Mollusca

General Characters

Mollusca are soft-bodied animals characterized by a shell, a foot, a mantle and gills or ctenidium.

Mollusca includes organisms such as snails, clams, oysters, squids and octopuses. In point of number of species it comprises, it stands second to Arthropods. It includes about 100,000 living species and about 35,000 fossil species.

1. Molluscs are ***multicellular*** organisms.

2. They have a ***bilateral symmetry***, but snails are ***asymmetrical.***

3. They are ***triploblastic*** animals.

4. They are ***coelomate*** animals. True coelom is reduced. The haemocoel is well developed in them.

5. They have ***organ system*** grade of organization.

6. The body is ***soft*** and ***unsegmented.***

7. The soft body is covered by a fleshy fold of the body wall. It is called ***mantle.***

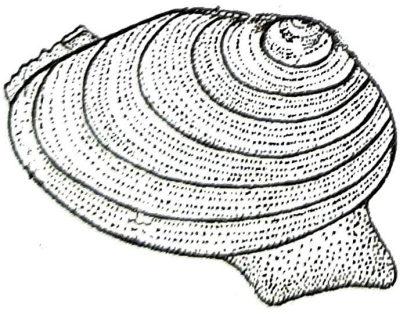


Fig.11.1: Freshwater mussel.

8. The molluscs are provided with one or two calcareous ***shells.*** The shells may be ***external*** or ***internal.***

9. Respiration is carried out by the gill or ***pulmonary chambers.***

10. The digestive system is well developed. It contains a ***radula*** and a ***hepatic pancreas.***

Fig.11.2: Radula.

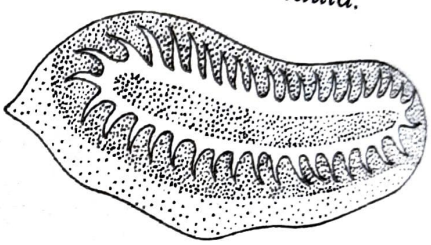


Fig.11.3: Osphradium.

11. The circulatory system is of an ***open type.***

12. The excretory organ is the ***kidney.***

13. The nervous system is well developed.

14. The sensory organs are ***eyes, statocysts*** and ***osphradia.***

15. Sexes are separate in them or they are ***hermaphrodites.***

16. The development in their case is either ***direct*** or ***indirect.***

Classification

Phylum ***Mollusca*** is divided into ***seven classes.*** They are the following:

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

Class 1. Aplacophora or Solenogasters

1. The body is ***worm-like***, ***bilaterally symmetrical*** and ***cylindrical.***

2. The head, mantle, foot, shell and nephridia are absent.

3. The body is covered with spicule-bearing ***cuticle.***

4. The digestive tract is straight with ***radula.***

5. A mid dorsal longitudinal ***keel*** or ***crest*** is often present.

Examples : *Neomenia, Chaetoderma,* etc.

Outline Classification of Phylum Mollusca

Class 1. Aplacophora or Solenogasters
Class 2. Monoplacophora
Class 3. Polyplacophora
Class 4. Gastropoda
- Subclass1. Prosobranchia (Streptoneura)
  - Order 1. Archaeogastropoda
    - Suborder 1. Docoglossa
    - Suborder 2. Rhipidoglossa
  - Order 2. Mesogastropoda
  - Order 3. Neogastropoda
- Subclass 2. Opisthobranchia
  - Order 1. Cephalaspidea
  - Order 2. Anaspidea
  - Order 3. Thecostomata
  - Order 4. Gymnostomata
  - Order 5. Notaspidea
  - Order 6. Acochlidiacea
  - Order 7. Sacoglossa
  - Order 8. Acoela
- Subclass 3. Pulmonata
  - Order 1. Basommatophora
  - Order 2. Stylommatophora

Class 5. Scaphopoda
Class 6. Pelecypoda
- Order 1. Protobranchiata
- Order 2. Filibranchiata
- Order 3. Pseudolamellibranchiata
- Order 4. Eulamellibranchiata
- Order 5. Septibranchiata

Class 7. Cephalopoda
- Subclass 1. Nautiloidea (Tetrabranchia)
- Subclass 2. Ammonoidea
- Subclass 3. Coeloidea (Dibranchia)
  - Order 1. Decapoda
  - Order 2. Octopoda

Class 2. Monoplacophora

1. The body is ***bilaterally symmetrical*** and ***segmented.***

2. The shell is formed of a ***single valve.***

3. The head is without eyes and tentacles.

4. The gills are external and serially arranged.

5. The ***nephridia*** are five pairs.

Example : *Neopilina galatheae.*

Class 3. Polyplacophora

1. These molluscs are ***bilaterally symmetrical*** and ***dorsoventrally flattened.***

2. The shell is composed of ***8 plates.***

3. The foot is ***flat*** and ***ventral.***

4. The radula is well developed.

Examples : *Chiton, Cryptochiton,* etc.

Class 4. Gastropoda

1. ***Gastro*** = stomach; ***poda*** = foot; It seems that these animals are moving on their stomach. Hence the name ***gastropoda.***

2. Gastropods are marine, freshwater or terrestrial animals. A few are parasitic.

3. The body is unsegmented and asymmetrical.

4. The shell is univalved and spirally coiled.

5. The head is distinct. It bears tentacles, eyes and a mouth.

6. Respiration takes place by gills or lungs or by both.

7. The visceral mass is turned through 180° by ***torsion.***

8. ***Mouth*** and ***anus*** lie on the same side.

9. The ***foot*** is ventral and muscular.

10. The buccal cavity is provided with a ***radula.***

11. The circulatory system is ***open.***

12. The sexes are mostly separate, while some forms are ***hermaphrodite.***

13. The development includes ***veliger*** and ***trochophore*** larvae.

Examples : *Fissurella* (key-hole limpet), *Haliotis* (abalone), *Trochus* (top shell), *Turbo, Cypraea* (cowrie), *Natica* (star shell), *Pila* (apple snail), *Murex* (rock shell), *Oliva, Conux* (cone shell), *Terebra, Aplysia* (sea hare), *Doris, Limnaea, Planorbis, Onchidium*, etc.

Sub-class 1. Prosobranchia (Streptoneura)

1. They are ***marine.***

2. The visceral nerve commissures are twisted into a figure of 8; hence the name ***Streptoneura*** (***Gr. Streptos***- curved, ***neuron***-nerve). This shape is attained by ***torsion.***

3. The mantle cavity containing the pallial complex opens anteriorly.

4. The ctenidia, if present, lie in front of the heart; hence ***Prosobranchia.***

5. Head has a single pair of non-retractile tentacles.

6. A calcareous shell with an ***operculum*** is present.

7. The sexes are separate; ***trochophore*** larva typical.

Order 1. Archaeogastropoda (Aspidobranchia, Diotocardia)

1. Primitive snails with incomplete atrophy of the left side so that they retain bilateral symmetry of the mantle cavity containing usually 2 auricles, 2 nephridia and 2 ctenidia.

2. Ctenidia are ***plume-like*** (bipectinate or aspidobranch).

3. The osphradium is poorly developed.

4. The nervous system is little concentrated.

5. The gonad opens into the right kidney serving as gonoduct.

6. Fertilization is ***external.***

Sub-order 1. Docoglossa : 1. Visceral sac and shell are conical in shape.

2. Ctenidium is single or absent or replaced by secondary gills.

3. Auricle is single.

5. Radula with few hooked teeth in each row.

Examples : *Patella, Acmaea (limpets)*, etc.

Sub-order 2. Rhipidoglossa : 1. Shell is usually spiral.

2. Ctenidia are paired.

3. Auricles are paired.

4. Radula has rows of numerous narrow teeth.

Examples : *Fissurella* (key-hole limpet),

Haliotis (abalone), *Trochus* (top shell), *Turbo*, etc.

Order 2. Mesogastropoda (Pectinibranchia, Monoto-cardia)

1. These are advanced snails with complete atrophy of the left side so that usually ***single auricle, nephridium, osphradium*** and ***ctenidium*** occur.

2. Edge of shell opening lacks a siphonal notch or canal.

3. Foot may be operculate.

4. The ctenidium is comb-like or monopectinate and is attached to the mantle by its whole length.

5. The osphradium is pectinate and is well differentiated.

6. The nervous system is concentrated.

7. The gonad has its separate duct and opening.

8. Fertilization is internal, larva is usually a free-swimming veliger.

Examples : *Cypraea* (cowrie), *Natica* (star shell), *Ampullaria, Strombus* (conch), *Triton, Pila* (apple snail), *Valvata, Vermetus,* etc.

Order 3. Neogastropoda (Stenopoda)

1. These are carnivorous species with an eversible proboscis.

2. Foot is ***operculate.***

3. ***Osphradium*** is large and bipectinate.

4. One gill with filaments in one row, one auricle in heart and one nephridium are present.

5. Nervous system is lightly concentrated.

6. Embryos are intracapsular; free-swimming veliger suppressed.

Examples: *Buccinum* (whelk), *Murex* (rock shell), *Urosalpinx* (oyster drill), *Purpura, Oliva, Mitra, Fasciolaria, Conus* (cone shell), *Terebra,* etc.

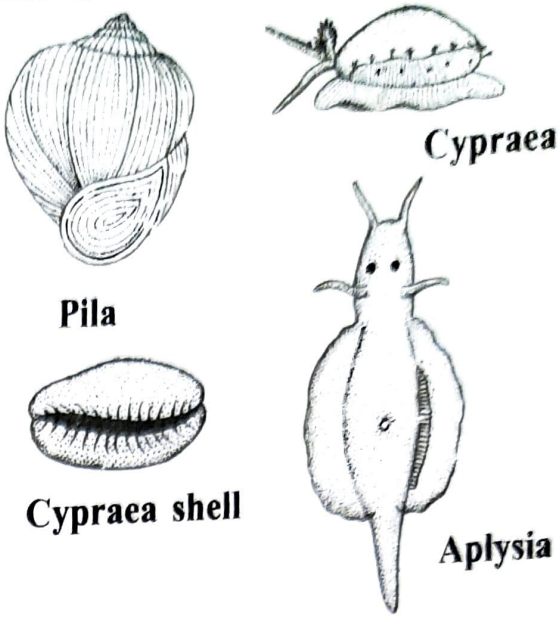


Fig.11.4: Common molluscs.

Sub-class 2. Opisthobranchia (Euthyneura)

1. Gastropoda in which owing to detorsion the visceral nerve loop is not twisted into a figure of 8, hence ***Euthyneura*** (Gr.***Euthus***-straight, ***neuron***-nerve).

2. The mantle cavity tends to become posterior and opens widely.

3. ***Ctenidia*** are replaced by secondary gills.

4. ***2 pairs*** of tentacles are present.

5. The ***shell*** and ***operculum*** are reduced, internal or absent.

6. Usually one auricle and one nephridium are present.

7. ***Hermaphroditism*** is universal. Larva is a ***veliger.***

8. Entirely marine.

Order 1. Cephalaspidea

1. They are burrowing having shield-like head.

2. Shell and mantle cavity are moderately developed.

3. Lateral parapodial lobes are prominent.

Examples: *Acteon* (bubble shell), *Bulla*, etc.

Order 2. Anaspidea

1. They are crawling or swimming forms having a pair of rhinophores on head.

2. They have small internal shell.

3. They have reduced mantle cavity on right side.

4. Parapodial lobes are prominent.

Examples : *Akera, Aplysia* (sea hare), etc.

Order 3. Thecostomata (Pteropoda)

1. These are shelled ***pteropods*** or ***butterflies.***

2. The shell is spirally coiled or a non-spirally coiled ***pseudoconch.***

3. Mantle cavity is well developed.

4. ***Parapodial fins*** are large.

Examples: *Cresis, Limacina, Cavolina, Clino,* etc.

Order 4. Gymnostomata

1. These are naked ***pteropods*** and ***planktonic.***

2. Shell and mantle cavity are absent.

3. Small ventral ***parapodial fins*** are present.

Examples: *Pneumoderma, Cliopsis,* etc.

Order 5. Notaspidea

1. Shell is external or reduced and internal.

2. Mantle cavity is absent; but a skirt-like projection of ***mantle*** covers gill on the right side.

Example : *Pleurobranchus.*

Order 6. Acochlidiacea

1. They are small, without shell and gill.

2. They have naked visceral mass projecting behind the foot and covered with spicules.

Example : *Acochlidium.*

Order 7. Sacoglossa

1. They are herbivores, with a modified radula and suctorial pharynx.

2. They are shelled or naked slug-like, with a gill.

3. Sperm duct is closed.

Examples : *Elysia, Oxynoe.*

Order 8. Acoela (Nudibranchia)

1. They are naked, bilaterally symmetrical sea-slugs without shell, mantle cavity, ctenidia and osphradium.

2. They have secondary gills around anus or surface outgrowths or cerata.

Examples : *Doris, Aeolis, Eolidia, Tritonia.*

Sub-class 3. Pulmonata

1. They are air-breathing gastropods in which the mantle cavity is modified into a lung with a small opening. The ctenidia are absent.

2. The shell is a simple spiral or vestigeal or absent and an operculum is never found.

3. Head has 1 or 2 pairs of tentacles and 1 pair of eyes.

4. They undergo ***torsion,*** but the nervous system is symmetrical owing to great shortening of visceral nerves and consequent withdrawal of the visceral ganglia into the sub-region.

5. The ***heart*** has a single auricle lying anterior to ventricle.

6. They are ***hermaphrodite***, gonad is single and development is ***direct.***

7. They are mainly freshwater and terrestrial forms, a few are marine members.

Order 1. Basommatophora

1. They have one pair of non-invaginable tentacles with the eyes at their base.

2. A delicate shell is present with a conical spire and large aperture.

3. Mostly freshwater, some marine and brackish-water forms.

4. Some have secondary gills.

5. Male and female gonopores are usually separate.

Examples : *Limnaea, Planorbis, Siphonaria, Physa,* etc.

Fig.11.5: Common molluscs.

Order 2. Stylommatophora

1. They have two pairs of retractile tentacles, with the eyes at the tips of the posterior pair.

2. Shell with a conical spire, rudimentary, internal or absent in slugs.

3. They are mostly terrestrial.

4. Male and female gonopores are usually united.

Examples : Land-snails *(Helix)* and Slugs (*Limax, Arion, Onchidium, Vaginulus).*

Class 5. Scaphopoda

1. The foot is ***boat-shaped.***

2. Shell is ***tubular*** opening at both ends.

3. No head.

4. The eyes, the tentacles and ctenidia are absent.

5. ***Marine,*** bilaterally symmetrical molluscs.

6. Includes ***tusk shells.***

Examples: *Dentalium, Siphonodentalium* and *Pulsellum.*

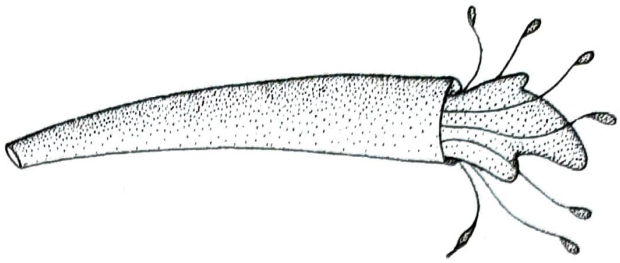


Fig.11.6: Dentalium.

Class 6. Pelecypoda (Bivalvia)

1. They have ***bilateral symmetry.***

2. The body is laterally compressed.

3. The shell consists of two ***valves*** and hence the name ***Bivalvia.***

4. The foot is ***wedge shaped*** and hence the name ***Pelecypoda.***

5. The ***head*** is absent.

6. ***Mouth*** and ***anus*** are at the opposite ends.

7. ***Mantle*** is formed of two lobes.

8. ***Radula*** is absent.

9. Alimentary canal shows a ***crystalline style.***

10. ***Respiration*** is by paired ***gills.***

11. ***Kidneys*** are paired.

12. ***Sexes*** are separate.

13. ***Gonads*** open into the mantle cavi

14. Development includes ***trochophore, veliger*** and ***glochidium larva.***

15. They are ***aquatic.***

16. They are sedentary or burrowing in habit.

Examples: *Unio, Cardium, Teredo, Pholas, Nucula, Mytilus, Lamellidens, Pecten, Pinctada,* etc.

Order 1. Protobranchiata

1. Gills are in the form of a single pair of plume.

2. The ***foot*** is dorsoventrally compressed.

Examples:*Nucula, Leda* and *Solenomya.*

Order 2. Filibranchiata

1. Gills are of single pair and ***plate-like.***

2. Out of the two adductor muscles, the anterior one is reduced or absent.

Examples: *Mytilus, Anomia, Trigonata,* etc.

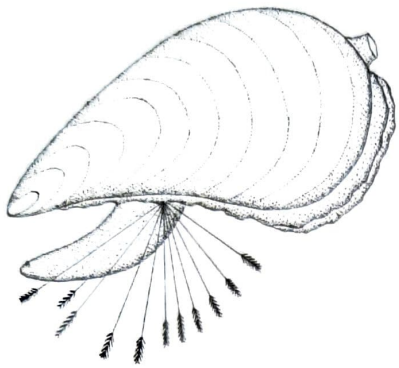


Fig.11.7: Mytilus.

Order 3. Pseudolamellibranchiata

1. The gills are plaited.

2. The cilia are present on the inter filamentar junctions.

3. Only posterior adductor muscle is present which is very large.

Examples : *Crassostrea, Pecten, Ostrea, Lima, Pinna,* etc.

Order 4. Eulamellibranchiata

1. Inter filamentar junctions and inter lammellar junctions are vascular.

2. The gills are ***basket-like.***

3. The two ***adductor muscles***, anterior and posterior are present.

Examples: *Unio, Lamellidens, Anodonta, Cardium, Teredo, Solen, Pholas,* etc.

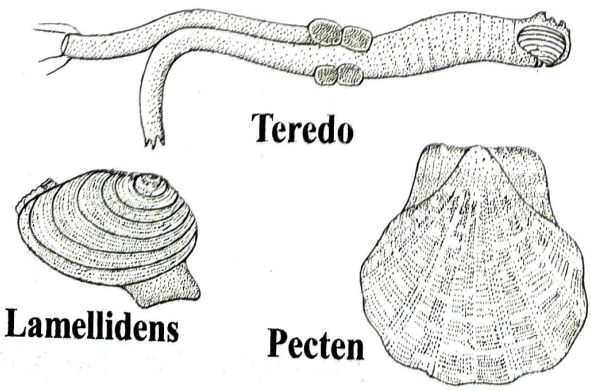


Fig.11.8: Some molluscs.

Order 5. Septibranchiata

1. The ***gills*** are reduced.

2. The ***gills*** are in the form of horizontal septa

3. The ***adductor muscles*** are two.

Examples : *Poromya, Guspidaira,* etc.

Class 7. Cephalopoda

1. The foot is modified into a funnel and tentacles (arms) present around the mouth Hence the name ***Cephalopoda.***

2. The body has a ***bilateral symmetry.***

3. The head is prominent and bears two large eyes.

4. The visceral mass is not coiled.

5. The shell is present or absent. It is external or internal.

6. The mouth is provided with ***jaws*** and ***radula.***

7. ***Gills*** are used for respiration.

8. The ***heart*** has two or four auricles and one ventricle.

9. Two pairs of kidneys are present.

10. ***Sexes*** are separate.

11. Development is ***direct.***

12. They are exclusively ***marine.***

Examples : *Loligo, Sepia, Spirula, Ammonites, Argonauta, Octopus,* etc.

Subclass 1. Nautiloidea (Tetrabranchia)

1. Shell external, coiled or straight; without complex sutures.

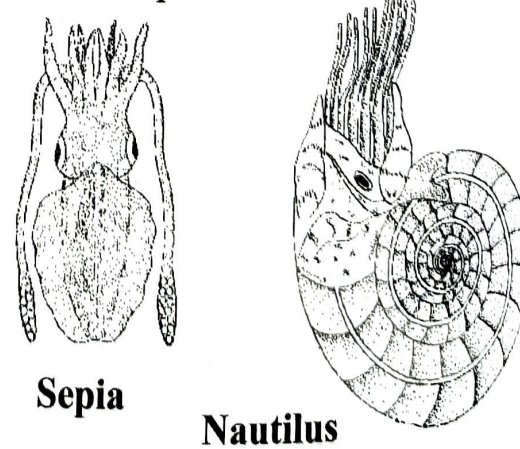


Fig.11.9: Some cephalopods.

