
- Digestion and absorption occur in the intestine.
- The undigested residue is passed out through anus.

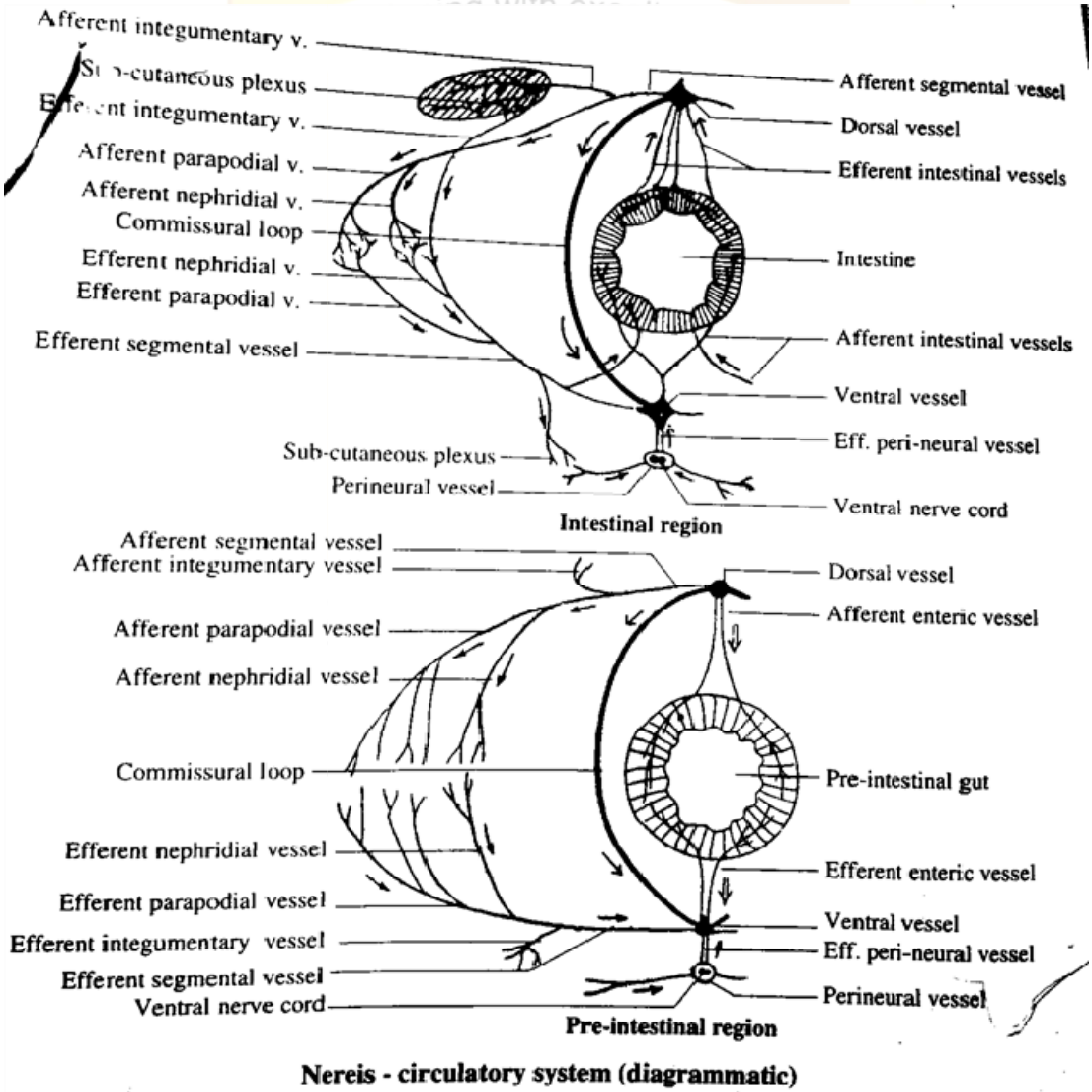
Respiratory system

- Specialized respiratory organs are absent in Nereis.
- Cutaneous respiration through skin is the rule.
- The richly vascular parapodia and body wall provide a vast respiratory surface for free gas exchange between blood and the surrounding sea water.

- Blood plasma contains the respiratory pigment haemoglobin, which plays an active role in oxygen transport.

Circulatory system

- The blood vascular system of Nereis is well developed
- It is of the closed type.
- It consists of blood, a system of distributing blood vessels, a system of collecting blood vessels and a network of capillaries connecting the distributing vessels with the collecting vessels.
- A distinct heart is absent.
- Blood is a red-coloured fluid.
- It consists of red-coloured plasma and numerous colourless and amoeboid corpuscles.
- Dissolved in the plasma is the respiratory pigment haemoglobin.



Nereis - circulatory system (diagrammatic)

- Blood plays a significant role in the transport of respiratory gases, distribution of nutrients and the transport of nitrogenous wastes.
- There are three major longitudinal blood vessels, namely dorsal, ventral and peri-neural.
- The dorsal vessel lies above the alimentary canal

- The ventral one below the alimentary canal
- The peri-neural vessel surrounds the ventral nerve cord.
- In the anal region, the dorsal and ventral vessels are continuous, forming a circum-rectal ring vessel.

Major blood vessels in the intestinal region

- Dorsal blood vessel receives two pairs of efferent intestinal vesselsfrom the intestinal wall, and gives out a pair of afferent segmental vessels to body wall and internal organs.
- Each afferent segmental vessel divides into three main branches, namely an ***afferent integumentary or afferent cutaneous*** vessel to body wall, an ***afferent parapodial*** vessel to parapodium, and an ***afferent nephridial*** vessel to nephridium.
- In each segment in the intestinal region, the ventral blood vessel receives a pair of efferent segmental vessels from body wall and internal organs, and gives out a pair of afferent intestinal vessels to the intestinal wall.
- Each efferent segmental vessel is formed by the union of three main vessels, namely an efferent integumentary vessel from body wall, an efferent parapodial vessel from parapodium, and an efferent nephridial vessel from nephridium.
- In each segment, the afferent and efferent blood vessels on each side are joined together by a capillary network.
- The dorsal and ventral vessels are joined together by a pair of lateral vessels, known as circum-intestinal vessels or commissural loops, around the intestine.

Blood vessels in the pre-intestinal region behind oesophagus

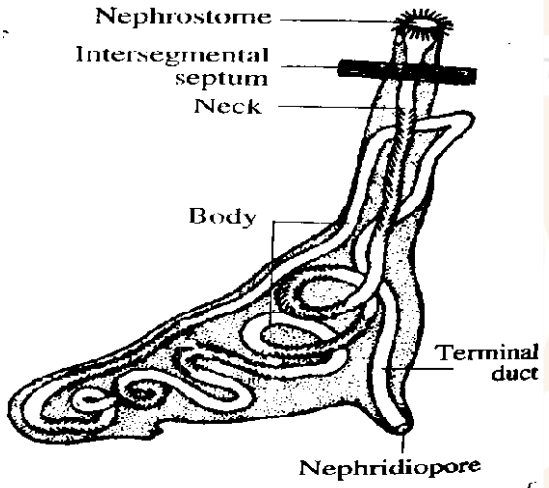
- The dorsal vessel gives out a pair afferent enteric vessel to gut wall, and a pair of afferent segmental vessels to body wall and internal organs.
- The afferent segmental vessel divides into afferent integumentary, afferent parapodial and afferent nephridial vessels.
- The ventral vessel receives a pair of efferent enteric vessels from the gut wall, a pair of efferent segmental vessel from body wall and internal organs, and a pair of efferent peri-neural vessels from peri-neural vessel.
- Each efferent segmental vessel, in turn, is formed by the union of an efferent integumentary vessel, an efferent parapodial vessel and an efferent nephridial vessel.

Blood vessels in the oesophageal region

- The dorsal blood vessel divides into two afferent oesophageal vessels.
- Each of them breaks up into a capillary network in the ventro-lateral part of oesophagus.
- From this capillary network, blood is carried to the ventral vessel by an efferent oesophageal vessel.

Excretory system

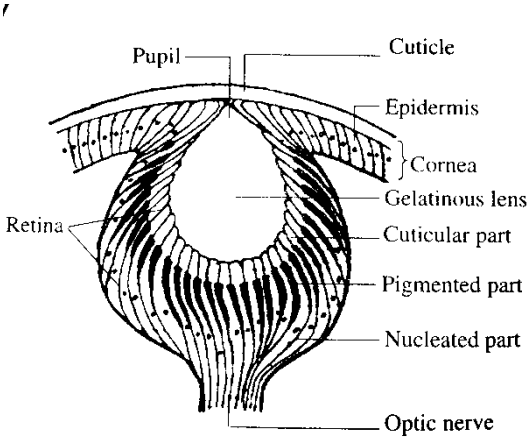
- Excretory organs of Nereis are a segmental series of exonephric metanephridia.
- They are exonephric because they open to the outside, they are termed metanephridia
- The nephridium of Nereis is a highly coiled ciliated tubule, surrounded by a protoplasmic mass.
- It is inter segmental in position, because it occupies two segments.
- Its initial part is seen in one segment, and the remaining part in the next segment.
- It has four regions, namely nephrostome, neck, body and nephridiopore.
- Nephrostome is a ciliated funnel that opens to the peri-visceral coelom.
- Neck is the short and narrow part that follows the nephrostome.
- Body is the highly coiled, glandular, tubular and internally ciliated part of the nephridium.
- Its terminal portion is called terminal duct.
- It opens to the outside ventrally near the base or a parapodium by a nephridiopore.



Metanephridium of Nereis

Sense organs

- Nereis has specialized sense organs in correlation with its active life and predaceous habit.
- They include the prostomial palps, prostomial and peristomial tentacles, nuchal organs and the prostomial eyes.
- Palps and tentacles are primarily tactile receptors.
- Palps serve also as olfactoreceptors and gustatoreceptors for testing the nature and quality of the food.
- Nuchal organs are glandular pits, lined by ciliated epithelium - seen one on either side of the prostomium – serve as chemoreceptors for detecting food.
- The light-sensitive and pigmented prostomial eyes are the most conspicuous receptor organs of Nereis – four in number, located on the dorsal surface of prostomium.
- Each eye is a cylindrical and pigmented cup, with distinct retina and a gelatinous lens.
- Retina is formed of tall, radially arranged pigmented and photosensitive epidermal cells.



Nereis - V.S. of eye

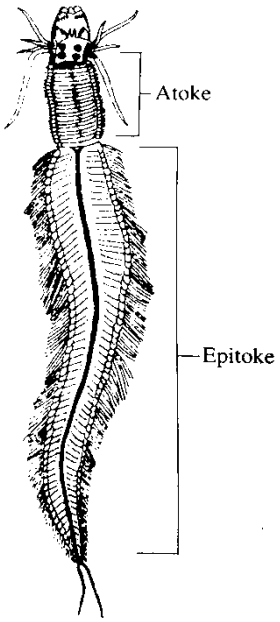
- Each cell has three parts, namely outer nucleated part, middle heavily pigmented part and inner cuticular part or "rod".
- The nucleated part is drawn into nerve fibre - All the nerve fibres converge to form an optic nerve.
- The pigmented part forms the main body of the cell.
- Cuticular part is a hyaline region.
- Retinal layer encloses a cavity, filled with a gelatinous substance secreted by the retinal cells.
- This gelatinous core forms an unspecialized lens.
- The exposed surface of the eye is covered by a transparent and unspecialized "cornea".
- The eye cup has a narrow opening, which forms the pupil.

Reproductive system

- Nereis is dioecious.
- Permanent and well differentiated gonads are absent
- Gonads are temporary structures, developing only during breeding season.
- Ovaries are numerous, arranged in segmental pairs.
- Specialized gonoducts are absent.
- Sex cells are directly released to the peri- visceral coelom.
- They remain in the coelomic fluid until they become mature.
- Ripe sex cells are supposed to find their way to the outside through nephridiopores, or by the rupture of the body wall.
- In each segment, there is a pair of dorsal ciliated organs - represent the gonoducts. On sexual maturity, they may open out temporarily to serve as gonoducts.

Heteronereis stage

- Some species of Nereis, exhibit two distinct phases in their life, namely non-sexual Nereis phase and sexual Heteronereis phase.
- The Heteronereis phase is characterized by striking morphological and anatomical modifications in the posterior half of the body during the breeding season.
- Heteronereis has two distinct regions, namely anterior non-sexual part, called atoke, and posterior sexual part, called epitoke.

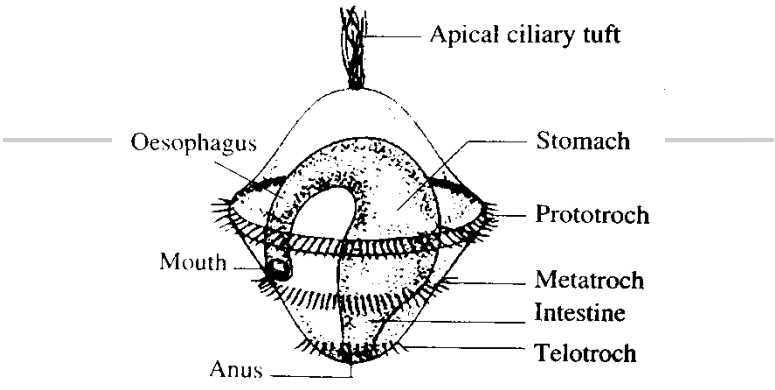


Heteronereis stage

Changes responsible for the transformation of Nereis stage to Heteronereis stage are the following:

1. Animal comes out of the burrow and swims about actively.
2. Body differentiated to sexual and asexual regions
3. Parapodia of the sexual region becomes enlarged
4. Pygidial papillae becomes more prominent
5. Eyes enlarge and becomes photosensitive
6. Pygidium gets modified with prominent sensory papillae
7. Parapodial setae gets replaced by long, flat and ore shaped ones

Trochophore larva



Annelidan trochophore-external

- Trochophore is a small, ciliated, pelagic larva.
- It has a single-layered epidermal covering.
- At the apical pole, the epidermis is thickened to form a sensory plate, known as apical plate.

- This plate is provided with a tuft of long sensory cilia
- Trochophore has a complete and ciliated digestive tract, differentiated into stomodaeum, mesodaeum and proctodaeum.
- Stomodaeum consists of mouth and oesophagus, mesodaeum consists of stomach, and proctodaeum consists of intestine and anus.
- Between the epidermis and the digestive tract is a spacious cavity, called blastocoel.
- Around the equator of trochophore, just in front of the mouth, is a ciliary ring, known as pre-oral ciliary ring or prototroch.
- A second one, known as post-oral ciliary ring or metatroch, may be present behind the mouth.
- Third one, known as peri- anal ciliary ring or telotroch, may also be present around the anal region.
- In the apical region of the larva, is a mass of nervous tissue.

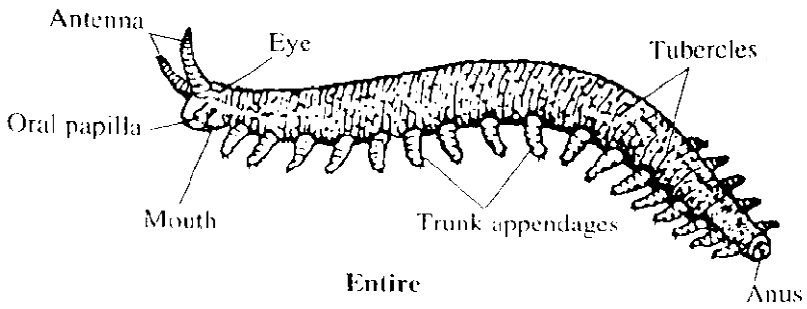
MODULE 2

PHYLUM ONYCOPHORA

- "Velvet worms or walking worms".
- Connecting link between annelida and athropoda
- Enjoy discontinuous distribution
- "Living fossils.
- Bilaterally symmetrical and cylindrical body, without external segmentation.
- Permeable and flexible cuticular covering,
- Paired, unjointed, hollow, short, stubby and terminally clawed appendages, called ***lobopods.***
- Presence of slime glands in the head region.
- Muscles of the body wall are undivided or unsegmented.
- Perivisceral cavity is a haemocoel.
- Respiratory system consists of tufts of tracheae and scattered spiracles.
- Excretory organs are segmentally paired coelomoducts.
- Ladder-like central nervous system, consisting of a bilobed brain and a pair of widely separated and non-ganglionated ventral nerve cord, joined together by transverse commussures.
- Sense organs include eyes, antennae, sensory cells, and the tubercles and papilae in the skin.
- Sexes are seperate

Peripatus

- Peripatus is a small, terrestrial, caterpillar-like predaceous carnivore
- Example of discontinuous distribution
- Lives in tropical rain forests of Congo, West Indies, Himalayas, Central America, Northern Part of South America, Africa,…
- Living fossil
- Looks much like a caterpillar.



Entire

- The body is covered by thin, lightly cutinized, soft, flexible and velvety skin.
- Skin bears numerous transverse rings of wart-like and scale-covered papillae.
- Head bears three pairs of appendages, a pair or simple dorsal eyes and the ventral mouth.

- Mouth is surrounded by ridged and spiny lips, and furnished with a toothed and muscular tongue.
- The first segment is pre-oral – bears a sensory antennae.
- Antennae are long mobile and annulated, and they bear spine-tipped papillae.
- The second segment bears a pair of claw-like, toothed and chitinous mandibles on the inner edges of the mouth - serve as jaws for grasping and cutting the food.
- The third segment bears a pair of short, conical and tuberculated oral papillae
- Opening on the surface of each papilla is a slime duct from a slime gland.
- Slime glands are modified crural glands – secrete the milky white slime – used to entangle the prey & small predators.
- Trunk bears 13 to 43 pairs of short, stubby, unjointed, uniramous, fleshy and hollow appendages, called ***walking legs or lobopods***.
- Each leg bears a nephridipore on the ventral surface of its base, and a coxal organ
- Just outside the nephrdiopore, are the openings of the crural glands in the males of some species.

Affinities of Peripatus

Annelidan features

- Vermiform body
- Unjointed, stumpy, saccular and parapodia-like appendages
- Straight and simple alimentary canal
- Segmentally paired nephridia, which are modified coelomoducts
- Structure of the eye is similar to that of polychaete eye.

Arthropodan features

- Antennae and toothed and jaw-like mandibles.
- Periodic moulting of the cuticular covering
- Clawed legs for locomotion.
- Presence or salivary gland
- Tracheal system win spiracles for respiration.
- Open type of blood-vascular system

Annelidan & arthropodan features

- Metamerically segmented body
- Segmentally paired appendages

Features unique to Peripatus

- Absence of external segmentation.
- Velvety integument with warty prominences
- Unjointed antennae
- Short, unjointed, hollow & clawed legs
- Irregularly scattered spiracles

MODULE 3

PHYLUM ARTHROPODA

Classification

1. Sub phylum trilobita
    i. Class trilobita

2. Sub phylum chelicerata
    ii. Class merostomata
    iii. Class arachnida
    iv. Class pantopoda

3. Sub phylum crustacean
    v. Class cephaloarida
    vi. Class copepod
    vii. Class cirripedia
    viii. Class malacostraca
    ix. Class remipedia
    x. Class branchiura
    xi. Class ostracoda

4. Sub phylum uniramia
    xii. Class symphyla
    xiii. Class chilopoda
    xiv. Class diplopoda
    xv. Class pauropoa
    xvi. Class insecta

Class Trilobita

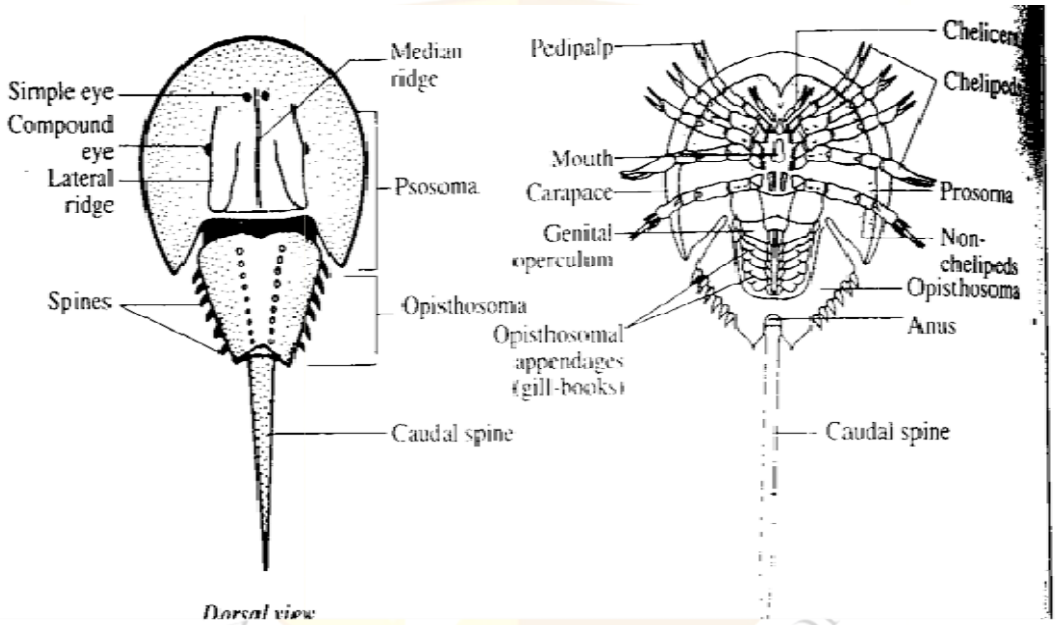
- Oldest group
- Extinct & exclusively marine
- Dorsoventrally flattened body covered by an exoskeleton of calcite
- Body is divided into head, thorax & tail
- Sexes are seperate

Class Merostomata

- Marine chelicerates
- Five or six pairs of abdominal appendages modified as gills & also by a spike like telson
- Excretory organs are coxal glands
- Larva - trilobite

Limulus

- ***King crab or horse shoe crab***
- ***Living fossil***
- Dark brown, flat, semi circular & externally unsegmented
- Body has two divisions, prosoma (cephalothorax) and opisthosoma (abdomen).
- Prosoma is covered dorsally by a horseshoe-shaped ***carapace*** - It forms a protective covering and also enables the animal to push through the sand. Carapace has three dorsal ridges, one median and two lateral.
- Close to the median ridge, is a pair of small simple eyes or ocelli, and close to each lateral eye is a large compound eye.



