bearing a gap in the middle. The ovary is covered by a ***capsule***.

An ***oviduct*** arises from the side of each ovary. It runs backwards and opens to the outside at the base of the 3rd walking leg by a ***female genital aperture***.

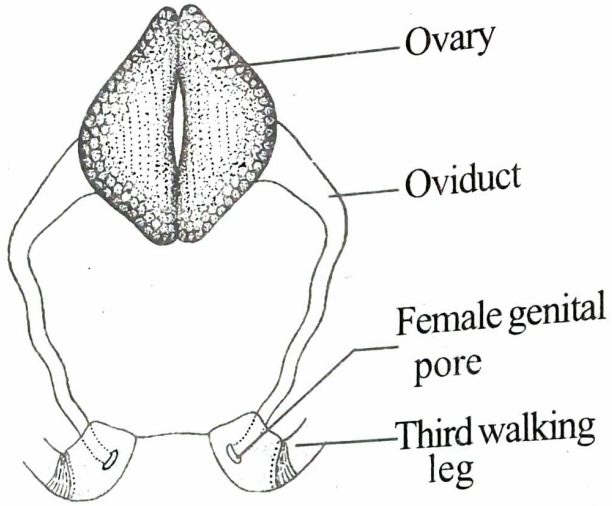


Fig.10.132:Palaemon; Female reproductive system.

Male Reproductive System

The male reproductive system consists of a pair of ***testes***, a pair of ***vasa deferentia***, a pair of ***seminal vesicles*** and a pair of male ***genital apertures***.

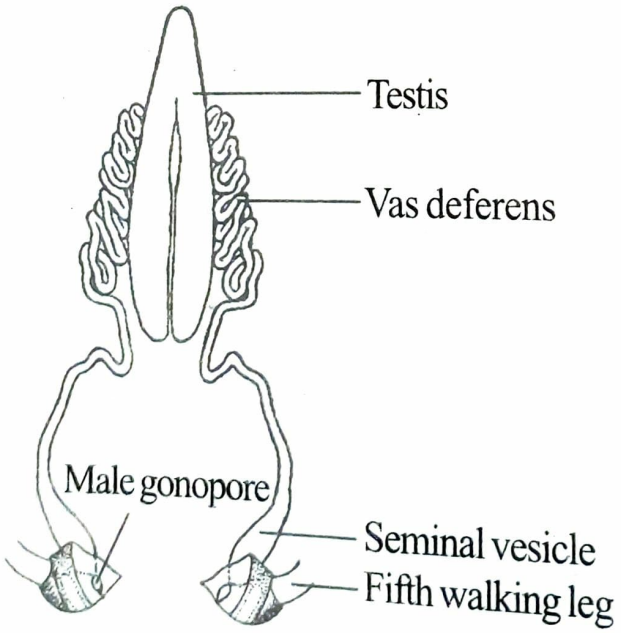


Fig.10.133:Palaemon; Male reproductive system.

The testes are elongated. They are located between the hepatopancreas and heart. They are fused at the anterior ends. The te is formed of numerous ***seminiferous tubu*** Spermatozoa are formed here.

A long coiled tube called ***vasdefere*** arises from the posterior end of each test becomes much coiled. The vas deferens le into a ***seminal vesicle.*** The seminal ve opens to the outside by a ***male genital ap ture*** at the base of the 5th walking leg.

Life Cycle

Palaemon breeds during May, June, J The male deposits sperms near the female g tal aperture. The female releases egg. Fe zation is ***external***. The female carries the e in the abdominal legs.

The development is ***direct***. There i larval stage. The eggs hatch into young pra The young prawns moult several times an come adults.

3. Cockroach (*Periplaneta americana*)

Phylum : *Arthropoda*
Class : *Insecta*
Order : *Orthoptera*

Cockroaches are widely distrib throughout the world except the polar re There are nearly 3000 species of cockroa The common Indian species are *Peripl americana* and *Blatta orientalis*.

Cockroaches are house - hold pests. are found under stones, damp leaves, etc. also inhabit kitchen, sewage channel, r rants, godowns, store rooms, ships, fruit trains, etc. They are active and nocturn mals, hiding in holes and crevices in d emerge at night in search of food. Th usually found in place where there is w and food.

The body is flat, broad and bilat

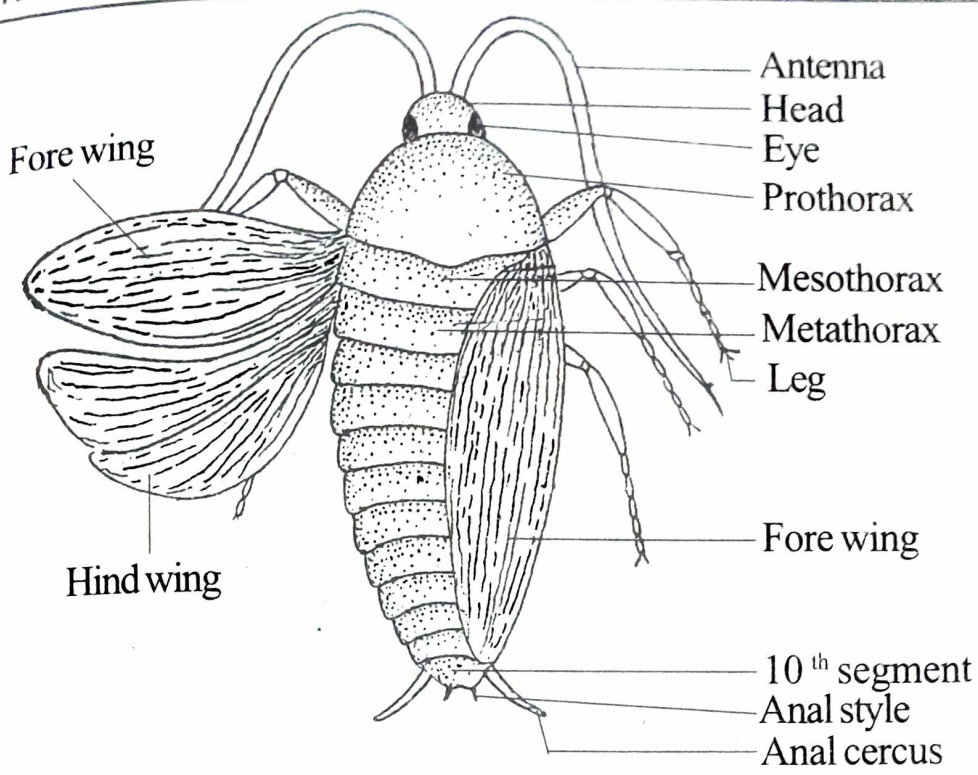


Fig.10.134: Periplaneta americana.

colour. The body is covered by ***chitinous exoskeleton***, the ***cuticle.***

The body consists of four distinct regions, namely the ***head, neck, thorax*** and the ***abdomen.***

The ***head*** is triangular or pear-shaped. It is formed by the fusion of ***six segments***.

The head contains ***mouth, mouthparts*** a pair of ***antenna***, a pair of ***compound eyes***. The head is enclosed in a ***head capsule.***

On either side of the head there is a large sessile ***compound eye***. A pair of long movable, many jointed ***antennae*** are found in front of the eyes. They are organs of touch and smell. At the base of each antenna there is a small rounded whitish area known as ***fenestra***. The ***mouth*** is present at the lower end of the head. It is surrounded by ***mouth-parts.***

The thorax is composed of three segments known as ***prothorax, mesothorax*** and ***metathorax.*** The exoskeleton of each segment is formed of a dorsal plate called ***tergum*** or ***notum*** and a ventral plate known as the ***sternum.*** These two are jointed by a ***cuticle*** on each side termed the ***pleuron***.