2. Recent species with many suckerless tentacles.

3. Two pairs of gills; two pairs of nephridia.

Example : *Nautilus.*

Subclass 2. Ammonoidea

1. Extinct.

2. Shell external and coiled with complex septa and sutures.

Examples : *Pachydiscus, Ammonites, Goniatites,* etc.

Subclass 3. Belemnoidea or Coeloidea (Dibranchia)

1. ***Shell*** internal or absent.

2. ***Tentacles*** a few with suckers.

3. One pair of ***gills***, one pair of ***nephridia.***

Order 1. Decapoda

1. Ten arms-two elongated ***tentacles*** and eight short arms.

Examples : *Loligo, Sepia, Spirula,* etc.

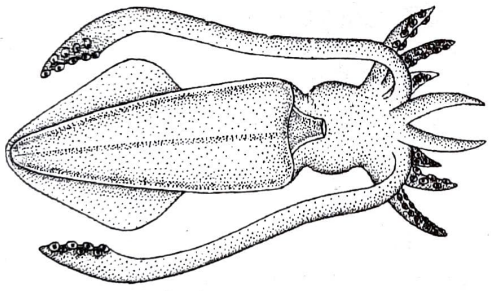


Fig.11.10: Loligo.

Order 2. Octopoda

1. Body globular and without fins.

2. Eight equal arms.

Examples : *Octopus, Argonauta,* etc.

Museum Specimens

1. Neomenia

Phylum : *Mollusca*

Class : *Solenogasters*

1. It is a ***marine*** animal.

2. The body is ***vermiform***.

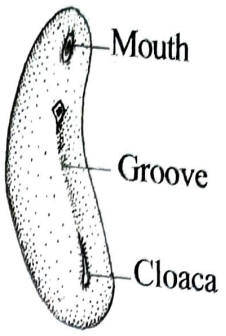


Fig.11.11: Neomenia.

3. It is ***bilaterally symmetrical.***

4. The head, foot, shell, gills are absent.

5. It has a ventral ***pedal groove.***

6. It is ***hermaphrodite.***

2. Chaetoderma

Phylum : *Mollusca*

Class : *Solenogasters*

1. It is a ***marine*** mollusc.

2. It is ***worm-like.***

3. It lives on the ***bottom.***

4. It has no ***mantle, foot*** and ***shell.***

5. The ***gills*** are reduced.

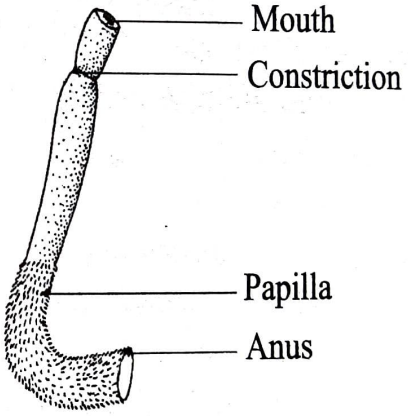


Fig.11.12: Chaetoderma.

6. The ***sexes*** are separate.

7. It has no ***pedal groove.***

3. Neopilina

Phylum : *Mollusca*

Class : *Monoplacophora*

1. *Neopilina galatheae* is a ***primitive marine mollusc***.

2. It is a ***connecting link*** between ***Annelida*** and ***Mollusca.***

2. Recent species with many suckerless tentacles.

3. Two pairs of gills; two pairs of nephridia.

Example : *Nautilus.*

Subclass 2. Ammonoidea

1. Extinct.

2. Shell external and coiled with complex septa and sutures.

Examples : *Pachydiscus, Ammonites, Goniatites,* etc.

Subclass 3. Belemnoidea or Coeloidea (Dibranchia)

1. ***Shell*** internal or absent.

2. ***Tentacles*** a few with suckers.

3. One pair of ***gills***, one pair of ***nephridia.***

Order 1. Decapoda

1. Ten arms-two elongated ***tentacles*** and eight short arms.

Examples : *Loligo, Sepia, Spirula,* etc.

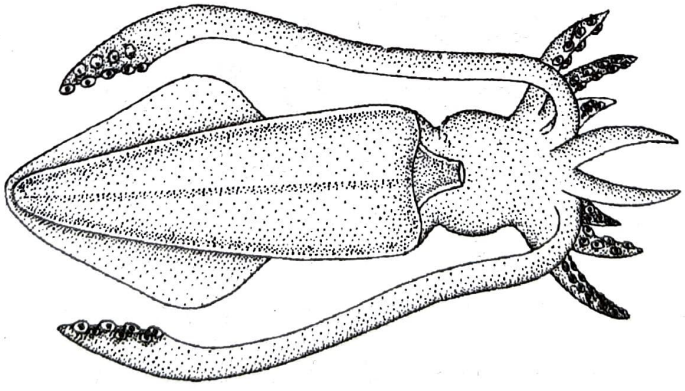


Fig.11.10: Loligo.

Order 2. Octopoda

1. Body globular and without fins.

2. Eight equal arms.

Examples : *Octopus, Argonauta,* etc.

Pila

Phylum : *Mollusca*
Class : *Gastropoda*
Order : *Pectinibranchia*

Pila is commonly called ***apple snail.*** It has a soft, unsegmented body covered by a mantle and a shell. Hence, it is placed in the phylum ***Mollusca***. It is an asymmetrical animal with a spirally coiled shell. It appears to walk on foot. Hence, it is included in the class ***Gastropoda.***

Pila is a freshwater animal. It lives in ponds, tanks, lakes, rivers, wells and paddy fields. It can also live on land. So it is an ***amphibious*** animal. It creeps on the substratum. It is ***herbivorous*** in habit.

Shell

The soft body of the *Pila* is covered by a ***shell.*** It is spirally coiled. The coils are called ***whorls.*** The upper whorl is small and is called ***apex.*** It is located at the top of the shell. It is the first formed whorl. Hence it is the oldest whorl. The lower most whorl is larger and it is called ***body whorl.*** It is the youngest whorl. The line of contact between the whorls is called ***suture.***

The surface of the shell is marked by vertical ridges called ***lines of growth.*** A few lines of growth are prominent and they are called ***varices*** (Sl=***varix***). The varices represent seasonal cessation of the growth of the shell.

The shell opens out by a large opening called ***shell mouth.*** The margin of the shell mouth is called ***lip.*** It is formed of an ***inner lip*** and an ***outer lip.*** The mouth is directed towards the right side. Hence the shell is ***dextral.*** Very rarely, the mouth is directed towards the left side. This type of shell is called ***sinistral.***

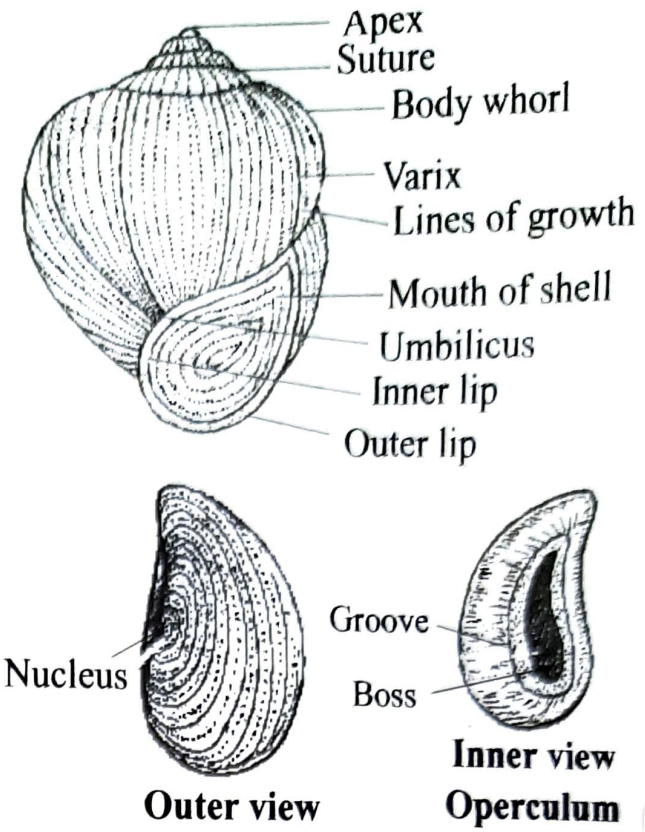


Fig.11.39: Pila shell.

The mouth of the shell is closed by a lid called ***operculum***. The outer surface of the operculum bears concentric lines called ***lines of growth***. They are placed around a nucleus. The inner surface of the operculum has an elliptical area called ***boss.*** Muscles are attached to the boss. The boss is surrounded by a ***groove.***

The ***shell*** is coiled around a central axis called ***columella.*** The columella is hollow. It opens to the exterior by a small opening called ***umbilicus.*** This opening is located near the ***inner lip.***

The shell is formed of three layers, namely an outer ***periostracum,*** a middle ***ostracum*** and an inner ***hypostracum.*** The periostracum is formed of a chitinous substance called ***conckiolin.*** The ostracum and hypostracum are made of ***calcium carbonate*** and ***conckiolin.***

Body Organization

The body of *Pila* is soft. It is divisible into three parts, namely ***head, foot*** and ***visceral mass.***

The head has two pairs of ***tentacles*** and a pair of ***eyes.*** The anterior pair of tentacles are called ***cephalic tentacles*** or ***labial palps.*** The mouth lies below the cephalic tentacles in the midline. The posterior tentacles are highly contractile and are called ***true-tentacles.*** The eyes are borne on stalks called ***ommatophores***. At the sides of the head, the mantle is produced into processes called ***nuchal lobes*** or pseudepipodia of the two pseudepipodia the left one is much longer than the right one.

The ***visceral mass*** forms the main part of the body and is spirally coiled like the shell. It is covered by a fold of skin known as ***mantle*** or ***pallium.*** Between the free margin of the mantle and the body there is a wide space known as ***mantle cavity,*** within which a number of organs are lodged.

The ***foot*** is ventral and highly muscular. It has a flat ventral ***surface*** known as ***creeping sole***. The foot is formed of two regions, namely an anterior ***propodium*** and a posterior ***metapodium.*** The operculum is attached to the metapodium.

Pallial Complex

The cavity lying between the body and the mantle is called ***mantle cavity.*** It contains a number of organs collectively called ***mantle complex*** or ***pallial complex***. The following organs form the pallial-complex:

1. Ctenidium

It is the gill used for aquatic respiration. It is arranged on the ***right side*** of the mantle cavity. It has a ***central axis*** and a series of gill lamellae arranged on one side of the axis. This type of ctenidium is known as ***monopectinate*** ctenidium.

2. Rectum

It is the posterior region of the digestive tract. It is located towards the left side of the ctenidium. It runs parallel to the ctenidium and opens into the mantle cavity by the anus situated on a projection called ***papilla.***

3. The Genital duct

The genital duct runs parallel to the rectum on the left side of it. The genital duct is the ***oviduct*** in the female and the ***vas deferens*** in the male. The external opening of

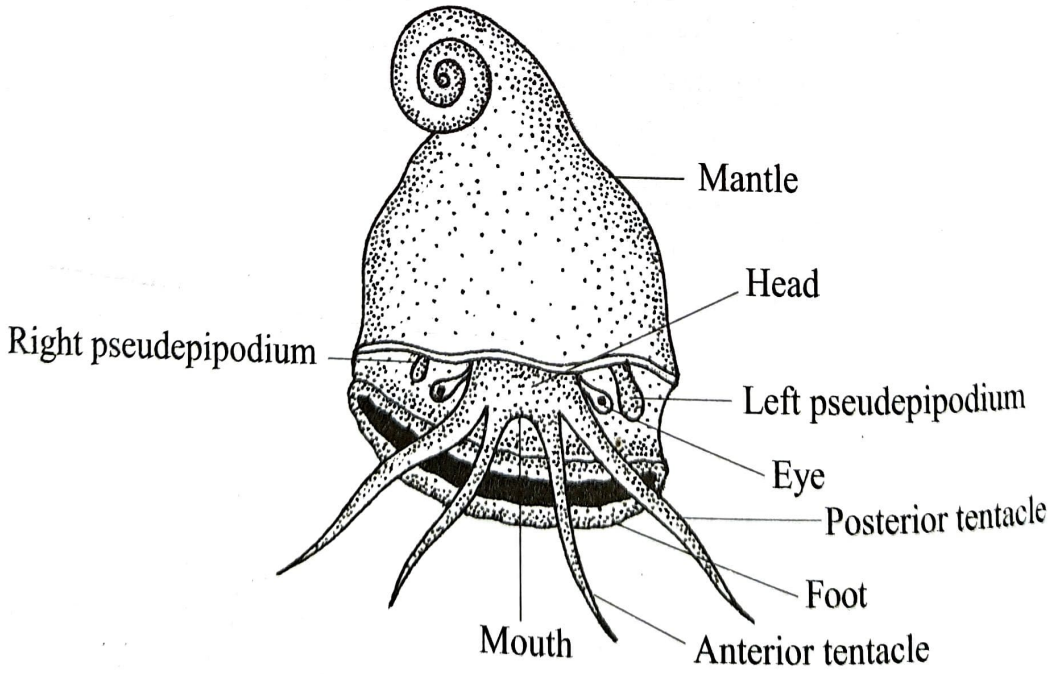


Fig.11.40: Pila-Shell removed.

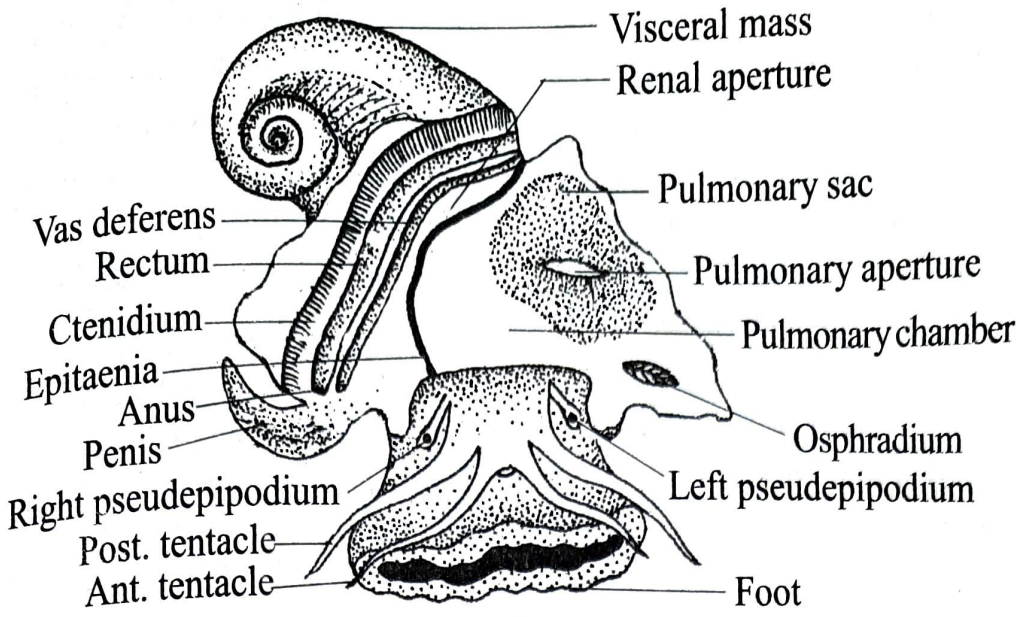


Fig.11.41: Pila-Pallial complex.

the genital duct is located near the anus. In the male there is a ***copulatory organ*** or ***penis*** lying close to the genital opening. At the base of the penis there is a glandular organ called ***hypobranchial*** gland.

4. The Epitaenia

It is a thick muscular ridge. It runs from the anterior edge of the right nuchal lobe to the posterior end of the mantle cavity. The ridge divides the mantle cavity into a right ***branchial*** or ***ctenidial chamber*** and a left ***pulmonary chamber.*** It plays an essential role in aerial and aquatic respirations.

5. The Anterior chamber of the Kidney

The anterior chamber of the kidney projects into the branchial chamber near the posterior end of ***epitaenia.*** It opens into the mantle cavity by the ***renal aperture.***

6. Pulmonary Sac

It is a sac hanging in the mantle cavity from the roof of the mantle. It opens into the mantle cavity by the ***pulmonary aperture.***

7. The Osphradium

It is a comb-shaped organ attached to the mantle near the left nuchal lobe. It is formed of a central axis and two rows of ***lamellae.*** It is olfactory in function.

8. Pseudepipodia

These are the foldings of the margins of the mantle on either side of the head. They are also called ***nuchal lobes.*** They are used for respiration.

Digestive System

The digestive system is formed of the ***alimentary canal*** and the ***digestive glands.***

Alimentary Canal

The alimentary canal is well developed. It consists of the ***mouth,*** the ***buccal mass,*** the ***oesophagus,*** the ***stomach,*** the ***intestine,*** the ***rectum*** and the ***anus.***

The mouth is a slit-like opening lying below the anterior tentacles. The mouth leads into the ***buccal mass.*** It has thick muscular wall and encloses a cavity. The cavity contains a pair of cuticular ***jaws*** and a ***radula.*** The radula is elongated and ***ribbon-shaped*** and it lies on an elevated ridge known as ***odontophore*** on the floor of the buccal mass.

The radula is formed of a ***flap*** and a narrow ***strap.*** The strap is covered with numerous minute teeth arranged in transverse rows. Each transverse row contains 7 teeth. They are central or median ***rachid-***

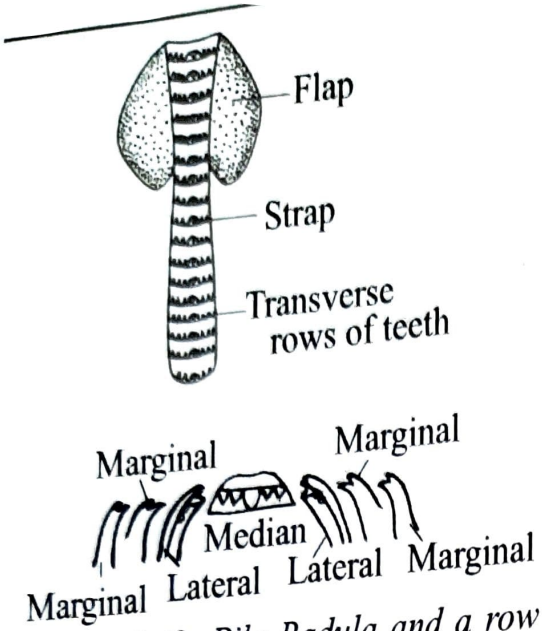


Fig.11.42: Pila-Radula and a row of teeth.

ian tooth, two smaller ***lateral teeth*** and four ***marginal teeth.*** The posterior part of the radula lies into a diverticulum called ***radular sac.*** The teeth are secreted by ***odontoblasts.*** The food materials are rasped by the radula.

The ***buccal mass*** leads into the ***oesophagus.*** It is a straight tube. It opens into the ***stomach.*** There are two round ***oesophageal pouches*** lying near the anterior end of oesophagus. They open into the anterior part of oesophagus. These are of unknown function.

The ***stomach*** is located on the left side of the visceral mass and is divisible into two parts, namely a sac-like ***cardiac*** region and a tubular ***pyloric*** region. A small rounded ***caecum*** arises from the pyloric region. The pyloric region leads into the intestine.

The ***intestine*** is long and coiled. It elongates into the rectum, which lies in the mantle cavity. The rectum opens into the mantle cavity by the ***anus.***

Digestive Glands

Pila has two types of digestive glands. They are the ***salivary glands*** and the ***hepatopancreas.***

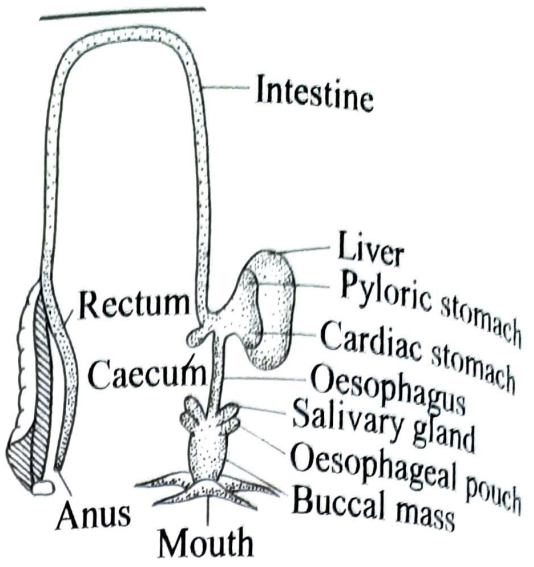


Fig.11.43: Pila-Digestive system.