- Opisthosoma is more or less hexagonal and movably articulated with the prosoma.
- It has an anterior limb-bearing part and a posterior limbless (apodous) part.
- Articulating with the apodous part is a long and mobile caudal spine, used for balancing.
- Ventrally, opisthosoma bears six pairs of abdominal appendages.
- Excretory organs are a pair of ***coxal glands***in the prosoma.
- Sexes are separate.
- Fertilization is internal.
- Life cycle involves a characteristic larva called ***trilobite larva***

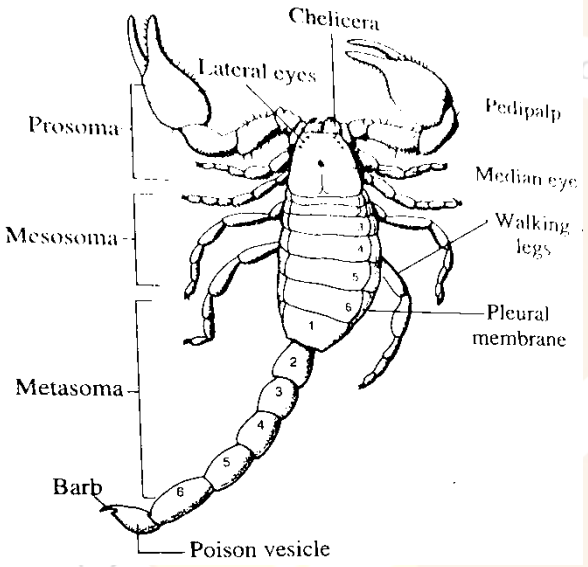
Class Arachnida

- Terrestrial
- Body regions – 3 – pro, meso & metasoma
- No antennae
- A pair of simple eyes

- Four pairs of locomotor organs
- Respiration by book lungs & trachea
- Body fluid – haemolymph
- Eg:- ***spider, scorpion***

Heterometrus (Palamnaeus)

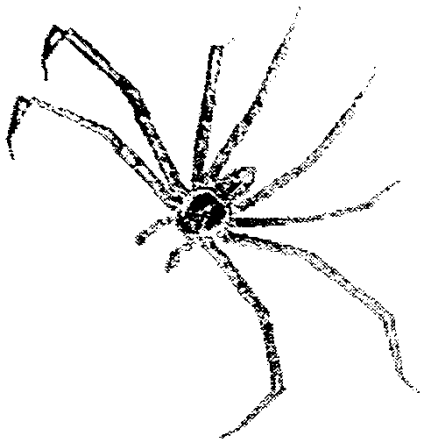
- **Scorpions** are ***poisonous, ovoviviparous*** arthropods
- They are predaecous carnivores
- Preying mostly on insects and spiders
- The body is divisible into Prosoma(cephalothorax), Mesosoma (pre-abdomen)&Metasoma (post-abdomen)
- Prosoma is covered dorsally by carapace,and ventrally by sternum
- Seen on the carapace are 2 or 3 pairs of lateral eyes and a pair of median eyes



- Ventrally, Prosoma bears the mouth and 6 pairs of appendages,namely a pair of chalicerae, a pair of pedipalps and 4 pairs of walking legs
- Mesosoma and metasoma are apodous
- Mesosoma is covered dorsally by tergites and ventrally sternites
- Laterally,these are connected by flexible and non-sclerotized pleural membranes
- The sternite of second mesosomal segment bears a pair of comb-like sensory structurescalled ***pectens***
- The last segment bears the anus and a ***poison sting***

Heteropoda (Huntsman spider)

- Commonly called ***huntsman spider, giant crab spider, banana spider, or cane spider***
- *H.venatoria* is the common "transtropical huntsman spider".
- Most usually, it lives in and around the human habitations of cold temperature regions, especially in sheltered places, such as houses, barns, sheds, under the boards on ground, etc.
- Being cold-sensitive, it will not normally live outdoor in areas of freezing Winter temperatures; it can live outdoor only in warmer climate.
- Heteropoda venatoria is relatively a large-sized spider.



- Its flattened body is an adaptation to fit into very small cracks, crevices and similar places.
- Body has two main divisions, namely prosoma and opisthosoma
- Prosoma is covered dorsally by carapace, and ventrally by labium and sternum.
- Dorsally, prosoma bears a group of ocelli or simple eyes, and ventrally it bears the mouth and six pairs of jointed appendages.
- Just in front of the eyes, is a creamy or yellowish area of carapace, called ***clypeus.***
- The appendages include a pair of chelicerae, a pair of pedipalps and four pairs of walking legs.
- Located at the base of each chelicera, and extending into the prosoma, is a ***venom gland.***
- The secretion of this gland contains a toxin **(H_pTX_2)** which is a potassium channel blocker.
- Predaceous fluid feeding carnivore
- ***Not a web spinner***

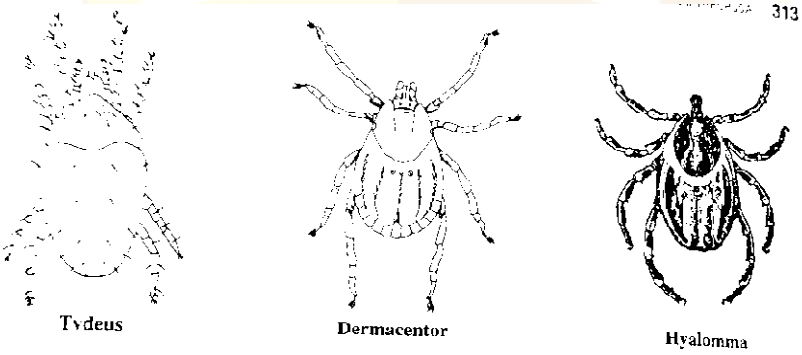
Order Aranea

- Spiders are poisonous
- Predaceous and fluid-reading terrestrial carnivores
- Male is much smaller than female
- Body has two divisions **Prosoma** (cephalothorax) and **Opisthosoma** (abdomen)
- Two part connect together by a short and battle ***pedicel***
- Prosoma is covered dorsally by a ***carapace*** ,ventrally by two chitinous plates namely small***labium*** and large ***sternum***
- Dorsally prosoma bears eight or more ***simple eyes***
- Ventrally bear mouth and six pair appendages
- Appendages are chelicerae,pedipalpiand four pairs of walking legs
- Chelicerae are provided with ***poison glands*** they serve as ***poison fangs***
- Pedipalps , in male serve as ***palpal organs*** for transferring sperm
- In female gonopores are covered by a fold , ***epigynum***
- A pair of ***tracheal spiracles*** presents in each side of the gonopores
- Posterior end of the opisthosoma is a group of 6 of 8 ***spinnerets*** or ***spinning organs***
- ***Silk gland*** or ***abdominal gland*** open on their surface

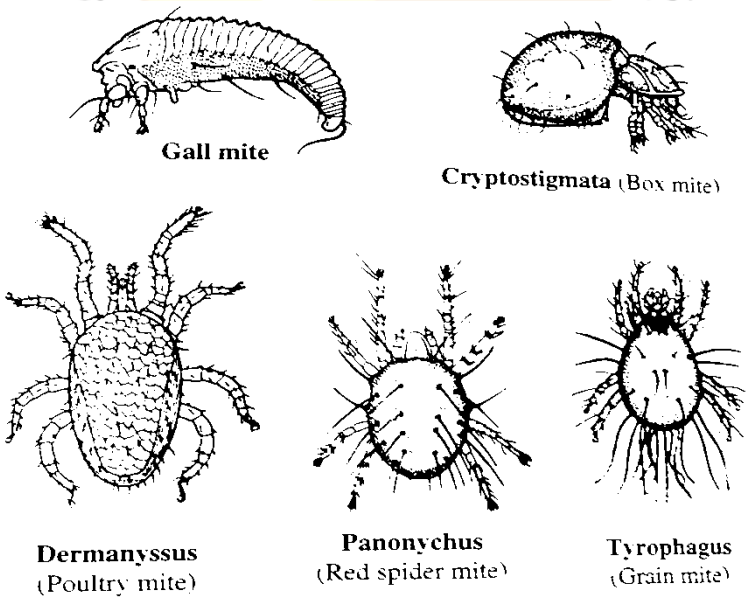
- Some spiders exhibit protective colouration and mimicry
- Only few species are dangerous to man (eg: latrodectus)
- Spiders have powers to regenerate their lost leg
- Female will suck in the body juice of the male after mating

Ticks & mites

- Ticks and mites are largest group of arachnida
- Mites are very minute
- Ticks are larger in relation to each other
- Study of ticks and mites is called ***acarology***
- Ticks are exclusively ectoparasitic on terrerestrial vertebrates
- Sometimes vectors of some pathogens
- They transmit many diseases of man and other vertebrates
- Eg: fatal viral disease, is transmitted by haemaphysalis spinigera.



- Mites are mostly free living but some ecto or endoparasites and still others are agricultural pest
- Free living mites usually abound in decaying vegetation they include herbivores, carnivoresand carrion-feeders or scavengers



Some common mites

- Ectoparasitic mites are more numerous than endoparasites

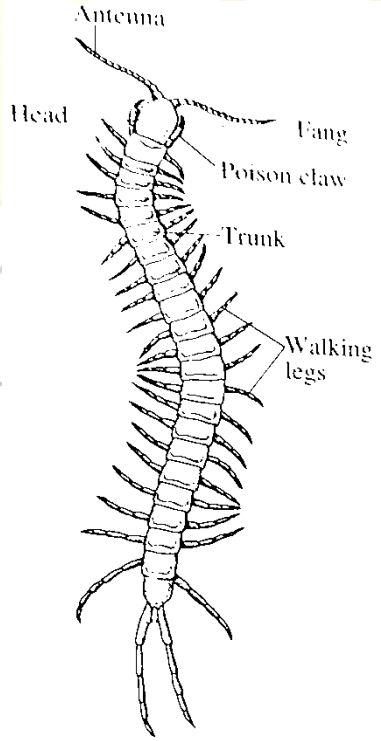
- Body is sac like and unsegmented without differentiate into cephalothorax and abdomen - covered by a single, sclerotized carapace, gnathosoma and capitulum
- Idiosoma is the large posterior part
- The whole bodysurface is beset with setae, which are most sensory structures

Class Chilopoda

- Terrestrial
- Body is divided into head & trunk
- A pair of antennae present
- One pair of simple eyes
- Locomotor organ – one pair per segment
- Tracheal respiration
- Body fluid – haemolymph
- Opisthogenital - gonopore present in the terminal segment
- Eg***:- scolopendra, scutigera***

Scolopendra

- Common ***centipede***
- Nocturnal
- Predatory carnivore
- ***Scolopendra gigantica*** – largest living centipede



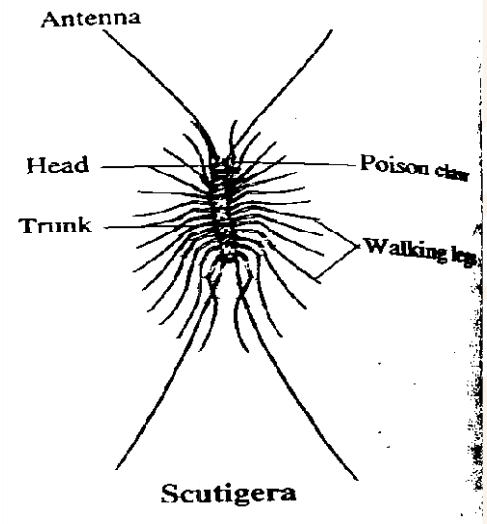
Scolopendra

- Body is divisible into head & trunk

- The chitinous exoskeleton is soft & flexible, with very low calcium content
- Trunk is many segmented
- Maxillipeds – first pair of legs – 4 segmented – modified as poison claws
- Feeds n insects & their larvae, spiders, annelids, nematods,…
- Venom is painful – not seriously toxic to man
- Sexes are seperate

Scutigera

- It is a ***house centipede*** , living in damp places
- Small in size , black in colour , long-legged
- Feed small insects , not harmful to man
- Body divides into two - Head and Trunk
- Antenna are many segmented tactile or feelers
- Near the base of antennae there is a pair of sense organs - ***Tomosvary organs***
- Serve as ***Hygroreceptors*** for detecting humidity



Scutigera

- Compound eyes are compact cluster of numerous Ocelli
- Eyes only for detection of light and darkness
- Last pair of legs are long for reduce slippage
- Last trunk segment- anus
- Tracheal system are highly specialised , trachea are lung like , spiracles are mid dorsal unpaired non valvular and closable

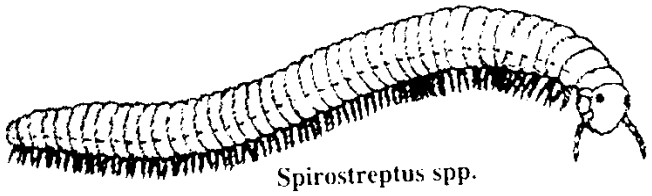
Class Diplopoda

- Terrestrial
- Body is divided into head & trunk
- A pair of antennae present
- One pair of simple eyes
- Locomotor organ – two pair per segment

- Tracheal respiration
- Body fluid – haemolymph
- Progenital - gonopore present in 3rd segment
- Eg:- ***spirostreptus, julus***

Spirostreptus

- Spirostreptus is the common ***millipede.***
- It is sluggish and a slow-moving animal
- Lives in damp places(underneath stones, logs,decaying leaves, rotten timber).
- Plays an important role in changing ***organic debris into soil.***
- Some species are pests



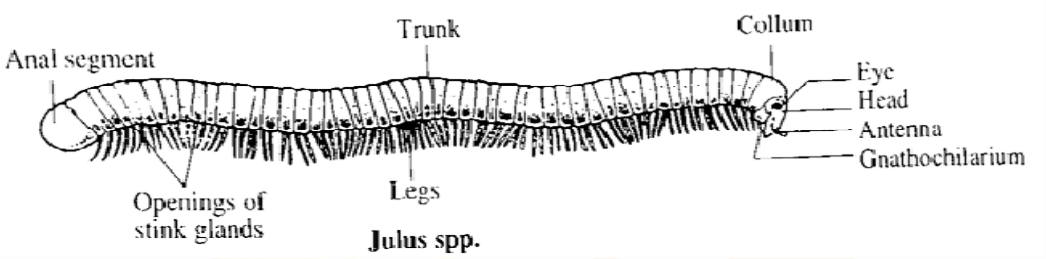
Spirostreptus spp.

- Body is cylindrical and covered by hard calcified exoskeleton
- Head has paired antennae, mandibles, first maxillae, and several ocelli. Second maxillae are absent.
- Each mandible has movable distal lobe called gnathal or masticulary lobe. Provided with teeth and rasping surface
- Antennae are short and tactile
- Mandibles are large
- The posterior floor bears three lobes which represent the hypopharynx
- Tusk is many segmented, each segment is covered by an exoskeletal ring, formed by the fusion of tergum, sternum and pleural plates.
- Most of the gunk segments are diplosegments or double segments, formed by the fusion of two separate so mites.
- Each diplosegments bears two pairs of legs in addition to spiraled, ostia, and nerve ganglia
- The first segment is limbless, known as ***collum***
- It forms collar behind the head.
- The first pair of legs serve as copulatory structures
- The 7th segment in male bears a pair of accessory copulatory apparatus.

- Last segment is the anal segment
- Respiratory organ are the trachea
- Excretory organs are two pairs of malpighian tubules.
- Heart is dorsal, long, tubular, chambered, and posteriorly closed. It has two pairs of ostia in each diplosegments and one pair in each monosegment.
- Sexes are separate.

Julus

- Commonly called as ***wire worm or millipede***.
- Body- elongated, cylindrical and perfectly segmented
- The body consists of about 45-105 segments and is divisible into a small head, a thorax and abdomen
- Each trunk segment except the first four and last segment bears two pairs of legs.
- Poison jaws are absent, sting glands are present at the sides of the body.



Julus spp.

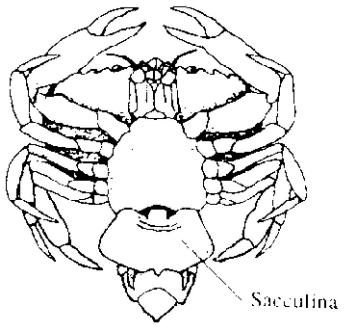
- The head bears a pair of eyes and a pair of seven segmented antennae.
- Head is covered by cephalic shields bent downwards.
- Sides of most terga have dark openings of odoriferous glands, secreting noxious substance.
- Animal moves very slow in spite of its so many legs. The colour may be yellowish brown orreddish-chestnut.
- Genital pores- located at the third segment behind the head
- Sexes are separate

Class Crustacea

- Aquatic & few terrestrial
- Body is divided into cephalothorax & abdomen
- Respiration occurs through gills or general body surface.
- The body is covered by a single large carapace.
- They possess two pairs of antennae and five pairs of appendages.
- They excrete through green glands or antennal glands.
- They have a pair of compound eyes and gonopores.
- Development is indirect. Larval stage is present.
- Eg., ***Daphnia, Palaemon, Penaeus***

Sacculina

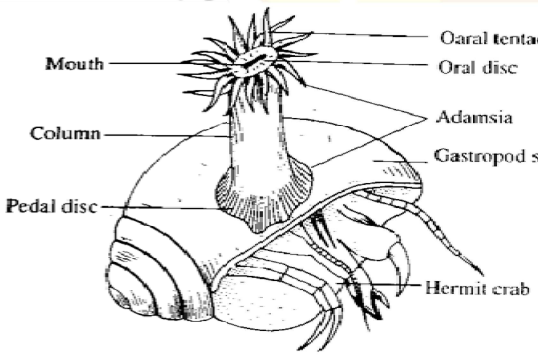
- ***Root - headed barnacle***
- Remarkable for extreme ***parasitic degeneration***
- Tumour like fleashy mass
- Remains atached to the ventral side of the abdomen of a crab by a stalk or peduncle
- Give from the peduncle are numerous root like processess.
- They extend to the soft tissues of the host and absorb nutrients.
- Metabolic wastes are removed from the parasite to the host through these roots
- On the lower side of Sacculina is an opening - mantle opening.
- It leads internally into the mantle cavity, which serves as a brood chamber.
- Protrogynous hermaphrodite with paired testes and ovaries.
- Cross fertilization



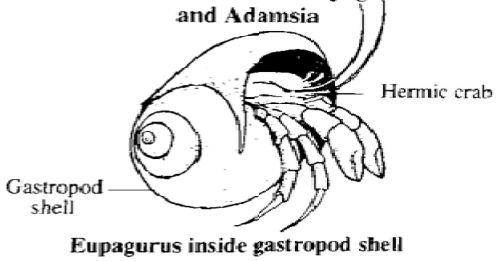
External Sacculina

- The parasitic effect of Sacculina on crab is highly interesting - ***parasitic castration***.
- The host undergoes morphological, physiological and behavioural transformations and becomes fully committed to the service of the parasite.
- The host gets sterilized and its moultingcycle is suppressed.

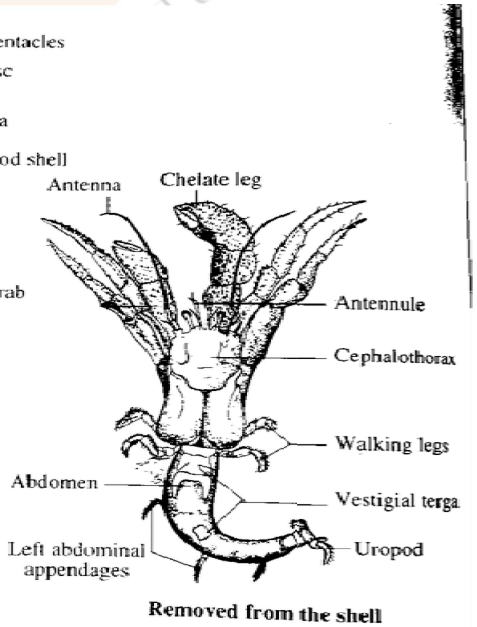
Eupagurus



Mutualism between Eupagurus and Adamsia



Eupagurus inside gastropod shell



Removed from the shell

Eupagurus

Prepared by Jasla Mol KK & Jamshiya Jaithun C
Assistant Professor, Department of Zoology

- ***Hermit crab***
- It lives in the empty shell of gastropods.
- Often, it kills the gastropod, slowly removes its body, and thus makes the shell empty for its own Stay.
- It may periodically change the shell.
- Body is long coiled somewhat compressed and asymmetrical.
- 1t has two divisions – cephalothorax & abdomen
- Abdomen remains permanently inside the shell.
- But, cephalothorax is periodically protruded out and retracted
- Head bears a pair or stalked compound eyes, a pair of small and biramous antennules, and a pair of long uniramous antennae
- Thorax has five pairs of legs.
- Abdomen is soft, fleshy, elongated and spirally twisted to fit within the shell.
- Abdominal appendages are absent on the right side and those of the left side are much reduced.
- The last pair of abdominal appendages, the uropods, are hook – like - used to cling to the shell.
- Well known for its facultative mutualism with sea anemone

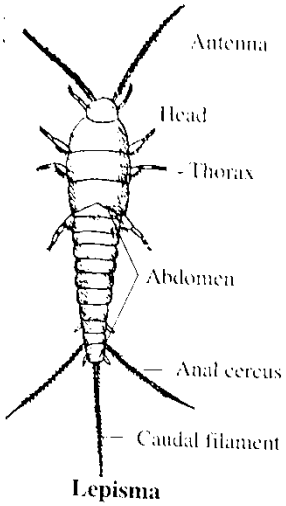
Class Insecta

- They are mostly terrestrial.
- The body is differentiated into head, thorax, and abdomen.
- Head bears a pre-segmental ***acron.***
- The thorax is divided into three segments.
- The abdomen has 7-11 segments.
- They have three pair of appendages.
- It has a pair of compound eyes
- They respire through gills and trachea.
- Malpighian tubules are the excretory organ.
- Development is indirect, and the larval stage is present.
- Eg:- ***Mosquitoes, Ants.***

Lepisma

- Commonly called “silver fish”
- It is a household domestic pest. It cause untold damages to paper, books ,manuscripts, clothes etc.
- It enjoys cosmopolitian distribution
- Nocturnal insect
- They avoid light. Hides inside books and other suitable places.
- It feeds mainly on starchy substances.
- Body is wingless delicate and broad
- Body clothed with glistening silvery scales
- Body is segmented, divisible into head, thorax &abdomen
- Respiratory organs are *tracheae.*

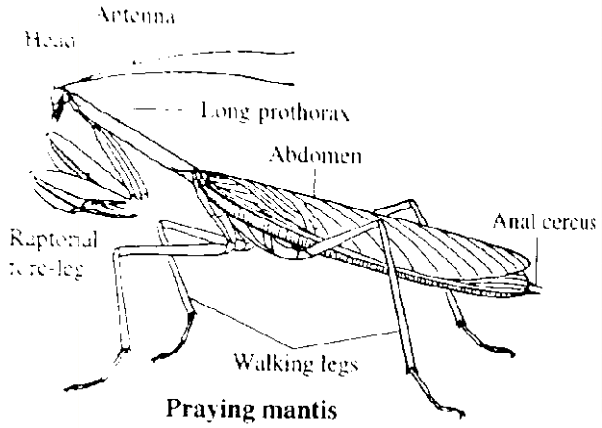
- Excretory organs are malpighian tubules.
- Sexes are separate.Fertilization is internal
- Eggs are laid inside books or in cervices.
- Development is direct with a nymphal stage.