The terga of the three segments are known as ***pronotum, mesonotum*** and ***metanotum*** respectively. The pronotum is the largest and it projects forwards to conceal the neck.

Each thoracic segment bears a pair of five jointed ***legs*** which are used in walking and running. The thorax has two pairs of ***spiracles,*** openings of the tracheal system. They are present in the ***mesothorax*** and ***metathorax*** one pair each.

The mesothorax and metathorax have each a pair of ***wings.*** The wings of the cockroach are expansions of the cuticle supported by a network of chitinous ridges called ***nervures*** or ***veins.***

The anterior or ***fore wings*** are narrow, brownish and opaque and it is leathery in texture. They form a protective covering for the ***hind wings*** at rest. So they are known as ***wing covers*** or ***tegmina***. They are not useful in flight.

The hind wings are thin, membranous, transparent, broad and used in flight. They are kept folded as a fan when the animal is at rest.

The ***abdomen*** is composed of ***eleven segments***, the last being vestigeal. Each segment has a dorsal ***tergum*** and a ventral ***sternum,*** connected at the sides by soft cuticle called ***pleuron***. The first seven segments are seen clearly. The eighth and ninth segments are tucked into and overlapped by the seventh.

The tergum of the tenth segment is divided into two lobes by a notch at its hind end. It bears a pair of small palp-like jointed processes the ***anal cerci.*** They arise from the sternum. They are formed of 15 joints. They are tapering.

In the male cockroach, the 9th segment bears a pair of ***anal styles***. They arise from the ***sternum.*** They are ***unjointed***. They are present only in the male.

The ***tergum*** of the eleventh segment is represented by a plate called ***epiproct.*** The ***sternum*** of the eleventh segment is represented by a ***podical plate*** or ***paraproct,*** lying on either side of the anus.

The ***anus*** lies beneath the tenth tergum and between the podical plates.

The ***genital opening*** is present below the anus and is surrounded by chitinous processes known as ***gonapophyses.*** Gonapophyses are chitinous processes arising from the sternum of 9th segments. They surround the genital aperture and function as external genital organs.

The abdomen has 8 pairs of ***spiracles*** on the side.

The abdomen of the female is broader than that of the male. In female the sternum of the seventh segment is large and boat shaped. It is divided posteriorly into two parts, the ***gynovalvular plates*** or ***apical lobes***. The sterna of the eighth and ninth segments are tucked into the previous segments and thus a ***brood pouch*** is formed. The brood pouch is divided into two parts, the anterior ***genital chamber*** and the posterior ***oothecal chamber***. The fertilized eggs are carried in the brood pouch till they are deposited in a safe place.

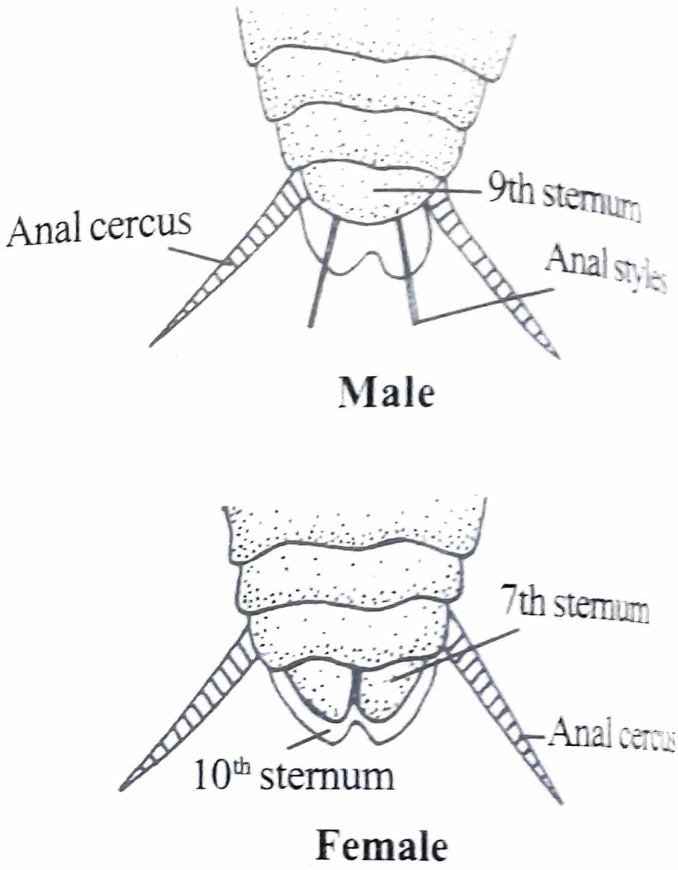


Fig.10.135: Abdomen of Cockroach.

Head Capsule

The head is covered by an exoskeleton called ***head capsule.***

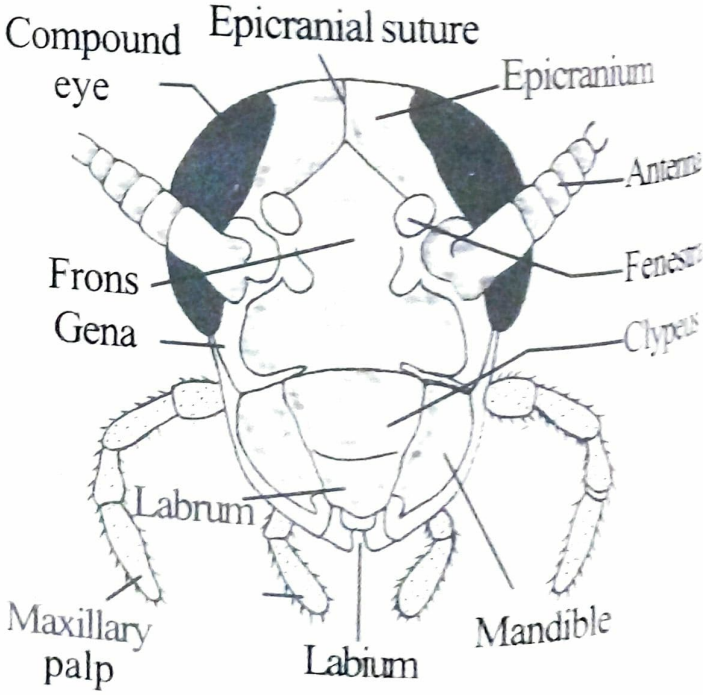


Fig.10.136: Cockroach-Head.

The exoskeleton of the head is known as ***epicranium***. It consists of six chitinous plates or ***sclerites.*** The top or back of the head is covered by a pair of ***epicranial plates*** joined in front by an Y-shaped ***epicranial suture.***

The front part lying below the epicranial plates is a triangular plate called the ***frons.*** Below the frons is a broad rectangular plate known as ***clypeus.*** The two sides of the eye are covered by two plates termed ***cheeks*** or ***genae*** lying below the eyes. Hinged on to the clypeus is a movable plate called ***labrum.*** It overhangs the mouth as an upper lip.