1. Salivary glands: *Pila* has a pair of salivary glands. They are located on the dorsal side of oesophageal pouches. From each gland arises a duct called ***salivary duct.*** The salivary glands open into the buccal cavity. The salivary secretion contains ***mucous*** and ***enzymes.***

2. Hepatopancreas: It lies in the visceral mass. It is brownish in colour. It is formed of two main lobes. Each lobe is formed of minute tubules. The tubules of each lobe unite together to form a large duct. The two ducts join together to form a common duct called ***hepatic duct.*** It opens into the stomach at the junction of ***cardiac*** and ***pyloric*** regions.

The hepatopancreas is formed of three types of cells, namely ***secretory cells, resorptive cells*** and ***lime-containing cells.*** The secretory cells secrete enzymes. The resorptive cells digest proteins ***intracellularly.*** The lime-containing cells store ***calcium carbonate.***

Feeding and Digestion

Pila is a ***herbivore.*** The food consists of aquatic plants. They are cut into pieces by the jaws. They are made into small particles by the rasping activity of the radula.

The secretion of the salivary glands is poured into the buccal cavity and the food

is mixed up with the secretion. It helps in digesting ***starch.*** Further digestion takes place inside the stomach by the secretion of the digestive gland. The digestion of cellulose is mainly completed here. After the digestion of cellulose some amount of food passes through the hepatic duct and is absorbed by the ***resorptive*** cells of hepatopancreas. These cells digest the food by ***intracellular*** method.

The digested food diffuses into the blood. From the stomach the food enters the intestine. The absorption of digested food takes places mainly in the intestine. The undigested food is passed into the mantle cavity through the anus. From the mantle it is passed out through the out going water.

Respiratory System

Pila is an amphibious animal. It has two modes of respiration. They are ***aquatic respiration*** and ***pulmonary respiration.***

1. Aquatic Respiration

When *Pila* is in the water, aquatic respiration takes place. The respiratory organ for aquatic respiration is the ***gill*** or ***ctenidium.*** *Pila* has a single gill. It is located in the branchial chamber of the mantle cavity.

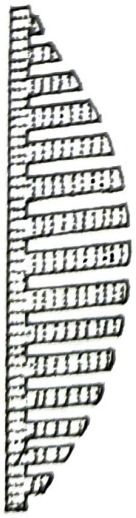


Fig.11.44:Pila-Ctenidium.

It has an ***axis.*** The axis is attached to the mantle along its length. The axis bears a single row of triangular plates called ***lamellae.*** This type of gill is called ***mono-pectinate.*** Each lamella has a broad base and a narrow end. It is attached to the axis by the broad base and the narrow end hangs into the branchial chamber. The lamellae of the middle region are larger and their size decreases towards the ends. The right side of the lamella is short. This side is called ***afferent side.*** The left side is long and this side is called ***efferent side.***

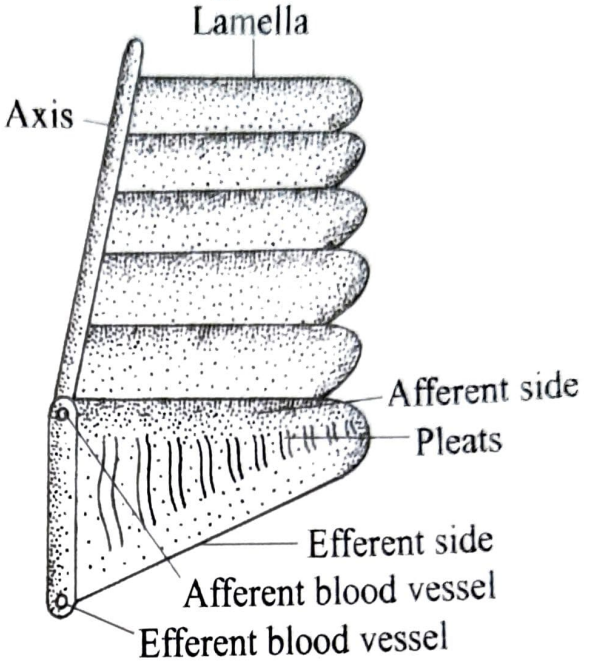


Fig.11.45: Pila-A portion of ctenidium.

Each lamella bears many transverse ridges called ***pleats*** on both of its flat surfaces. The pleats are longer at the base of lamella and shorter at the apex. The pleats are richly supplied with blood-vessels. The lamellae are ciliated.

Mechanism of Aquatic Respiration

When *Pila* is in the water, aquatic respiration takes place. The cilia of the ctenidium and the continuous rise and fall of the floor of the mantle cavity create a water current. The water enters the pulmonary chamber through the left ***pseudepipodium.***

It crosses the epitaenia and enters the branchial chamber. The ctenidium is bathed in water. The exchange of gases takes place between the blood of ctenidium and water. The used up water is passed out through the right ***pseudepipodium.***

2. Pulmonary Respiration

It occurs when *Pila* is on land. The respiratory organ is the ***lung*** or ***pulmonary sac.*** It is located in the pulmonary chamber of the mantle cavity. The pulmonary sac is in the form of a bag hanging from the roof of the mantle. It is a part of the modified mantle. It opens into the pulmonary chamber by an opening called ***pulmonary aperture.*** The wall of the pulmonary sac is highly vascular.

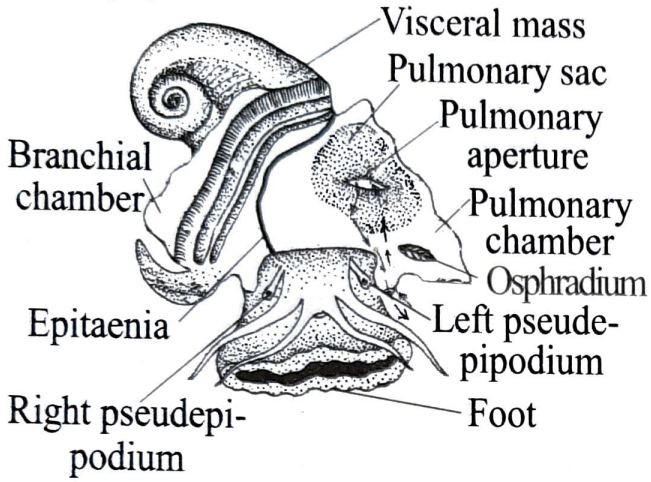


Fig.11.46: Pila-Aerial respiration.

Mechanism of Pulmonary Respiration

In pulmonary respiration air is used. The left pseudepipodium is used as the ***respiratory siphon.*** Air enters the pulmonary chamber through the left pseudepipodium. At this time the epitaenia is raised and is applied to the mantle. Hence the branchial chamber is cut off from the pulmonary chamber. The pulmonary sac exhibits rhythmic contraction and relaxation. During relaxation, the air from the pulmonary chamber enters the pulmonary sac through the pulmonary aperture. During contraction, the air passes into the pulmonary chamber from the pulmonary sac. The blood of the pulmonary sac takes in O_2 from the air and gives out CO_2.

Circulatory System

The circulatory system is ***open type.*** It consists of blood, pericardium, heart, arteries, sinuses and veins.

Blood

The blood is blue in colour. It contains plasma and corpuscles. The plasma contains a blue pigment called ***haemocyanin.*** This gives the blue colour to the blood. The corpuscles are colourless.

Pericardium

Pericardium is an oval sac. It encloses a cavity called ***pericardial cavity.*** The heart lies in the pericardial cavity. The posterior renal chamber opens into the pericardial cavity by the ***renopericardial aperture.*** The pericardial cavity represents the true coelom.

Heart

The heart is formed of two chambers, namely an ***auricle*** and a ***ventricle.*** The auricle is posterior in position. It is thin-walled and triangular in shape. It opens into the ventricle through an ***auriculoventricular aperture.*** It is guarded by a pair of ***semilunar valves.*** They allow the flow of blood from the auricle to the ventricle and not in the reverse direction. The auricle receives pure blood from the following three veins:

1. The efferent ctenidial vein brings blood from the gill.
2. The efferent pulmonary vein brings blood from the lung.
3. The efferent renal vein brings blood from the posterior renal chamber.

The ventricle is anterior in position. It is oval in shape and thick-walled. It receives blood from the auricle. A large artery arises from the ventricle. The artery is called ***aortic trunk.***

Arteries

A large vessel called ***aortic trunk*** arises from the ventricle. It divides into two branches, namely an anterior ***cephalic aorta*** and a posterior ***visceral aorta.*** The cephalic aorta is dilated near its own base to form a sac

called ***aortic ampulla.*** The aortic ampulla contracts rhythmically to help the flow of blood in the cephalic aorta. The cephalic aorta divides into many branches and they supply blood to the mantle, the pseudepipodium, the oesophagus, the skin, the head and the foot.

The visceral aorta divides into many branches and they supply blood to the stomach, the intestine, the liver, the gonad and the pericardium.

Sinuses

The impure blood from the various parts of the body is collected into small spaces called ***lacunae.*** These spaces join together to form large spaces called ***sinuses.*** These sinuses represent the ***haemocoel.*** There are four main sinuses. They are as follows:

1. Peri-visceral sinus: It is located below the mantle cavity. It surrounds the oesophagus and buccal mass.

2. Peri-intestinal sinus: It lies around the intestine.

3. Branchio-renal sinus: It lies along the right side of the anterior renal chamber.

4. Pulmonary sinus: It is located in the walls of the pulmonary sac.

Veins

The veins transport blood from the various parts of the body. There are five main veins. They are as follows:

1. Afferent ctenidial vein: It transports blood from the perivisceral sinus to the ctenidium.

2. Efferent ctenidial vein: It carries blood from the ctenidium to the auricle.

3. Afferent renal vein: It carries blood from the peri-intestinal sinus to the posterior renal chamber.

4. Efferent renal vein: It transports blood from the posterior renal chamber to the auricle.

5. Pulmonary vein: It carries blood from the pulmonary sac to the auricle.

Course of Circulation

The blood from the heart is supplied to all the organs of the body through the branches of the ***cephalic*** and ***visceral aortae.*** The blood is then collected in the ***perivisceral*** and ***peri-***

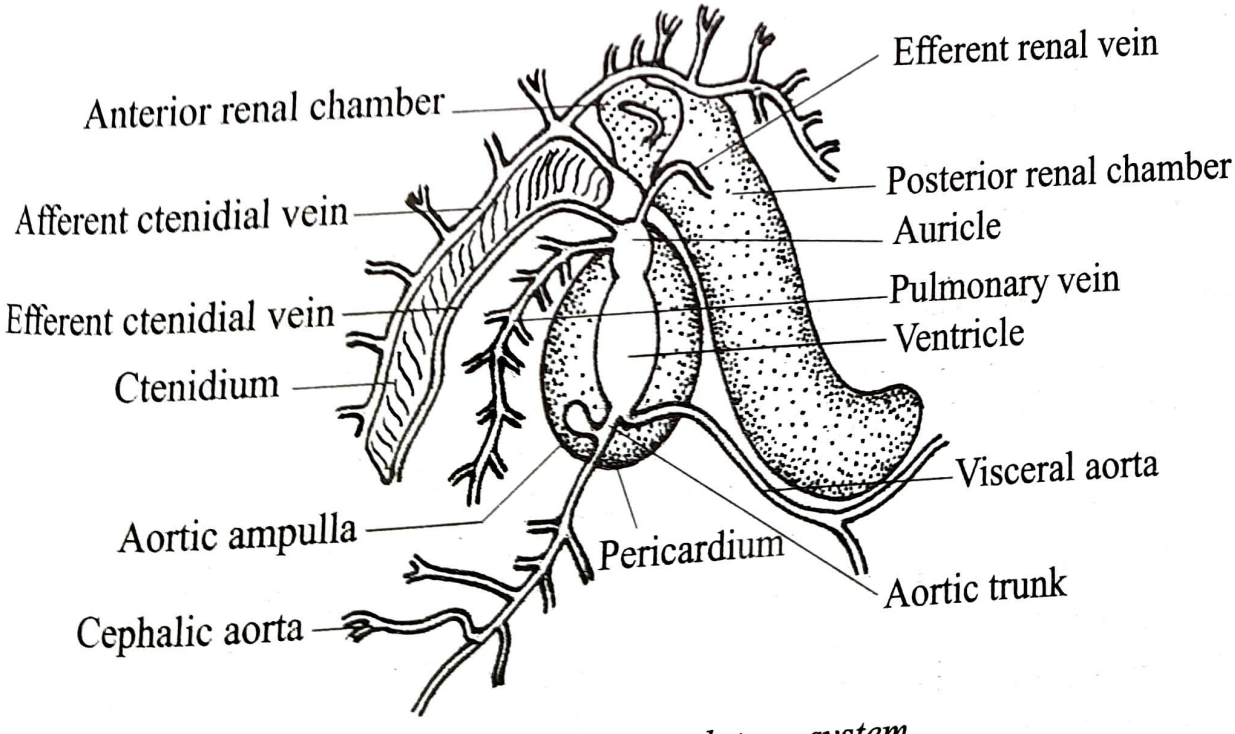


Fig.11.47: Pila-Circulatory system.

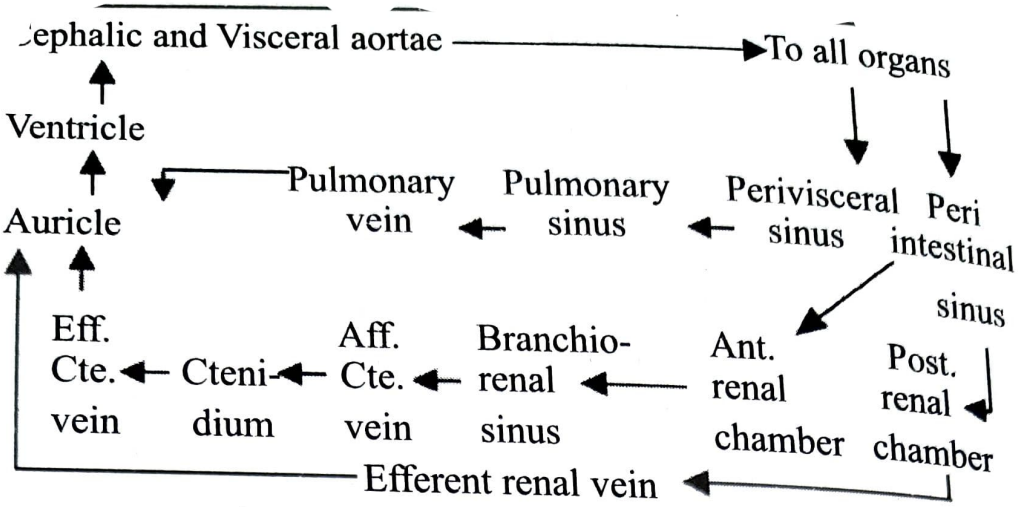


Fig.11.48: Pila-Course of circulation.

intestinal sinuses. From the perivisceral sinus, the blood passes into the branchiorenal sinus. During ***aquatic respiration,*** the blood from the branchiorenal sinus passes into the ctenidium through the afferent ctenidial vein. After the exchange of gases, the blood from the ctenidium passes through the efferent ctenidial vein into the auricle. During ***aerial respiration,*** the blood from the perivisceral sinus passes into the ***pulmonary sinus.*** After the gaseous exchange it enters the auricle through the pulmonary vein.

From the peri-intestinal sinus the blood enters the anterior and posterior renal chambers. After the removal of excretory waste materials inside the renal organ, the blood from the posterior renal chamber enters the auricle through the efferent renal vein. The blood from the anterior renal chamber goes to the ctenidium. After the gaseous exchange, the pure blood enters the auricle. Thus the auricle receives both the pure and impure blood.

Excretory System

The excretory system is formed of a single ***renal organ*** or ***kidney*** lying nearer to the pericardium. The kidney consists of an ***anterior chamber*** and a ***posterior chamber.***

The anterior chamber opens into the mantle cavity by the ***renal aperture.*** The anterior renal chamber is a reddish oval sac. The cavity of the anterior chamber is provided with many ***lamellae.***

The posterior chamber is broad at one end and hooked at the other end. The posterior chamber opens into the pericardium by the ***renopericardial aperture.*** It also opens into the anterior renal chamber. The afferent and efferent renal veins repeatedly branch into the roof of this chamber. The two renal chambers are supplied with blood from which the nitrogenous waste materials are separated. The waste material from the posterior chamber at first passes into the anterior chamber, from where it is liberated through the renal aperture into the mantle cavity. When the animal is inside water, it excretes ***ammonia*** and when it is on land it excretes ***uric acid.***

Nervous System

The nervous system of *Pila* is well developed. It has two special features. They are as follows:

1. Most of the ganglia are placed in the form of a ring around the buccal mass.

2. The nervous system is twisted in the form of the figure 8.

The nervous system is formed of ganglia, commissures, connectives and nerves.

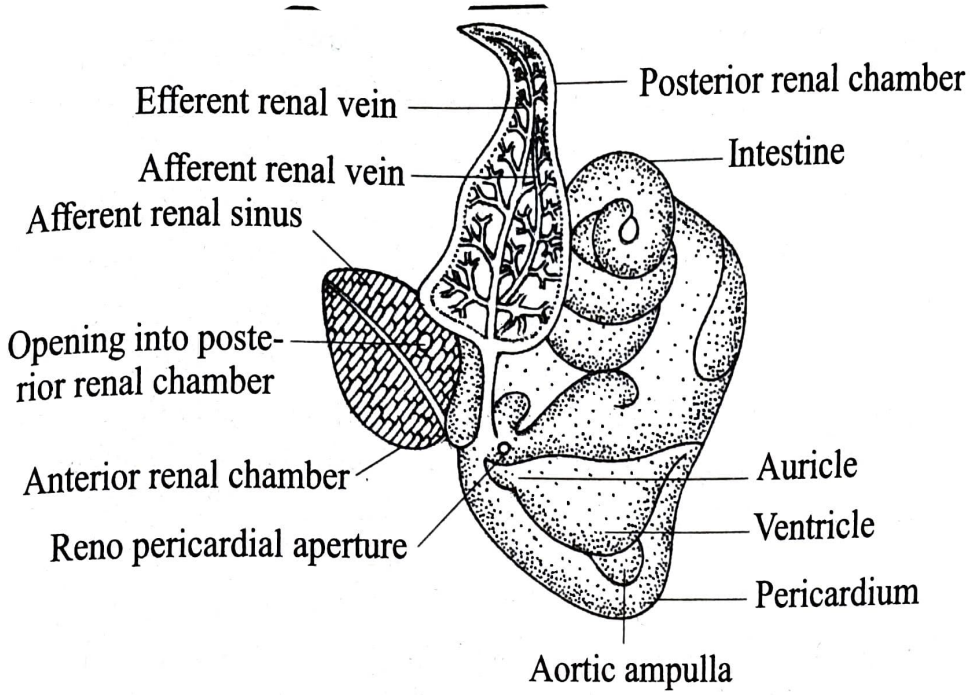


Fig.11.49: Portion of excretory organ with heart.

Ganglia

The nervous system of *Pila* has the following ganglia:

1.Cerebral ganglia: These are a pair of ganglia located beneath the buccal mass near its anterior end.

2. Pleural ganglia: These are a pair of ganglia situated beneath the buccal mass at its posterior end.

3. Pedal ganglia: *Pila* has a pair of ***pedal ganglia.*** They are situated on the inner side of the pleural ganglia. They are partly fused with the pleural ganglia.