Lepisma

Mantis

- Commonly called 'praying mantis'
- Mostly arborel insect
- It is a predatory carnivore
- Body is long and lean
- Popularly known as '***tiger of insect world*** ',by virtue of its cunning nature and clever hunting habits

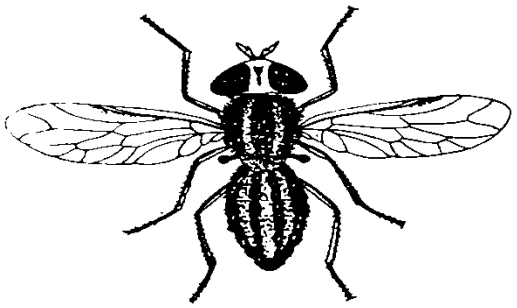


Praying mantis

- Body is divisible into head,thorax and abdomen
- Head bears a pair of filiform antennae,a pair of compound eyes,3 ocelli and chewing type of mouth parts
- Thorax is 3 segmented and it bears three pairs of legs and 2 pairs of wings
- Prothorax is exceptionally elongated,prothoracic legs are pincer like and raptorial, specialised for striking ,seizing and holding the prey
- Abdomen is 10 segmented
- Last segment bears a pair of anal cerci
- Male has a pair of anal style also on the nineth segment
- They are armed with sharp ,tooth like spines on femur and tibia
- Wings are flat and permanently folded and they cover the body
- All species of mantis are remarkable for their cryptic colouration and concealing protective mimicry
- Some are coloured like flowers ,this is an adaptation for deceiving and hunting flower-hunting insects
- Female is a cannibal;she may kill and eat the male soon after courting and copulation
- She lays egg in ootheca ,remain attached to sticks,twings,stones,..
- Ootheca formed by a forthy material,on exposure to air,it hardens to form the egg case

Tabanus

- Commonly called the cattle-flies or gad-flies
- Adult flies closely resembles to house flies
- Body is thick set head is big and compound eyes are large
- Three rows of white spots on the abdomen
- This are abundant in areas where temperature is moderately high, availability of water is sufficient and there is proximity of forest
- Most common during in rainy season
- Active during day time
- There are more than 2000 species of Tabanid flies.



Tabanus striatus

- Subsist on Nectar, Honey Dew, Oozing plant Sap etc..
- Females are sanguivores
- Different species of tabanids suck in blood from specific parts of their preference
- They are suspected to transmit anthrax, surra and swamp fever among horses and a kind of filariasis among human beings.

Troides minos

- Popularly known as ***southern birdwing***
- Large, strikingly imposing and attractive butterfly, ***endemic to south India.***
- Largest Indian butterfly with wing span of 140-190 mm

- The ***state butterfly of Karnataka***.

- It is listed as ***'least concerned' in the Red list of IUCN.***
- By fluttering the forewings at high frequency, it hovers above the flowers.
- During feeding, it balances its body with hindwings and holds small flowers with its six legs.Then it inserts its proboscis into the small flower with unerring precision and imbibes the nectar.
- *Ixora, Lantana, Clerodendrum and Mussaendra* are the nectar plants.
- The caterpillars of Troides sequester the toxin *aristolochic acid*, imbibed from the host plant *Aristolochia* spp.
- The toxin makes the caterpillar, pupa and the adult butterfly unpalatable and keeps the predatory birds away

Papilio Buddha

- ***State butterfly of Kerala***
- ***Malabar banded peacock***
- Greenish blue colour

- ***Endemic to western ghats***
- Hind wings are tailed
- Wing margin is light brown with a chain of light orange & black spots

Apis

- Honey bees
- Economically important
- Produces honey
- Best pollinators
- Social insect

- Division of labour – queen, worker, soldier
- Queen – fertile
- Workers & soldiers- sterile

Type : Penaeus Indicus

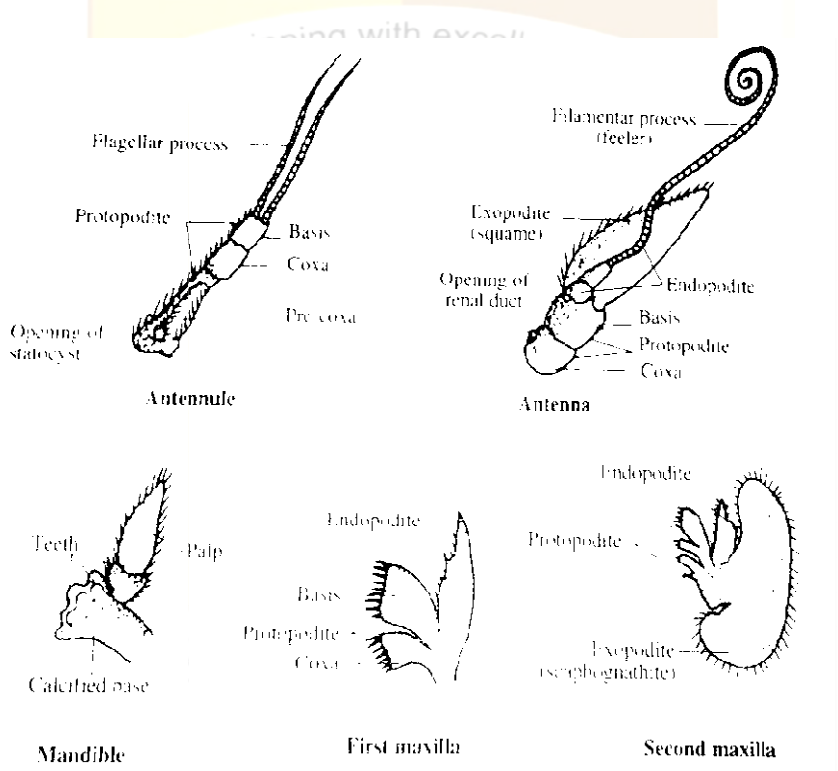
Morphology

- The segmented body of prawn has two regions,cephalothorax and abdomen.
- Cephalothorax is formed by the fusion of thirteen segments,namely five cephalic and eight thoracic.
- Abdominal region has segments and a terminal conical process,called ***telson***.
- The whole body of prawn is covered by a segmented cuticular exoskeleton,secreated by the underlying epidermis.
- It is formed of chitin and protein.
- Exoskeleton protects the body and provides provisions for the attachment of muscles.
- Exoskeletal covering is segmented,and its segments are called ***sclerites***
- Cephalic appendages are five pairs in number - antennules,antennae,mandibles,first maxillae and second maxillae.
- Antennules and antennae are tactile structures,mandibles are masticatory structures used to cutting the food into pieces,and the first and second maxillae serves as feeding food.
- Thoracic appendages are eight pairs in number -It includes first,second and third maxillipede and five walking legs
- In these first three walking legs are ***cheliped*** and other two are ***non-cheliped.***
- Abdominal appendages are six pairs in number.
- They are used for swimming and hence called ***pleopods.***
- Last pair of pleopods are called ***uropods.***
- First pleopod is different in two sexes

Cephalic Appendages:

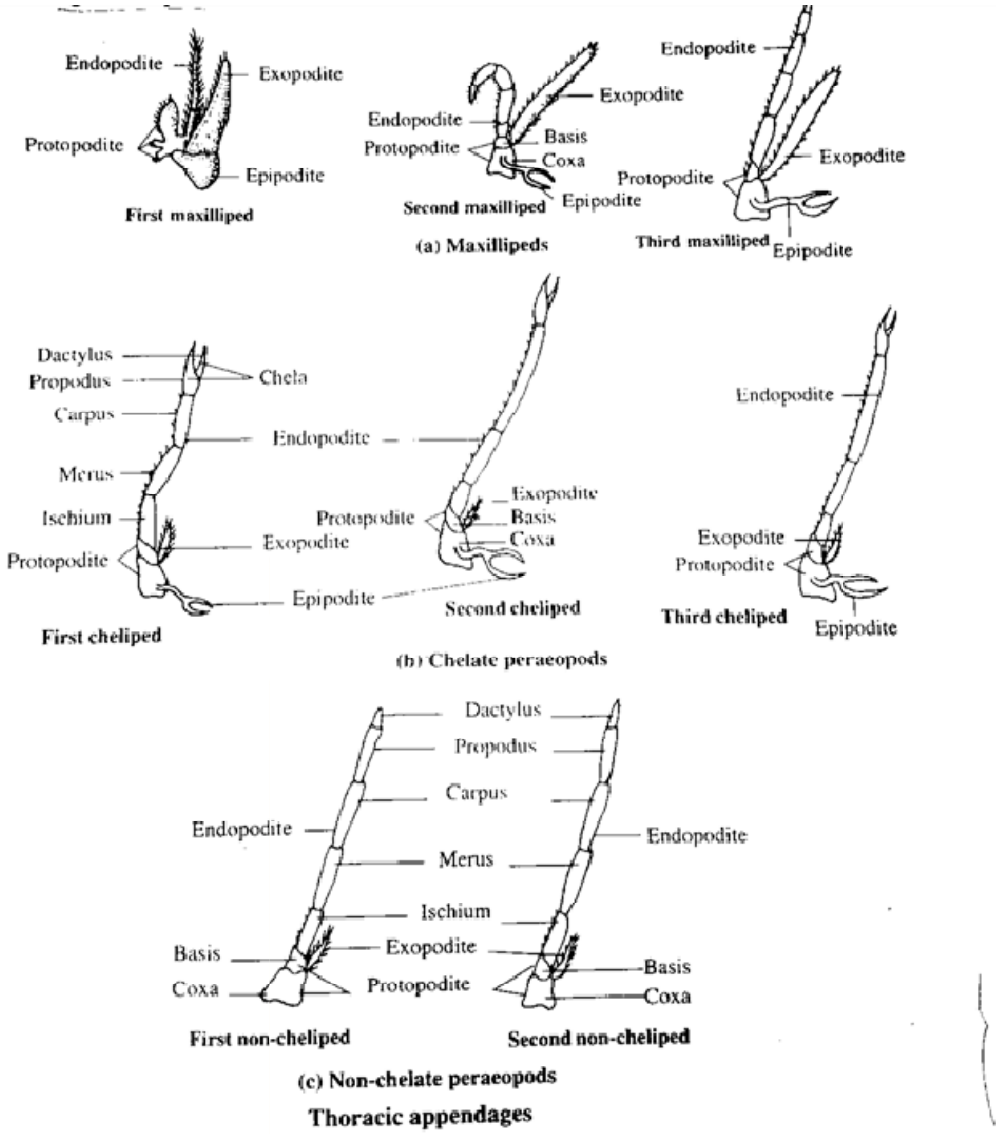
- Five pairs - the antennules, the antennae, the mandibles, the first maxilla and the second maxillae.
- ***The antennule (first antenna)*** is situated in front of the mouth just behind the base of the eye-stalk.
- Its protopodite consists of three segments: ***precoxa, coxa and basis.***
- ***The antenna (second antenna)*** is also pre-oral in position.

- Its peduncle or protopodite consists of two segments: ***coxa and basis.***
- The excretory organ or green gland is lodged inside the coxa, and the urinary opening or renal aperture is situated on its inner margin.
- ***Mandible -*** third appendage and lies on the outer side of the mouth.
- Its spoon-shaped proximal part is called the ***apophysis***
- ***First Maxilla -*** smallest of all the appendages and is placed behind the posterior lip of the mouth.
- The maxillula consists of three foliaceous plates, the margins of which are covered with sensory setae.
- The maxillula helps to push bed into the mouth.
- ***Second Maxilla -*** thin foliaceous appendage placed behind the maxillula
- Large fan-shaped exopodite is known is the ***scaphognathite***
- The scaphognathite helps in respiration by maintaining a constant flow of water through the gill-chamber.



Thoracic Appendages

- Three pairs of maxillipedes or foot-jaws and five pairs of walking legs.
- The ***first maxillipede*** has a protopodite consisting of two segments, coxa and basis.
- These are flattened leaf-like structures carrying stiff setae on their inner margins.
- They push food into the mouth.
- Attached to the outer side of the coxa, there is a bilobed structure called epipodite which helps in respiration

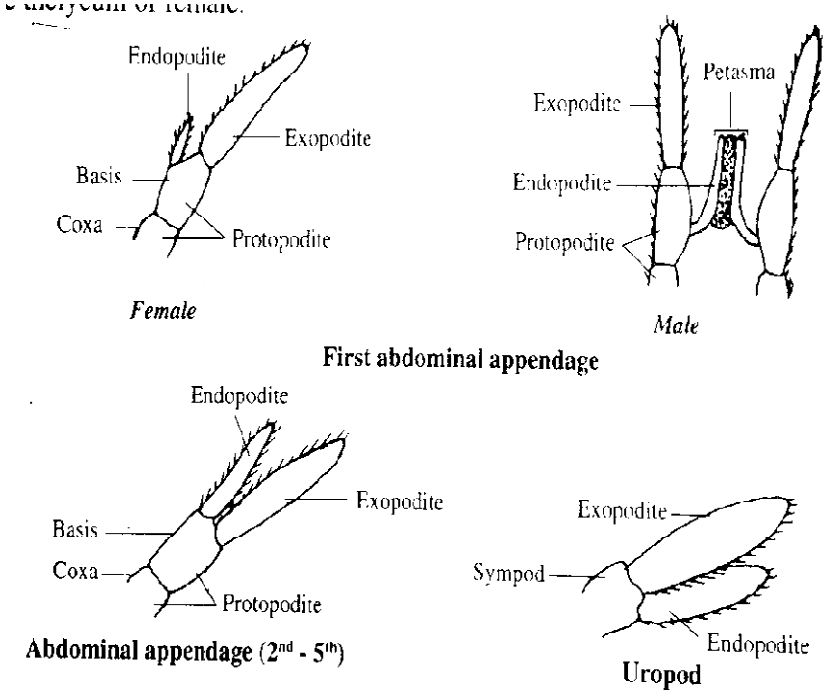


- The ***second maxillipede*** is less foliaceous than the first.
- Endopodite is curved like an interrogation mark
- Its protopodite consists, as usual, of coxa and basis.
- The coxa is short and covered with setae on its inner margin
- The ***third maxillipede*** is pediform or leg-like in appearance.
- Straight endopodite
- Its protopodite consists of coxa and basis.
- The ***first and second walking legs*** carry pincers at their proximal ends; hence they are known as the ***chelate legs***.
- The ***last three legs*** are ***non-chelate***.
- The second walking leg is very much larger and bears spines and setae.

Abdominal appendages

- Six pairs of abdominal appendages called ***pleopods or swimmerets***
- Help the prawn in swimming.

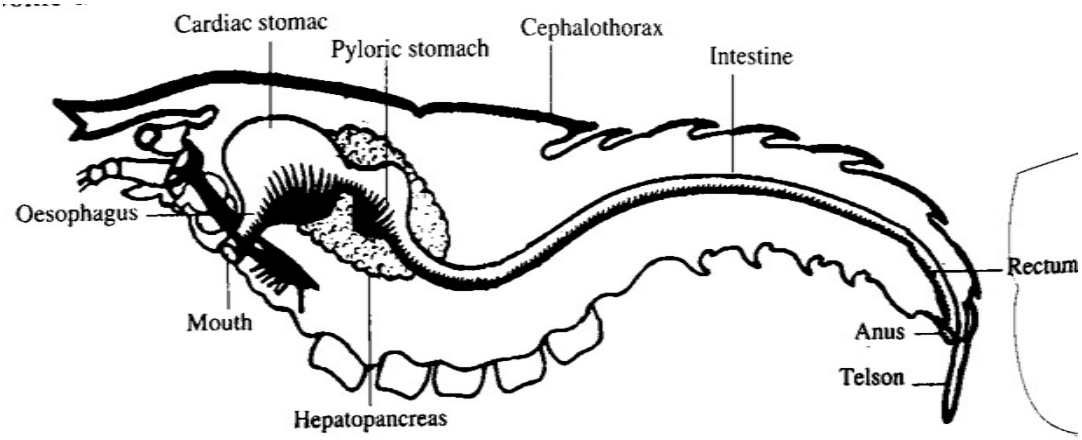
- The last pair are specially called uropod's because they form with the telson a powerful tail-fin which is used for leaping backward.
- Each pleopod is a typical biramous type of appendage.
- Its protopodite consists of a short proximal coxa and an elongated distal basis.
- The basis carries a pair of leaf-like rami, the outer exopodite and the inner endopodite



Digestive system

- Composed of the alimentary canal and the digestive gland.
- **Alimentary canal** extends from mouth to anus, and consists of three distinct parts
  Foregut or stomodoeum
  Midgut or mesenteron
  Hindgut or proctodoeum.
- The ***foregut*** includes mouth, buccal cavity, oesophagus, and stomach
- The ***midgu***t is the long and narrow intestine
- The***hindgu***t consists of the terminal bulb or rectum and the anus.
- The mouth is a large opening on the ventral side of the cephalothorax between the third and the fourth segment.
- It is bounded anteriorly by a shield-shaped labrum, posteriorly by the labium, and on each side by the incisor process of a mandible.
- The buccal cavity is a short and narrow chamber which connects the mouth with the oesophagus.
- The oesophagus is a wide rectangular tube running vertically upwards to join the stomach.

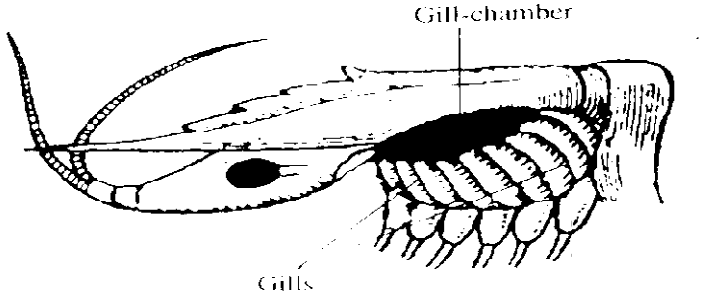
- Stomach is a spacious chamber - It fills most of the cephalothoracic region.
- lt has two unequal divisions, large cardiac stomach and small pyloric stomach.
- Cardiac stomach mainly serves for the storage and grinding of the food
- Pyloric stomach is mainly concerned with sorting and straining.
- Leading backward from the pyloric stomach is the intestine - It is a straight and narrow muscular tube, which runs along the entire length of the abdomen.
- Intestine leads to the rectum that opens out by the anus at the base of the telson.
- Anal opening is guarded by a muscular sphincter.



- **Digestive gland** - bilobed hepato pancreas (mid-gut gland or liver).
- It surrounds the lateral, ventral and posterior portions or the stomach.
- Leading from each lobe of the hepatopancreas is a hepato-pancreatic duct.
- It opens to the hinder part of the pyloric stomach.
- Hepato-pancreas serves the functions of the liver, pancreas and intestinal glands of vertebrates.
- It secretes proteolytic, anmylolytic and lipolytic enzymes, stores glycogen, fats and calcium, and absorbs some digested food

Respiratory system

- Respiratory structures of prawn include the gills or branchiae, epipodites or mastigobranchiae, and the vascular lining of branchiostegites.
- Gills are the principal respiratory organs.
- Gills of prawn are the vascular and feathery or plumose outgrowths from the thoracic appendages.
- There are eighteen gills on each side, lodged in the branchial chamber in between the branchiostegite and the thoracic wall.
- Each gill is a *crescentic structure*.
- It has a central axis or stem, called ***gill axis***.
- Borne on this are numerous thin, flat and bilaterally arranged plates, called ***gill lamellae.***



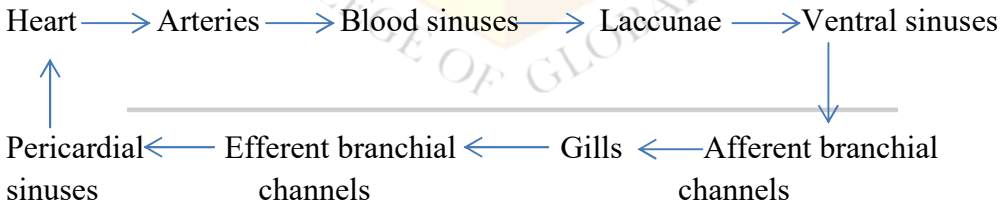
Penaeus - branchial chamber and gills

- Gill axis and gill lamellae are covered by a thin layer of chitin.
- Each lamella divides and sub-divides into fine ***gill filaments.***

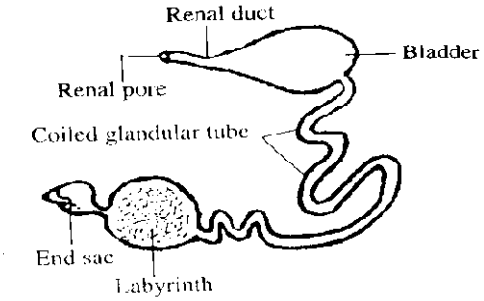
- This type of gills in which the gill lamellae branch and re-branch in a tree-like fashion are called ***dendrobranchs or dendrobranchiae***
- Gill axis and gill lamellae are richly vascularised.
- Each gill is attached to the body by a root Gill filaments through which blood vessels and nerves pass.
- Based on the point of attachment, three types of gills
- Podobranchs - attach to the coxa of the thoracic appendages.
- Arthrobranchs - attached to the arthrodial membrane - at the junction between thoracic wall and the appendage
- Pleurobranchs - attached to the inner wall of the branchial chamber.
- *Mechanism of respiration* - For respiratory exchange of gases a constant current of water is maintained over the gills in the gill chambers - called ventilation of the gills.
- 1t is accomplished by the activity of the scaphognathites or balers
- This water current bathes the gills, epipodites and the lining of the branchiostegal plates.
- Gas exchange takes place between the O_2 in the water and the CO_2 in the vascular channels or the respiratory structures.