Legs

Cockroach has 3 pairs of legs. They are present in the thorax. Each thoracic segment bears a pair of legs. Each leg is formed of ***5 segments,*** a pair of ***claws*** and a ***pulvillus***. The 5 segments are the following:

1. The ***coxa*** by which the leg is articulated with the thorax.

2. A small triangular ***trochanter,***

3. A stout ***femur***, which is the strongest part of the leg,

4. A slender and long ***tibia;*** the tibia bears stout bristles, the ***tibial spurs***,

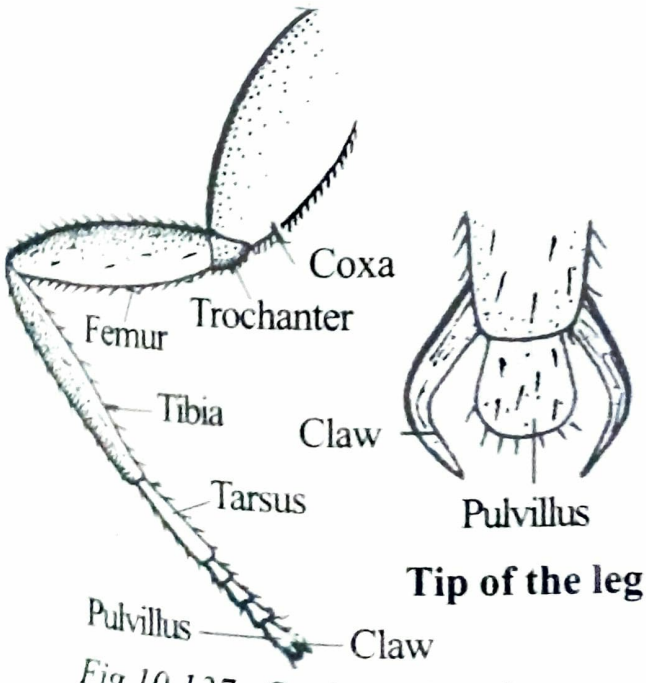


Fig.10.137: Cockroach; a leg.

5. The ***tarsus*** is composed of ***five*** movable segments. The terminal segment of tarsus is called ***pretarsus.*** It bears a pair of ***claws*** and a spongy pad called ***pulvillus.*** Fine bristles are present in the pulvillus. The pads help to have firm grip on the smooth and slippery surfaces.

Body Wall

The body wall consists of three distinct layers, the ***cuticle,*** the ***epidermis*** and the ***basement membrane.***

The cuticle is formed of three layers 1. an outer thin ***epicuticle*** of waxy nature 2. a middle thicker pigmented ***exocuticle*** and an inner much thicker ***endocuticle*** of soft laminated chitin.

The epidermis has a single layer of columnar cells which secrete the cuticle. ***Dermal glands*** and ***oenocytes*** are present in the epidermis.

The basement membrane is thin and it limits the body internally.

The body wall has many outgrowths, like the immovable spine and hair-like movable setae.

The body wall forms the protective covering for the internal organs. It checks the loss of water by evaporation. It provides a surface for attachment of muscles. Outgrowths of the cuticle act as sensory, feeding, filtering, copulatory and locomotory organs.

Body Cavity

The true coelom is reduced and is represented by the cavities of reproductive organs. The body cavity is filled with blood and is called the ***haemocoel.*** It is an expansion of the blood vascular system.

Loose tissues known as the ***fat bodies*** or ***corpora adiposa*** are found in the body cavity. They store fat, proteins and glycogens. Some of the fat body cells store the nitrogenous waste materials in the form of uric acid. Still others have symbiotic micro-organisms.

Digestive System

It includes the mouth-parts, alimentary canal and associated glands.

Mouth-parts

The appendages found around the mouth are called the ***mouth-parts***. In cockroach, the mouthpart is of the ***chewing*** or ***mandibulate type.*** Mouth-parts consists of the ***labrum***, the ***mandible,*** the ***first maxillae***, the ***second maxillae*** and the ***hypopharynx.***

Labrum: It is the ***upper lip***. It lies in front of the mouth.

Mandibles: The mandibles have teeth like ***denticles*** on their inner edge. The two mandibles serve to cut and masticate the food. The mandibles move from side to side.

First maxillae: They are present on the sides of the mouth just behind the mandibles. Each maxilla is ***biramous*** and consists of three parts, the basal ***protopodite***, the inner ***endopodite*** and the outer ***exopodite.***

The protopodite is made up of a ***cardo*** and a ***stipes.***

From the outer side of the stipes arises a five-jointed palp, the ***maxillary palp.*** At the base of the palp is a small structure called the ***palpiger.*** From the inner side of the stipes arise two processes, the outer ***galea*** and an inner ***lacinia.***

The maxillae serve to hold the food by the claws of lacinia and bring it to the mandible for mastication. They are also used for cleaning the antennal palps and front legs.

Labium: Labium is the ***lower lip***. It is also called ***second maxillae***. It lies behind of the maxillae. It consists of three parts, ***submentum***, ***mentum*** and ***prementum.***

The pre-mentum bears a ***ligula*** and a pair of ***labial palps.*** Each half of ligula consists of an inner ***glossa*** and an outer ***paraglossa.***

The ***labial palp*** is 3 jointed. It is present on a small projection known as ***palpiger.***

The palps bear bristles and act as a sense organs. The glossae and paraglossae help in pushing the masticated food into the preoral cavity.

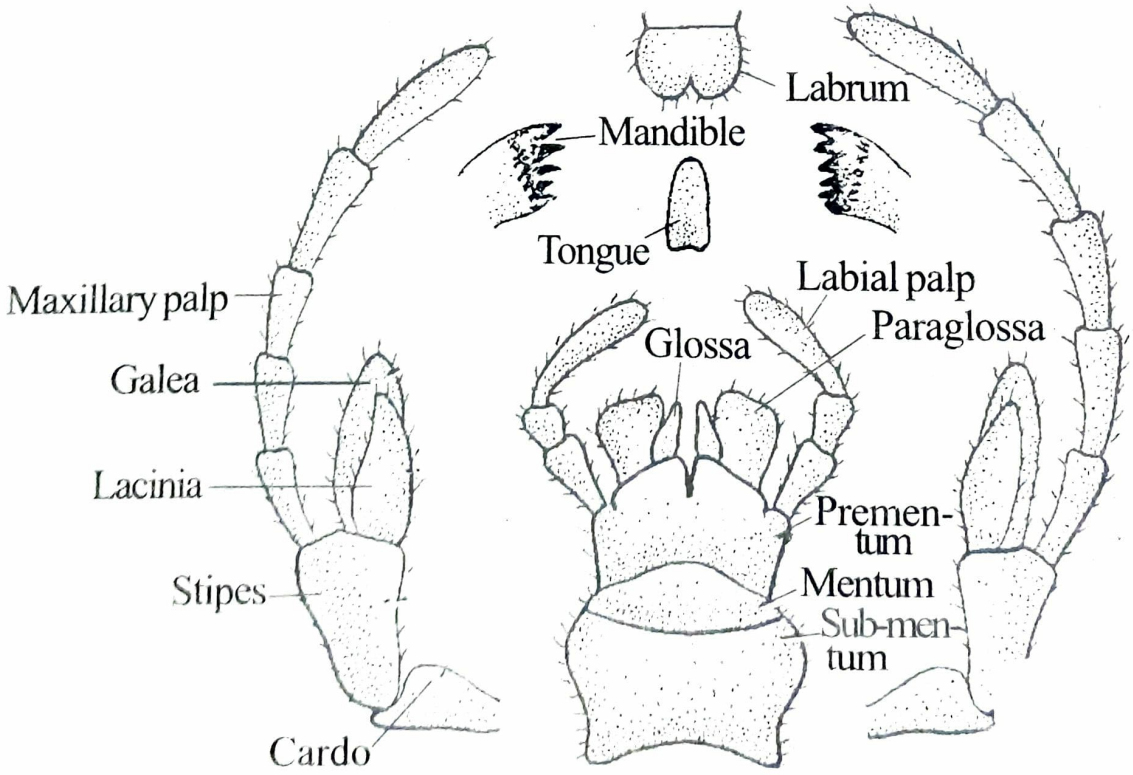


Fig.10.138: Cockroach; Mouth-parts.