4. Supra intestinal ganglion: It is a single ganglia located behind the left pleural ganglia.

5. Visceral ganglia: These are a pair of ganglia located in the visceral mass. They are fused together.

6. Buccal ganglia: These are paired ganglia located beneath the junction of the buccal mass and the oesophagus.

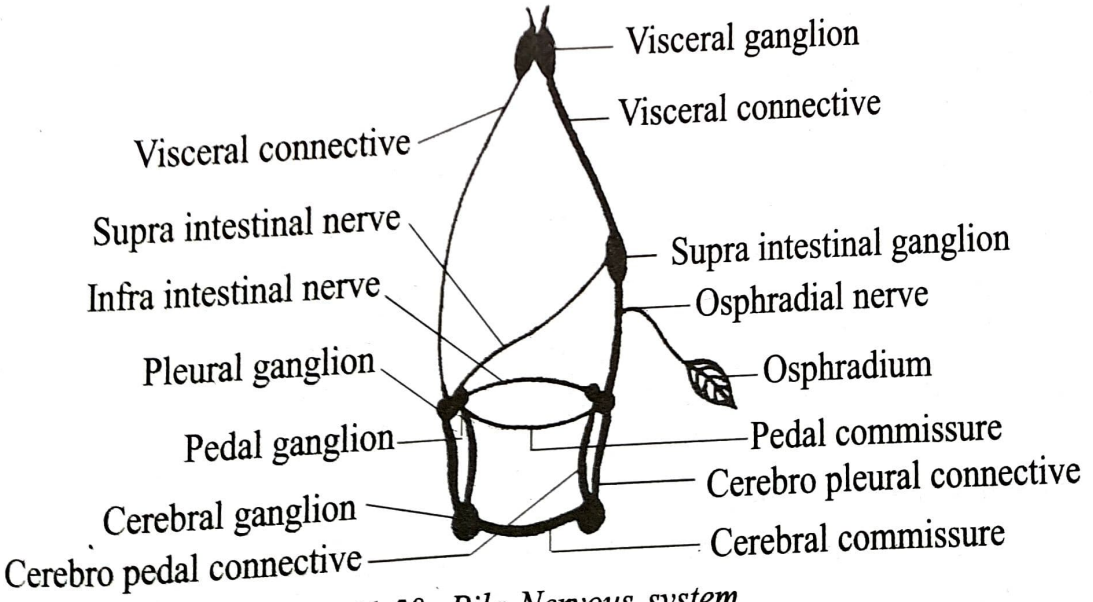


Fig.11.50: Pila-Nervous system.

Commissures

The nerves connecting similar ganglia are called ***commissures.*** *Pila* has the following commissures:

1. Cerebral commissure: It is a nerve connecting the two cerebral ganglia.

2. Pedal commissure: It is a nerve connecting the two pedal ganglia.

3. Buccal commissure: The buccal ganglia are connected together by a buccal commissure.

Connectives

The nerves connecting two dissimilar ganglia are called ***connectives.*** *Pila* has the following connectives:

1. Cerebro-pleural connectives: The nerves connecting cerebral ganglia with the pleural ganglia are called ***cerebro pleural connectives.***

2. Cerebro-pedal connectives: They connect the cerebral ganglia with the pedal ganglia.

3. Cerebro-buccal connectives: They connect the cerebral ganglia with the buccal ganglia.

4. Left visceral connective: It connects the supra intestinal ganglion with the visceral ganglion.

5. Right visceral connective: It connects the visceral ganglia with the right pleural ganglion.

Nerves

Pila has the following nerves:

1. Infra-intestinal nerve: It connects the two pleural ganglia. It runs below the oesophagus.

2. Supra-intestinal nerve: It connects the supra-intestinal ganglion and the right pleural ganglion. It runs above the oesophagus.

3. Osphradial nerve: It supplies the osphradium. It arises from the supra-intestinal ganglion.

Sense Organs

Pila has the following sense organs:

1. *Eyes*
2. *Osphradium*
3. *Statocysts* and
4. *Tentacles*

1. Eyes

Pila has two eyes. They are situated on the head. They are stalked and the stalk of the eye is called ***ommatophore.*** Each eye is in the form of an oval capsule called ***optic vesicle.*** It is embedded in the connective tissue. The wall of the optic vesicle is formed of two layers, namely an outer connective tissue and an inner layer of ***retinal cells.*** The retinal cells receive nerve connections. Anteriorly the optic vesicle is covered by a transparent membrane called ***inner cornea.*** Outer to the inner cornea, there is another transparent epithelial layer called ***outer cornea.*** The cavity of the optic vesicle is filled with a gelatinous substance called ***lens.*** The eyes cannot form images. But they detect changes in the intensity of light.

2. Osphradium

The ***osphradium*** is a leaf-like structure. It hangs from the mantle near the left nuchal lobe. It is a bipectinate structure. It has a ***central axis*** with two rows of leaf-like structures called ***lamellae.*** Osphradium is a ***chemoreceptor.*** It tests the chemical nature of water, entering through the left nuchal lobe. The foul water is prevented from entering the mantle cavity by the closure of the left nuchal lobe.

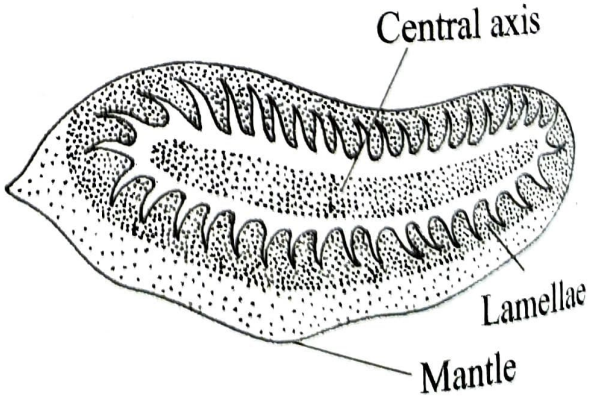


Fig.11.51: Pila-Osphradium.

3. Statocysts

Pila has two statocysts. Each statocyst is located in a depression in the foot near the pedal ganglion. It is a round ***capsule*** lined with ***epithelial cells*** and surrounded by ***connective tissues.*** The cavity of the statocyst is filled with a fluid. In this fluid a group of minute calcareous particles float. They are the ***statoconia.*** Each statocyst is innervated by the nerves from the cerebral ganglia and pedal ganglia. The statocyst maintains ***equilibrium.***

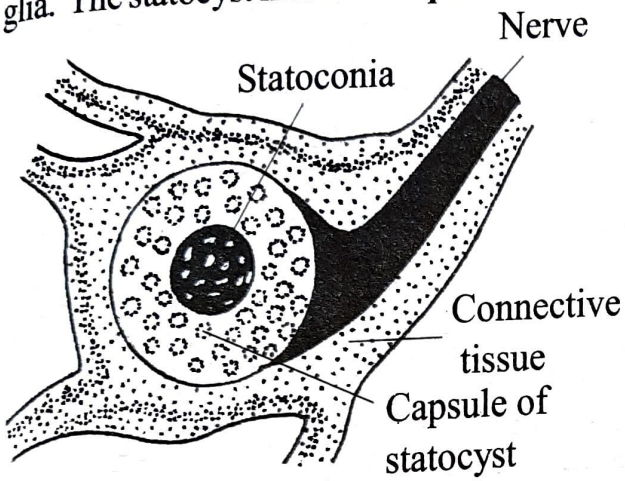


Fig.11.52: Pila-Statocyst.

4. Tentacles

There are two pairs of tentacles. They are located in the head. They are ***tactile*** sensory organs.

Reproductive System

In *Pila,* the sexes are separate. The females are comparatively larger in size. The male has a well developed copulatory organ.

Male Reproductive System

The male reproductive organs include the ***testis, vasa efferentia, vas deferens,*** the ***seminal vesicle,*** the ***copulatory organ*** and the ***hypobranchial gland.***

The ***testis*** is a single, flat, plate-like whitish structure occupying the upper part of the first two or three whorls of the shell. It is closely attached to the digestive gland. Numerous minute ***vasa efferentia*** arise from the testis and these tubules lead into a single ***vas deferens.*** The vas deferens consists of 3 portions, namely the upper thin-walled ***tubular*** portion, the middle swollen portion called ***seminal vesicle*** and the terminal ***glandular*** portion. The third portion opens into the mantle cavity on a genital papilla. The copulatory organ called ***penis*** lies in a ***penis-sheath*** and it gets connection with the genital opening only at the time of copulation. A ***hypobranchial gland*** of unknown function lies at the base of the penis-sheath.

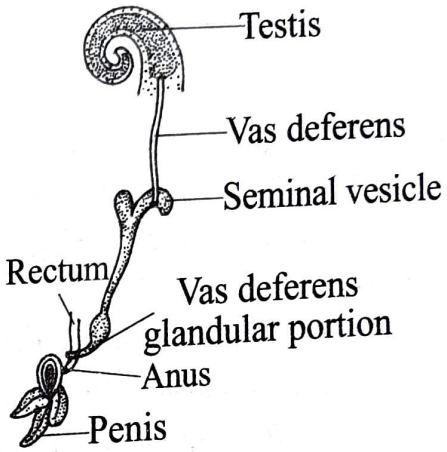


Fig.11.53: Pila-Male reproductive system.

Female Reproductive System

The female reproductive organs include the ***ovary,*** the ***oviduct,*** the ***seminal receptacle, uterus,*** the ***vagina,*** the ***genital aperture*** and a poorly developed ***hypobranchial gland.***

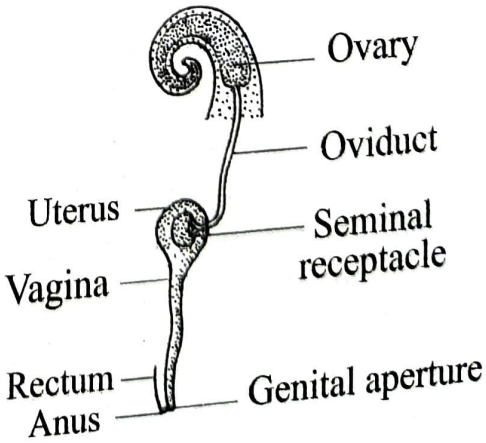


Fig.11.54: Pila-Female reproductive system.

The ***ovary*** occupies the same position as the testis in the male. It is dark in colour in the adults. From the ovary arises a long ***oviduct.*** The oviduct opens into a small spherical ***seminal receptacle.*** It leads into an enlarged ***uterus.*** It is continued into a ***vagina,*** which opens into the mantle cavity through the female ***genital aperture.*** The hypobranchial gland is poorly developed in the female.

Fertilization and Development

By means of copulation, the sperms are introduced into the seminal receptacles of the female. Fertilization is internal and more than 200 eggs are produced at a time. The eggs are laid on safe places and the young ones resemble the adult in form. Hence development is direct.

2. Foot in Mollusca

Foot is a muscular organ characteristic of mollusca. It is an outgrowth of the integument. It does different functions in different molluscs. On the basis of its function, it is variously modified in the different species of molluscs.

1. Foot in Amphineura

In *Neomenia,* the foot is vestigeal and it is in the form of a ciliated groove.

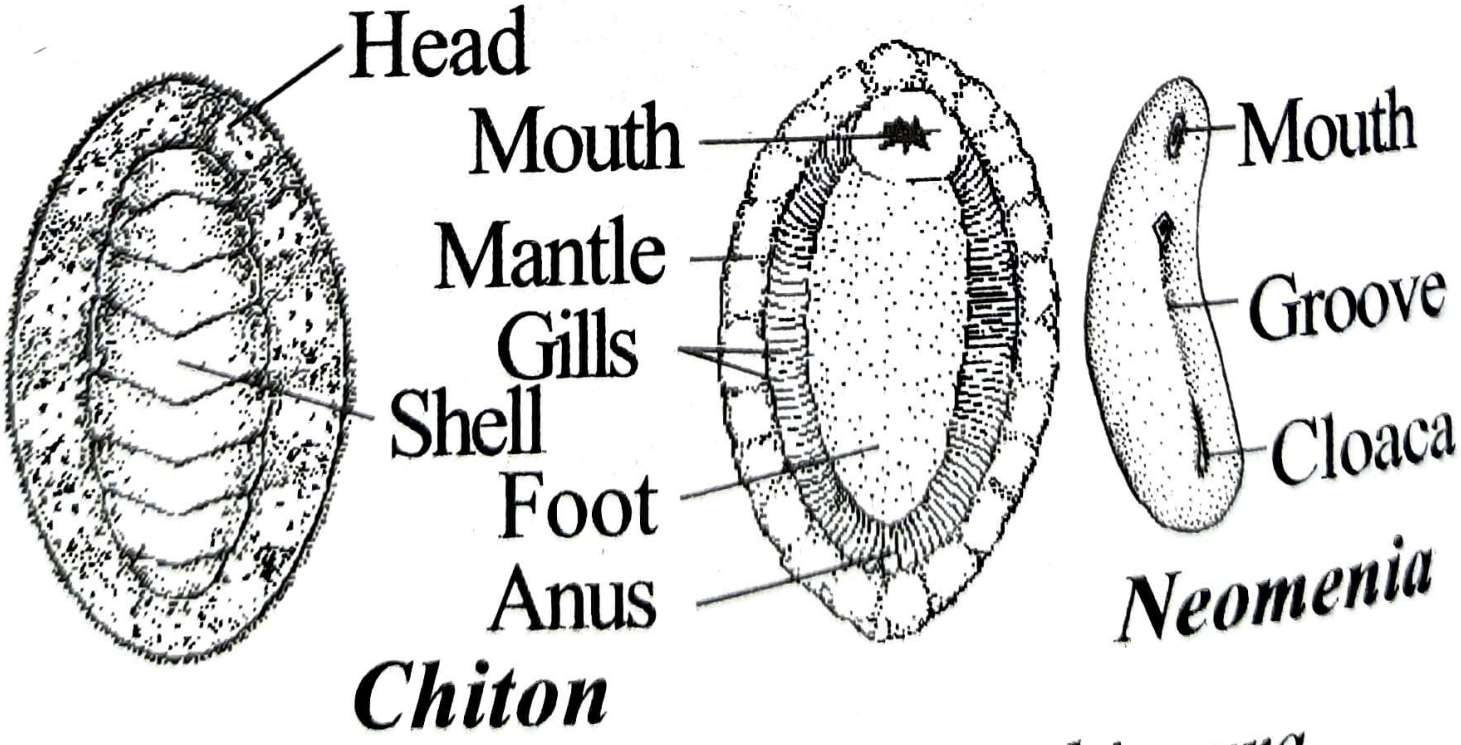


Fig.11.90: Foot in Amphineura.

In *Chiton,* foot is large, flat and sole-like. It occupies the whole length of the body on the ventral side.

2. Foot in Scaphopoda

In *Dentalium,* the foot is conical in shape. The free end of the foot is trilobed. In *Siphonodentalium*, the foot ends in a ***disc*** bearing papillae on the margin.

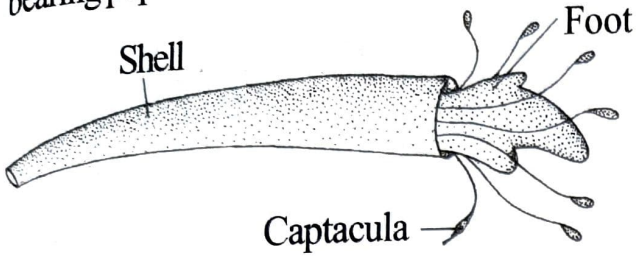
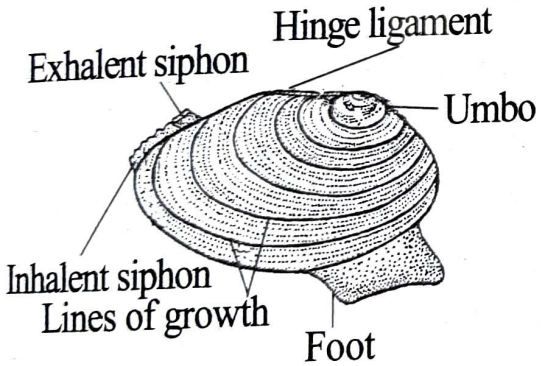


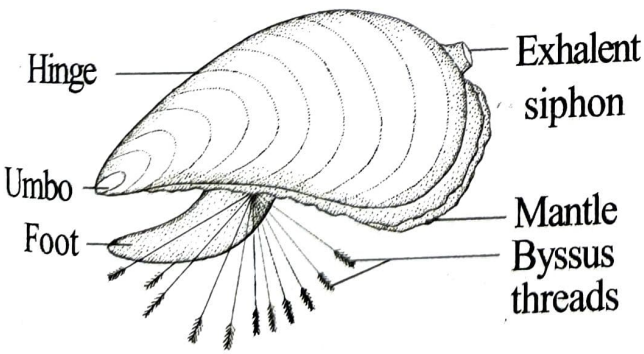
Fig.11.91: Foot in Dentalium.

3. Foot in Pelecypoda

The foot of pelecypods contains inside a part of the visceral organs like the stomach, the intestine, the liver, the gonads, etc. The foot attains different shapes in pelecypods. It is ***axe***-shaped in *Lamellidens*.



Lamellidens



Mytilus

Fig.11.92: Foot in Pelecypoda.

In *Mytilus,* the foot is ***tongue***-like and is provided with a number of thread-like structures called ***byssus threads***. In *Cardium,* it is long and can be bent. In *Nucula* and *Arca* the foot is flat.

Pholadomya and ***Holicardia*** have ar accessory foot-like organ called ***opistho po dium*** at the hind end of the visceral mass. Ir *Pholas, Pecten* and *Ostrea,* the foot is reduced owing to disuse.

4. Foot in Gastropoda

In gastropods, the foot is broad, flat and has a creeping sole. A typical foot consists of three parts, namely an anterior ***propodium***, a middle ***mesopodium*** and a posterior ***metapodium.*** (Fig.11.93). The foot contains the following structures:

1. Parapodium : These are the lateral lobes or wing like extensions of the foot. Eg. *Aplysia, Limacina, Cresis.*

2. Epipodium : It is a prominent fold arising from the sides or base of the foot along its entire length. Eg. *Haliotis, Fissurelia, Trochus,* etc.

3. Pedal Glands : These are mucous glands secreting mucous. The mucous lubricates the sole and helps creeping.

4. Operculum : It is attached to the metapodium. It is used to close the shell mouth. It is a disc-shaped in majority of gastropods. But in *Rostellaria* it is sharp and dagger shaped.

5. Foot in Cephalopoda

In cephalopods, the foot is developed into ***arms, tentacles*** and ***siphon***. The arms and tentacles develop from the anterior part of the foot and the siphon or funnel develops from the posterior part of the foot.(Fig.11.94).

Octopus has 8 arms. *Sepia* and *Loligo* have 8 arms and 2 tentacles. In the male one tentacle is modified into a ***hectocotylized arm*** used for copulation.

The arms and tentacles bear cup-like structures called ***suckers.*** The suckers are

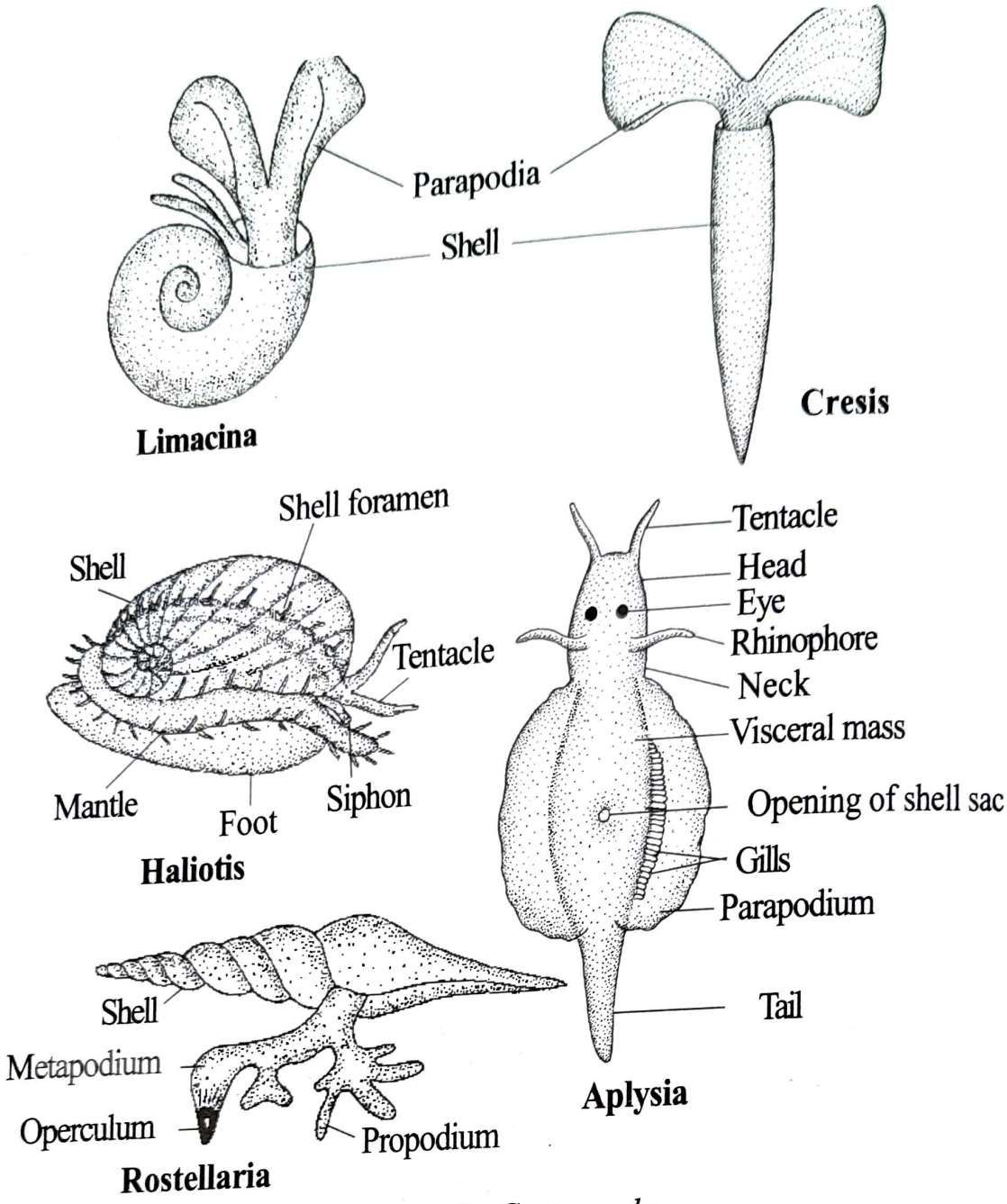


Fig.11.93: Foot in Gastropoda.

stalked in *Sepia* and *Loligo* but sessile in *Octopus.* The suckers may be armed with hooks. The arms and tentacles are used for attachment and food-capturing.