Blood-vascular system

- Blood vascular system is of the open or lacunar type - blood flows through open channels and spaces, known respectively as ***sinuses and lacunae***.
- The whole system consists of blood, heart, arteries and a 1arge number of sinuses and lacunae.
- Capillaries and veins are absent.
- Blood is a light blue fluid – consist of plasma and colourless and amoeboid leucocytes. Haemoglobin and erythrocytes are absent.
- Dissolved in the plasma is the copper containing respiratory pigment haemocyanin.
- The course of blood circulation



Excretory system

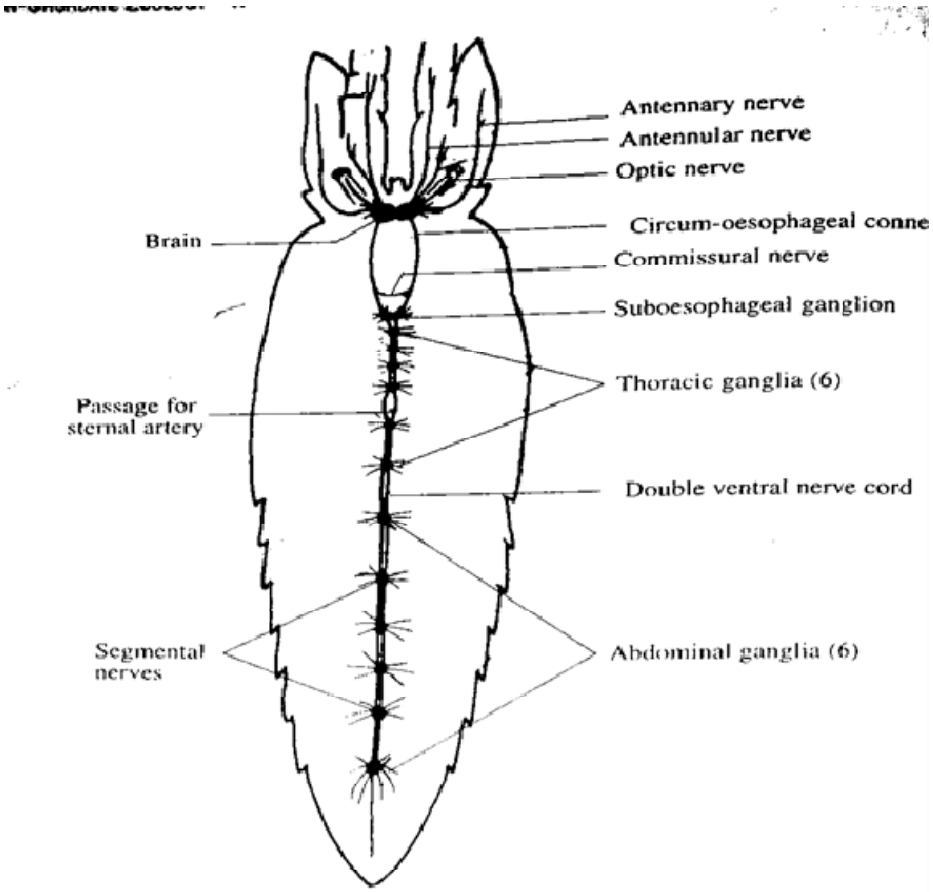


Antennary gland of Penaeus

- A pair of antennary glands (coxal glands, green glands, or renal glands) - situated in the coxal segments of antennae.
- Each gland of penaeus has four parts, namely end sac, labyrinth, glandular tube and bladder.
- End sac is a closed mesodermal sac, that encloses a coelomic cavity.
- It communicates with the labyrinth through a small opening.
- Labyrinth, or glandular plexus, is a spongy, glandular mass of highly coiled and branching renal tubules.
- All the renal tubules open to the end sac by a common aperture, Glandular tube is the coiled excretory tube that leads from the labyrinth and opens to the bladder.
- Bladder is a thin-walled chamber, lined by excretory cells.
- Produced from its inner side is a small excretory duct (renal duct), that opens to the outside by an excretory pore (renal pore) on the coxal segment of the antenna.
- Green glands have adual function of excretion and osmoregulation.

Nervous system

- Nervous system is composed of a circum oesophageal nerve ring, fused and ganglionated double ventral nerve cord and a large number of nerves.
- The circum oesophageal nerve ring consists or a supra oesophageal ganglionic mass or brain above the oesophagus, a sub oesophageal ganglionic mass below the oesophagus, and a pair of circum oesophageal connectives around the oesophagus.
- The connectives connect the two ganglionic masses together.
- They are connected to each other by a transverse nerve, called oesophageal commisssure
- The supra oesophageal ganglionic mass serves as an unspecialised brain.
- It is formed by the fusion of several ganglia. Following important nerves are given out:
- (i) a pair of antennularnerves to antennules, statocysts, etc.
- (ii) apair of antennary nerves to antennae
- (iii) a pair of optic nerves to compound eyes.



Penaeus - Nervous system

- The sub oesophageal ganglionic mass is also formed by the fusion of a few ganglia.
- From it, five pairs of nerves are give out, one pair each to mandibles, first maxillae, second maxillae, first maxillipedes, and second maxillipedes.
- The fused double ventral nerve cord has six thoracic ganglia and six abdominal ganglia.
- From each ganglion, three pairs of nerves are given out; two pairs to muscles and one pair to appendages.
- Between the 11^{th} and 12^{th} body segments, the two nerve cords diverge from each other, leaving a passage for sternal artery.

Sense organs

- The major sense organs of prawn include the statocysts, compound eyes, the tactile feelers of antennules, antennae and mandibles, and the olfactory bristles of several appendages.

Statocysts

- Statocysts are the structures of orientation and equilibrium.
- Situated in the pre-coxal segment of antennules.
- A statocyst consists of a chitinous sac attached to the pre-coxa through a short stalk.

- Functionally, sand grains of statocysts serve as statoliths
- Any change in the swimming position of the animal, or any movement in the surrounding water, will cause their corresponding displacement.

Compound eyes

- Prawn has a pair of stalked and movable compound eyes, seen at the base of the rostrum.
- Since the eyes are mounted on eyestalks, they will have much wider field of vision.
- Each compound eye is formed of a large number of (2000 - 2500) 1ight-perceiving visual units or simple eyes, known as ***ommatidia***.
- Adjacent ommatidia are placed side by side and are separated from each other by a layer of black pigment
- Ommatidia are long, rod-shaped and closely packed structures.
- Each ommatidium has its own focusing apparatus, light-transmitting system, photoreceptor cells, and field of vision.
- The fields of vision of adjacent ommatidia overlap.
- The axons from all the ommatidia of a compound eye collectively form an optic nerve which in turn joins the brain
- Each ommatidium rests on a porous membrane called ***basal membrane or basal lamina***

Reproductive system

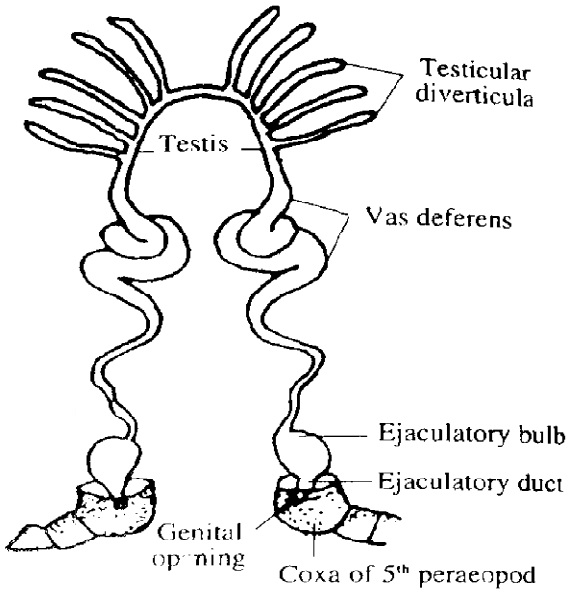
- Sexes are separate in prawn.
- Male and female prawns exhibit some degree of sexual dimorphism.
- The major external differences between them are the following
  (i) Male has ***petasma*** for transferring sperms to female. Petasma is absent in female.
  (ii) In female, the sternum of the last thoracic segment has a cup-like outgrowth, called ***thelycum.*** It serves as a seminal receptacle for receiving sperms from male. Thelycum is absent in male.
  (iii) Male genital openings are seen on the coxal segment of the last pair of walking legs, but female openings are seen on the coxa of

  the 3rd pair of walking legs.

Male organs

- Male genital organs include a pair of testes, one on either side of the thorax.
- They are compound tubular glands, formed of numerous long and coiled seminiferous tubules in which sperms are elaborated.
- The right and left testes are continuous or united anteriorly.
- Posteriorly they remain separate.
- Lateraly, each testis has several blunt outgrowths, called ***testicular diverticula.***
- Leading backward from each testis is a long and coiled ***sperm duct or vas deferens***.
- Terminally, it dilates to a glandular chamber, called ***seminal vesicle***there may be a very short ejaculatory duct, that opens out on the coxa of the last walking leg.
- From the testis, mature sperms reach the seminal vesicle.

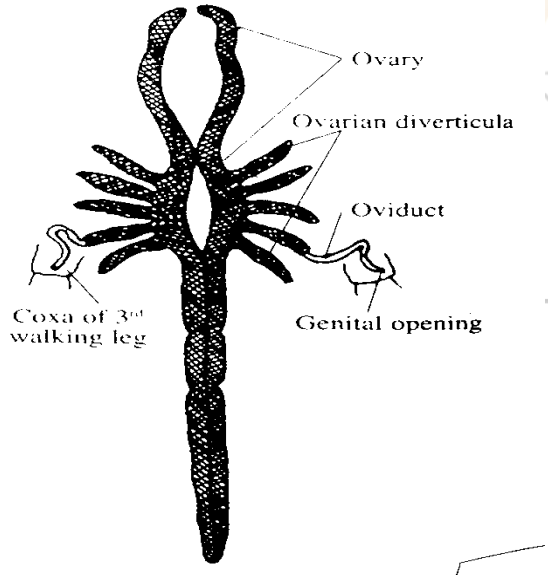
- Secretions of the seminal vesicle glue them together and form sperm clusters, called ***spermatophores***.
- These are stored in the seminal vesicle until they are transferred to the female during mating



Penaeus - Male reproductive system

Female organs

- Female genital organs include a pair of ovaries, one on each side of the thoracic and abdominal regions.
- The right and left ovaries are united together posteriorly, but anteriorly they remain separate.
- Anteriorly, each ovary gives out several lateral outgrowths, called ***ovarian diverticula***.
- Leading from the middle of each ovary is a short oviduct.
- It opens out on the coxa of the 3rd walking leg.



Penaeus - Female genital organs

Development

- Fertilization – external
- Development – indirect
- Male deposits sperm to thelycum
- Simultaneously female discharges large numbers of ova

- Ova remain attached to the ventral part of the abdomen for sometime
- Female carries the fertilized eggs for sometime

PHYLUM MOLLUSCA

Salient features :

- Soft and unsegmented body
- Head, visceral mass and foot
- Radula
- Calcareous shell
- Mantle or pallium
- Reduced coelom in adult
- Open circulatory system
- Chambered and myogenic dorsal heart
- Respiratory organs : Ctenidia and pulmonary sacs
- Paired nerve ganglia
- Sense organs : tentacles , eyes , *osphradia* & statocysts
- Sexes: usually separate , external/internal fertilization
- Indirect development : involves : trochophore , glochidium/ veliger larvae

Classification of phylum mollusca :

7 classes:

1. ***Aplacophora***
2. ***Monoplacophora***
3. ***Polyplacophora***
4. ***Scaphopoda***
5. ***Gastropoda***
6. ***Pelecypoda***
7. ***Cephalopoda***

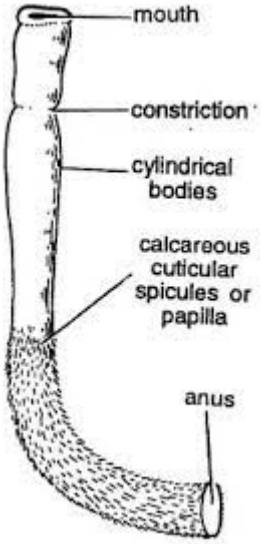
APLACOPHORA(without plate)

- Solenogasters and mudmoles
- Primitive , worm-like ,bottom dwelling marine molluscs
- Without plate
- Body covered by skin
- Posterior cavity present
- Straight & well differentiated alimentary canal
- Poorly developed excretory system
- Bilateral symmetry
- Vermiform body
- Primitive & ladder-like nervous system
- Poorly developed head with well differentiated mantle and foot
- Mostly hermaphrodite

Eg: Chaetoderma

Example : Chaetoderma

Prepared by Jasla Mol KK & Jamshiya Jaithun C
Assistant Professor, Department of Zoology

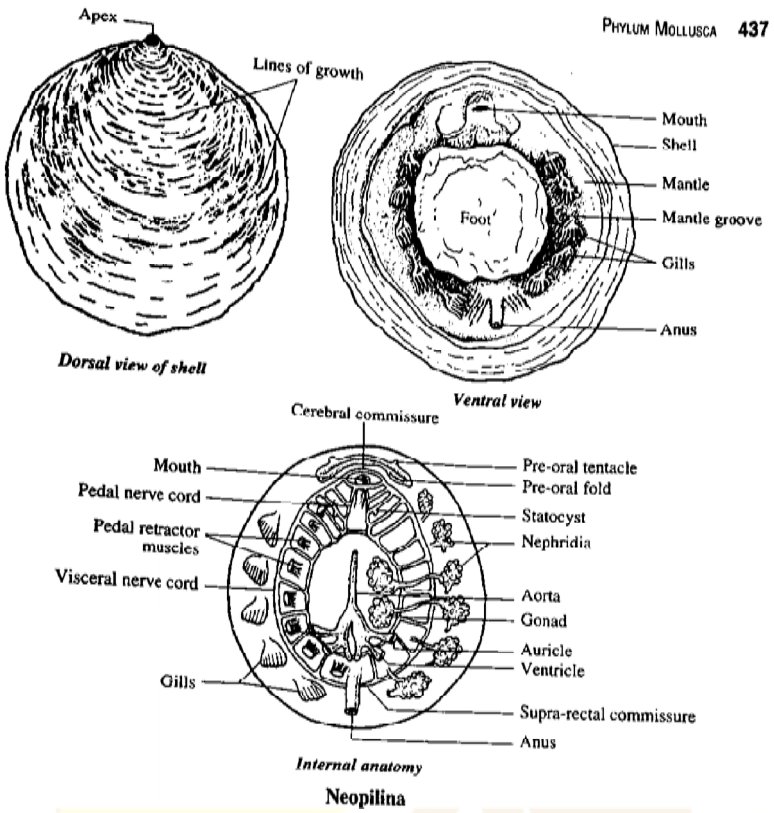


- Glisten worm
- Shell-less , worm like mollusk
- Pallial cavity generally enlarged**, bearing distinct orange brown secretions**
- Foot : round, mouth in its deep frontal cleft
- Dorso-terminal sense organ not extending as far as pallial integument border
- Digestive mid gut gland long
- Large ctenidia

MONOPLACOPHORA(single shell)

- Single plate
- Bilateral symmetry
- Flat, oval and internally segmented
- *Pseudometamerism*
- Dome shaped mantle
- Much reduced head without eyes and tentacles
- Flat, ventral, circular and weakly creeping muscular sole
- Serially arranged external gills
- Segmentally repeating nephridia & gonads
- 5/6 chambered heart
- Tetramerous , primitive & ladder-like nervous system
- Gonochoric
- Eg: Neopilina

Example : Neopilina



Neopilina

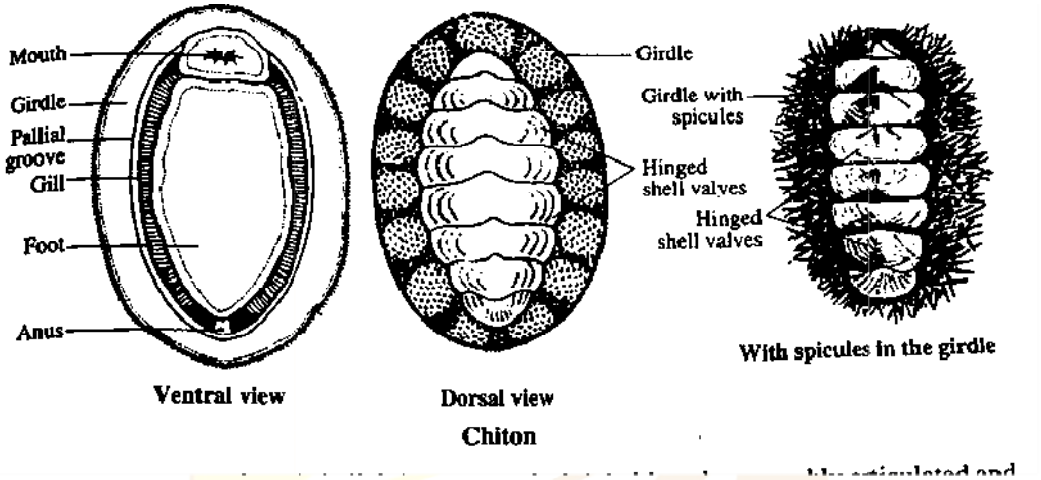
- Primitive
- Living fossil : connecting annelids & early molluscs
- Resembles gastropod limpet
- Body : flat , nearly oval, bilaterally symmetrical , internally segmented
- Body is enveloped by mantle and covered dorsally and laterally by thin , flat , sub-circular , bilaterally symmetrical and univalved shell
- Body : 3 : head , visceral mass and foot
- Head : reduced , devoid of eyes and true tentacles
- Visceral mass : 5 segmented
- Foot : ventral broad , flat & glandular
- Between foot and mantle : mantle groove
- Mantle groove lodges 5 gills & 6 nephridiopores
- Digestive system has : circular buccal cavity , salivary gland , radula , radula sac , heavily ciliated , oesophageal pouches , gastric caecum, style sac , mid-gut glands, coiled intestine
- Microphage
- Respiratory system : 5 pairs of monopectinate gills
- Excretory organ : 6 pairs of nephridia
- Nervous system : ladder like
- Separate sexes
- Evolutionary significant

POLYPLACOPHORA(many plates)

- Chitons
- More than 2 plates
- Bilateral symmetry

- Dorsoventrally flattened
- Indistinct head without eyes and tentacles
- Mantle groove or pallial groove between girdle and foot
- Gonochordite
- Eg: chiton

Example : Chiton

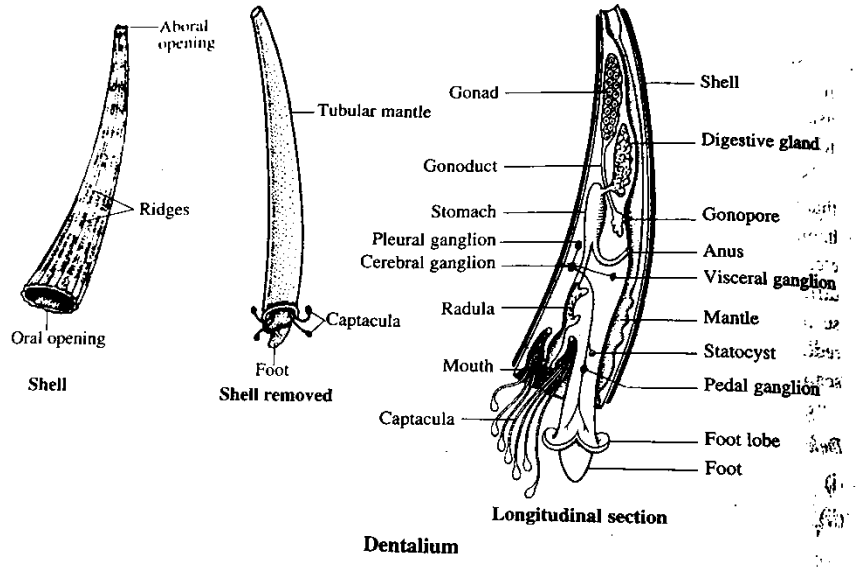


- Semi sedentary/ slow moving
- Attached to rocks / stones
- Bilaterally symmetrical , dorso-laterally flattened & roughly ovoid
- Body : divisible into: head, visceral mass & foot
- Indistinct head
- No eyes and tentacles
- Foot : broad & flat ventral sole , specialised for adhesion & creeping
- Mouth & anus at the opposite ends
- Body is covered dorsally by thick , stiff & leathery mantle
- Marginal part of mantle around shell : girdle
- Mantle edge :may be smooth /covered with scales,bristles ,spicules etc
- In between girdle and foot , ventrally , there is groove : *pallial groove* which lodges gill
- Mantle secretes dorsal shell : composed of 8 hinged /movably articulated & overlapping transverse plates: *shell valve*
- Digestive system is well differentiated
- 3 chambered heart
- Sexes are separate
- Negatively phototropic
- microphages

SCAPHOPODA (head;foot)

- Foot on head
- Bottom dwelling mollusks
- Tusk shells/tooth shells
- Long,slender
- Untorted and cylindrical
- Bilateral symmetry
- *Captacula*
- Tubular mantle
- Shell is univalved, tubular and terminally tapering
- Gills absent
- Gonochoric
- Heart: absent/rudimentary
- Eg: Dentalium(tusk shell or tooth shell)

Example : Dentalium



Dentalium

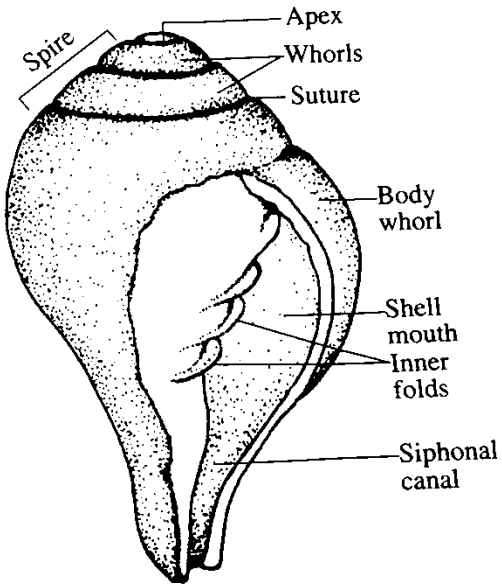
- Tusk shell / tooth shell
- Burrowing , deep water , marine mollusk
- Lives partially buried in the sandy bottom
- Long, slender and bilaterally symmetrical
- Enveloped by tubular mantle
- Enclosed by a tubular shell
- Mantle tube and shell are open at both the ends
- Body : divisible into: head, foot & visceral mass
- Head : short & conical projection : proboscis
- Head and foot are protrusible and form anterior part of body
- Devoid of eyes, tentacles or osphradium
- Head bears a group of protrusible, prehensile , ciliated and sensory cephalic filaments :Captacula : feeding organ , chemoreceptor & tactile organ
- Foot is narrow , conical , trilobed ; specialized for digging and anchorage

- Foot contains pedal haemocoel
- Gills are absent ; mantle is the respiratory surface
- Nephridia : excretory organ
- Indirect lifecycle : larva : trochophore and veliger
- Larval shell is bivalve and larval mantle is bilobed

GASTROPODA (stomach,;foot)

- Foot on stomach
- Torted or detorted
- Torsion:180^{o}
- Unsegmented and asymmetrical
- Spirally coiled and univalved shell
- U shaped digestive tract
- Asymmetrical organisation of internal parts
- Open circulatory system
- Nephridia
- Ctenidia : respiratory organ
- Myogenic , trilocular heart
- Cephalized nervous system
- Largest group of molluscs
- Mostly gonochordite
- Eg: Turbinella(Xancus)

Example : Turbinella



Turbinella

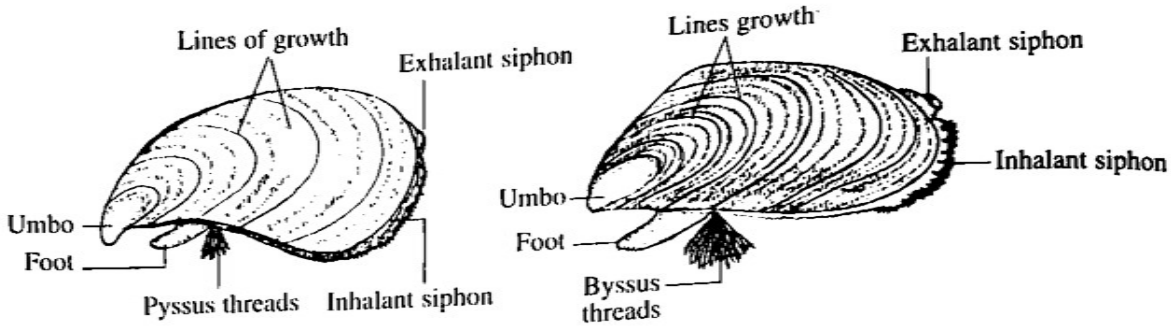
- Indian chank shell
- Gregarious marine mollusk
- Body is soft & unsegnmented
- Head : divisible into : head , foot & visceral mass