Hypopharynx: It is the tongue located inside the buccal cavity. A salivary duct opens into the base of the hypopharynx.

Alimentary Canal

It consists of three regions, the ***fore-gut*** or ***stomodaeum***, the ***mid-gut*** or ***mesenteron*** and the ***hind-gut*** or ***proctodaeum***. The fore-gut and hind-gut are ectodermal, lined with cuticle where as the midgut is endodermal, without a cuticular lining.

Foregut: It is composed of the ***pre-oral cavity***, ***mouth***, ***pharynx***, ***oesophagus***, ***crop*** and ***gizzard***. The ***pre-oral cavity*** is bounded in front by the labrum, posteriorly by the labium and on each side by a mandible and a maxilla. Inside the cavity the hypopharynx is present. The ***mouth*** lies on the roof of the pre-oral cavity.

The mouth leads into a tubular ***pharynx***, which is followed by a slender, narrow ***oesophagus***. It expands into a large sac called the ***crop***. It extends up to the first two segments of abdomen.

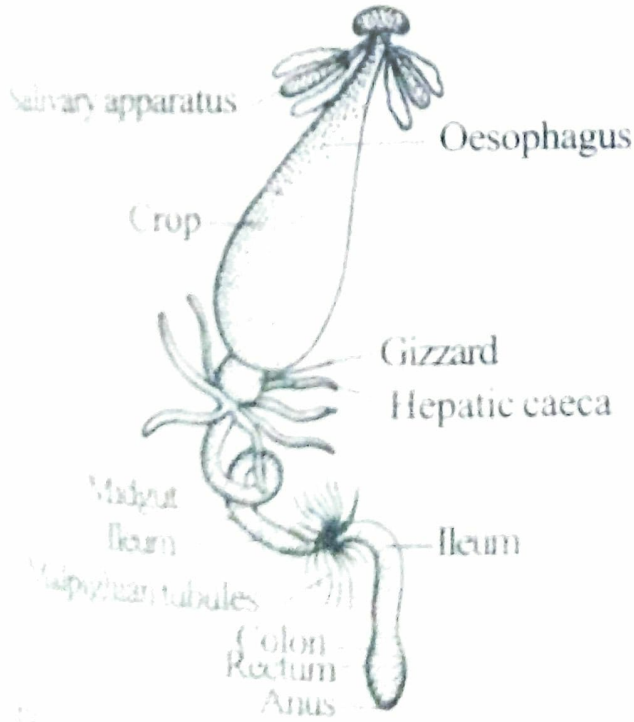


Fig. 10.139: Cockroach: Digestive system.

The crop opens into a ***gizzard***. It is a muscular thick walled bag. Its chitinous inner lining is thrown into six powerful teeth. Behind each teeth is a ring shaped cushion, the ***pulvillus***. It consists of long backwardly directed bristles. The teeth serve to grind the food while the bristles act as a strainer, allowing only the well crushed food to pass on. The end of gizzard projects into the mid-gut in the form of a funnel-like narrow tube the ***stomodeal valve***, which prevents the passage of food from the mid gut to the gizzard.

Midgut: It is a short narrow tube lined with glandular endodermal cells. From the anterior end of the midgut arises seven or eight blind tubular outgrowths called ***hepatic caeca.*** They project into the haemocoel.

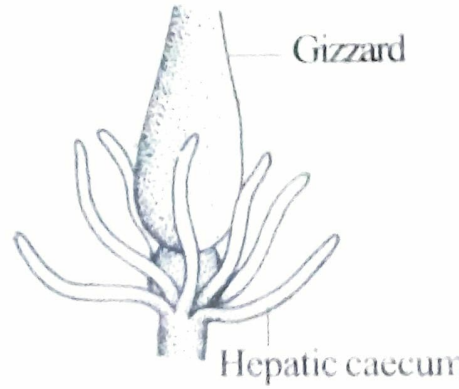


Fig. 10.140: Hepatic caeca.

Hind gut: It is formed of three parts, namely a ***ileum***, ***colon*** and a ***rectum***.

The ***rectum*** opens by the ***anus*** lying posteriorly below the tenth tergum.

At the junction of the midgut and hindgut there are 60 to 70, fine, yellow thread-like processes called ***Malpighian tubules***. They are ***excretory*** in function.

Digestive Glands

Salivary apparatus: Cockroach has a ***salivary apparatus***. It is located on the sides of oesophagus. It consists of two pairs of ***salivary glands*** and a pair of ***salivary receptacles.***

The ducts of the two glands of a side unite into a ***salivary gland duct***, which runs forwards and joins a similar duct from the other side to form a ***common salivary gland duct.***

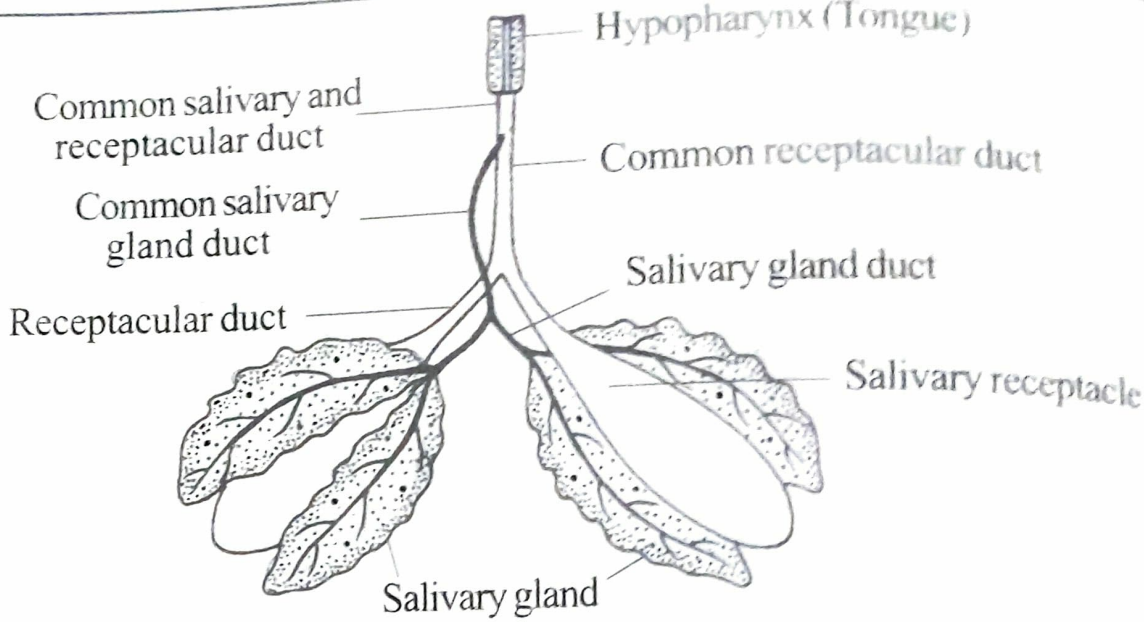


Fig.10.141: Salivary apparatus.

Similarly the ducts of the two receptacles unite into a ***common receptacular duct.*** The common salivary duct joins with the common receptacular duct to form a ***common salivary*** and ***receptacular duct.*** It opens on the hypopharynx.

The salivary glands secrete a fluid called ***saliva.***

Feeding and Digestion

The cockroach is ***omnivorous*** feeding on any kind of materials like animal or plant materials, bits of papers, leather, bread, cloth, etc. The food is located by the antennae and palps. It is masticated with the mandible. The laciniae, galeae of maxillae and glossae and paraglossae of the labium hold the food during the act of crushing. The labium and labrum prevent the loss of food from the jaws.