The siphon is tube-like. One end of siphon opens into the mantle cavity and the other end opens to the outside. *Sepia* and *Octopus* dart quickly by forcing out jets of water through the funnel.

Modifications of Foot on the Basis of Mode of Life

The foot is used for locomotion and for many other functions. Accordingly, the foot is modified in different molluscs. The modifications, according to their way of life, are given below:

1. Sedentary forms : In sedentary forms, the foot is reduced or absent. Eg. *Ostrea.* In *Mytilus,* the foot is reduced and cylindrical; It contains ***byssus threads*** by which the animal is attached to the rocks.

2. Parasitic forms : In molluscan parasites like *Stylifer, Thyco*, etc. the foot is completely absent or reduced to small appendages.

3. Creeping forms : In creeping forms, the foot is large, flat and sole-like. Eg. *Chiton.*

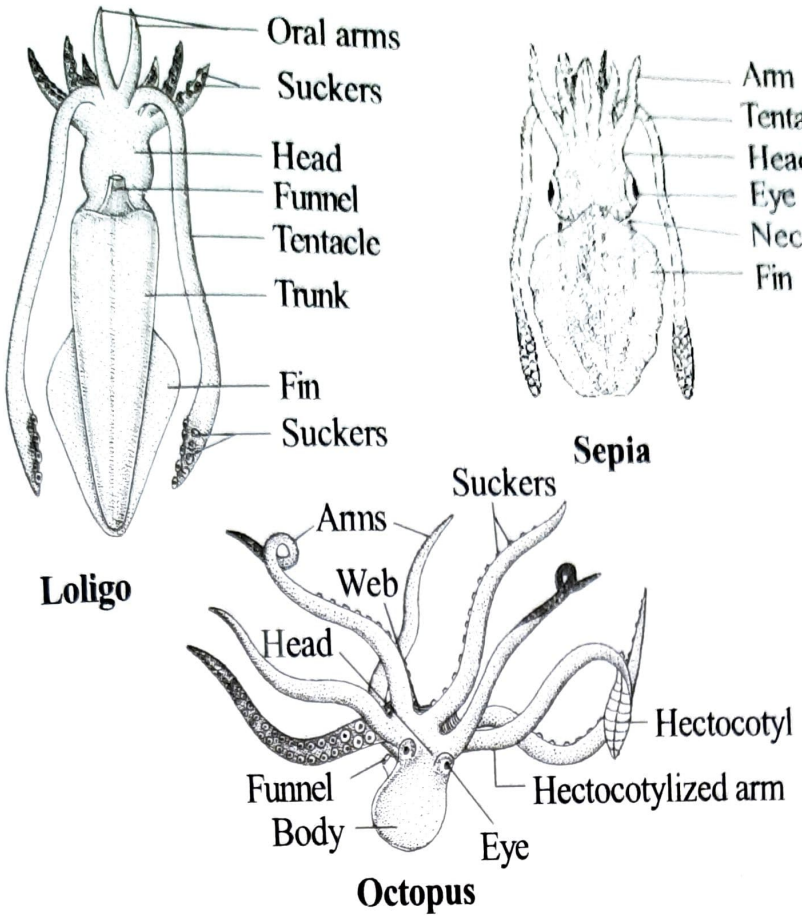


Fig.11.94: Foot in Cephalopoda.

4. Leaping forms : In *Cardium,* the foot is large and narrow. It can be bent on itself and can be straightened suddenly. This helps the animals to leap.

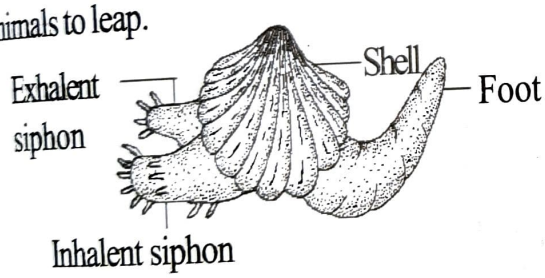


Fig.11.95: Cardium.

5. Swimming forms : In *Aplysia,* the lateral extensions of the foot are called ***parapodia.*** They are used as fins for swimming. In *Loligo* and *Sepia,* the ***arms, tentacles*** and the ***siphon*** are used for swimming.

6. Floating forms : In floating forms, the foot is produced into fin-like structures called ***parapodia.*** The parapodia are used for floating. In *Limacina,* the parapodia are large. In *Cavolina,* each epipodium is broad and trilobed.

7. Burrowing forms : In burrowing gastropods, the propodium is used for digging. Eg. *Natica, Oliva,* etc.

In pelecypods, the foot is wedge-shaped. In *Dentalium,* the free end of the foot is conical and trilobed. In *Solen* and *Ensis,* the foot is large and conical in shape. It can swell with the flow of blood and it becomes a very stiff digging organ.

8. Siphoning forms : In siphoning forms, water is forced out in the form of a jet through the siphon. This act propels the body. This type of locomotion is exhibited by *Sepia, Loligo* and *Octopus*. In these forms, the posterior part of the foot is modified into a siphon. One end of the siphon opens into the mantle cavity and the other end opens to the outside. The water from the mantle cavity is forced out in the form of a jet.

9. Boring forms : The boring forms make holes in ships, wood and rocks. The bor-

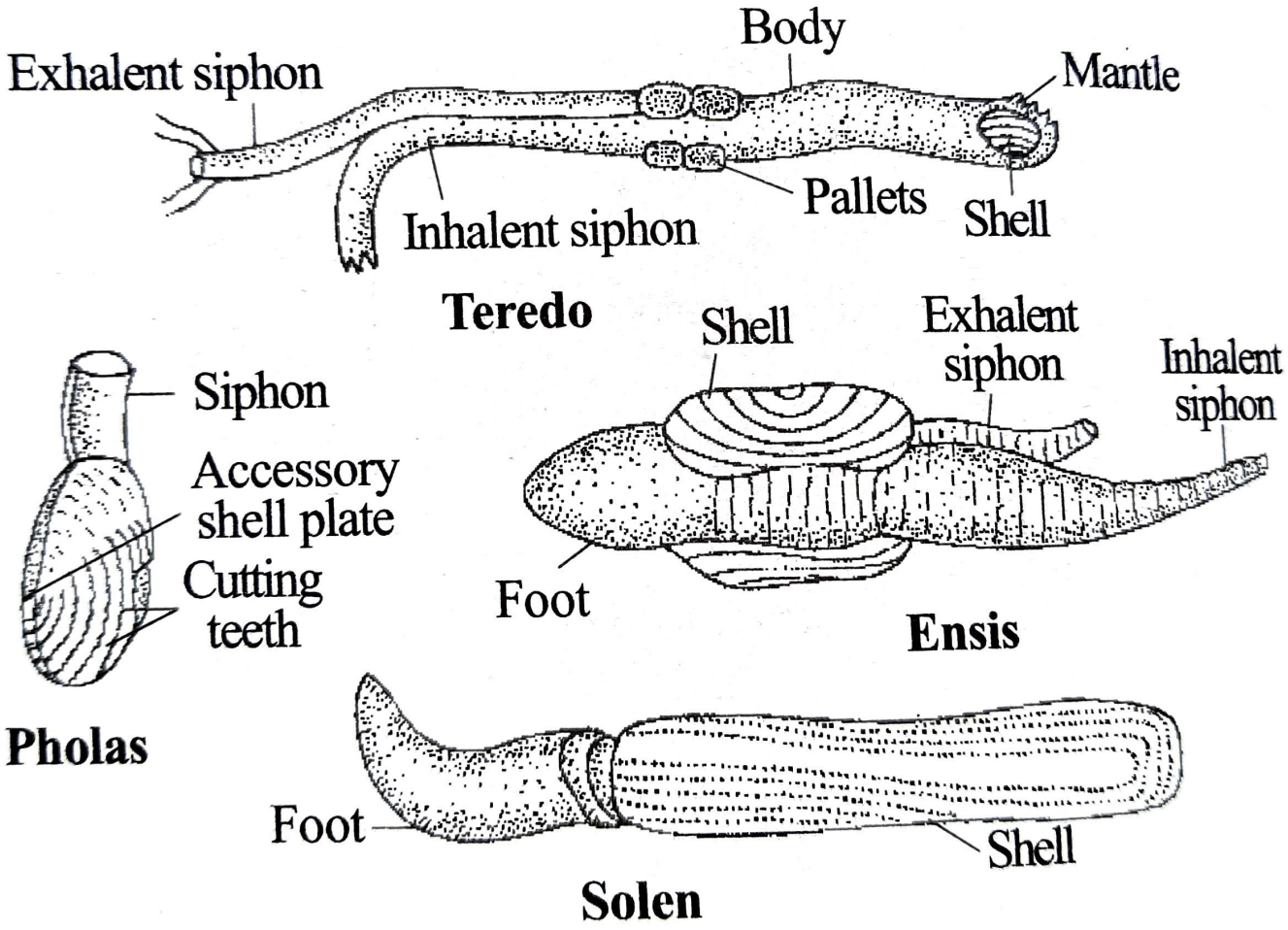


Fig.11.96: Boring molluscs.

ing is helped by the shell and the foot. Eg. *Teredo, Pholas, Lithodomus*, etc.

Echinodermata

General Characters

Echinoderms are a group of exclusively ***marine***, ***spiny skinned,*** pentaradially symmetrical animals with an endoskeleton and a water-vascular system. This phylum forms the highly advanced group among invertebrates. The common examples of this group are star-fishes, sea-urchins, sea- cucumbers, etc. This phylum is characterized by the following salient features :

1. ***Echinoderms*** are exclusively ***marine*** beings.

2. They are ***triploblastic*** and ***coelomate*** animals.

3. They have ***radially symmetrical*** body. The radial symmetry is due to sedentary or sessile mode of life and it is a ***secondary*** character in echinoderms.

4. They have ***organ system*** grade of organization.

5. They have well developed ***endoskeleton*** formed of calcareous ossicles and spines.

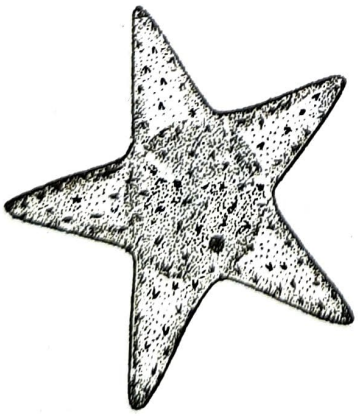


Fig.12.1: Star fish.

6. They have a water vascular system with ***tube-feet*** for locomotion, feeding and respiration.

7. Circulatory system is of ***open-type.***

8. The sensory organs are poorly developed in them.

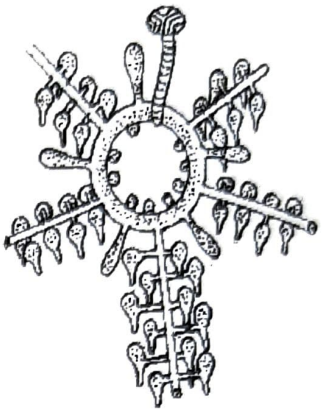


Fig.12.2: Water vascular system.

9. The excretory organs are absent from them.

10. They have ***pedicellariae.***

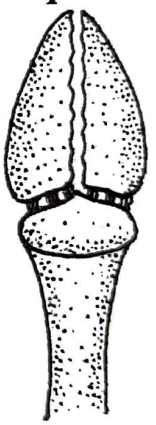


Fig.12.3: Pedicellaria.

11. Development is ***indirect.***

12. The larval forms are bilaterally symmetrical.

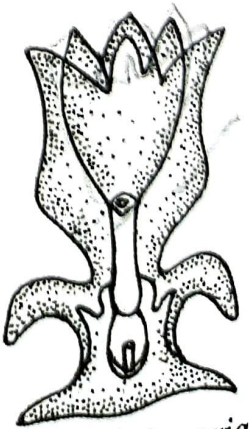


Fig.12.4: Bipinnaria.

Star Fish
(Asterias rubens)

Phylum : *Echinodermata*
Class : *Asteroidea*
Order : *Forcipulata*

Starfish is a marine, spiny-skinned, radially symmetrical animal. Hence it is included in the phylum ***Echinodermata***. It is star-shaped.

Hence it is included in the class ***Asteroidea.*** The commonly found starfish is *Asterias rubens.*

Starfish is a marine animal. It lives at the bottom of the sea. It is a crawling animal. It has a ***cosmopolitan*** in distribution. It is a ***carnivorous*** animal.

Asterias has a star-shaped body. It consists of a ***central*** disc and five arms. The lower surface of the body is flat and is called ***oral surface.*** The upper surface is convex and is called ***aboral surface.*** The five arms represent the ***radii;*** the region of the central disc between the arms is called ***inter-radius.***

The upper convex surface is called ***aboral surface.*** It is covered with stout and blunt immovable calcareous ***spines***. The spines are supported on irregularly-shaped calcareous ***plates*** or ***ossicles*** buried in the integument.

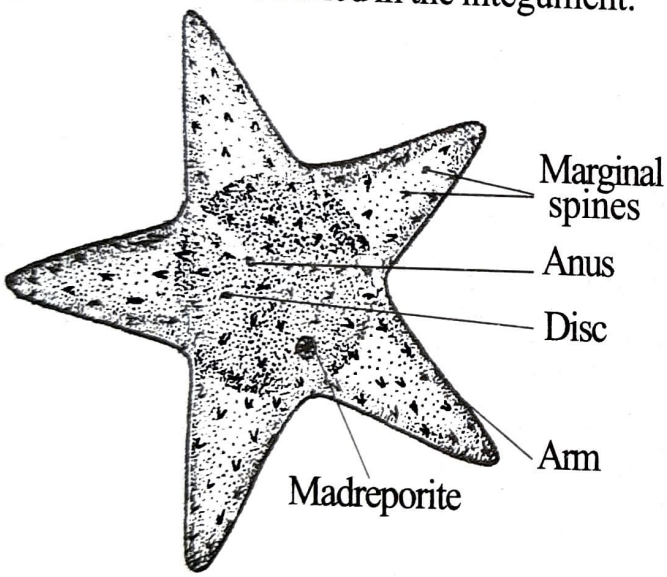


Fig.12.28: Starfish; Aboral view.

Between the ossicles there are number of minute ***dermal pores.*** From each dermal pore projects a small, soft and contractile process called ***dermal branchia*** or ***papula.*** It is respiratory in function.

Between the spines there are microscopic pincer-like bodies called ***pedicellariae***. The aboral surface bears the anus situated near the centre of the disc and a flat, circular sieve-like plate called ***madreporite*** placed between the bases of two arms. The two arms between which the madreporite lies are known as ***bivium*** and the rest of the three arms are known as ***trivium.***

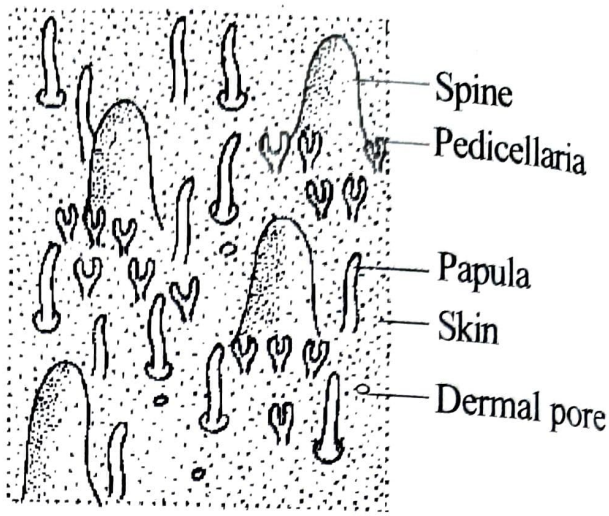


Fig.12.29: Skin; Aboral view.

The lower surface of the body is termed as ***oral surface.*** It is flat. In the centre of the oral surface there is a five-rayed or pentagonal aperture called ***mouth.*** The mouth is surrounded by a soft membrane called ***peristome***. Five narrow ***ambulacral grooves*** arise from the five corners of the mouth and run along the middle of each arm upto its tip. Two or three rows of movable calcareous spines are present on either side of this groove. They are called ***ambulacral spines.*** At each angle of the mouth these spines become larger and grouped together to form a ***mouth-papilla***.

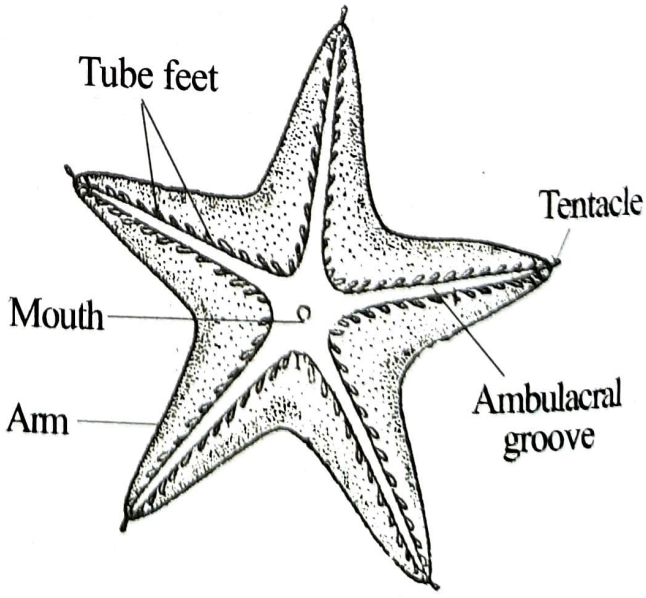


Fig.12.30: Starfish; Oral view.

Each ambulacral groove contains four rows of thin-walled tubular structures called ***tube feet.*** They serve as organs of locomotion. At the end of each ambulacral groove there is a small red spot, the eye and above the *eye* there is a small terminal ***tentacle***.

Pedicellaria

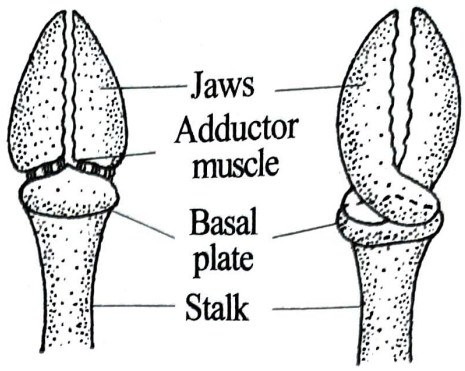
Pedicellariae are microscopic pincer-like structures embedded in the skin of echinoderms. They are the modified spines. They are found at the bases of the spines both on the oral and aboral sides. Pedicellariae are peculiar to echinoderms and they are not formed in other animal groups.