- Spirally coiled visceral mass enveloped by mantle
- Large foot : feeding organ
- Sexes are separate
- Development indirect: trochophore & veliger larva
- Shell : univalve , thick , massive , fusiform and spirally coiled with nipple like apex, long siphonal canal and several folds
- Shell whorls are coiled around a central axis : columella
- Shells are mostle dextral : genetically determined
- Shell is considered sacred

PELECYPODA (Bivalvia) (foot;plate)

- Bilateral symmetry
- Mussels
- Bivalved shells
- Laterally compressed body
- Left and right mantle lobes
- Lamelliform or plate like gills
- Large, ventral, muscular foot adapted for burrowing
- Cephalic region: rudimentary , without eyes & tentacles but with labial palps
- Byssus glands and byssus threads in some for attachment
- Coiled alimentary canal
- Lamelliform gills ; respiratory organ
- Suspension feeders
- Mostly gonochoric
- Eg: Mytilus(Perna)

Example : Perna



Green mussel **Brown mussel**

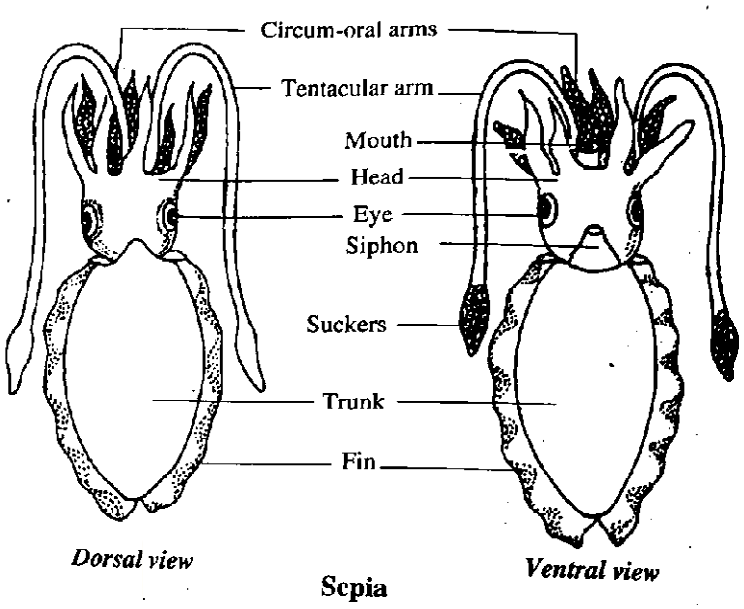
- Sea mussel
- Edible , sedentary , marine mollusk
- Forms mussel bed
- Body : soft & divisible into : foot & visceral mass ; distinct head is absent
- Body is enclosed within calcarious shell

- 2 shell valves are equal & symmetrical ; hinged together antero dorsally by hinge ligament
- Each valve is wedge shaped
- Umbo is at narrow anterior end
- Foot : long , narrow , cylindrical & extensile
- Foot has ventral groove which leads basally to byssus cavity ; contains byssus gland , which secretes byssus threads
- Visceral mass : soft & massive
- Ctenidia : well developed
- Economically important

CEPHALOPODA (head;foot)

- Foot on head
- Exclusively marine
- Mostly pelagic
- Entirely carnivorous and actively moving predators
- Bilateral symmetry
- Distinct head with well developed eyes and a crown of circum-oral arms
- Shell absent or present
- Cartilaginous endoskeleton
- Closed circulatory system
- Highly organized nervous system & sense organs (intelligence & learning power)
- Ink gland and power of colour change
- Gonochoric
- Male has : spadix
- Direct development
- Movements : by water –jet propulsions
- Eg: Sepia(Cuttle Fish)

Example : Sepia



Sepia

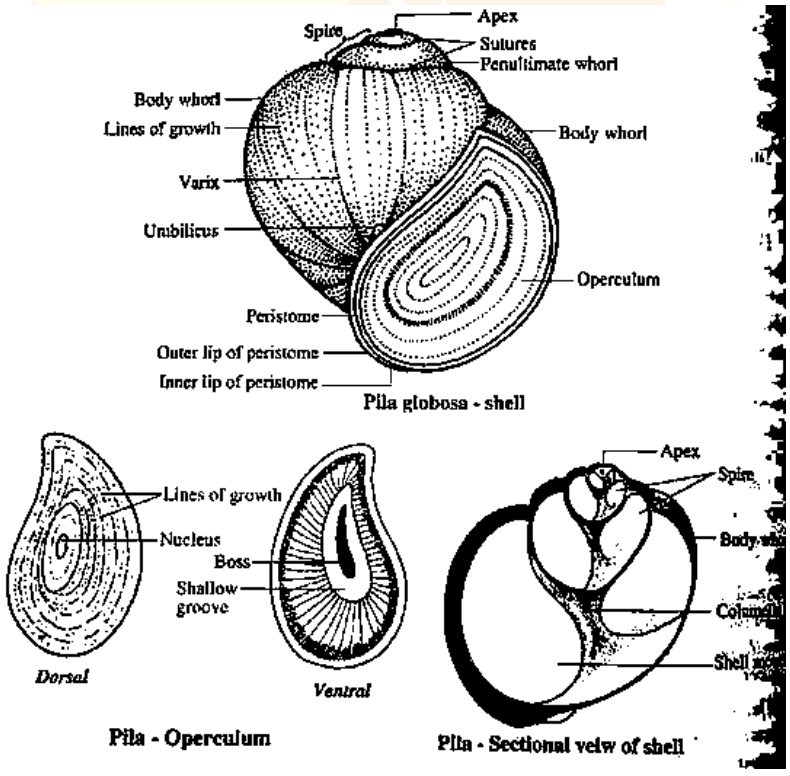
- Cuttle fish
- Shell is internal , completely covered by mantle
- External shell absent
- Cuttle bones
- Body : 2 divisions : head & trunk
- Distinct foot absent
- Head bears mouth , eyes and 5 pairs of circum-oral arms with suckers
- 4^{th} pair of arm : tentacular arms
- Male produces spadix on left tentacular arm
- Trunk : covered by thick and leathery mantle
- Mantle bears frill like lateral folds : fins for swimming
- Mantle cavity communicates with outside through siphon
- Skin : color change
- Has ink sac: with melanin pigment

Type study : *Pila Globosa*

HABIT AND HABITAT OF PILA GLOBOSA:

- Pila globosa or the apple snail is one of the largest freshwater molluscs.
- It is commonly found in freshwater ponds, pools, tanks, lakes, marshes, rice fields and sometimes even in streams and rivers.
- They occur in those areas where there is a large amount of aquatic vegetation like Vallisneria, Pistia, for food.
- They are amphibious being adapted for life in water and on land.
- The animal creeps very slowly by its ventral muscular foot, covering about five cm per minute.
- The movement of the animal is like the gliding movement of planarian.
- During the rainy seasons Pila comes out of the ponds and makes long terrestrial tours, thus, respiring air directly.
- It can overcome long periods of drought in a dormant condition and buried in the mud; this period of inactivity is called aestivation or summer sleep.

EXTERNAL FEATURES OF PILA GLOBOSA:



Shell of Pila:

- The shell of Pila globosa, as in other Gastropoda, is univalve but coiled around a central axis in a right-handed spiral.
- The top of the shell is the *apex* which is formed first and growth of shell takes place from it, the apex contains the smallest and the oldest whorl.
- Below the apex is a spire consisting of several successively larger whorls or coils followed by penultimate whorl and the largest whorl or *body whorl* which encloses most of the body.
- The lines between the whorls are called *sutures.*

Prepared by Jasla Mol KK & Jamshiya Jaithun C
Assistant Professor, Department of Zoology

- Internally all the whorls of the shell are freely communicated with one another; such a shell is called *unilocular*.
- The *body whorl* has a large mouth or opening, the margin of the mouth is called a *peristome* from which the head and the foot of the living animal can protrude.
- shell is spiralled clockwise, then it is spoken of as being right-handed or dextral.
- The outer margin of the mouth is called an *outer lip,* and the inner margin as inner or *columellar lip.*
- In the centre of the shell runs a vertical axis or *columella* around which the whorls of the shell are coiled; the columella is hollow and its opening to the exterior is known as an *umbilicus.*
- Shells with an umbilicus are *umbilicate* or perforate.
- The lines of growth of shell are visible, some of them appear as ridges known as *varices.*
- The shell of Pila globosa varies in colour from yellowish to brown or even blackish.

Operculum of Pila Globosa:

- Fitting into the mouth of the shell is a calcareous operculum, its outer surface shows a number of rings of growth around a nucleus; the inner surface has an elliptical boss for attachment of muscles, the boss is cream- coloured and is surrounded by a groove. The operculum is, in fact, secreted by the glandular cells of the foot.

Microscopic Structure of Shell:

- The shell of Pila globosa consists of an outermost pigmented layer called *periostracum* made of a horny organic *conchiolin*, below this is a *prismatic layer* made of crystalline calcareous plates running vertically, the innermost *nacreous layer* is made of calcareous plates running longitudinally.
- Shells of Gastropoda display an infinite variety of shapes, sculpturing, patterns, and colours. Inside the shell is the mantle which secretes the shell.

BODY OF PILA:

- The body consists of a head, a foot and a visceral surface, mass.
- In an expanded animal the head and foot come out of the shell-mouth but the visceral mass lies inside the shell whorls.
- A collumellar muscle arises from the foot and is inserted in the columella, it attaches the body to the shell and it withdraws the animal inside and closes the operculum.

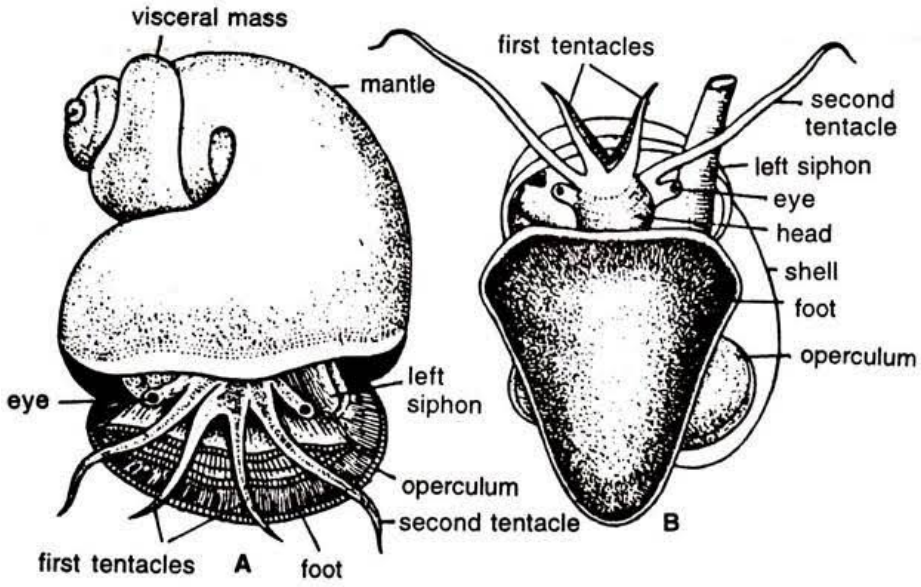


Fig. 26.12. Pila sp. Shell removed A. Dorsal view, B. Ventral view

1. **Head:**
   - There is a distinct head produced into a snout
   - the head bears two pairs of tentacles.
   - The first pair of tentacles or labial palps are small and lie in front, behind them there is a second pair of tentacles which are long.
   - The tentacles are hollow and capable of much extension and contraction.
   - Behind the tentacles the head has a pair of eyes borne on *stalks* or *ommatophores.*
2. **Foot:**
   - Below the head is a large muscular foot, its lower surface is gray and flattened sole.
   - It is triangular with the apex pointing backwards, it is used for creeping; its upper surface is spotted and the dorsal posterior surface bears the operculum.
   - When the foot is withdrawn the operculum closes the mouth of the shell.
   - In the foot is a pedal mucous gland which forms a slime trail during locomotion.
   - Waves of contraction which sweep from the anterior to the posterior end of the foot provide the main power for locomotion.

In fact, the head and the foot together constitute the head-foot complex which is connected to the visceral mass by an inconspicuous neck.

3. **Visceral Mass:**

   - Above the head-foot complex is a visceral mass containing the main organs, it fills all the whorls of the shell and it is spirally-coiled like the shell.
   - The visceral mass exhibits the phenomenon of torsion which is distinct from coiling.
   - It is soft and grey to dark brown in colour.

4. **Mantle:**

- The mantle, also referred to as pallium, covers the visceral mass and it forms a hood over the animal when it is withdrawn.
- The edge of the mantle is thick and contains shell glands which secrete the shell, above the thickened edge there is a supra-marginal groove
- The mantle also has two fleshy lobes called nuchal lobes or pseudepipodia which are joined on either side of the head.
- The left pseudepipodium forms a long tubular respiratory siphon for aerial respiration and a respiratory current enters, through it, the right pseudepipodium is less developed and not a regular tube, respiratory current passes out through it.

Mantle Cavity and Pallial Complex:

- In the anterior part there is a large space between the mantle and the body, this is a mantle or pallial cavity which has been shifted to the front by a process of torsion.
- It encloses a number of organs and the head can be withdrawn into it.
- The mantle or pallial cavity encloses within it a number of important organs which are collectively known as pallial complex.
- Near the right pseudepipodium is a prominent ridge or epitaenia which runs backwards up to the end of the mantle cavity, it divides the mantle cavity into a right branchial cavity and a left pulmonary sac.
- In the branchial cavity or chamber lie a single gill or ctenidium, rectum and anus, the genital aperture and the anterior chamber of the kidney as a reddish mass near the posterior end of the epitaenia.
- Near the left pseudepipodium is a fleshy osphradium a typical molluscan sense organ.

Coelom of Pila Globosa:

- The coelom is reduced to unpaired cavities of pericardium, kidney and gonad.
- The renal and pericardial cavities communicate, but the cavity of gonad is unconnected.
- The visceral organs are surrounded by means of sinuses or spaces containing blood.
- These blood-filled spaces constitute the haemocoel.

DIGESTIVE SYSTEM OF PILA GLOBOSA:

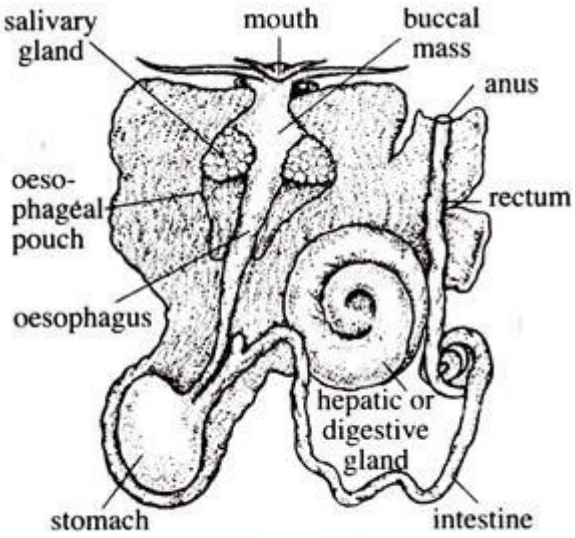


Fig. 1.83 : Digestive system of *Pila*.

The digestive system of *Pila Globosa* comprises:

i. A tubular alimentary canal
ii. A pair of salivary glands
iii. A large digestive gland

Alimentary Canal:

The alimentary canal is distinguished into three regions, viz:

- The *foregut* or *stomodaeum* including the buccal mass and oesophagus,
- The *midgut* or *mesenteron* consisting of stomach and intestine, and
- The *hindgut* or *proctodaeum* comprising the rectum.

The midgut alone is lined by endoderm, while the other two are lined by ectoderm.

1. Foregut:

Includes the mouth, buccal mass and oesophagus.

Mouth:

- The mouth is a narrow vertical slit situated at the end of snout.
- There are no true lips but the plicate edges alone serve as secondary lips.

Buccal Mass:

- The mouth leads into a large cavity of buccal mass or pharynx having thick walls with several sets of muscles.
- The anterior part of the cavity of buccal mass is vestibule.
- Behind the vestibule are two jaws hanging from the roof of the buccal mass.
- The jaws bear muscles and their anterior edges have teeth-like projections for cutting up vegetable food.

Buccal Cavity:

- Behind the jaws is a large buccal cavity.
- On the floor of the buccal cavity is a large elevation called odontophore.
- The front part of odontophore has a furrowed subradular organ which helps in cutting food.
- The odontophore has protractor and retractor muscles and two pairs of cartilages, a pair of triangular superior cartilages which project into the buccal cavity, and a pair of large S-shaped lateral cartilages.

Radula:

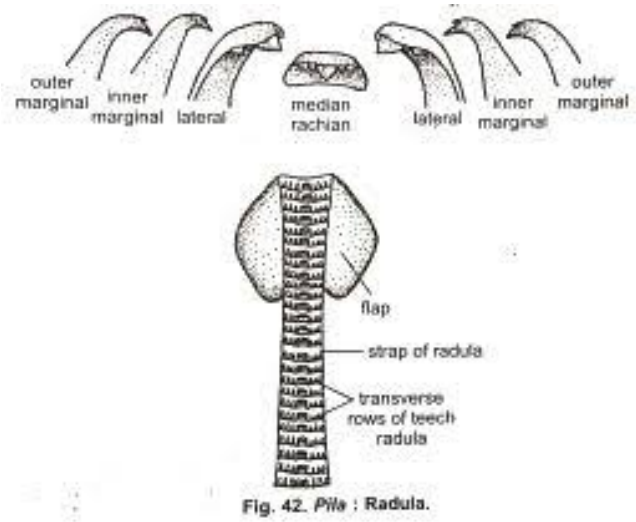


Fig. 42. *Pila* : Radula.

- Above and behind the odontophore is a bag-like radular sac which is a diverticulum of the buccal cavity.
- The radular sac has transverse rows of cells called Odontoblasts.
- Inside the radular sac is a radula which is characteristic of Mollusca.
- The radula is made of many transverse rows of horny teeth.
- Each row has seven teeth, two marginal and one lateral tooth on each side and a central or rachidian tooth in the middle, thus, giving a formula 2, 1, 1, 1, 2.
- The radula moves forward and backward on the odontophore for rasping food particles; these movements of radula are called chain saw movements.
- The teeth are made of chitin which is reinforced by hardened protein, they have sharp cutting projections which act like a file and rasp vegetable food.
- The teeth of the radula are worn off in front and new teeth are formed all the time by odontoblasts.
- On the roof of buccal cavity, above the radula, is a pair of grooved buccal glands which are digestive.

Oesophagus:

- The buccal mass leads into a long narrow oesophagus.
- From near the origin of the oesophagus arise a pair of round, whitish oesophageal pouches.
- They arise by short ducts and lie below the salivary glands.
- They are prolongations of the oesophagus, they probably secrete digestive enzymes.
- Oesophageal pouches serve for a temporary storage of food and digestion begins in them.
- Some extracellular digestion is brought about in the stomach by the enzymes produced by the salivary glands and oesophageal pouches.

2. Midgut:

Includes the stomach and intestine.

Stomach:

- The stomach begins on the left side just below the pericardium and runs backwards as a blind pouch on the postero-lateral sides of the main whorl of the visceral mass.
- It is a rectangular sac of dark red colour having a broad U-shaped internal cavity of rose-red colour.
- The stomach is differentiated into two chambers—cardiac chamber and pyloric chamber.

- The cardiac chamber is rounded in appearance and possesses longitudinal folds on its inner surface. The oesophagus opens into it.
- The pyloric chamber is tubular and has transverse folds on its inner surface.
- From the pyloric chamber arises a short bag-like caecum but it has no crystalline style as found in many gastropods.
- The duct of digestive gland opens into the stomach at the junction of its two chambers.

Intestine:

- From the pyloric chamber arises an intestine which runs along its anterior edge and further along the digestive gland beneath the posterior renal chamber.
- It then turns upwards and backwards in the visceral mass where it forms 2½ or 3 coils between the gonad in front and the digestive gland behind, before joining the rectum.

3. Hindgut:

- The rectum or terminal part of the alimentary canal is a thick-walled tube.
- It enters the mantle cavity and passes downwards to open by an anus on the right of the head.

Salivary Glands:

- The two salivary glands lying one on each side of the posterior limit of the buccal mass and partially cover the oesophagus.
- The surface and margins of each gland are greatly cut up, giving it the appearance of a somewhat branched type of gland.
- The duct of each gland begins near its internal anterior corner and immediately enters the muscles of the buccal mass and opens into the buccal cavity.
- The secretion of salivary glands contains mucus and an enzyme which digests starch.
- The mucus lubricates the radula and helps in the transport of food.

Digestive Glands:

- The digestive gland, often referred to as liver or hepatopancreas, of Pila globosa is a somewhat triangular plate or cone with a very convex outer and more or less flattened inner surface.
- The cone is spirally coiled from the tip inwards and downwards following the whorls of the shell.
- The gland is of a brownish to dirty green colour and is quite soft when fresh.
- Two main ducts arise from the two main lobes of the digestive gland; these ducts unite just before reaching stomach to open into it by a common aperture.
- The digestive gland is made up of a number of fine tubules bound together by connective tissue.
- These tubules unite with one another to form larger tubules which terminate in two main ducts corresponding to two main lobes of the gland.
- The terminal part of each tubule is glandular, called the alveolus and the rest of the tubule is ciliated.
- The alveoli have three kinds of cells, they are secretory, resorptive and calcareous cells or lime cells.
- The secretory cells produce a brown liquid containing an enzyme which dissolves cellulose of plants in the stomach converting in into pulp.
- The resorptive cells produce a proteolytic enzyme. This enzyme brings about intracellular digestion of cellulose pulp.
- The calcareous cells store phosphate of lime.

Digestion

The salivary glands pour their secretion by means of their ducts into the buccal cavity where it mixes with the food. It helps in digesting the starch by converting it into sugar. In the stomach the food is digested by the secretion of digestive gland. Secretion of digestive gland digests various kinds of food but cellulose is digested inside the resorptive cells only.

Thus, both extracellular and intercellular digestion occur. The stomach is the site of extracellular digestion and the digestive gland is the site of intracellular digestion and absorption, this is characteristic of Mollusca. Absorption of digested food takes place mainly in the digestive gland and some in the intestine.

RESPIRATORY ORGANS OF PILA GLOBOSA:

Consists of a single ctenidium or gill, a pulmonary sac or lung and a pair of nuchal lobes.