The food is mixed with ***saliva***, poured into the preoral cavity by the common salivary duct. The saliva contains an enzyme called ***amylase*** which digests starch into glucose. The food is then pushed through the oesophagus into the crop. The saliva continues its action on starch in the crop also.

Next the food passes to the gizzard. In the gizzard, the food is masticated by the cuticular teeth and is then filtered by the bristles.

The secretion of the hepatic caeca contains ***proteolytic*** and ***lipolytic*** enzymes which digest proteins and lipids respectively.

The digested food is absorbed in the midgut and in the caeca. The rectum removes the excess amount of water and the undigested food is egested through the anus as dry pellets. Some of the absorbed food is stored as reserve in the form of fat, glycogen, etc. in the fat bodies lying in the haemocoel.

Blood Vascular System

It is of ***open type.*** It consists of the ***heart***, the ***aorta, haemocoel*** and the ***blood.***

Heart

The heart is a long ***tube.*** It is ***contractile.*** It extends along the mid dorsal line. The heart is surrounded by a ***pericardium.*** The pericardium encloses a ***pericardial sinus.***

The pericardium is perforated and the pores are valvular allowing the blood to flow into the pericardial sinus, but not in the reverse direction. There are triangular muscles extending between the pericardium and the body wall. These muscles are known as ***alary muscles.***

2. Chewing and Lapping Type

It is found in ***bees, wasps***, etc. It is mod fied for collecting nectar and pollen grai from flowers. It has the following features:

1. The mandibles are smooth and spa late. The workers use them in building t comb.

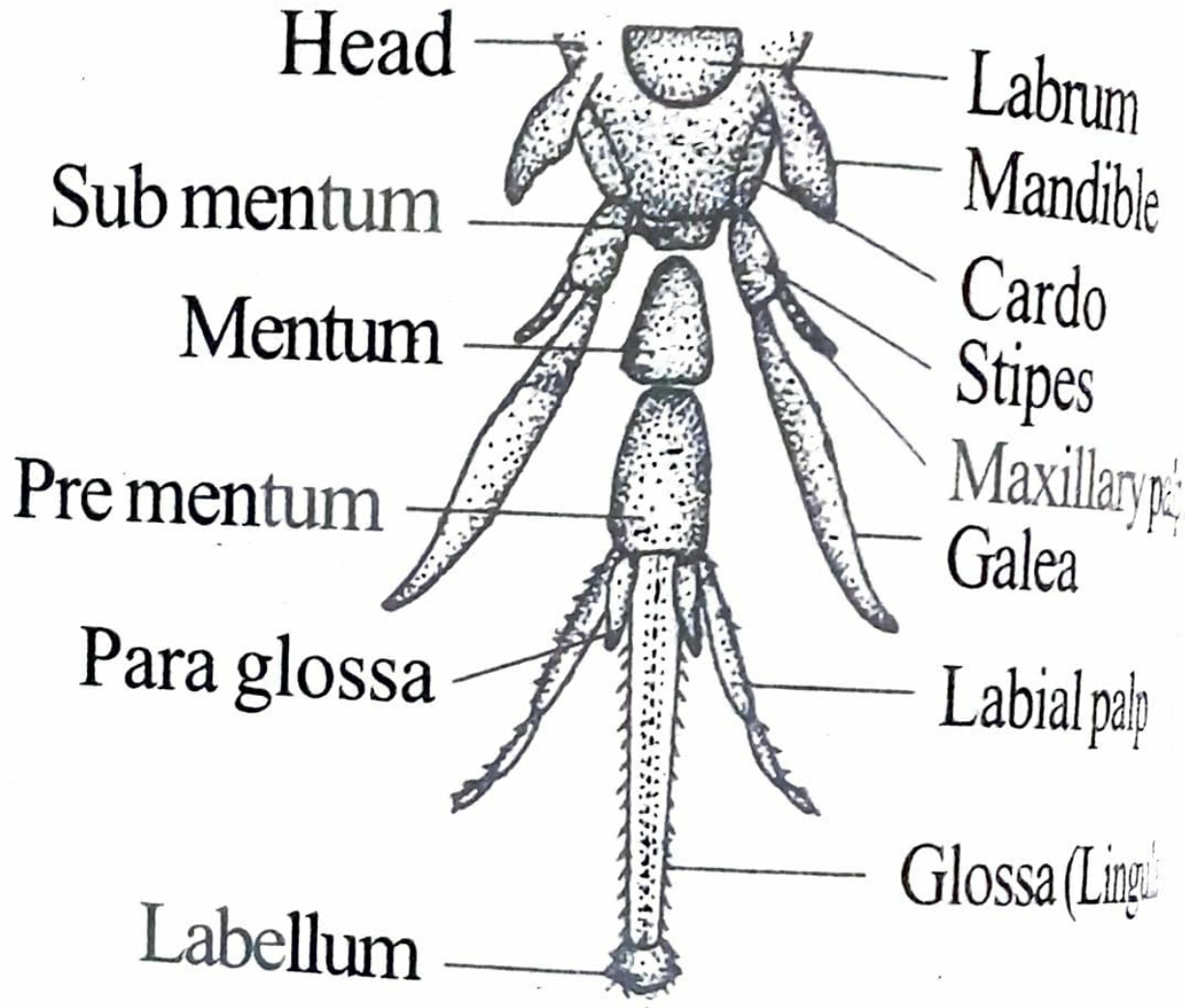


Fig. 10.292: Chewing and lapping ty - Honey bee.

3. Para-glossae are greatly reduced. Glossae are united and elongated to form the retractile ***ligula*** which terminates distally in a ***honey-spoon*** or ***labellum.*** Labial palps are elongated.

While feeding, the galeae and labial palps are brought close together forming a hollow tube which can be inserted deeply into the corolla of a flower. The centre of the tube is occupied by the glossae moving backward and forward to collect the pollen and to suck the nectar.

3. Piercing and Sucking Type

The piercing and sucking type of mouth parts is used to puncture and suck the sap of plants and blood of animals. Eg. *Mosquito, bugs*,etc.

There are two kinds of piercing and sucking mouth parts. They are 1. Dipterous mouth parts and 2. Hemipterous mouth parts.

1. Dipterous Mouth parts

1. It is found in ***mosquitoes.***

2. Labium forms an elongated, fleshy and mid-dorsally grooved hollow protective tube called ***proboscis.***

3. The labrum is fused with the epipharynx to form ***labrum-epipharynx.***

4. The labrum-epipharynx, the mandibles, the maxillae and the hypopharynx are elongated to form six needle-like structures called ***stylets.*** They are used for piercing.