Structure of a Typical Pedicellaria

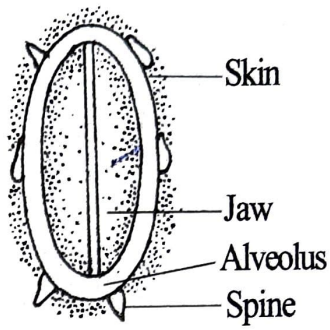
A pedicellaria consists of a ***stalk*** and ***3 ossicles*** (calcareous plates). The stalk is flexible. One end of the stalk is embedded and attached in the skin. The free end of the stalk bears 3 ossicles. Of these 3 ossicles, one lies horizontally at the apex of the stalk and it is called ***basal piece.*** It is immovable. The other two ossicles are ***movably*** articulated to the basal piece in a vertical position. These two vertical ossicles are called ***jaws*** or ***valves.*** The inner margin of the jaws are serrated.

The jaws can be opened and closed by two sets of muscles lying between the basal piece and jaws. The closure of the jaws is brought about by the operation of 2 pairs of ***adductor muscles.*** The opening of the jaws is brought about by the operation of a pair of ***abductor muscles.*** The jaws work like a forceps and hence this type of pedicellaria is called ***forcipulate pedicellaria.***

The pedicellariae are of two types. They are ***pedunculate pedicellaria*** and ***sessile pedicellaria.***



Straight type **Crossed type**



Bivalved alveolar pedicellaria

Fig.12.31: Star-fish; Pedicellaria.

1. Pedunculate Pedicellaria

Pedunculate pedicellaria have a ***stalk.*** They are also called ***stalked pedicellaria.*** In *Asterias,* all the pedicellaria are pedunculate type. The pedunculate pedicellaria has a stalk and 3 ossicles, namely a ***basal piece*** and two ***jaws.***

The pedunculate pedicellaria is further classified into two types, namely ***straight type*** and ***crossed type.***

a. Straight pedicellaria: In straight pedicellaria, the two jaws remain straight on the basal piece. The jaws work like a forceps.

b. Crossed pedicellaria: In crossed pedicellaria, the basal part of the jaws are curved and they cross each other. They work like scissors.

2. Sessile Pedicellaria

The sessile pedicellaria has no stalk. It is situated in a small depression on the skin called

alveolus. It has two jaws and are arranged like the valves of a clam. They can be opened and closed by the operation of muscle. Sessile pedicellariae are not found in *Asterias;* but they are found in *Oreaster*, a sea star, allied to *Asterias.*

Functions of Pedicellaria

The pedicellaria has the following functions:

1. The pedicellaria function as organs of offense and defence.
2. They help to clean the surface of the body of debris, sand grains, etc.
3. They are used to capture small prey.
4. They protect the papulae.

Digestive System

The digestive system extends from the oral to the aboral side. It is straight and much shortened by the flattening of the body. It presents a radial symmetry. It is formed of the ***alimentary canal*** and the ***digestive glands.***

Alimentary Canal

The alimentary canal is formed of a mouth, an oesophagus, a stomach, the intestine, the rectum and the anus.

The oral surface bears the ***mouth,*** situated in the centre of the disc. It is surrounded by a membrane called ***peristome***. The mouth leads upwards into a short, wide ***oesophagus*** which expands into a large ***stomach.***

The stomach consists of two parts, a ***cardiac*** stomach immediately following the oesophagus and a ***pyloric*** stomach lying above it. The cardiac stomach is a five-lobed sac. It is capable of being everted outside the animal while feeding. The cardiac stomach is held in place by five pairs of mesenteries called ***gastric ligaments*** made up of connective tissues and muscles. The wall of the cardiac stomach has ***gland cells*** which secrete ***mucous.*** Above the cardiac stomach is a small, flattened and pentagonal ***pyloric stomach.***

The pyloric stomach leads upwards into the intestine. It gives inter-radially five pairs of hollow diverticula called ***intestinal*** or ***rectal caeca.*** The intestine leads into the ***rectum.*** The rectum opens to the outside aborally by the ***anus.***

Digestive Gland

The digestive gland of *Asterias* is called ***pyloric caeca.*** There are five pairs of pyloric caeca, one pair in each arm. Each pyloric caecum is formed of two rows of ***glandular pouches.*** They open into a ***median duct.*** The two ducts of an arm unite together to form a common duct called ***pyloric duct.*** The pyloric duct opens into the pyloric stomach. The pyloric caeca are suspended from the roof of the arms by paired ***mesenteries.***

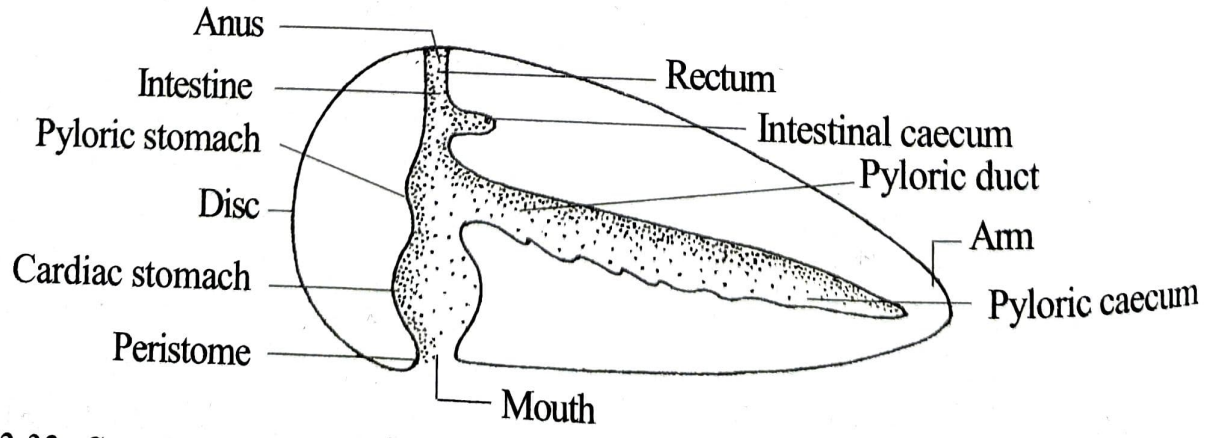


Fig.12.32: Star fish-Vertical section of the disc and arm showing the digestive system.

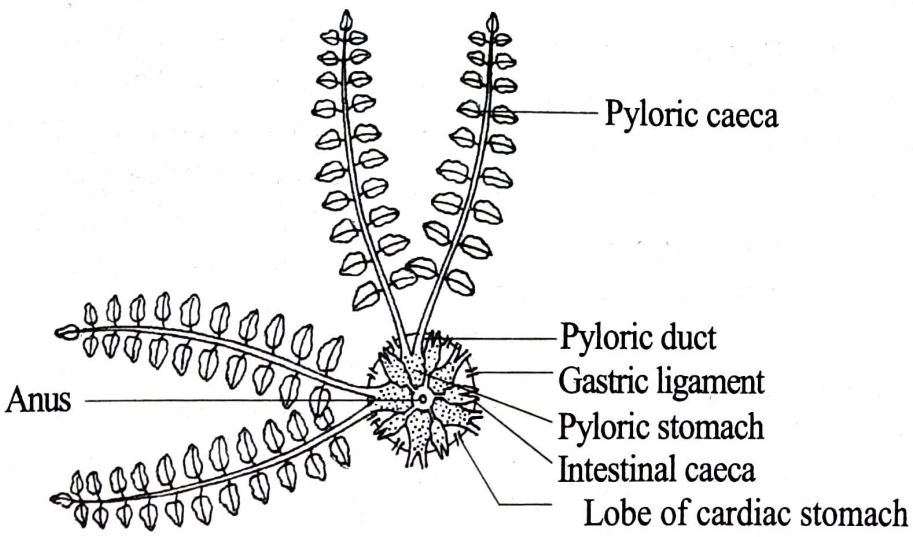


Fig.12.33: Star fish-Digestive system.

The pyloric caecum is formed of four types of cells, namely ***ciliated cells***, ***enzyme producing cells, mucous cells*** and ***storage cells.***

Feeding and Digestion

Starfish is ***carnivorous*** and it feeds on crustaceans, molluscs and fishes. When a star fish comes across a mussel, it bends its flexible arms over the body of the mussel and attaches the tube feet to the two valves with their suckers. When the two valves are separated, the cardiac stomach is everted out and inserted between the valves and curved over the body of the mussel. Then the mussel is digested by the digestive juices poured over it. When the digestion is completed, the cardiac stomach is withdrawn into the body. Thus digestion is ***extracellular.***

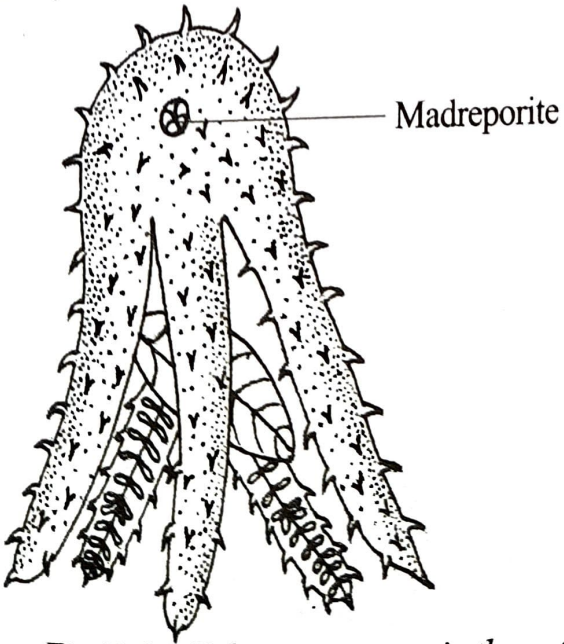


Fig.12.34: Echinaster sentus in the act of devouring a mussel. (From Shipley and Mac Bride).

Digested food is absorbed into the pyloric caeca. Here the undigested particles are digested by ***intracellular*** digestion. The surplus food is stored in the storage cells of caeca. From the caeca the food is diffused into the coelomic fluid. The coelomic fluid distributes the digested food to the various parts of the body. The undigested food is passed out through the anus.

Respiration

Respiration is carried out by thousands of ***dermal branchiae*** or ***papulae***. The dermal branchiae are simple, transparent, hollow outgrowths of the skin. They are present on the aboral surface projecting through minute openings. Their cavities are in continuation with the coelom and they are covered with cilia. O_2 dissolved in sea-water is extracted by these gills in exchange of CO_2. The thin walls of the tube foot may also serve for exchange of gases.

water-Vascular System

It is otherwise called the ***ambulacral system***. It is peculiar to echinoderms and not present in any other animal group. This is a system of canals filled with a fluid consisting of sea-water and certain ***corpuscles.*** The essential parts of the system are the ***madreporite, stone canal, ring canal, radial canals, Tiedmann's bodies, polian vesicles, lateral canals*** and ***tube feet.***

1. Madreporite: It is a hard rounded and calcareous plate lying on the aboral surface. It is situated in the inter radial position. The surface of the madreporite is provided with a number of radiating grooves or furrows. The bottom of these furrows are perforated by

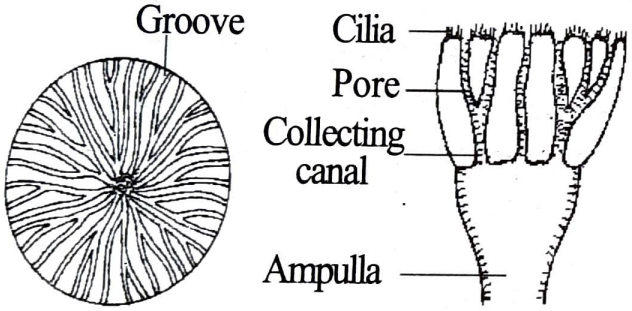


Fig.12.35: Madreporite.

minute ***pores***, so that the whole plate looks like a sieve. Each pore leads into a pore-canal and all the pore canals merge into ***collecting canals.*** The collecting canals converge into a small bag-like ***ampulla*** beneath the madreporite. The ampulla opens into a ***stone canal.***

2. Stone Canal: It is an ***S-shaped*** canal. The walls are strengthened by a series of ***calcareous rings*** and hence the name. Internally the stone canal is lined with ***cilia,*** the movement of which draws the sea-water from outside into the canal. One end of the tube opens to the outside through the madreporite. The other end opens into a ***ring canal.*** The lumen of the stone canal is occupied by a ***ridge*** with spirally coiled ***lamellae.***

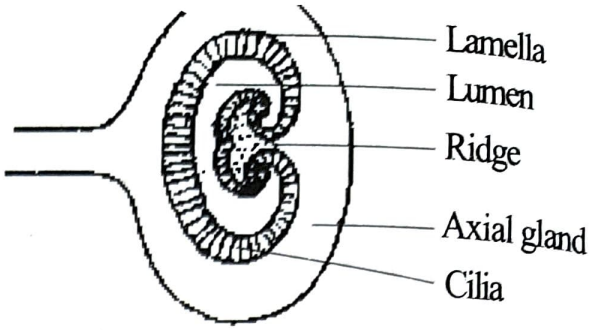


Fig.12.36: T.S. of stone canal.

3. Ring Canal: It is a wide pentagonal ***ring-like*** vessel lying around the mouth.

4. Tiedmann's Bodies: The ring canal gives off ***inter radially*** from its inner surface 10 small yellowish rounded glandular bodies called ***Tiedmann's bodies.*** In *Asterias* only 9 Tiedmann's bodies occur, the position of the 10th being occupied by the stone canal. They produce phagocytes.

5. Polian Vesicles: The ring canal bears on its outer side five pear-shaped structures called ***polian vesicles.*** They are inter-radially arranged. These are thin walled bladders with long and narrow necks. The polian vesicles serve as store houses for the fluid in the water vascular system.

6. Radial Canals: From its outer surface the ring canal gives off five radial canals, one entering each arm. The radial canal runs upto the tip of the arm and ends in the terminal tentacle.

7. Lateral Canals: Each radial canal gives off many paired ***lateral canals*** on both the sides, which lead to a tube foot or podium. Each canal is provided with a valve to prevent backward flow of fluid into the radial canal.

8. Tube Feet: The tube-foot is a hollow, elastic thin walled closed cylinder. It consists of an upper sac-like ampulla, a middle tubular ***podium*** and a terminal disc-like ***sucker.*** Muscle fibres are present in the walls of the ampulla and the podium. The tube feet are

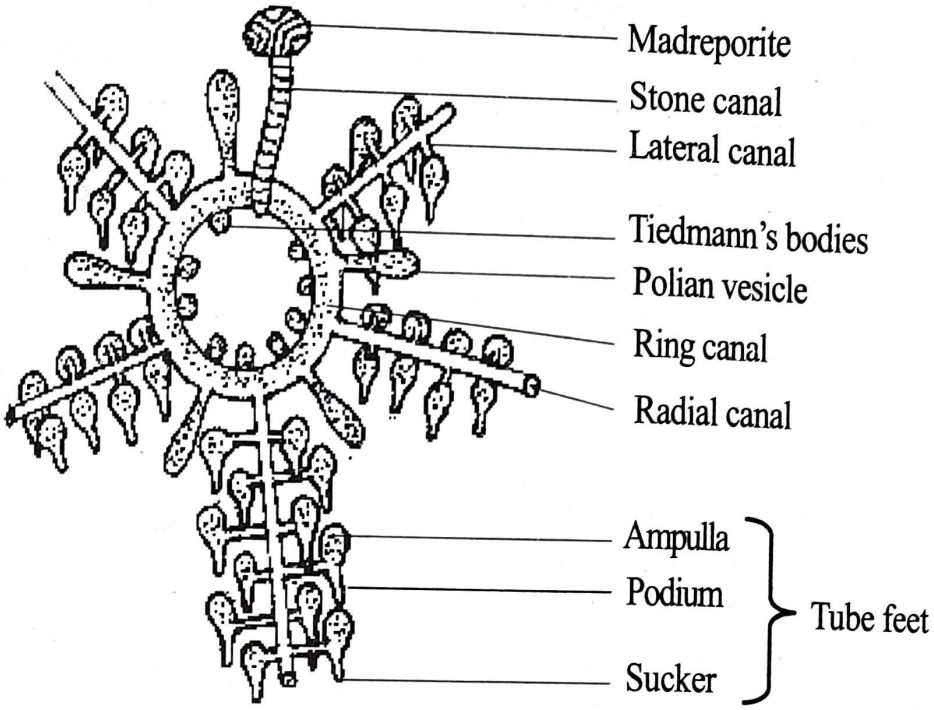


Fig.12.37: Star fish: Water vascular system.

capable of greater extension and when extended they come out through the ambulacral grooves.

Functions of the Water Vascular System

The water vascular system has three main functions. They are as follows:

1. Locomotion
2. Food capture and
3. Attachment

1. Locomotion

1. Starfish exhibits creeping movement.
2. It creeps on the tube feet.
3. It can move at a speed of 15 cm per minute.
4. The water vascular system helps in locomotion.
5. The water vascular system sets up a ***hydraulic pressure*** mechanism which brings about the locomotion.
6. In the direction of movement, one or two arms are slightly raised from the substratum.
7. The ampullae of tube feet contract. The valves in the lateral canals close. The water flows into the podium. The hydraulic pressure within the tube feet increases.
8. The tube feet elongate in the direction of movement.
9. The tube feet extend forward and adhere firmly to the substratum by the suckers.
10. After attachment, the tube feet assume a vertical posture by pulling the body forward.
11. The podia now contract. This causes the flow of water from the podia into the ampulla.
12. This results in the shortening of the tube feet.
13. The suckers are released and the tube feet are raised and moved forward to repeat the process.

2. Food capture

The tube-feet are used to capture the prey. The suckers are used to open the shells of molluscs.

3. Attachment

The star fish can be attached to the rocks by the tube feet.

Circulatory System

Circulatory system of star fish is of ***open*** type. It is formed of two systems, namely:

1. Perihaemal system and
2. Haemal system

1. Perihaemal System

It is a system of channels derived from the ***coelom.*** Like the true coelom, it is lined with ***ciliated epithelium***. It encloses the water-vascular system and the haemal system. It is formed of aboral ring sinus, genital sinus, oral ring sinus, axial sinus, radial perihaemal sinus, lateral channels, marginal sinuses and peribranchial sinuses.

1. Aboral ring sinus: It is a pentagonal tube lying around the intestine in the central disc on the aboral side.

2. Genital sinus: The aboral ring sinus produces a pair of tubes called ***genital branches*** from its corner. Each branch ends in a sac called ***genital sinus.*** It encloses the gonad.

3. Oral ring sinus: It is a circular channel lying around the mouth in the central disc. Internally, it is divided into two channels by a septum called ***haemal strand***. The two channels are ***outer oral ring sinus*** and ***inner oral ring sinus.***

4. Axial sinus: It is a vertical tubular sinus. It encloses the ***axial gland*** and ***stone canal.*** The axial sinus, axial gland and stone canal are together called ***axial complex***.

The aboral end of the axial sinus is connected with the aboral ring sinus and the oral end is connected with the oral ring sinus. The aboral end is also connected with the ampulla of madreporite.

5. Radial perihaemal sinus: It lies in the arm. It arises from the outer oral ring sinus. It extends upon the tip of the arm. It is also internally divided into two channels by the haemal strand.

6. Lateral channels: These arise from the radial perihaemal sinuses on either side. They supply the tube-feet.

7. Marginal sinuses: In each arm, there are two marginal sinuses lying in the margins. They are connected with the radial perihaemal sinuses by the lateral channels.