1. Ctenidium or Gill:

- The ctenidium or gill is the organ of aquatic respiration.
- The ctenidium is situated on the dorsolateral wall of the branchial chamber of the mantle cavity.
- It is composed of a long series of thin triangular leaflets or lamellae, lying parallel to each other, which are attached to the mantle wall by their broad bases but have their apices hanging free in the branchial chamber.
- The line of attachment of the lamellae to the wall of the mantle forms the ctenidial axis.
- The ctenidial axis is provided with an afferent blood vessel (carrying deoxygenated blood) and an efferent blood vessel (carrying oxygenated blood) from gills to heart.
- Monopectinate gill: All the gill lamellae are not of the same size; these are largest in the middle and gradually smaller towards the two ends.
- Each lamella bears transverse ridges or pleats on both its anterior and posterior surfaces.
- These pleats are low ridges gradually decreasing in size from the base of the lamella to its apex.
- Each ridge contains branches of blood vessels.
- Each lamella has a smaller right side, which receives blood from the afferent vessel, is called the afferent side and a longer left side, from which blood goes into the efferent vessel, is called the efferent side.
- The ctenidium of Pila, though situated on the right side of the animal, is morphologically the gill of the left side, which has shifted to the right on account of the development of an extensive pulmonary sac on the left side.
- Histologically, each lamella appears to be a hollow cavity lined on either side by the epithelium containing non-ciliated columnar cells, ciliated columnar cells and a few glandular cells.
- The epithelial layer is followed by a thin basement membrane below which are found connective tissue cells having scattered nuclei and oblique muscle fibres.

2. Pulmonary Sac or Lung:

- The pulmonary sac or lung is a closed cavity like a bag which hangs from the dorsal wall of the mantle in the pulmonary chamber.
- The dorsal wall of the pulmonary sac is densely pigmented, while the ventral wall is creamy white. The walls of the sac are highly vascular, i.e., richly supplied with blood vessels.
- The pulmonary sac communicates with the pulmonary chamber of the branchial cavity by an aperture known as the pneumostome.

3. Nuchal Lobes:

- The right and left pseudepipodia or nuchal lobes are fleshy and highly contractile processes of the mantle on either side of the head.
- They form elongated funnels or siphons during respiration for the entry and exit of water.

Mechanism of Respiration:

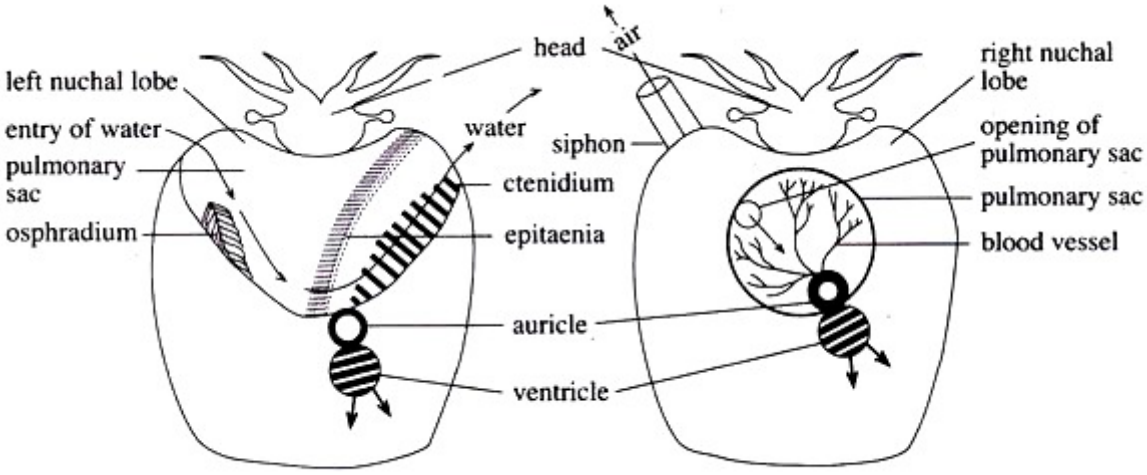


Fig. 2.64 : Respiration in *Pila*, (a) aquatic (b) aerial.

There are two types of respiration in Pila which are as follows:

Aquatic Respiration:

- True aquatic respiration takes place when the snail lies at the bottom of a pond or aquarium, when it is floating or lying suspended in mid-water and when it is attached to plants or Weeds in water.
- At this time the head and foot is fully extended and the two nuchal lobes further increase in size and the left lobe takes the form of a distinct gutter in which a current of water flows.
- In aquatic respiration a current of water enters the left nuchal lobe and first comes in contact with the osphradium which tests the nature of the water.
- It enters the mantle cavity and passes over the epitaenia into the branchial chamber to bathe endothelial layer blood space the ctenidium, then the current passes out through the right nuchal lobe
- The ctenidium takes in oxygen from the current of water and gives out carbon dioxide which diffuses into water.

Aerial Respiration:

- The pulmonary sac or lung is used in aerial respiration in two ways.
- When the snail comes to the surface of water its left nuchal lobe projects as a tube above the water and air is drawn into it, the air goes to the pulmonary chamber and then into the lung; the branchial chamber being shut off by the epitaenia pressing against the mantle.
- When the snail comes on land it takes in air directly into its lung through the mantle cavity and no siphon is formed by the left nuchal lobe.

In both types of aerial respiration alternate contractions and relaxations of the muscles of the lung walls take place, when the muscles contract the floor of the lung gets arched increasing its cavity and air is drawn into the lung, when the muscles relax the cavity of the lung decreases and air is expelled, inward and outward movements of the head and foot also help in the process of taking in air.

The blood vessels in the lung take in oxygen from the air and give out carbon dioxide (Fig. 60.16 B). Pila globosa also respires by its pulmonary sac during aestivation period by means of the air already imprisoned in the pulmonary sac.

BLOOD VASCULAR SYSTEM OF PILA GLOBOSA:

Due to double mode of respiration the blood vascular system of Pila globosa has become very much complicated. It is of open type.

It consists of:

- Blood
- Heart
- Arteries
- Sinuses
- Veins, through which the blood flows.

Blood:

- respiratory pigment :haemocyanin :compound of copper and protein
- blue colour

Heart:

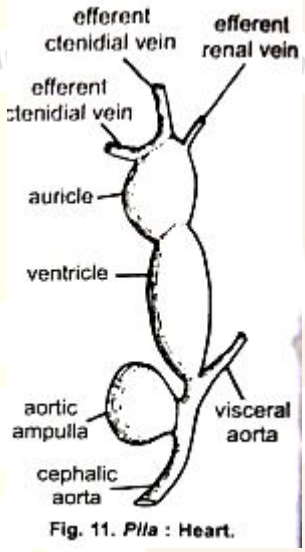


Fig. 11. *Pila* : Heart.

- The heart of Pila globosa has a single auricle and one ventricle found enclosed in the pericardium
- myogenic.

(a) Auricle:

- The auricle lies in the dorsal part of the pericardium, while the ventricle is situated just below it in the same vertical axis.
- The auricle is a thin-walled, highly contractile sac and more or less triangular in shape.
- The efferent ctenidial vein from the ctenidium and the efferent renal vein from the posterior chamber of the renal organ open into the apex of the auricle, while the pulmonary vein from pulmonary sac opens at a slightly lower level at its anterior end.
- The auricle communicates with the ventricle by an aperture auriculo-ventricular opening having two semi-lunar valves, so arranged as to allow the blood from the auricle to flow into the ventricle but not in the reverse direction.

(b) Ventricle:

- The ventricle is ovoidal in shape and has thick spongy wall formed of a large number of muscular strands forming a meshwork which greatly reduces the cavity of the ventricle.
- The aortic trunk arises from the lower end of the ventricle and divides immediately into two branches, the cephalic aorta and visceral aorta.

- The opening between ventricle and aortic trunk is guarded by two *semi-lunar valves* which prevent the flow of blood from back into the ventricle.

Arteries:

From the ventricle arises an aorta or aortic-trunk which divides into two branches:

- **Cephalic aorta**
- **Visceral aorta.**

- The cephalic aorta has a bulbous outgrowth called aortic ampulla
- The cephalic aorta sends arteries to the head and buccal mass, the visceral aorta forms arteries going to the visceral mass.
- The cephalic aorta, immediately beyond aortic ampulla, gives out three arteries; first supplying to the skin, the cutaneous artery, second supplying to the oesophagus, the oesophageal artery and third being stout and thick supplies to the left side of the mantle (organs like left nuchal lobe and osphradium), the left pallial artery.
- The cephalic aorta on its inner side gives out an artery supplying to the pericardium, renal chambers and to a portion of the genital organs, the pericardial artery.\
- The main trunk of cephalic aorta then runs ahead and crosses over the oesophagus so as to reach to its right side.
- It now gives off numerous small branches to the oesophageal area and supply to the right part of mantle, a right siphonal artery, supplying to the right nuchal lobe and a penial artery, supplying to the copulatory organ.
- The main trunk of cephalic aorta, branches to give a radular sac artery supplying to radular sac, an optic artery supplying to the eyestalks and eyes, a tentacular artery supplying to the tentacles and pedal arteries supplying to the foot.

The visceral aorta runs into the visceral mass and supplies to its different organs by giving off many branches.

These branches are:

- A pericardial artery to the pericardium, skin and digestive glands
- A gastric artery to the stomach
- Many small intestinal arteries to the intestine
- Many renal arteries to the roof of the posterior renal chamber
- A hepatic artery to the digestive gland and gonad
- Several small arteries to the tip of the genital duct and then finally the visceral aorta terminates in the rectal wall.

Sinuses:

- The blood after being distributed to the various parts of the body through the arteries and their branches passes into small lacunae, which in turn unite to form large sinuses.
- There are four chief sinuses in the body:
- Anterior peri-visceral sinus.

- Anterior peri- intestinal sinus.
- Branchio-renal sinus and
- Pulmonary sinus.

Veins:

The veins carry venous blood from different parts of the body to the auricle directly or through the gill, mantle and kidney.

The chief veins are as follows:

(a) Afferent ctenidial vein:

It lies above the rectum and receives branches from the rectum, terminal part of the genital duct, peri-visceral sinus and branchio-renal sinus.

It sends blood through numerous branches, to the gill-lamellae for purification.

(b) Efferent ctenidial vein:

It lies along the roof of the anterior renal chamber and carries blood from ctenidial leaflets, mantle and conveys to the auricle.

(c) Afferent renal vein:

It is situated on the roof of posterior renal chamber, and originates from the peri-intestinal sinus. It pours its blood into the posterior renal chamber.

(d) Efferent renal vein:

It carries the blood of the posterior renal chamber to the auricle.

(e) Pulmonary vein:

It collects blood from the walls of the pulmonary sac and opens into the auricle.

Course of Circulation:

- All parts of the body are supplied with blood from the ventricle through the cephalic and visceral aortae.
- The cephalic aorta carries blood to the head and its associated structures, a part of the mantle, the buccal mass, the oesophagus, the copulatory organ and the columellar muscle.
- The visceral aorta supplies the whole of the visceral mass.
- The blood is collected from the various parts of the body into two main sinuses the peri-visceral and peri-intestinal.
- From these sinuses, the blood passes either into the ctenidium, pulmonary sac or into the renal organ.

During aquatic respiration the blood from the peri-visceral sinus goes to the ctenidium and is purified; an efferent ctenidial vein then takes this blood into the auricle. During aerial respiration the blood from the peri-visceral sinus goes to the lung and is purified; a pulmonary vein takes this blood into the auricle.

- The blood from the peri-intestinal sinus takes two courses, it either goes from this sinus to the anterior renal chamber and from there to the ctenidium and is purified, then through the efferent ctenidial vein it goes to the auricle.

- Or the blood from the peri-intestinal sinus goes to the anterior renal chamber, then to the posterior renal chamber (blood from the peri-intestinal sinus can also go direct to the posterior renal chamber

without going to the anterior renal chamber); in any case the blood from the posterior renal chamber goes through an efferent renal vein into the auricle.

Thus, the auricle receives pure blood from the ctenidium or the lung and impure blood from the posterior renal chamber, this mixed blood enters the ventricle and is distributed to the arteries. The renal chambers, however, remove waste substances from the blood.

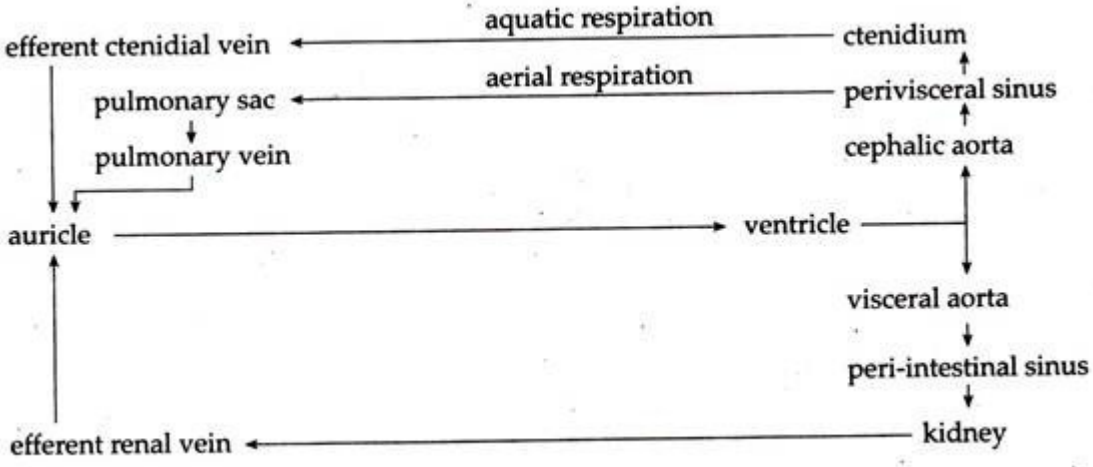


Fig. 1.87 : Flow chart of circulation in *Pila*.

EXCRETORY SYSTEM OF PILA GLOBOSA:

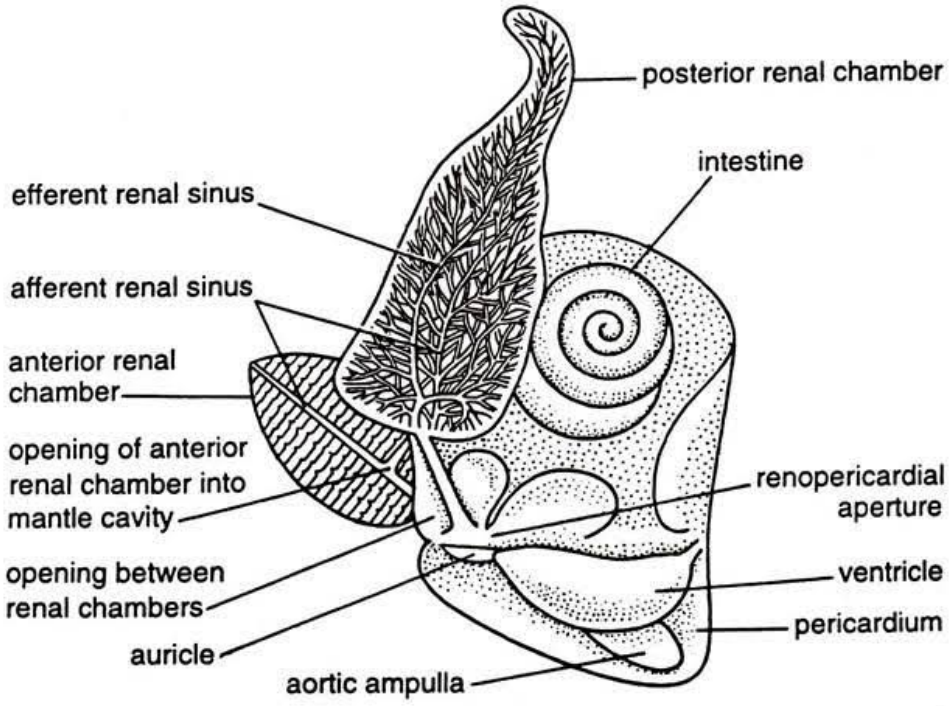


Fig. 26.21. Pila sp. Pericardium and Chambers of kidney (renal organ). Slightly diagrammatic

- Single large renal organ or kidney or organ of Bojanus lying behind the pericardium.
- Glandular & richly vascular
- Left kidney ; right one modified as genital duct
- Mesodermal
- Lies in branchial chamber ,close to pericardium
- It is a thick-walled sac which is folded within.
- The renal organ consists of two distinct chambers: bilocular

- A right anterior renal chamber
- A left posterior renal chamber.

Anterior Renal Chamber:

- It is a reddish oval sac
- Situated in front of pericardium and the posterior renal chamber.
- It projects into the mantle cavity and opens through renal pore ; & at other end with posterior renal chamber
- Has dorsal and ventral renal lamellae ,arranged alternatively,which extends to renal cavity from roof & floor respectively
- The lamellae on the roof are arranged on either side of a median longitudinal axis, the efferent renal sinus. The lamellae on the floor are arranged on either side of a similar median axis, the afferent renal sinus which is the branch of the peri-intestinal sinus.
- It breaks up into numerous branches to supply the lamellae on both the sides.

Posterior Renal Chamber:

- The posterior renal chamber is a broad, hook-shaped area of a brownish to dusky grey colour
- situated behind the anterior renal chamber in between the rectum on the left and pericardium and digestive gland on the right.
- It contains a large cavity in which a genital duct and a few coils of intestine lie.
- The roof of the chamber is richly supplied with blood vessels resulting from a repeated division of the afferent and efferent renal vessels of this chamber.
- Lumen is spacious and communicates with pericardial cavity through reno-pericardial aperture

Physiology of Excretion:

- Ammonotelic in water & uricotelic on land
- Owing to a single external opening, the excretory products from the posterior chamber are collected and emptied into the anterior chamber, from where they are discharged into the pallial cavity through the external renal opening.
- The kidney removes nitrogenous waste from the blood, waste is discharged into the mantle cavity

NERVOUS SYSTEM OF PILA GLOBOSA:

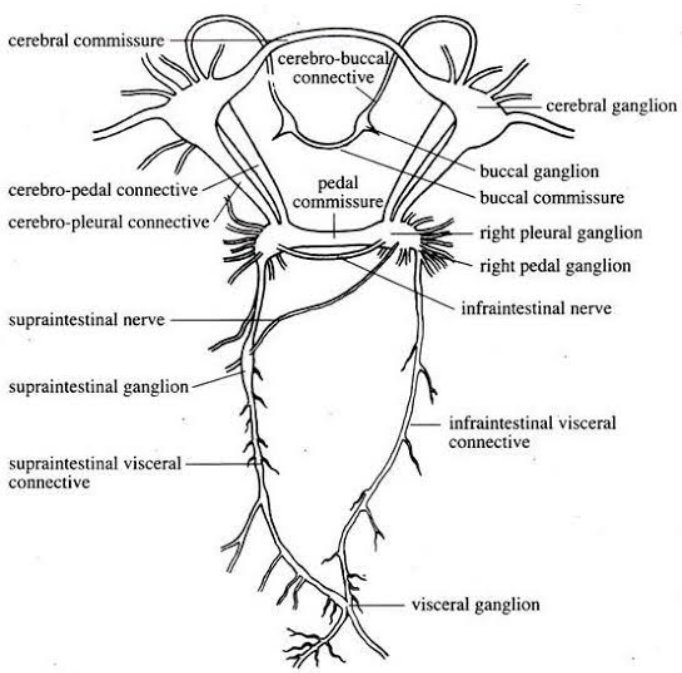


Fig. 2.108 : Nervous system of *Pila*.

- Assymetrical
- Spirally twisted
- Ganglia are concentrated anteriorly and connected by commisures and connectives forming nerve ring : *somatogastric nerve ring*
- The nervous system of Pila globosa consists of paired and unpaired ganglia with their commissures and connectives.
- The commissures are the nerves which establish connections between similar ganglia, while connectives are the nerves which connect two dissimilar or different ganglia.
- However, the paired ganglia of Pila are cerebral, buccal, pleural, pedal and visceral, while unpaired ganglia are supraintestinal and infraintestinal.

1. Cerebral Ganglia:

- There are two triangular cerebral ganglia, one on each side above the buccal mass
- They are connected to each other by a thick cerebral commissure running transversely above the buccal mass, and by a thin labial commissure lying below the buccal mass.
- Each cerebral ganglion is further connected with the buccal ganglion of its side through a very slender cerebro-buccal connective.

2. Buccal Ganglia:

- At the junction of the buccal mass and oesophagus are two buccal ganglia.
- They are connected to each other by a transverse buccal commissure.
- Nerves from each buccal ganglion supply the buccal mass, radular sac, salivary glands, oesophagus and the oesophageal pouches.

3. Pleuro-pedal Ganglionic Mass:

- Pleural and pedal ganglia of each side join together to form a pleuro-pedal ganglionic mass situated below the buccal mass.
- In a pleuro- pedal ganglionic mass, the pleural ganglion is placed towards the outer side and the pedal ganglion to the inner side.
- The pleuro-pedal ganglionic mass is connected to the cerebral ganglion of its side by a cerebro-pleural connective and cerebro-pedal connective.
- The two pedal ganglia are connected to each other by two pedal commissures

4. Supra-intestinal Ganglion:

- Unpaired
- The supra-intestinal ganglion is a slightly swollen, more or less fusiform ganglion lying in a sinus about a quarter of an inch behind the pleuro-pedal mass of the left side.
- Connected to right pleura pedal ganglionic mass by supra-intestinal nerve
- Connected to lest pleuropedal ganglionic mass by zygoneuric nerve
- It is connected with the pleuro-pedal mass by a stout connective, called zygoneury. It gives off on the inner side a thin supra-intestinal nerve which runs anteriorly above the intestine to the right side to join the right pleural ganglion. The supra-intestinal ganglion also sends off posteriorly a branch, the left visceral connective which connects it with the visceral ganglion.

5. Visceral Ganglion:

- The visceral ganglion is formed by the fusion of two spindle-shaped ganglionic masses.
- It lies near the base of the visceral mass close to the anterior lobe of the digestive gland and to the right of the pericardium.
- The visceral ganglion is connected with the supra-intestinal ganglion by a stout supra-intestinal or left visceral connective.
- It is further connected with the fused right pleural and infra-intestinal ganglion through the infra-intestinal or the right visceral connective.

- Nerves from the cerebral ganglia go to the head, tentacles and eyes.
- The buccal ganglia send nerves to the buccal mass.
- Nerves from the pedal ganglia innervate the foot, and those from the pleural ganglia go to the mantle, ctenidium and siphons.
- From the visceral ganglion nerves go to the intestine, kidney and gonads. These nerves constitute the peripheral nerves.