2. Hemipterous Mouth parts

1. It is found in ***bugs.***

2. The labium forms a three-jointed ***rostrum.***

3. The ***stylets*** are only four in numbers two ***mandibles*** and two ***maxillae.***

4. The maxillary palps and labial palps are absent.

4. Sponging Type

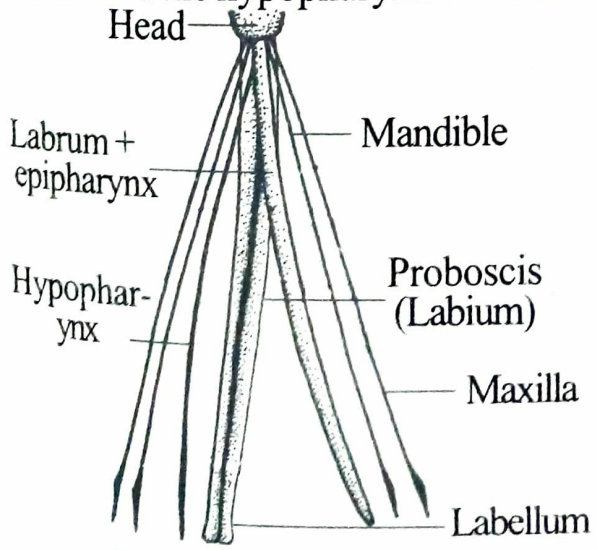
This type is found in ***housefly.*** It is modified for ***sucking liquid*** food. It has the following features:

1. Mandibles are absent.

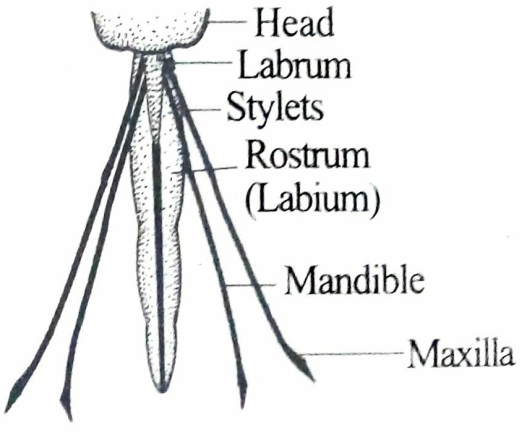
2. Maxillary palp is made of a single piece.

3. The labium is modified to form a ***proboscis.***

The proboscis consists of three regions, namely a proximal ***rostrum***, a middle ***haustellum*** and a distal ***labellum.*** The rostrum is cone-like and it bears ***maxillary palps.*** The haustellum has a mid-dorsal groove called ***labial groove*** and a ventral heart-shaped plate called ***theca.*** The labial groove functions as a food passage from the mouth to the pharynx.



Dipterous - Mosquito



Hemipterous - bug

Fig.10.293: Piercing and sucking type.

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. Lamellidens

Phylum : *Mollusca*
Class : *Pelecypoda (Bivalvia)*
Order : *Eulamellibranchiata*

Lamellidens marginalis is commonly called ***freshwater mussel***. It has a ***bilaterally symmetrical*** soft body covered by the ***mantle*** and ***shell***. Hence it is included in the phylum ***Mollusca***. The shell is formed of two pieces and the foot is wedge shaped. Hence it is included in the class ***Bivalvia*** or ***Pelecypoda.***

It is a freshwater animal. It lives in ponds, rivers, streams, lakes, etc. It lives partly buried in mud. In this position, the posterior part is exposed above the mud. The animal is ***omnivorous***. It feeds by the ***filter-feeding*** method.

The freshwater mussel is laterally compressed. It is ***elongated*** and ***oval*** in shape. It has ***anterior, posterior, dorsal, ventral*** and ***lateral*** sides. The anterior end is ***broad*** and the posterior end is ***narrow***. The lateral sides are ***flattened.***

The soft body is covered by a shell. The shell is formed of two pieces called ***valves.*** The shell is bilaterally symmetrical. It is ***long*** and ***oval*** in shape. The anterior end is ***broad*** and the posterior end is ***narrow.*** The two valves are free ventrally; but they are movably joined together along their dorsal edges by a tough elastic band called ***hinge ligament.*** The ligament serves to open and close the valves. Near the hinge ligament the valves are articulated by the teeth and socket system.

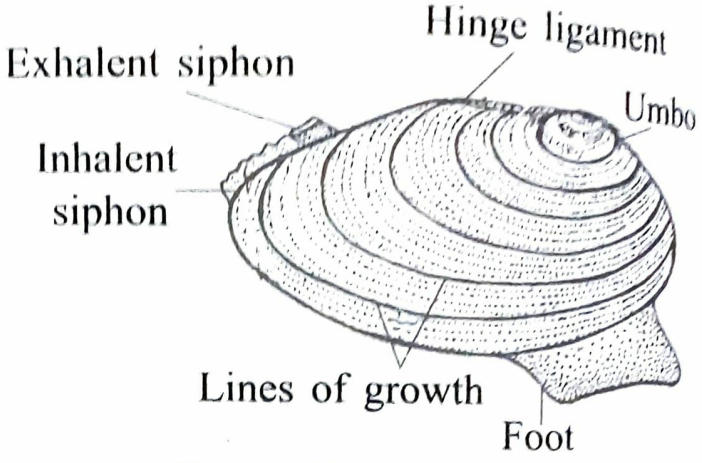


Fig.11.55: Lamellidens.

Near the anterior side of the hinge ligament, there is a white elevation called ***umbo.*** It is the oldest part of the shell. There are many concentric lines around ***umbo***. These lines are called ***lines of growth***. They are parallel to the ventral margin of the shell.

The inner surface of the shell has many impressions. Along the ventral edge, there is an impression called ***pallial line***. It is marked by the attachment of the mantle to the shell. At the anterior end of the pallial line there is a large marking called ***anterior adductor impression*** produced by the anterior adductor muscle. By the side of this marking, there are two small markings. One marking is dorsal called ***anterior retractor impression*** and the second marking is ventral called ***anterior protractor impression.*** At the posterior end of the pallial line, there is a large impression called ***posterior adductor impression.*** Near this there is a small scar called ***posterior retractor impression.***

The shell is composed of ***calcium carbonate*** and a horny substance ***conchiolin***. It is composed of ***three layers.*** They are as follows:

1. **Periostracum :** It is the ***outermost*** layer. It is ***brown*** in colour. This layer is formed of a horny substance called *conchiolin.*

2. **Prismatic layer :** This is the ***middle*** layer made up of minute ***prisms*** of calcium carbonate separated from each other by thin layers of ***conchiolin.***

3. **Nacreous layer :** This is the ***innermost*** layer composed of many thin alternate layers of ***calcium carbonate*** and ***conchiolin***. These thin layers are arranged parallel to the surface. The nacreous layer is also called ***"the mother of pearl layer".***

The body is soft and is enclosed by the hard shell. The body consists of the ***mantle***, the ***viscera*** and the ***foot***. It has no head.

The soft body is covered by a skin called mantle. It is formed of two halves called ***mantle lobes.*** The two lobes are fused together dorsally. But they are free ventrally and anteriorly. Posteriorly, the two mantle lobes are closely associated with each other to form two tubes. These tubes are called ***inhalent siphon*** and ***exhalent siphon***. Water enters the body through the inhalent siphon and comes out through the exhalent siphon.

The cavity enclosed by the mantle is called ***mantle cavity***. This cavity communicates to the exterior by the inhalent and exhalent siphons. The mantle cavity contains a pair of ***ctenidia*** and two pairs of ***labial palps.***

The viscera includes all the internal organs like the gut, the digestive glands, the circulatory system, the nervous system and the gonads, etc.

The foot is ***wedge-shaped***. Internally the foot contains the intestine, the digestive gland and the gonads. The foot is used for burrowing.

Musculature

The two shell valves are operated by two large muscles called ***anterior*** and ***posterior adductor muscles.*** The two adductor muscles pass across the body between the two shell valves. The shell-valves open, when the adductor muscles relax. When they contract, the valves close.

Near the adductor muscles there are two smaller muscles. They are the ***anterior*** and ***posterior retractor muscles***. These muscles run from the foot to the shell. They serve to withdraw the foot.

Close behind the anterior adductor muscle there is a small ***protractor muscle***, which serves to compress the visceral mass, causing the protrusion of the foot. It also serves in the backward movement of the animal.