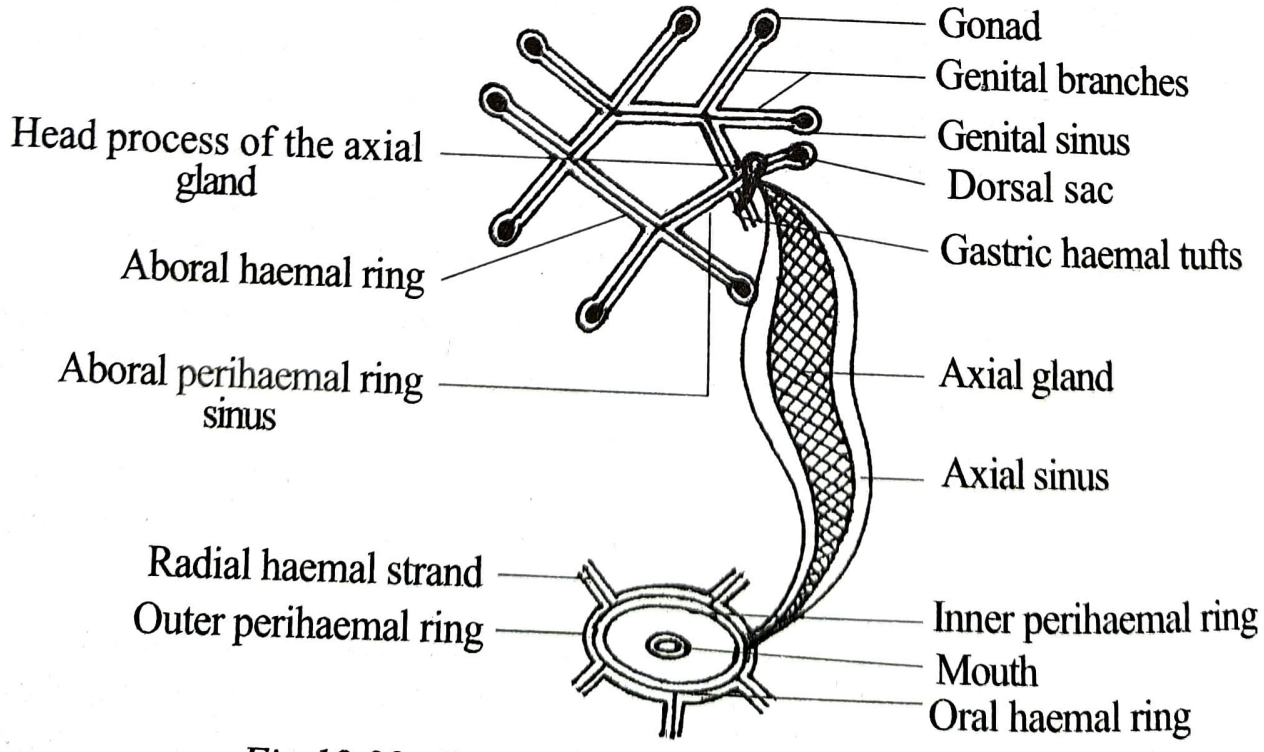


Fig.12.38: Star-fish; Haemal and perihaemal systems.

8. Peribranchial sinuses: These sinuses are located around the bases of the dermal branchiae.

2. Haemal System

This is the blood lacunar system. It is of ***open type***. It is similar to the haemocoelic system of leech, arthropods and molluscs. It is derived from blastocoel and is filled with coelomic fluid. The haemal system is formed of oral haemal ring, aboral haemal ring and axial gland.

1. Oral haemal ring: It lies around the mouth. It is located in the haemal strand. It gives off five ***radial haemal sinuses*** entering the arms. They are located in the septum separating the radial perihaemal sinus. The radial haemal sinus gives off ***lateral branches*** to the tube feet.

2. Aboral haemal ring: It lies inside the aboral perihaemal ring sinus. It gives off five pairs of ***genital haemal strands*** to the gonads.

3. Axial gland: It is elongated and fusiform. It is spongy in nature. It is formed of a network of ***connective tissue*** and ***amoebocytes*** and has a covering of ***coelomic epithelium.*** The axial gland is enclosed by the axial sinus. The oral end of the axial gland is connected with oral haemal ring and the aboral end is connected with the aboral haemal ring. The aboral end of the axial gland has a process called ***head process.*** The head process is enclosed by a sac called ***dorsal sac.*** A pair of ***gastric haemal tufts***, arising from the haemal sinuses of the cardiac stomach wall, opens into the axial gland near its aboral end. The digested food from the cardiac stomach passes into the haemal system through the gastric haemal tufts.

The axial gland produces the ***sex cells.***

Functions of the Haemal System

The haemal system does the following functions:

1. It distributes food materials.
2. The dorsal sac maintains the flow of blood by its contractile activity.
3. The axial gland produces the sex cells.

Excretion

There are no specialized excretory organs in starfish. Excretion is made possible by the ***amoebocytes*** found in the coelomic fluid. *Amoebocytes* collect waste particles from the coelomic fluid. The waste materials are accumulated at the base of the dermal branchiae. They pass out of the ***papulae*** through their thin walls. The nitrogenous excretory products consists mainly of ammonia compounds.

Nervous System

The nervous system in starfish is a primitive type and is closely connected with epidermis of the skin. Just like other systems of the body, it is ***radially symmetrical.*** It is made up of nerve cells and a network of nerve fibres which are concentrated in some places so as to form nerve-strands. The nervous system is of four types, which are inter-related:

1. *Ectoneural nervous system* or *superficial nervous system,* 2. *Deep oral nervous system,* 3. *Aboral coelomic nervous system* and 4. *Endodermal nervous system.*

1. Ectoneural Nervous System

It consists of a central ***circum oral nerve ring*** enclosing the mouth. From it originates five ***radial nerves,*** which extend to the tips of arms, where each terminates in an eye. The five radial nerves are situated below the radial ambulacral vessels.

From the radial nerves branches arise to the tube-feet. As the components of this nervous system are developed from the ***ectoderm,***

it is called ***ectoneural*** nervous system. It is ***sensory*** in function.

2. Deep Oral Nervous System

It is developed from the mesoderm. It is motor in function. It consists of a double ***circum oral nerve ring*** around the mouth and five pairs of ***Lange's nerves*** extending into the arms.

3. Aboral or Coelomic Nervous system

It is formed of an aboral ***anal nerve ring*** in the disc and five nerves in the arms. It is ***mesodermal*** in origin and ***motor*** in function.

4. Endodermal nervous system

This system is a continuation of the ectoneural system. It is located in the wall of the alimentary canal and is sensory in function.

Sense Organs

Star fish contains two types of sensory organs. They are

1. Neurosensory cells

2. Eyes

1. Neurosensory cells

Neurosensory cells are specialized sensory cells distributed throughout the epidermis. They are abundant in the tentacles, tube feet and the bases of pedicellariae. They are fusiform and are connected to nerve fibres. They may be ***tactile*** or ***olfactory*** in function.

2. Eyes

Star fish has five ***eyes.*** They are situated at the terminal end of the arm beneath the tentacle.

Each eye is made up of numerous ***eye-pits*** or ***ocelli.*** Each eye-pit is cup-shaped. It is filled with a transparent gelatinous tissue. The mouth of the cup has a ***lens*** and is covered by a ***cuticle.***

The wall of the cup is made up of ***pigment cells*** and ***retinal cells.***

The inner end of each retinal cell is ***bulb-like*** and projects into the cavity of the eye-pit and the other end is connected to a ***nerve fibre.***

The eye cannot form image; but it detects changes in light intensity.

Reproductive System

In star fish, sexes are separate (unisexual). There is no sexual dimorphism.

It has five pairs of gonads, one pair in each arm at its base. The gonad is enclosed in a ***genital sinus.***

From each gonad arises a ***gonoduct*** which opens to the outside on the aboral surface by a minute ***gonopore.***

The gametes originate in the ***axial gland*** and later they migrate into the gonads.

Life Cycle

Star fish is a marine sedentary animal. The development is ***indirect*** as there are larval forms.

Fertilization

The fertilization is ***external.*** It occurs in the sea. The fertilized egg is called ***zygote.***

Cleavage

The segmentation is ***holoblastic***, ***equal*** and ***indeterminate.*** It is a ***rapid*** process. The cleavage converts the zygote into a ***blastula*** in one day.

Blastula

It is spherical and ciliated. It is hollow and hence called ***coeloblastula.*** The cavity is called ***blastocoel***. It is surrounded by a layer of ciliated cells. The blastula swims freely in water.

Gastrulation

The blastula invaginates to form a double-layered cup called ***gastrula.***

Gastrula

Gastrula is in the form of a double-layered cup. The two layers are the outer ***ectoderm*** and the inner ***endoderm***. The cavity of the gastrula is called ***archenteron.*** It opens to the outside by an opening called ***blastopore***.

The endoderm at the inner end gives off cells into the blastocoel. These cells form the ***mesoderm.*** The archenteron produces two pouches. These pouches are pinched off from the archenteron as two sacs. These sacs develop into coelom and the water vascular system. The gastrula swim in water. After some time, it develops into a larva called ***dipleurula larva.***

Dipleurula Larva

This larva develops from the gastrula. It has the following salient features:

1. Dipleurula is the fundamental larva of the echinoderms. It is the first larva in the life cycle.
2. It is microscopic.
3. It is a free swimming larva.
4. It is bilaterally symmetrical.
5. It is oval in shape.
6. It has a gut formed of the mouth, the oesophagus, the intestine, the stomach and the anus.

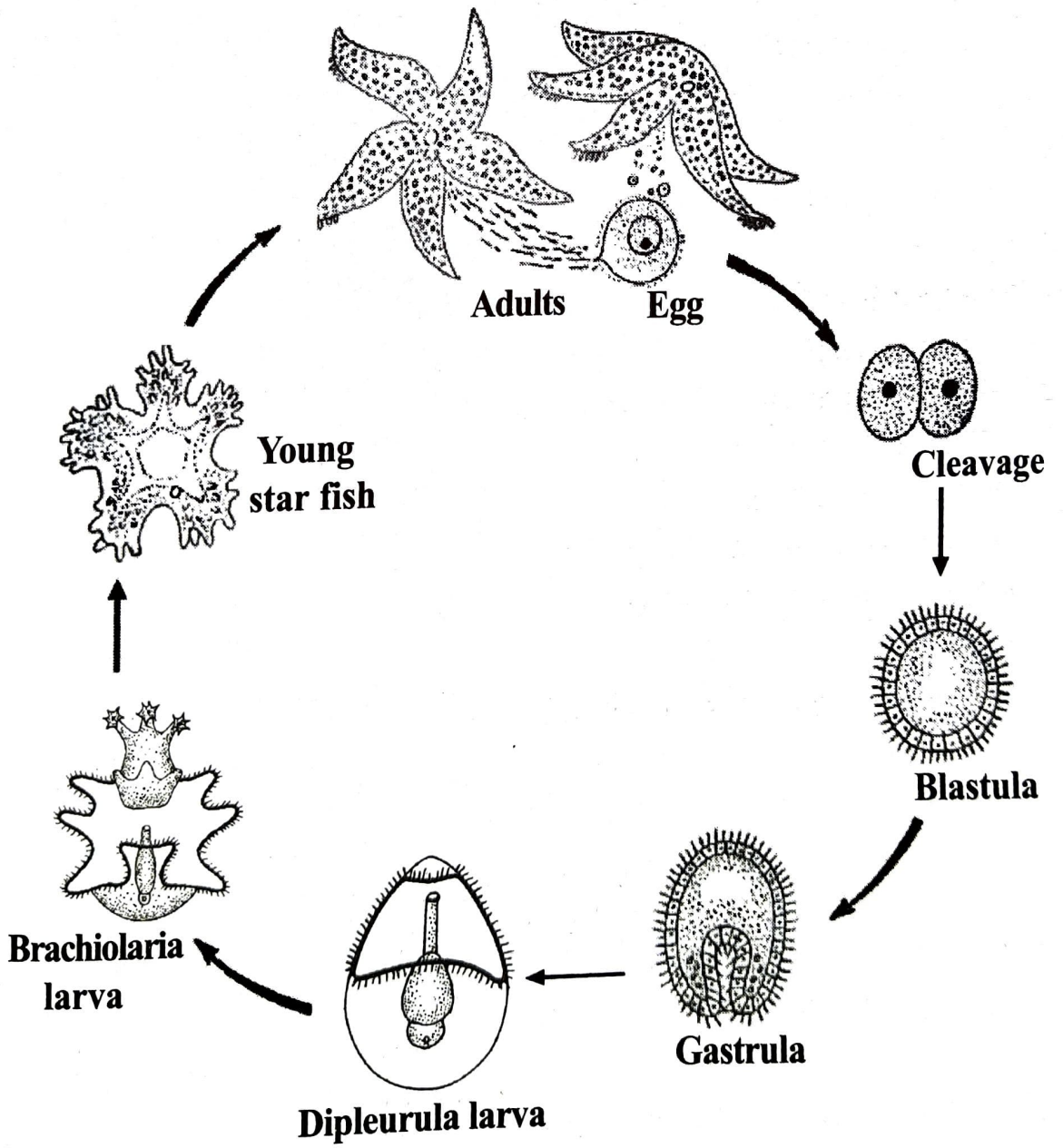


Fig.12.39: Life cycle of star fish.

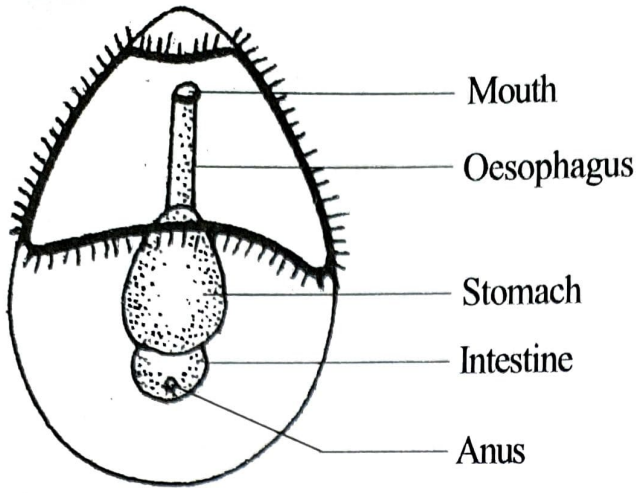


Fig.12.40: Dipleurula larva.

7. It has two ciliary bands, namely a ***perioral band*** around the mouth and an ***adoral band*** inside the mouth.

8. The perioral band is used for locomotion and the adoral band is used for the collection of food.

9. It feeds on diatoms.

10. The dipleurula develops into the bipinnaria larva.

Bipinnaria Larva

It is the second larva of star fish. It develops from dipleurula larva. It has the following salient features:

1. It is minute and microscopic.
2. It swims freely on the surface of water.
3. It is ***bilaterally symmetrical.***
4. It has a straight alimentary canal with a ***mouth*** at the anterior end and an ***anus*** at the posterior end.
5. It has a ***preoral lobe*** and a ***postoral lobe.***
6. The body has a number of outgrowths called ***arms.*** The arms are covered by ciliated bands and are used for locomotion. It has two unpaired arms and 5 pairs of paired arms. They are,
   1. Median dorsal arm
   2. Median ventral arm
   3. Preoral arms
   4. Post-oral arms
   5. Antero dorsal arms
   6. Postero dorsal arms and
   7. Postero lateral arms.

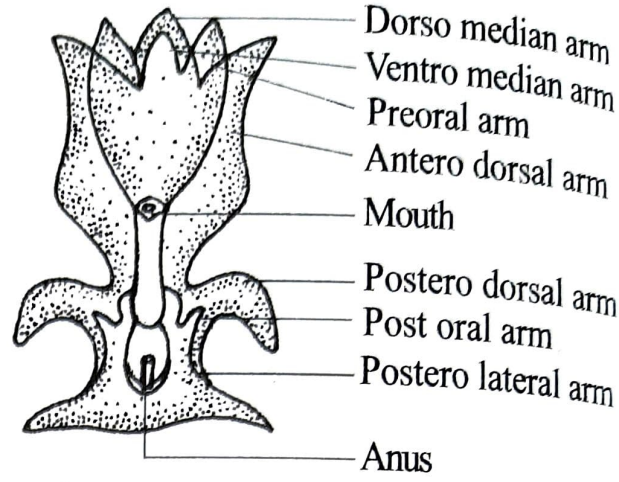


Fig.12.41: Star fish - Bipinnaria larva.

Brachiolaria Larva

It is the third larva of star fish. The bipinnaria larva after a short free swimming life, is transformed into the brachiolaria larva. The preoral region of this larva has three processes called ***brachiolar arms***. These three arms are tipped with suckers. It swims and feeds like a bipinnaria.

Metamorphosis

Metamorphosis occurs in the following ways:

1. The brachiolaria larva sinks to the bottom of the sea.
2. It gets attached to the substratum with the help of the brachiolar arms.
3. The mouth, anus and the ciliary bands disappear.
4. A new mouth is formed on the left side of the larva.
5. A new anus is formed on the right side of the larva.
6. The mouth represents the ***oral side*** and the anus represents the ***aboral side.***

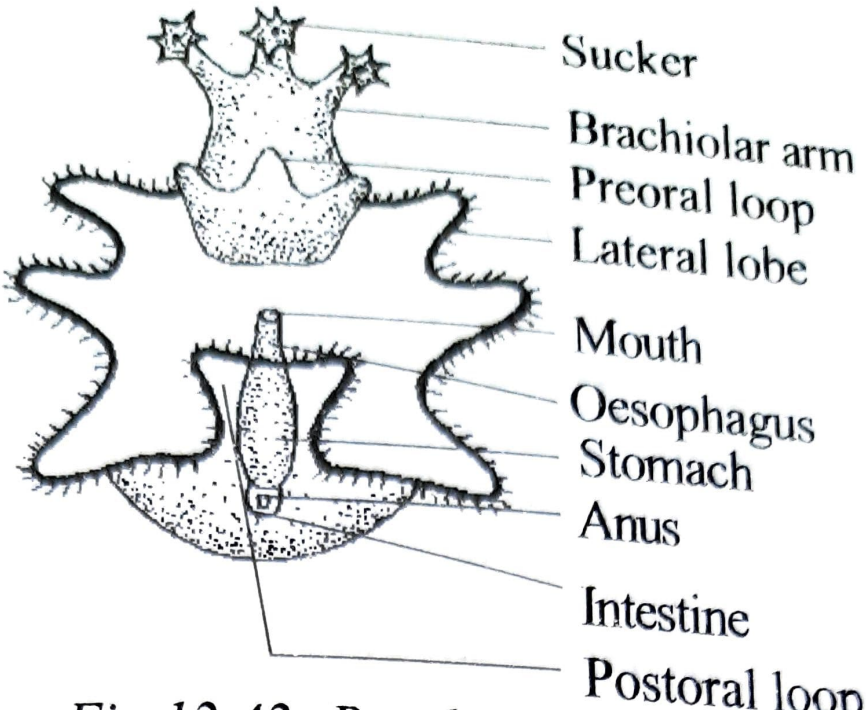


Fig.12.42: Brachiolaria larva.

7. Five lobes grow between the mouth and the anus. These are the ***arm rudiments.***

8. The ***bilateral symmetry*** is transformed into the ***radial symmetry.***

Regeneration

There is considerable power of regeneration in starfish. If the central disc is detached from all its arms, it will regenerate them all. A single arm with a small part of the disc will regenerate the whole animal.

Autotomy

When an arm is injured, the animal casts off the arm. This process is called ***autotomy***, which helps to protect the animal, when it is caught by one or more arms. After casting them off, it can run away. The cast-off parts generally regenerate.

Larval forms of Echinodermata

In Echinoderms, the development may be ***direct*** or ***indirect.*** In direct development there is no larva. Direct development is seen in only a few echinoderms living in ***Arctic*** and ***Antarctic*** waters. In indirect development, the life cycle includes one or more larvae. Many types of larvae occur in echinoderms. They are the following:

1. Dipleurula larva
2. Bipinnaria larva
3. Brachiolaria larva
4. Ophiopluteus
5. Echinopluteus
6. Auricularia larva
7. Doliolaria of Holothuroidea (pupa)
8. Doliolaria of Crinoidea
9. Pentacrinoid larva

1. Dipleurula Larva

This larva develops from the gastrula. It has the following salient features:

1. ***Dipleurula*** is the fundamental larva of all echinoderms.

2. It is ***microscopic.***

3. It is a ***free-swimming*** larva.

4. It is ***bilaterally*** symmetrical.

5. It is ***oval*** in shape.

6. It has a ***gut*** formed of the mouth, the oesophagus, the intestine, the stomach and the anus.

7. It has two ciliary bands, namely a ***perioral band*** around the ***mouth*** and an ***adoral band*** inside the mouth.

8. The perioral band is used for ***locomotion*** and the adoral band is used for the ***collection of food.***

9. It feeds on ***diatoms.***

10. The dipleurula develops into the ***bipinnaria larva.***

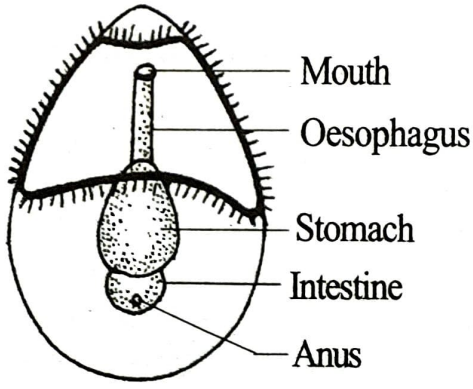


Fig.12.71:Dipleurula larva.