SENSE ORGANS OF PILA GLOBOSA:

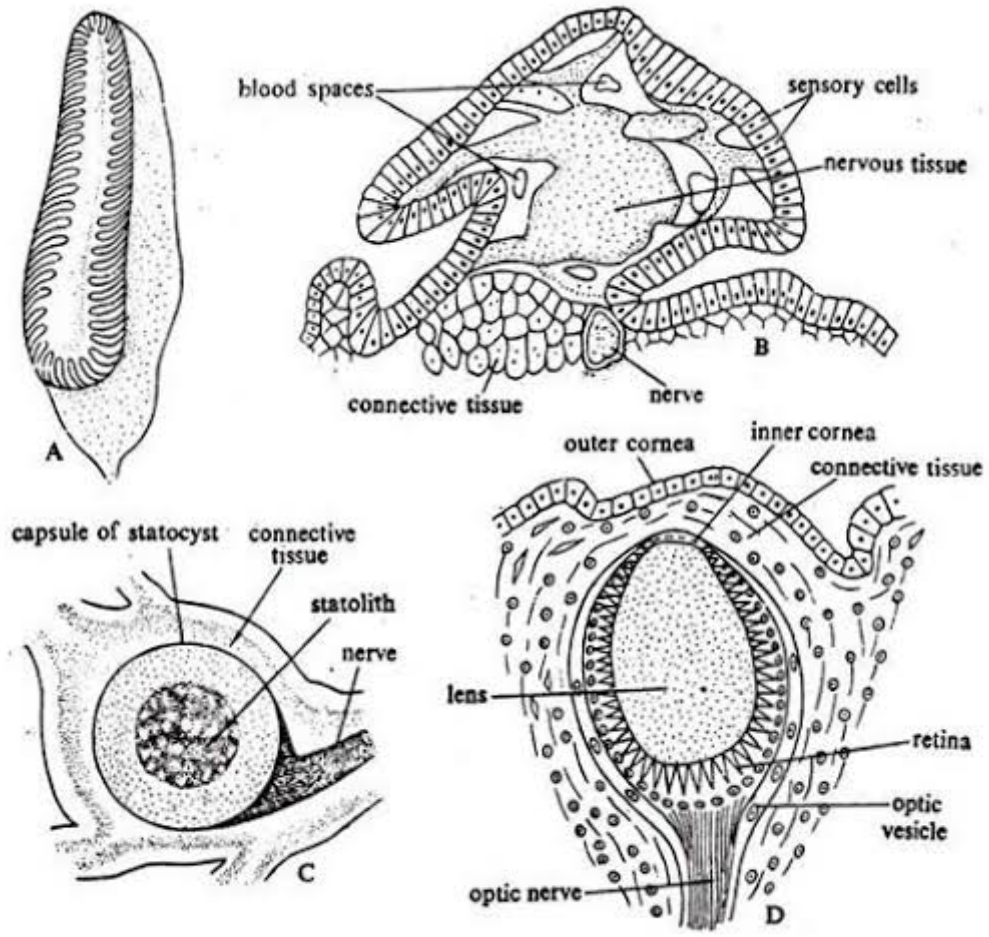


Fig. 2.109 : Sense organs in *Pila*. A. An entire osphradium. B. Sectional view of an osphradium. C. A statocyst. D. Sectional view of an eye.

1. Osphradium:

- Chemoreceptor : It is a chemoreceptor and tests the current of water which enters the mantle cavity through the left pseudepipodium, it also exercises selection over the food taken in.
- Situated close to left nuchal lobe
- Believed to be modified right ctenidium
- Small,oval with 22 to 28 fleshy leaflets arranged on the sides of a central axis(bipectinate)
- Lamellae attached to central axis by narrow inner edge and to the mantle by broad and triangular outer edge
- Epithelium composed of : gland cells & sensory cells
- Innervated by osphradial nerve
- Hangs like a curtain from roof of mantle

2. Statocysts:

- Paired , small , pyriform sacs
- Located in the foot near each pedal ganglion lies a statocyst in a depression.
- It is a round capsule lined with epithelial cells and surrounded by connective tissue.

- In the cavity of the capsule are small calcareous statoconia.
- The statocysts receive nerves from pedal and cerebral ganglia, they are organs of equilibrium and regulate the position of the snail.

3. Eyes:

- There is a pair of eyes, each borne on an ommatophore.
- Has invagination : optic capsule; covered by optic sheath
- Optic nerve enters optic vesicle posteriorly
- Optic capsule has oval,hyaline & gelatinous body: lens
- Optic capsule : 2 parts : outer connective tissue layer & inner retina
- Retina : sensory & pigmented : formed of photosensitive cells & packing cells
- Anteriorly , infront of lens , retina forms transparent & non-pigmented inner cornea
- Eyes are not true visual organ
- Only sensitive to changes in intensities of light & can detect only quick moving objects

4. Tentacles:

- 2 pairs : cephalic & posterior true tentacles
- The tentacles and foot are liberally supplied with nerves, they are sensory to contact, tentacles contain both tactile and chemoreceptor cells and probably gustatory also.
- Cephalic tentacles are also gustatoreceptors.

REPRODUCTIVE SYSTEM OF PILA GLOBOSA:

- In Pila Globosa, the sexes are separate, i.e., dioecious
- There is a definite sexual dimorphism :The shell of the male is usually smaller in size and less swollen than the female.
- There is a well developed copulatory organ in the male but it is quite rudimentary in the female.

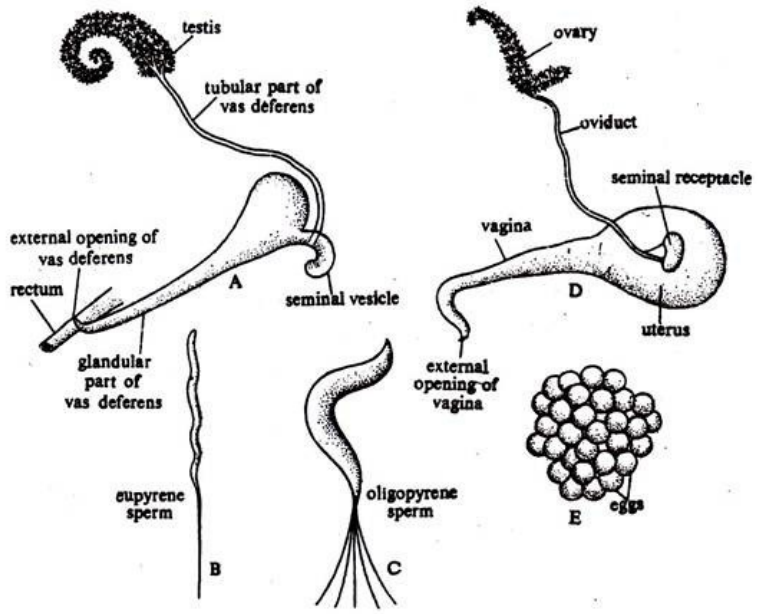


Fig. 1.89 : Reproductive systems in *Pilla*. A. Male reproductive system, B. Eupyrene sperm, C. Oligopyrene sperm, D. Female genital system and E. Cluster of eggs.

Male Reproductive Organs of Pila Globosa:

The male reproductive organs consist of:

1. Testis with its fine vasa efferentia
2. Vas deferens with the vesicula seminalis and the terminal glandular part of the vas deferens
3. Penis with its sheath
4. Hypobranchial glands.

1. Testis:

- It is a flat plate-like whitish structure, more or less triangular ,situated in the upper part of the first 2½ – 3 whorls of the shell.
- Spread over hepatopancreas
- Minute ducts the vasa efferentia lead downwards from the different parts of the testis and unite with one another before opening into the sperm duct :vas deferens.\
- Vas deferens consists of three distinct parts:
  - Proximal thin tubular portion leading from the testis,
  - Vesicula seminalis and
  - Thick glandular portion which opens into the mantle cavity near the anal opening.

3. Penis Sheath and Penis:

- The penis is a long and stout flagellar structure, about half an inch long arising from the attached right side of the flap of the mantle
- The edge of the mantle bears on its inner surface a thick glandular flap of a yellowish colour.
- The flap is attached on its right-side but is free on its left; its edges are slightly rolled in to form a spout-like sheath, *penis sheath* for the penis.

- The penis is capable of extension.

4. Hypobranchial Gland:

- At the base of penis sheath is an oval hypo-branchial gland.

- Spermatozoa of Pila are of two kinds:

1. Eupyrene sperms : hair like ,mobile, functional
2. Oligopyrene sperms : immobile , abnormal , large

Female Reproductive Organs:

The female reproductive organs consist of:

1. Ovary with numerous minute ducts
2. Main oviduct
3. Receptaculum seminis
4. Uterus
5. Vagina
6. Hypobranchial gland.
7. 7.Rudimentary copulatory organ

1. Ovary:

- The ovary in the female lies in the same position as the testis in the male but it is not so extensive.
- It occupies the upper and inner surfaces on the first 2 – 2½ whorls and is covered over by a thin but stout skin-coat.
- Ovary is a much branched structure of a light orange colour which becomes darker in fully mature individuals.
- The branches of ovary consist of single-layered flask-shaped lobules :acini ,with their closed rounded ends directed outwards and the elongated necks of the flasks descending to meet those of the adjacent acini to form minute ducts which in their turn open into the main oviduct.

2. Oviduct:

- The narrow and transparent oviduct originates from about the middle of the ovary.
- It runs anteriorly just below the skin along the inner margin of the digestive gland.
- Near the renal organ it turns downwards and then upwards to enter the receptaculum seminis.

3. Receptaculum Seminis:

- It is a bean-shaped structure, lying in the cavity of the posterior renal chamber closely attached to the uterus.

- A thin-walled pouch arises directly from the wall of the uterus and is called the pouch of the receptaculum.

4. Uterus:

- It is a large pear-shaped structure, deep-yellow in colour.
- It lies inside the body whorl below the intestine and the right of the renal chambers.
- The apex of the uterus points forwards and is continued as the vagina, while its basal portion is broad and rounded and is connected on its outer side with the receptaculum seminis.

5. Vagina:

- The vagina is a white or cream coloured, band-like structure lying immediately beneath the skin.
- It extends from the uterus to the upper end of the columellar muscle.
- The vagina enters the mantle cavity at its right posterior corner and continues forwards to the female genital aperture situated on a small papilla, a little behind the anus.

6. Hypobranchial Gland:

- The hypobranchial gland of female is poorly developed.
- There is a rudimentary glandular thickening in the area of hypobranchial gland.

7. Copulatory Apparatus:

- The female has a rudimentary penis lying beneath the glandular fold at the edge of the mantle.
- It is a thin flagellar structure with a rudimentary groove along its inner surface.

Copulation in Pila Globosa:

- Copulation in Pila globosa occurs either in water or on land, it lasts for 3 hours.
- Male and female Pila come together facing each other.\
- The penis of the male is expanded and gets attached to the genital papilla by its base.
- Then the penis and its sheath are inserted into the mantle cavity of the female.
- The tip of the penis is put into the female genital aperture and spermatozoa are transferred through the vagina into the receptaculum seminis.

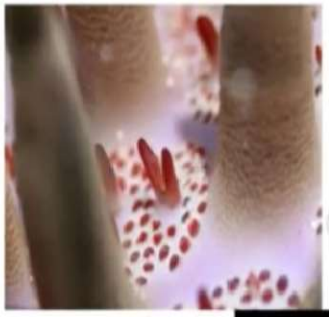
Fertilisation of Pila Globosa:

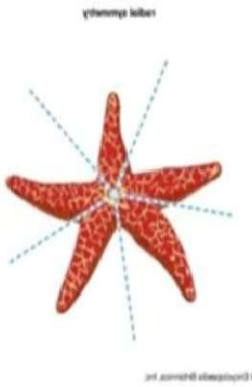
- Eggs are fertilised in the uterus and oviposition starts a day or two later.
- The fertilised eggs are laid in masses of 200 to 800 in moist earth near ponds and lakes.

Torsion takes place, the shell and visceral mass are rotated through 180 degrees in relation to the head and the foot, but coiling of the visceral hump usually precedes torsion.

PHYLUM ECHINODERMATA

- Popularly known as spiny skinned animals
- Pentamerous radial symmetry evolved from bilateral symmetry
- Spiny exoskeleton
- Calcareous endoskeleton of separate dermal ossicles
- Spacious enterocoelic coelom
- Water vascular system with tube feet
- Complete and straight or coiled alimentary canal
- Dermal branchiae, peristomial gills, genital bursaand respiratory tree
- Pedicellariae on the body wall
- Circulatory system lacks distinct heart and definite blood vessels
- Simple and primitive nervous system without brain
- Indirect development with bilaterally symmetrical, ciliated and pelagic larva
- Reproduction is sexual





CLASS CRINOIDEA

- Consist of both extinct and extant forms
- Popularly known as sea lilies (sessile)and sea feathers (free swimming)
- Most ancient and primitive echinoderms
- Gregarious echinoderms
- Body:stalked or stalkless and pentamerous,consist of aboral cup(calyx)and an oral cover (tegmen)
- Mouth and anus located on the upper side

Prepared by Jasla Mol KK & Jamshiya Jaithun C
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- Arms:long and movable,branched or un branched,and with or without alternating bilateral process called pinnules
- Ambulacralgroove:open and ciliated and they extend up to the tip of arms and pinnules
- Madreporite ,spines and pedicellariaeare absent
- Tube feet have no suckers
- Sessile form have aboral ,jointed and heavily calcified stalk for attachment
- Sexes are separate
- Development is indirect with barrel – shaped ***doliolaria***larva

- Eg:Antedon

Example : ANTEDON

- Commonly known as "Sea lilly"
- It is a temporarily attaching echinoderm
- Living among the rocks and coral reefs
- Most of the time it remains attached to solid subjects. But occasionally, it may move about swimming or walking
- Their stalk is provided with a root-like structure called cirri. It help for attachment and anchorage
- Their body has two parts
    5. central portion-crown or corona
    6. basal portion -stem, stalk or Column
- Their Crown is brilliantly coloured, because presence of carotenoid pigments
- Crown has two parts

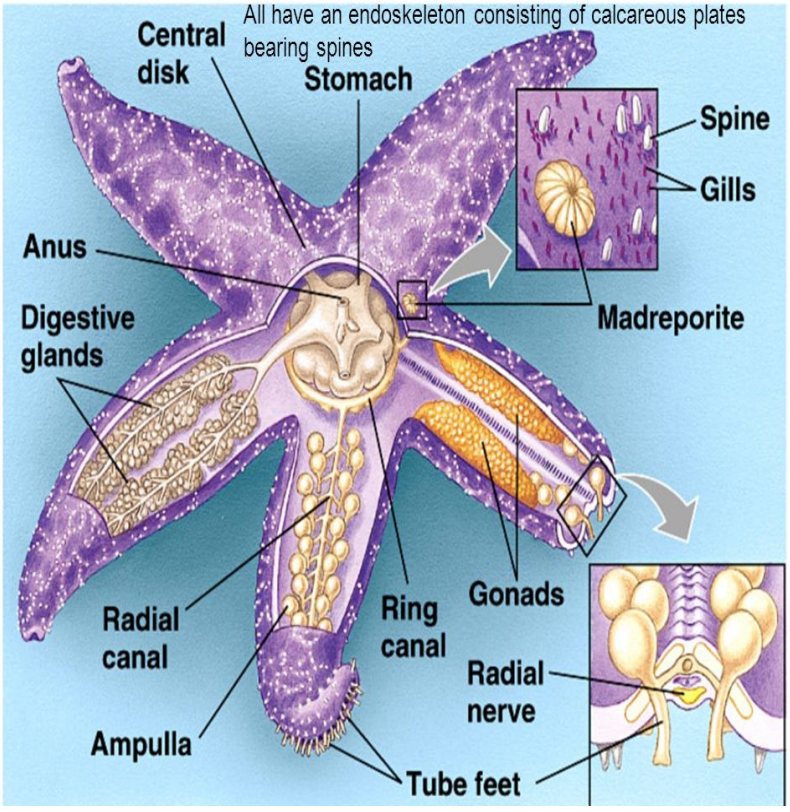
1. calyx
2. pentamerously arranged radial Arms

- Calyx is cup-shape ;upper side-concave ;lower side-convex
- Upper surface is covered by a leathery membrane, called tegmen
- Tegmen is perforated by numerous water pores, which open directly to the body cavity
- Radial arms arise from the rim of the calyx, each arm divides into long branches
- Each branch has numerous alternately arranged bilateral branches called pinnules
- Mouth is bordered by five triangular flaps called oral valves
- Running from mouth to arms are five ciliated grooves, calledambulacral or food grooves, this may extend to the pinnules

- Antedon is a ciliary suspension feeder, the feed mainly zooplanktons
- It has high regenerative powers. It can easily regenerate its lost or damaged arms
- Sexes are separate, no sexual dimorphism between male and female
- External fertilization and indirect development
- Larva-Doliolaria

CLASS ASTEROIDEA:

- Asteroids are flattened and free-living echinoderms, commonly called star fishes or sea stars.
- Spiny, flat and pentagonal body with a central disc 5-20 or more radial arms or rays, and distinct oral and aboral surfaces.
- Mouth and ambulacral grooves are on the lower side, and anus and madreporite are on the upper side
- Ambulacral grooves are open channels, studded with sucker-bearing tube feet.
- Dermal ossicles are loose, flexible and separate pieces.
- Respiratory structures are dermal branchiae or skin gills.
- Sexes are separate. Development is indirect with bipinnaria larvae.
  There are nearly 1500 species of living Asteroids. They enjoy worldwide distribution, especially in coastal waters
- Example:Astropecten



Example : ASTROPECTEN

- Astropecten is a common star fish.
- Inhabiting in the sea.
- Body is flat &pentamerous,with upper & lower surface.

- Consists of a central disc & five radial arms.
- Mouth is located on lower surface of disc & madreporite on upper surface.
- Anus is absent.
- Mouth is surrounded by a leathery membrane called peristome.
- Each arm bears a tentacle & an eye spot.
- Aboral surface of disc & arms bears numerous short & blunt spines,arranged in bundles called paxillae.
- In each paxillae,spines are arranged in a circle around a basal stalk.
- On the aboral surface of disc,in between two arms is a circular,grooved& porous plate called madreporite.
- Seen in its grooves are numerous openings called hydropores,which are the gateways to water vascular system.
- Body wall is thin,soft& transparent.
- Body wall is supported by numerous calcareous plates & rods called dermal ossicles.
- Sexes are separate.
- Fertilization & development are external.
- Development is indirect with a ciliated, free-swimming pelagic larva called bipinnaria.

WATER VASCULAR SYSTEM

- The water vascular system is a modified part of coelom and it consists of a system of sea- water filled canals having certain corpuscles.
- It plays most vital role in the locomotion of the animal and comprises :
  1. Madreporite
  2. Stone canal
  3. Ring canal
  4. Radial canal
  5. Tiedeman's bodies,
  6. Lateral canals,
  7. Tube feet.

Madreporite:

- madreporite is a rounded calcareous plate occurring on the aboral surface of the central disc in inter-radial position.
- Its surface bears a number of radiating, narrow, straight or wavy grooves or furrows.

- Each furrow contains many minute pores at its bottom.
- Each pore leads into a very short, fine, tubular pore canal which passes inward in the substance of the madreporite.
- There may be about 200 pores and pore-canals.
- The pore-canals unite to form the collecting canals which open into an ampulla beneath the madreporite.

Stone Canal:

- The ampulla opens into a S-shaped stone canal.
- The stone canal extends downwards (orally) and opens into a ring canal, around the mouth.
- The walls of stone canal are supported by a series of calcareous rings.
- The lumen of stone canal is lined by very tall flagellated cells.

Ring Canal:

- The ring canal or water ring is located to the inner side of the peristomial ring of ossicles and directly above (aboral) to the hypo neural ring sinus.
- It is wide and pentagonal or five sided.

Tiedemann's Bodies:

- The ring canal gives out inter-radially nine small, yellowish, irregular or rounded glandular bodies called racemose or Tiedemann's bodies, from its inner margins.
- The Tiedemann's bodies rest upon the peristomial ring of ossicles.
- The actual function of Tiedemann's bodies is still unknown, however, they are supposed to be lymphatic glands to manufacture the amoebocytes of the water vascular system.

Polian Vesicles:

- The ring canal gives off on its inner side in the inter-radial position one, two or four, little, pear-shaped, thin-walled, contractile bladders or reservoirs with long necks called polian vesicles.
- They are supposed to regulate pressure inside ambulacral system and to manufacture amoeboid cells of ambulacral system

Radial Canal:

- From its outer surface the ring canal gives off a radial water canal into each arm that runs throughout the length of the arm and terminates as the lumen of terminal tentacle.
- In the arm the radial water canal runs immediately to the oral side of the ambulacral muscles.

Lateral Canals:

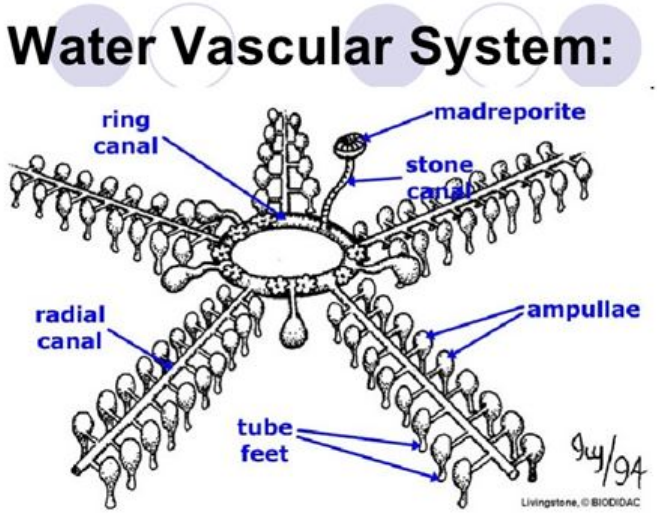
- In each arm, the radial canal gives out two series of short, narrow, transverse branches called lateral or podial canals.
- Each lateral canal is attached to the base of a tube foot and is provided with a valve to prevent backward flow of fluid into the radial canal.

Tube Feet:

- There are four rows of tube feet in each ambulacral groove.
- A tube foot or podium is a hollow, elastic, thin-walled, closed cylinder or sac-like structure having an upper sac-like ampulla, a middle tubular podium and a lower disc-like sucker.
- The ampulla lies within the arm, projecting into the coelom above the ambulacral pore which is a gap between the adjacent ambulacral ossicles for the passage of the podium.
- The tube feet are chief locomotory and respiratory organs of Asterias

Locomotion of Asterias:

- Asterias lacks in head or anterior end, therefore, capable to move in any direction according to its desire.
- It can move on horizontal as well as on vertical surfaces by the help of tube feet."