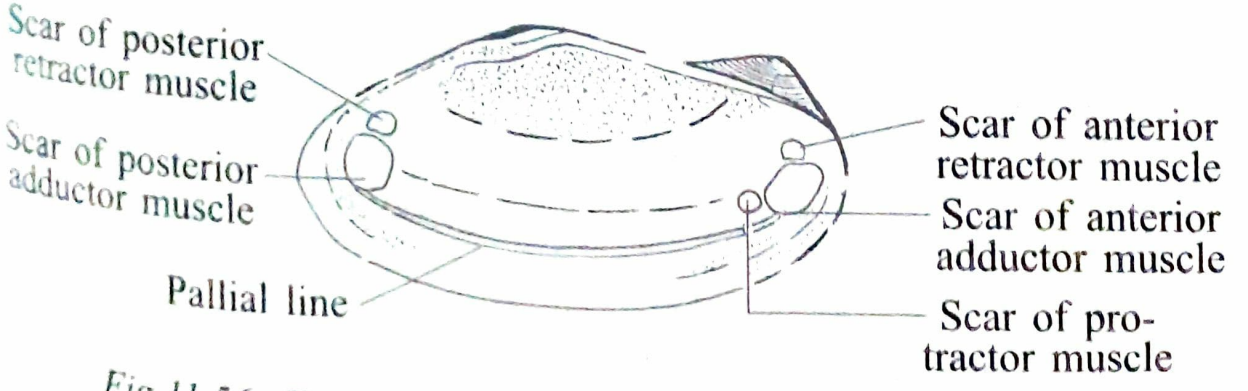


Fig.11.56: Freshwater mussel-Inner view of a shell valve.

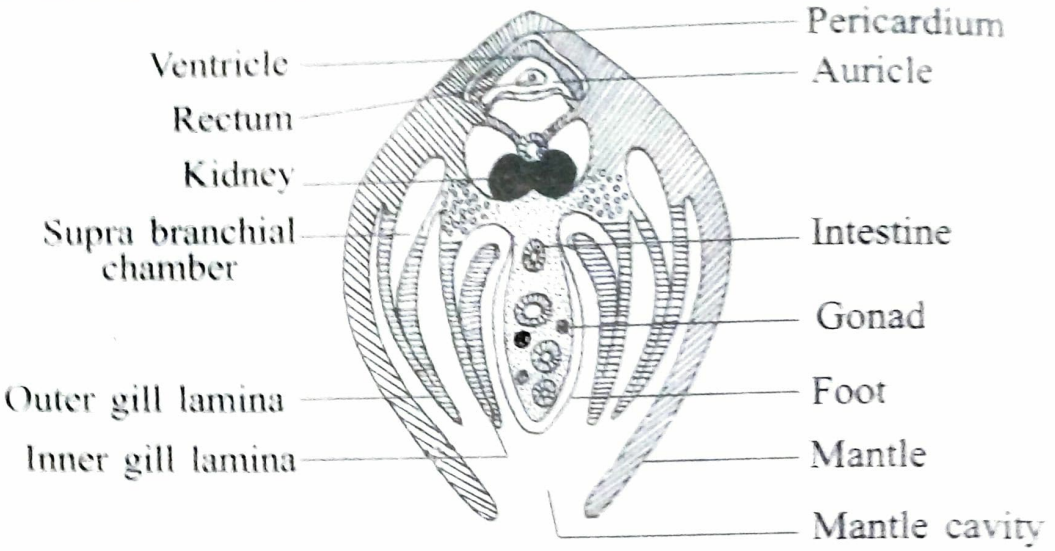


Fig. 11.57: T.S. of Freshwater mussel: T.S through foot.

Respiration

Lamellidens is aquatic in habit. Hence it exhibits ***aquatic respiration*** or ***gill respiration.*** There are two types of aquatic respiration. They are

1. Mantle respiration and

2. Gill respiration.

1. Mantle Respiration

Mantle is a fold of skin covering the soft body below the shell. It is formed of two lobes one on either side. It is richly supplied with blood and is continuously bathed in water. Exchange of gases occurs between the blood of mantle and the water. This is called ***mantle respiration.***

2. Gill Respiration

Gill respiration is carried out by ***gills*** or ***ctenidia***. Gills are formed as outgrowths of the skin.

There are two gills. They are located one on either side of the body.

The gills are situated inside the mantle cavity. They are protected by mantle.

The gills of bivalves are plate-like: hence they are called ***lamellibranchs***. Each gill has a central axis and plate like structures on either side. Hence the gills are called ***bipectinate gills***.

Each gill is a 'W' shaped structure. It consists of two plate like structures called ***laminae.*** One lamina is situated on the inner side called ***inner lamina*** and the other is situated on the outer side called ***outer lamina***. Each lamina is a 'V' shaped structure.

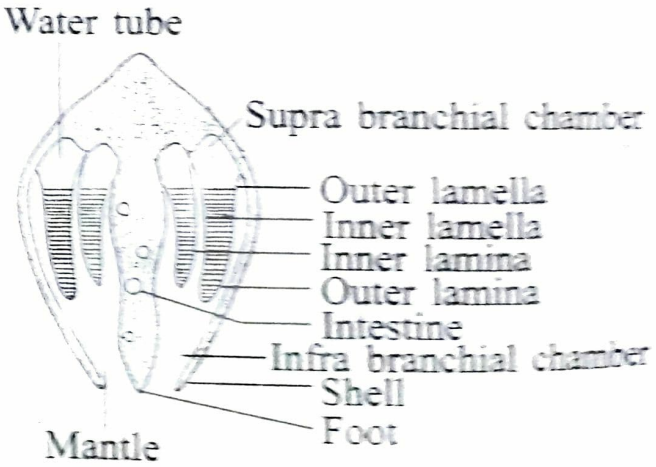


Fig. 11.58: Freshwater mussel - T.S. through the gill region.

Each lamina is formed of two vertical plates called ***lamellae.*** The outer one is called ***outer lamella*** and the inner one is called ***inner lamella***. The inner and outer lamellae are united together at their anterior, ventral and posterior edges, but are free dorsally.

Each lamella is formed of series of vertical filaments called ***gill filaments***. The gill filaments of the two lamellae of a lamina are continuous at the free ventral side.

The gill filaments are joined to one another by horizontal bars called ***inter filamentar junctions.*** Two lamellae of a lamina are joined together by ***inter lamellar junctions.***

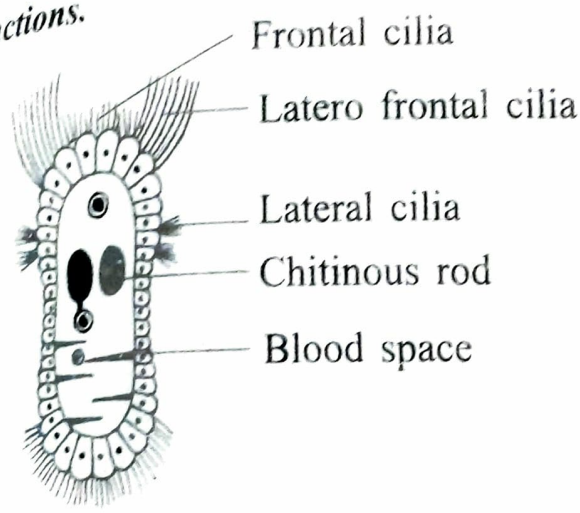


Fig.11.59: Freshwater mussel; T.S. of a gill filament.

The inter lamellar junctions divide the cavity lying between the lamellae into vertical chambers called ***water tubes.*** Dorsally all the water tubes open into a large cavity called ***suprabranchial chamber.*** This chamber communicates to the exterior through the ***exhalent siphon***. The portion of the mantle cavity lying below the gill is called ***infra branchial chamber***. It communicates to the exterior through ***inhalent siphon.***

The lamellae are perforated by minute openings called ***ostia.*** They are located between the gill filaments and inter filamentar junctions. Through ostia, water tubes open into the mantle cavity.