2. Bipinnaria Larva

It is the second larva of starfish. It develops from dipleurula larva. It has the following salient features:

1. It is ***minute*** and ***microscopic.***

2. It swims freely on the surface of the water.

3. It is ***bilaterally*** symmetrical.

4. It has a straight alimentary canal with a ***mouth*** at the anterior end and an ***anus*** at the posterior end.

5. The body has a number of outgrowths called ***arms.*** The arms are covered by ***ciliated bands*** and are used for ***locomotion.*** It has two unpaired arms and 5 pairs of paired arms. They are

1. Median dorsal arms
2. Median ventral arms
3. Pre-oral arms
4. Post-oral arms
5. Antero-dorsal arms
6. Postero dorsal arms and
7. Postero-lateral arms.

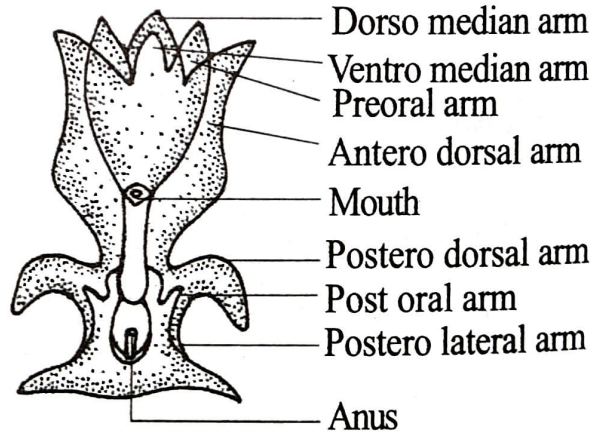


Fig.12.72: Bipinnaria larva.

3. Brachiolaria Larva

It is the third larva of starfish. The bipinnaria larva, after a short free swimming life, is transformed into the brachiolaria larva. The preoral region of this larva has three processes called ***brachiolar arms***. These three arms are

tipped with ***suckers***. It swims and feeds like a bipinnaria.

4. Ophiopluteus

1. It is the larva of ***Ophiuroidea.***
2. The preoral lobe is small.
3. The ***ciliated band*** is single.
4. The arms are supported by ***calcareous rods***.
5. The larva has a pair of ***pre oral arms***, a pair of ***post oral arms***, a pair of ***postero dorsal arms*** and a pair of ***postero lateral arms***.
6. The postero lateral arms are always longer and directed forward, so that the larva appears like a ***V.***

4. The larva is provided with a pair of ***preoral arms***, a pair of ***post oral arms***, a pair of ***antero lateral arms***, a pair of ***antero dorsal arms***, a pair of ***postero dorsal arms***, a pair of ***postero lateral arms*** and a median ***posterior arm***.
5. The ***postero lateral*** arms are very short and directed backwards.

6. Auricularia Larva

1. It is the larva of ***Holothuroidea***.
2. There is a well developed ***pre-oral lobe***.
3. ***Ciliated band*** is single.

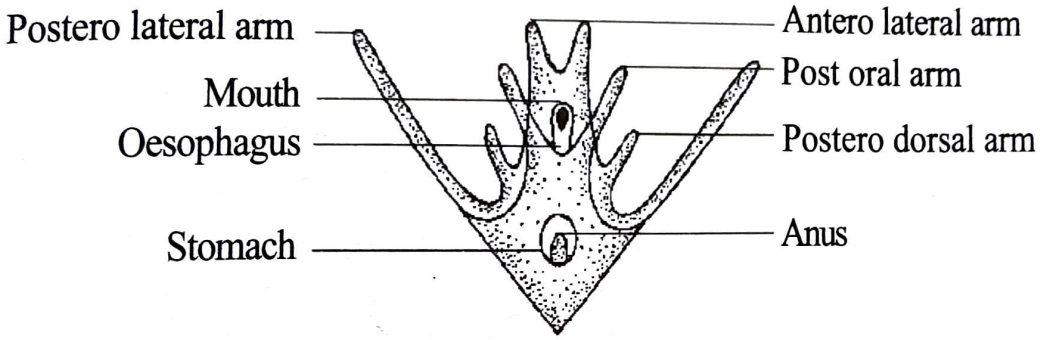


Fig.12.73: Ophiopluteus.

5. Echinopluteus

1. It is the larva of ***Echinoidea.***
2. It has a small pre-oral lobe and a single ciliary band.
3. The arms are supported by ***calcareous rods***.
4. ***Arms*** are supported not by calcareous rods but the calcareous structures are in the form of ***wheels, spheres, star-shaped*** bodies, etc.

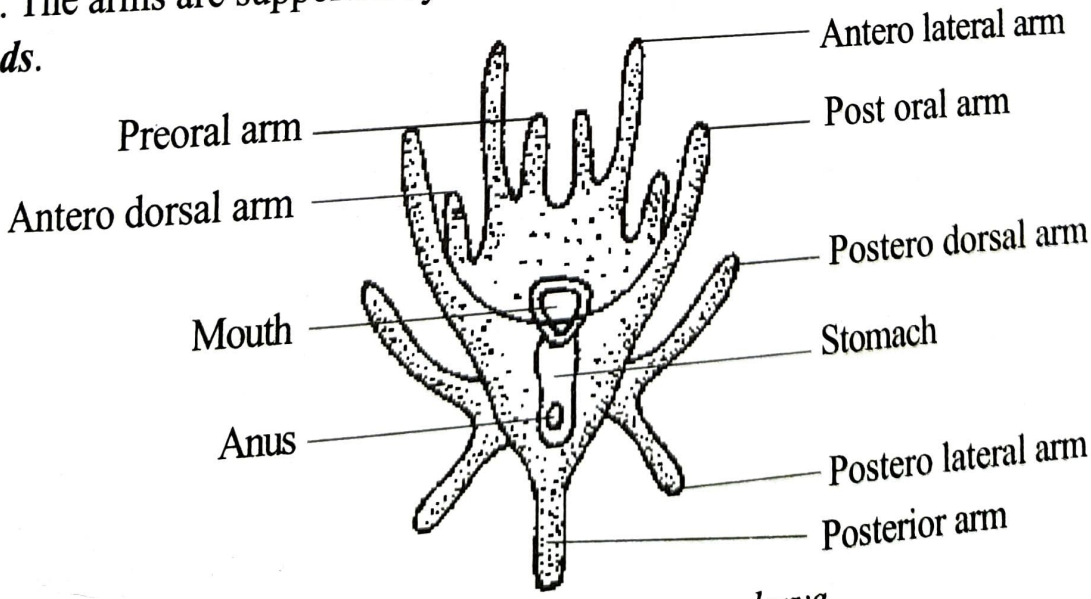


Fig.12.74: Echinopluteus larva.

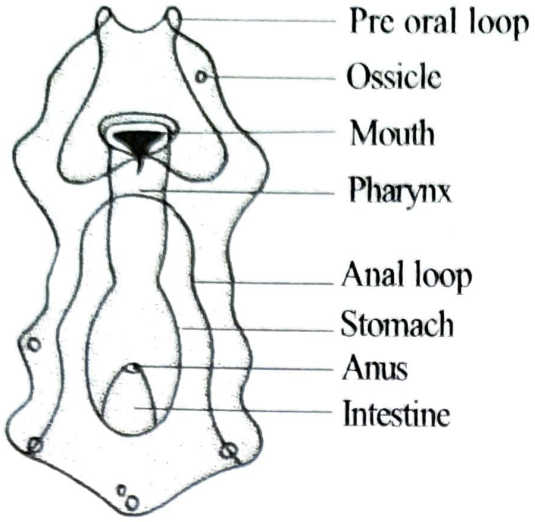


Fig.12.75: Auricularia larva.

7. Doliolaria of Holothuroidea (Pupa)

1. In Holothuroidea (sea-cucumber), the auricularia larva develops into doliolaria larva.
2. This larva is also called a ***pupa.***
3. It is a free-swimming larva.
4. It is ***barrel-shaped.***
5. The calcareous skeleton is in the form of spheres.
6. The ciliated bands are broken into pieces.
7. Metamorphosis begins during free swimming life. After metamorphosis, the larva sinks into the bottom to become the adult.

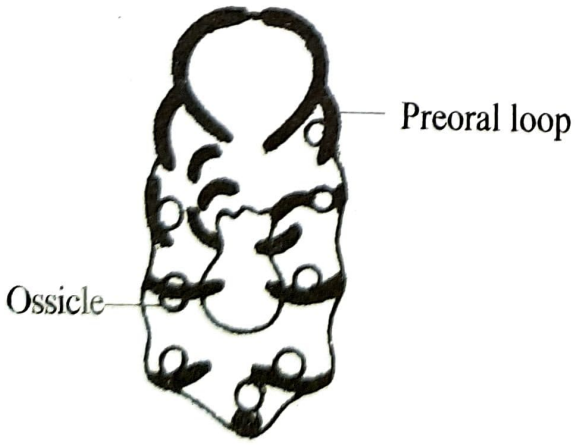


Fig.12.76: Doliolaria larva.

8. Doliolaria of Crinoidea

1. It is the larva of ***Antedon.***
2. It is a ***free-swimming*** larva.
3. It is ***bilaterally*** symmetrical.

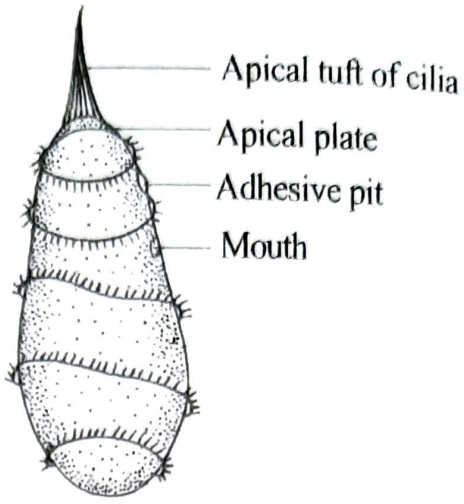


Fig.12.77: Doliolaria of Antedon.

4. It is ***barrel-shaped.***
5. It has four or five ***ciliary bands.***
6. At the anterior end the ectoderm thickens to form an apical plate.
7. The apical plate bears a tuft of cilia called ***apical sensory tuft.***
8. An ***adhesive pit*** is present between the first and second ciliary bands. It is used for attachment.
9. A ***mouth*** is located between the second and third ciliary bands.

9. Pentacrinoid Larva

1. It is the second larva of ***Antedon.***
2. It develops from ***Doliolaria larva.***
3. It looks like a ***sea-lily.***
4. It has a ***stalk.***
5. The stalk develops from the pre-oral lobe of ***Doliolaria.***
6. One end of the stalk is attached to the substratum with the help of a ***disc*** and the free end bears a ***crown.***
7. The crown consists of a central ***mouth*** surrounded by a circle of ***tentacles.***
8. During metamorphosis, the crown develops ***cirri*** and breaks off from the stalk as a free living ***Antedon.***

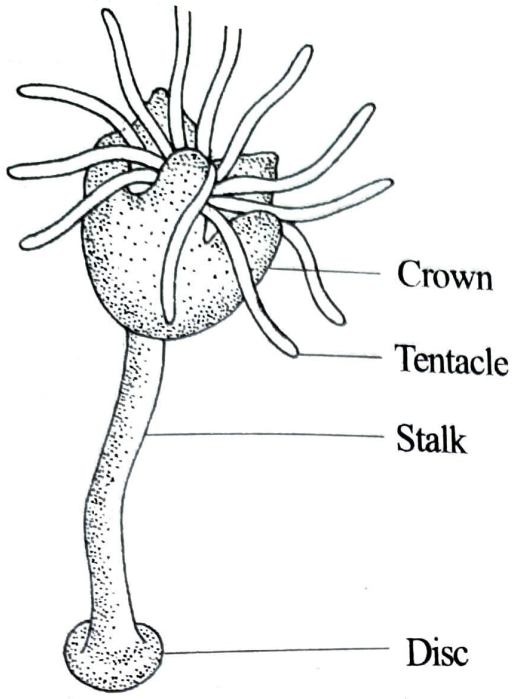


Fig.12.78: Pentacrinoid larva.

Metamorphosis

During metamorphosis, the ***bilaterally symmetrical*** larvae become transformed into ***radially symmetrical*** adults.

In all these larval forms during metamorphosis, there is ***alteration of the position of the mouth.*** In the crinoidea, the mouth is shifted to the posterior end. But in all other echinoderms, mouth is shifted to the left side with the corresponding shifting of the coelomic cavity.

In Crinoidea and Asteroidea, the larva becomes fixed to some substratum by the preoral lobe at the time of metamorphosis and a ***fixation disc*** is formed for this purpose. In the Crinoids, the fixation persists until the adult form is completely formed. But in Asteroidea fixation is temporary.

Significance

All the larvae of echinoderms have a ***bilateral symmetry***. Hence it is believed that the ancestor of echinoderms was a bilaterally symmetrical animal. According to ***Bather*** (1900), this ancestor was called ***dipleurula***. But according to ***Semon*** (1888) this ancestor was called ***pentactula.*** The pentactula ancestor was universally accepted.

The radial symmetry of echinoderm is ***secondary.*** But the radial symmetry exhibited by Coelenterata and Porifera is primary. The radial symmetry in echinoderms is only superficial, concealing the true bilateral symmetry.

The adult echinoderms are more primitive than their larvae because they possess the features of lower animals like porifera and coelenterata. The primitive characters are radial symmetry, absence of head, lack of anterior and posterior ends, etc. Hence during metamorphosis the advanced larva becomes a primitive adult. Hence the metamorphosis is ***retrogressive.***

Economic Importance of Mollusca

Molluscs are of major interest to man as about 10,000 species are of economic importance. Mostly they are beneficial to man although there are some molluscs which are indirectly harmful.

[I] Beneficial molluscs

1. As food. Chitons formed the main food of Red Indians. The gastropods are consumed by numerous predators chiefly fish, birds and mammals. The large land snail *Helix pomatia*, large foot of *Haliotis* and apple snail (*Pila*) form common food in New York, California and South India, respectively. Oysters, scallops, marine mussels and clams have been often used for food. Romans cultivate oysters to meet their great demand for countries like USA. Oysters are served fried, the hard shell marine clam, *Venus mercenaria* as whole on half shelled or cooked in chowder, *Mya arenaria*, a soft shelled clam, is steamed in shells and served with butter. *Mytilus edulis* is used in chowder, and adductor muscle of *Pecten* are served in flour and fried. Pelecypods also furnish food for star fish, boring sponges, drilling snails, some marine leeches, fish and shore birds.

Squids, cuttle fish and devil fish are popular as food articles in Oriental and Mediterranian

countries. *Sepia* is used as food either cooked or dried in open air in European countries. *Loligo* are split, sundried and preserved for later use. *Octopus,* the devil fish is used in Canada and Alaska on many occasions. *Nautilus pompillus* is much prized as food by Pacific islanders. Cephalopods also form food for other animals like marine mammals and large fish.

2. As bait. Many gastropods are very useful to man, as bait for catching fish. Squids make an excellent bait for marine fishes especially cod in United States. Small *Octopus* are used as bait by the line fishermen of Palk Bay.

3. Money. Red Indian tribes of America used the common *Dentallium indianorum* as sawampum or money. Value of shells varied lengthwise. Gastropodan shells were source of money for various native races, including Vampum of American Indians. Shell of gastropods made media of barter in Africa and other countries. American *Oyster, Crassostria viginica,* is commercially cultivated and harvested and provides millions of dollars to the industry. Squids, cuttle fish and devil fish earn money as they are sold in market for food in China, Japan, India and Italy.

4. Ornamentation. Scaphopod, *Dentallium indianorum,* tooth shells are valued as ornaments. Tools, utensils and objects of delight have been formed from gastropodan shells. Some marine snails of South Pacific (turban shells) have a calcarious operculum so rounded and coloured as to resemble a vertebrate eye. These opercula known as "cat's eye", are sought as curios. *Nautilus* shell is much used for decoration, art and for many other useful purposes.

5. Useful dyes and ink. Some gastropods like *Nucella* (*Purpura*) and *Murex*, are sources of Tyrian purple from their juices. Dye for royal purple in Biblical literature originally came from a gland of the snail, *Murex truncutus.* Secretion is colourless but becomes a beautiful purple by exposure to the air. Contents of ink-sac of cuttle-fish provides a rich brown pigment called "sepia", used by the artists. Originally Indian ink was obtained from the ink of a cuttle-fish, *Sepia cubrata.* Now-a-days a certain brown finish of photograph is termed as sepia finish.

6. Buttons and pearls. Gastropodan shells are used to manufacture buttons and other articles. Shells of certain bivalves have been used for mother-of-pearl layer also for buttons, knife handles etc. Buttons are made by hand by cutting shells of freshwater bivalves and some marine clams. Pearls are made by clam and pearl oysters themselves and are among the most beautiful and valuable of our jewels.

7. In art and medicine. Shell cameos are made mostly from snails notably that of *Cypraea tigris* and *Cases tuberosa. Nautilus* shell is commonly used in art. It is a pretty object thrown ashore during monsoon storms on the Indian coasts.

A rather odd and unexpected use for fossil cephalopods is found among the Red Indians of Montana and Wyoming. Their medicine men collect specimens of beautifully preserved fossil ammonoids from Cretaceous Strata and keep them as 'medicine'. The internal calcarious shell of *Sepia,* the "cuttle-bone" is used as medicine as well as for other purposes.

8. In literature. There are stories about giant squids and octopuses cited to play exaggerated role in popular literature. One such story, pictures a huge squid dragged a small ship beneath the waves and grabbed the helpless sailors in its cruel, snake-like arms and crushed them to death. Large squids and octopuses are feared more rightly for their dangerously powerful beaks and ability to sieze men from boats or grip persons under water by their deadly tentacles.

9. Animal inventions. Cephalopods get credit for two animal inventions. One of them is the principle of "jet propulsion" only recently discovered by man but used by squids and octopuses for millions of years. The second novel invention is the use of a "smoke screen", in both offence and defence, is another novel invention by cephalopods. A smoke screen is formed by ejecting a brownish ink into the water. This diffuses into a large area and allows cephalopod to stalk stealthily through the "smoke" searching for its prey, or to escape in cloudy water if persued by an enemy. Man could use such a device in warfare not earlier than first World War.

[II] Harmful Molluscs

1. Destructive forms. The destructive activities of some molluscs are of great importance to global economy.

(a) Herbivores. Some gastropods like land slugs and snails cause damage to gardens, orchards, green houses and mushroom beds by feeding upon the succulent parts of seedlings and mature plants. They do not spare the vegetable crops, flowering plants and other decorative plants. Certain pelecypods burrow or bore into wood and stone. The *Teredo*, the shipworm, is not a worm instead a bivalve mollusc and does more harm to wooden boats and ships. According to an estimate, the shipworm caused 2,500,000 dollar's damage to wooden structures in San Francisco Bay in four years time (1917-1921).

(b) Carnivores. Some gastropods are ferocious predators (*Natica, Buccinum, Murex, Urosalpinx*), that bore into and fed on other molluscs. Marine snail *Urosalprinx,* causes serious losses to *oyster* industry. It is known as 'oyster drill'. Cephalopods are all predaceous and carnivorous molluscs, devouring great number of fish, crustaceans and other molluscs and are much destructive to fisheries. Crabs fall favourite food of *Octopus*. Giant squid (*Architeuthis princeps*) are known to engage in battles with whales and devour their tongue by their sharp beaks.

(c) Parasites. Members of the families Pyramidellidae (e.g. *Brachystomia*) and Eulimidae of gastropoda are ectoparasites and suck blood from bivalve molluscs, polychaetes and echinoderms. *Stylifer* (family Styliferidae) is an endoparasite in the wall of echinoderms. Among the pelecypod parasites, *Entovalva* lives within the gut of a sea-cucumber *(Synapta)* and absorbs predigested food of the host.

(d) Intermediate hosts. Snails are of considerable importance from a medical point of view as many of them serve as intermediate hosts for parasitic flat worms, such as *Fasciola* and *Schistosoma.*

(e) Commensals. There are commensal pelecypods which include – *Phylyctaenachlamys* living in burrows of a shrimp of Great Barrier Reef, *Lepton* in burrows of shrimps and Polychaeta, Mediolaria in the test of sea-squirts and Vulsella in sponges.