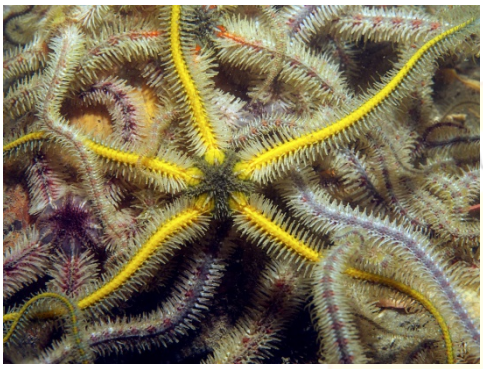
CLASS OPHIUROIDEA

- It is the largest class of echinoderms.
- Popularly known as basket stars, brittle stars or serpent stars.
- Basket stars- branched arms.
- Brittle star- fragile and easily breakable arms
- Serpent star-serpentine movement of the arms.
- Their body consist of central disc and arms.
- Arms are long, slender and more sharply set off from the disc
- Flat body with a thin disc & five or more slender and flexible arms.
- Arms are formed of a series of segment-like sections or articles, each article being formed of four shields.
- Ambulacral grooves, pedicellariae and dermal branchiae are absent
- Tube feet are without ampullae and suckers.
- Gut is a blind sac, without intestine and anus
- Madreporite is on the oral surface.
- Sexes are separate. Development is indirect with a larva called ophiopluteus
- many ophiuroids have the powers for autotomy and regeneration.
- Eg:- Ophiothrix

Example :OPHIOTHRIX

- Spiny brittle star
- Solitary, fast-moving, nocturnal animal
- Small and rounded *central disc and five long and slender radial arms*
- Arms many-jointed,flexible,and freely movable
- Covered by calcareous plates and with spines on all sides

- Disc flat upper aboral and lower oral surfaces
- Oral side bear mouth and madreporite
- Anus,ambulacral grooves, dermal branchiae and pedicellariae are absent
- Mouth provided with five movable calcareous plates ,serve as jaws over the mouth are some spines serve as strainers
- Base of each arm on the side of the disc a pair of slits called bursal slits
- Each slit lead into a pouch called genital bursa
- Gonoducts open to the genital bursae
- Mature sex cells and nitrogenous wastes pass out through the bursal slit
- Genital bursae serve also as respiratory surface called genito-respiratory pouches

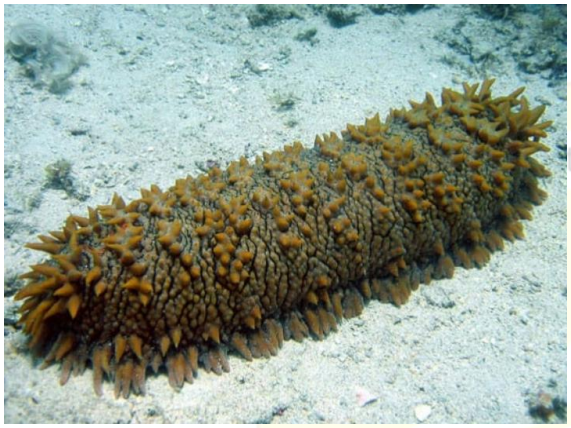


- Lower side of the arms there are small openings called podial pores. Through them tube feet protrude to the outside
- Digestive system is simple and without caeca, intestine and anus
- Stomach is large, non-glandular sac
- Practically a mud-feeder and its food mainly includes microscopic organisms and decaying organic matter
- Sexes are separate
- gonads are simple coelomic sacs
- Fertilization external
- Development is indirect with a larva called *ophiopluteus*

CLASS HOLOTHUROIDEA :

- Commonly called sea cucumber
- Body is long, cylindrical, almost bilaterally symmetrical
- Mouth and anus are at opposite end
- Arm, spines and pedicellariae are absent
- Ambulacral grooves are absent
- Madreporite is internal
- Alimentary canal is long and coiled, with definite cloaca
- Respiratory organ called respiratory trees or cloacal gills
- Develepment is indirect, with a larva called auricularia
- There are nearly 1200 species

- There are living in sea bottom
- Sea cucumber exhibit an odd habit of autotomy and evisceration
- Which the internal organ such as digestive tract, respiratory trees and gonads are throw out through mouth or anus, at time of dangerous
- These internal organs are sticky and the enemy may get entanged in them, some release toxic substance also
- This enables the cucumber to escape from the enemy
- The lost part would be regenerate later
- Examples : Holothuria, cucumaria



Example : HOLOTHURIA

- It's a common sea-cucumber
- Inhabitant of the sandy sea coasts
- Body is long and cylindrical
- Mouth and anus are at opposite ends
- Mouth- surrounded by a peristomial membrane
- Bordering this is a ring of buccal podia,modified as oral tentacles for gathering food
- Body wall is thick and leathery
- There is no arms,ambulacralgrroves and pedicellariae
- Locomotor tube feet also absent
- In their place ,there are numerous warty or papillae projections
- Maderoporite is internal
- Connected to the cloaca are two branching gills,called cloacal respiratory trees
- Devolpment is inderict with auricularia and doliolaria larvae
- Self defence:
  - It have a unique type of self defence by autotomy and evisceration
  - At the time of danger,it contracts violently and severs some internal organs,such as respiratory trees,alimentary canal and gonad this is called autotamy or self mutilation
  - The served parts are soon thrown out through mouth or anus this is known as evisceration
  - The eviscerated mass diverts attention of enemy or entragle this enables cucumber to escape from the enemy

- The lost parts are soon regenerated
- Another curious behavior is the expulsion of numerous long,sticky and toxic filament or tubules when frightened,threatened,or attacked this filament contains a toxic substance called holothorin
- Holothurin is quite toxic to human beings
- It May cause rashes,burning and inflammation of skin
- When eyes happen to contact it ,blindness would be result

CLASS ECHINOIDEA

- Egg shaped , circular body which is hemispherical
- Skeletal plates that bear many movable spines and 3 jawed pedicellariae
- Radially symmetrical
- Skeleton well suited for fossil preservation
- Benthic
- Arms and ambulacral grooves are absent
- Body enclosed : box-like shell : corona / test
- Movable spines
- Mouth : surrounded by peristome
- Chewing apparatus : *Aristotle's lantern*
- Most retain anus at aboral pole and hence have a circular circumference
- External fertilization
- Development : indirect : echinopluteus larva

Example : ECHINUS

- Common Name: Sea Urchin
- The common sea urchin is an invertebrate with a large rounded shell-like external skeleton referred to as a test.
- This exoskeleton is composed of calcareous plates. It varies in colour from pinkish-red to yellow, purple or green.
- Individuals that live in shallower marine waters tend to be more flat than individuals living in deep water.

- The test is covered in many spiny bristles that serve as a protection mechanism from predators.
- They feed on seaweeds and other invertebrates.
- They are able to move from place to place via tube feet.
- Breeding takes place in the spring through external fertilization between male and female individuals.
- They can be found in high densities in offshore areas on rocky substrates.
- The common sea urchin is also referred to as the edible sea urchin.

PHYLUM HEMICHORDATA

- Hemichordata was considered as a sub-phylum under phylum Chordata
- Body is soft , vermiform , unsegmented and bilaterally symmetrical
- With 3 unequal divisions :
  1. Proboscis
  2. Collar
  3. Trunk
- Notochord absent
- Present of buccal diverticulum or stomochord in the proboscis
- Several pairs of permanent gill-slits
- Single-layered epidermis and the absence of dermis
- Enterocoelic coelom, divided into 3 compartments : Protocoel , mesocoel and metacoel.
- Body divisions (proboscis,collar and trunk)
- Simple and open type of circulatory system
- Primitive nervous system
- Asexual reproduction in few forms
- Sexual in others.
- Asexual reproduction takes place by budding.
- Asexually reproducing forms will have high powers for regeneration
- Sexes are separate
- Sexual reproduction involves indirect or direct development
- Indirect development with *tornaria larva*

Example : BALANOGLOSSUS

- Popularly known as 'acorn-worm'or 'tongue –worm'
- It excavates U-shaped burrows in sand, tube is plastered and strengthened by a mixture of mucus, sand and mud. Mucus is unpleasant odour, and forms a repellent against enemies.
- **Body** is unsegmented, soft,cylindrical and superficially worm like, without exoskeleton and external appendages.
- Body has three divisions,
  1. Proboscis
  2. Collar
  3. Trunk

Proboscis

- Short, muscular and conical anterior part, used for burrowing.
- It contains stomodaeal diverticulum called *stomochord.*
- In base, they have two opening, water enters through this opening.
- Posteriorly, narrow to a slender *Proboscis stalk,* entirely concealed by collarand it strengthened by a layer of cartilage -like chondroid tissue.

Collar

- Cylindrical and muscular middle part.

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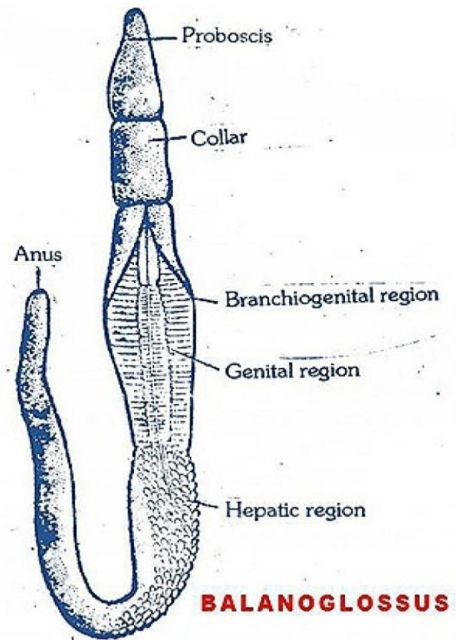
- Its funnel like anterior part, that encircles Proboscis stalk, called *collarette.*
- Collar separated from trunk by circular fold.
- Collar cavity communicates with exterior by a pair of *collar pores.*

Trunk

- Last division of body, flat and superficially annulated or ringed.
- Trunk has three region,
  - Branchio-genital region – it is produced into a pair of thin, flatand leaf-like lateral flaps, known as *genital wings.*They carry gonads.
  - Hepatic region- irregular external elevation. These correspond to sacculation of intestine, called *hepatic caeca.*
  - Post-hepatic region – long progressively tapering and terminally it bears anus.
- Sense organs are absent.
- Very primitive nervous system.
- Reproduction is sexual.
- Ciliary mud feeder, organic material contains mud.
- Fertilisation is external
- Development is indirect, free-swimming ciliated larva called *tornaria.*

Tornaria

- Free –swimming planktonic life.
- It is oval and glassy, with apical ciliary organ, well developed digestive tract and definite ciliary bands.
- Apical organ consist apical plates, a tuft of sensory cilia, and pair of eye spots.
- Ciliary bands include pre-oral ciliary band or prototroch and post-oral ciliary band or telotroch
- It sinks to elongates, undergoes metamorphosis and transforms to a burrowing adult.



PHYLUM PHORONIDA

- Translucent, cylindrical,worm like sessile and benthic coelomates.
- Commonly called horse shoe worms
- Inhabitants of tropical and subtropical seas.
- Cylindrical and apodous body with external bilateral symmetry and internal asymmetry
- Mouth is surrounded by horse shoe shaped and spirally coiled tentacular crown called lophophore (serves as an organ of feeding and gas exchange)
- Body has three parts :
    1. Epistome:
        - antero- dorsal Part.
        - Contains a space called protocoel
    2. Mesosome:
        - Middle part,
        - Bears,anus,mouth,nephridiophores and lophophore
        - Contains coelomic space mesocoel
    3. metasome:
        - Large posterior part
        - Has swollen terminal part ampulla
        - Contains coelomic space called metacoel
- Body wall has 6 parts
    1. Cuticle
    2. Epidermis
    3. Basement membrane
    4. Circular muscle
    5. Longitudinal muscle
    6. Peritoneal lining
- Digestive tract is U shaped,with mouth and anus close to each other.
- Closed type of blood vascular system
- Respiratory system is absent
- Excretory organs are a pair of metanephridia
- Nervous system is primitive and sub epidermal
- Reproduction is sexual in most asexual in some
  Sexual forms are
- hermaphrodite, external cross fertilization is rule
- Development is indirect through free swimming *actinotroch* larvae.

Example : PHORONIS

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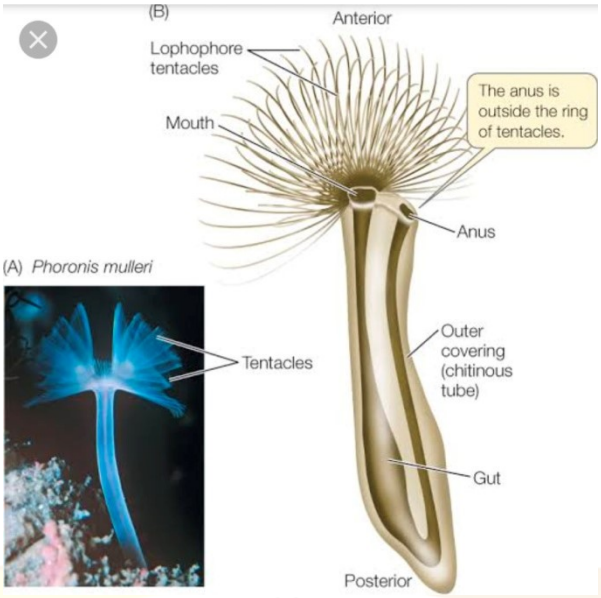


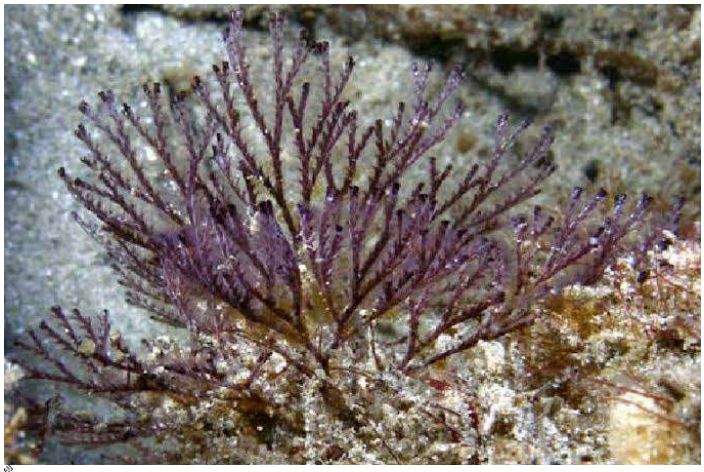
- Lives in a self secreted chitinous tube
- Body is long , slender, cylindrical and unsegmented without appendages
- Anterior end bears mouth anus & nephridiophores and the lophophore
- Around the base of inner series of tentacles is a mucus secreting glandular pit , called lophophoralgland
- Posterior end has a swollen base , called ampulla
- Body of phoronis has 3 divisions
    1. anterior epistome
    2. middle mesosome
    3. posterior metasome
- Epistome forms upper lip & it overhangs the mouth
- It contains a blastocoelic space called protocoel
- Mesosome bears the mouth anus nephridiophores and contains coelomic space called mesocoel or lophophoral coelom
- Metasome represents trunk region contains a coelomic space called metacoel or trunk coelom
- Alimentary canal is U – shaped
- Mouth and anus are anteriorly placed
- Different parts include mouth, oesophagus, stomach, intestine, rectum and anus
- Anus is dorsal , close behind the lophophore
- Is a suspension feeder
- Specialized digestive glands are absent
- Digestion is intracellular, occuring in stomach
- Closed type of blood vascular bundles , without heart
- Blood contains two corpuscles
- Specialized respiratory organs are absent
- Excretory system consist of U – shaped Metanephridia
- Nervous system consist of circum – oesophageal nerve ring
- Specialized sensory organs are absent
- Reproduction sexual

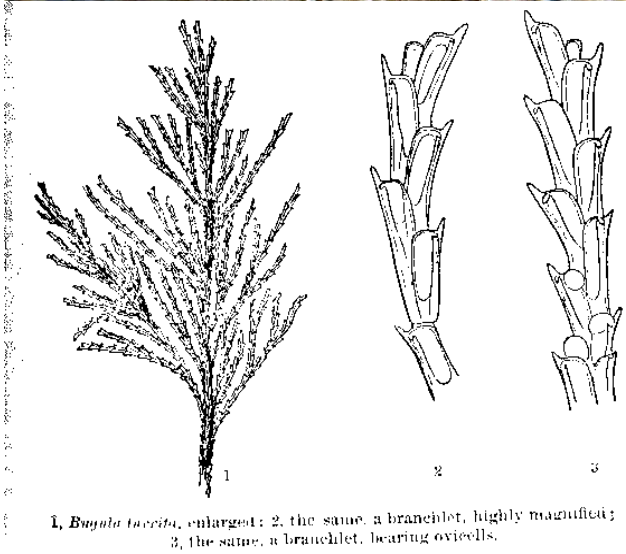
- Mature gametes discharged to ceolomic fluid through nephridiophores
- Development is indirect with a actinotroch larva
- Larva has nerve ganglion , protonephridia , tentacular ridge , ciliary ring
- Larva leads a 20 days of planktonic life And then undergoes catastrophic metamorphosis and transforms to a young phoronis

PHYLUM ECTOPROCTA

- Marine animals, popularly known as "moss animals" or "sea mats".
- They are tiny, bilaterally symmetrical unsegmented, colonial and coelomate ophorates
- Build by calcareous stony skeleton
- Similar to coral skeleton.
- Benthic colonies, with solitary species called Monobryozoonbulans ambulans
- Most colonies are attached and immobile, but some are motile.
- Zooid secretes a protective cup-like exoskeleton called zooecium. It is calcareous or chitinous in marine forms, but gelatinous in freshwater forms.
- The anterior end of zooid bears a or horseshoe-shaped lophophore.
- The anterior part of the body.forms proboscis or introvert.The remaining part'is çalled trunk. A cuticular flap, called operculum, covers the retracted introvert.
- Alimentary canal is U-shaped, with mouth and anus.
- Gut is differentiated into pharynx, oesophagus, stomach, intestine and rectum.
- Stomach hast hree parts, cardiac stomach, pyloric stomach and caecum.
- Nervous system consists of a nerve ganglion.
- Special sense organs are absent.
- Reproduction is asexual and sexual.
- Eg: Bugula

Example : BUGULA



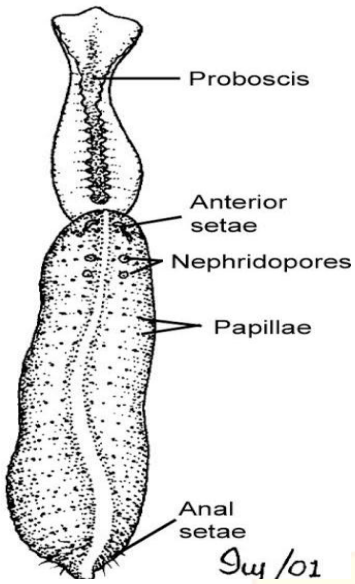


1, *Bugula turrita*, enlarged: 2, the same, a branchlet, highly magnified; 3, the same, a branchlet, bearing ovicells.

- Marine colonial bryozoan
- Commonly called bird's head coralline
- Its colony is plant like
- Brown or purple coloured
- Each stem is dichotomously branched and it bears numerous zooids
- Colony is polymorphic
- On the exterior bird's head like special type zooid called avicularium
- It has jaw that can open and snap to prevent animals from settling on the surface
- Anterior – introvert,it bear mouth and anus, and forms a rounded *lophophore*
- It bears ciliated tentacles
- Digestive canal U shaped
- Respiratory, excretory, circulatory organs are absent
- Reproduction is sexual and asexual
- Asexual reproduction by budding
- Bugula is monoecious
- Coelom has a brood pouch called *ooecium*
- Indirect development with a *coronate larva*
- *B.neritina* is important source of the cytotoxic chemicals brayostatins

PHYLUM ECHIURA

- Commonly called spoon worms
- They live in burrows in sand and mud
- Majority of echurians live in shallow waters
- Body billaterally symmetrical, soft and thick and consist of sausage-shaped and ovoid trunk and scoop-shapedand non-retractille probosics(richly ciliated pre-oral extension of head)
- Adults are unsegmented, but larvae are segmented
- Body wall is thick and fleshy. Epidermis bears rings of papillae
- Coelom large and undivided
- Alimentary canal highly coiled and longer than body
- Mouth is situated at the base of proboscis.
- Circulatory system is simple & closed With dorsal and ventral longitudinal vessels. Heart and lateral vessels are absent.
- Excretory system is represented by large nephridium. It also act as gonoduct.
- Nervous system consist of a mid ventral nerve cord. Ganglia absent.
- There is no special sense organ. But,Probocisserves as a feeler.
- Sexes separate. Sexual dimorphism in some cases.
- Reproductive cells are formed from coelomic epithelium &mature in coelom.
- Fertilization is external.
- Development is indirect with trochophore larva.
- Most echiurans are detritivores.



Example : BONELIA

- Commonly called spoon worms
- Shows sexual dimorphism

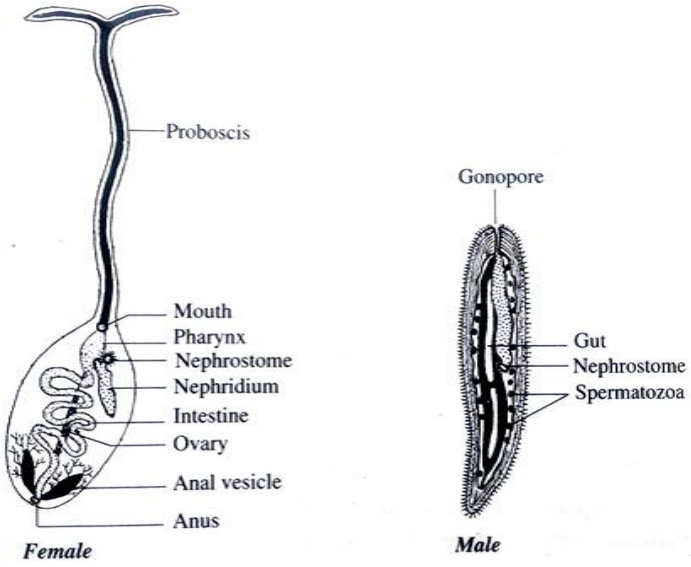
Female Bonellia

- It is large sized, massive body and long, slendercell terminally attached to proboscis
- It remain buried in the mud and collects micro-organisms on thesurface of the mud by its ciliated proboscis
- Brain is located inside the proboscis
- Mouth open at the base of the proboscis and anus at the posterior end
- Skin is coverd with minute and irregularly scattered papillae
- A pair of hook-like midventral setae is present close to the anterior end of the body
- Bodyattached to proboscisis dermo-muscular
- Coelomic fluid has floating respiratory cell, containing haemoglobin
- Closed circulatory system with longitudinal vessels
- Excretion is by a single nephridium called brown tube which alsofunction as a uterus

Male Bonellia

- The male bonellia lives symbiotically inside the reproductive organs of the female
- It is ciliated without proboscis
- It has a setae, a brown tube and a reduced alimentary canal without mouth or anus
- Male enters the pharynx of female and after attaining sexual maturity lives permanently in nephridia as a parasite
- Fertilization is internal taking place inside brown tube
- Development is external and indirect with larval stage
- Its larva is called *strocophore*
- Initially larva are not sexually differentiated
- Larva which settle at the bottom develop as female and which come in contact with proboscis of female with proboscis of female will be the parasitic male

- The anal vesicles arising from rectum also believed to be excretory in function



Bonellia