Cilia

Each gill filament is covered by a layer of ***ciliated epithelial cells.*** Internally the gill filament is supported by chitinous rods. The surface of the gill filament is provided with ciliated epithelium. The cilia are longer on the outer, latero-external and lateral parts of the filaments. These longer cilia are referred to as ***frontal, laterofrontal*** and ***lateral cilia.***

Blood Supply

The gills receive venous blood from the kidney through ***afferent branchial vessels.*** In the gills the blood is oxygenated. The oxygenated blood is carried to the auricle through ***efferent branchial vessels***.

Mechanism of Respiration

The beating of the cilia of the gills and the mantle draws water into the ***infrabranchial chamber*** through the ***inhalent siphon***. From here it enters the ***water tubes*** through ***ostia***, from the water tubes it passes into the

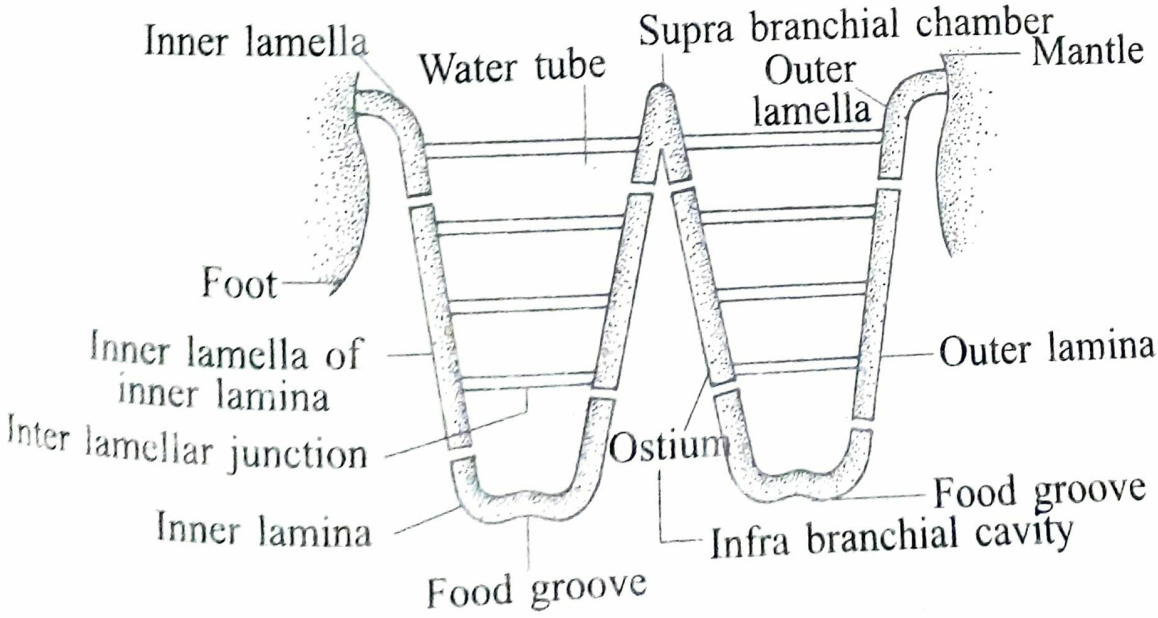


Fig.11.60: One side gill - Anterior view.

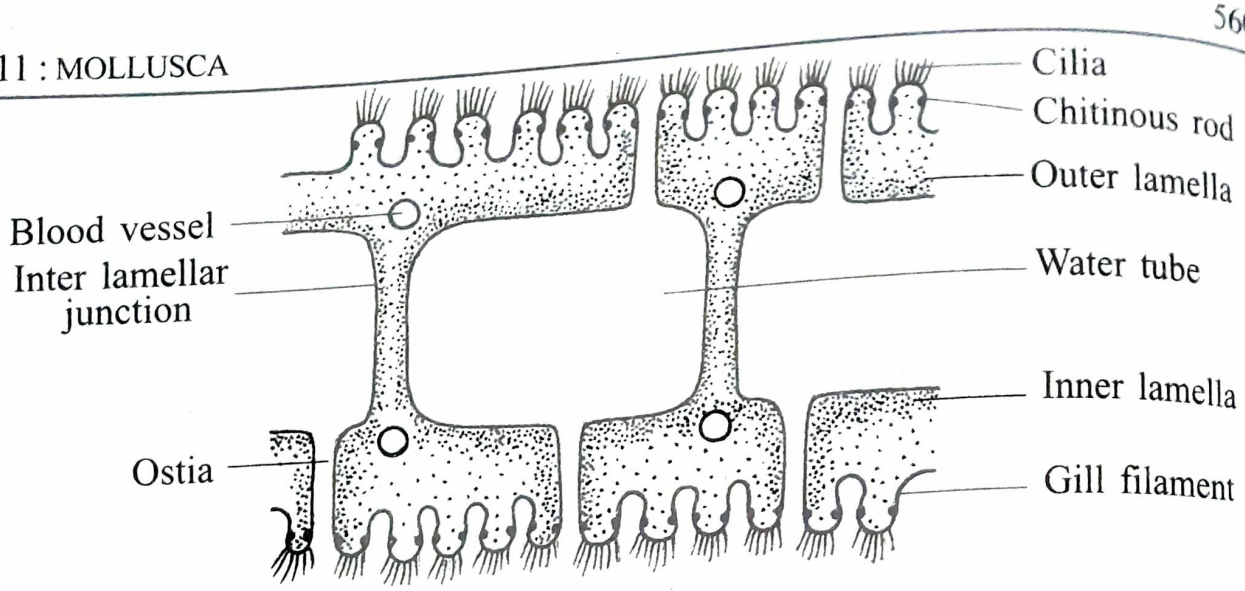


Fig.11.61: T.S. of lamina.

suprabranchial chamber. Then the water passes out through the exhalent siphon.

Exchange of gases occurs when the water passes over the mantle (infrabranchial chamber) and the gills. The outgoing water carries with it CO_2, nitrogenous wastes and gametes.

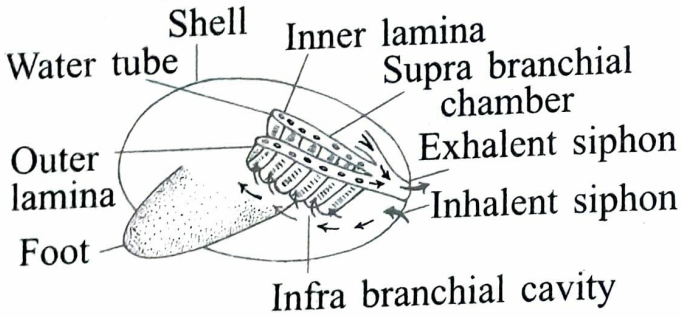


Fig.11.62: Respiratory water current.

Digestive System

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

Alimentary Canal

The alimentary canal is formed of ***mouth, oesophagus, stomach, intestine, rectum*** and ***anus.***

Mouth : The mouth is situated anteriorly. On each side of the mouth, there are two muscular flaps called ***labial palps.*** One is called ***external labial palp*** and the other is called ***internal labial palp.*** The external labial palps of the two sides join together to form the ***upper lip***. Similarly the internal labial palps of the two sides unite together to form the ***inner lip.*** The labial palps are provided with ***cilia***. The cilia push the food particles towards the mouth.

Oesophagus: Oesophagus is a ***short tube*** arising from the ***mouth.*** It leads into the ***stomach***.

Stomach : Stomach is a ***large sac***. It is completely surrounded by the ***liver.***

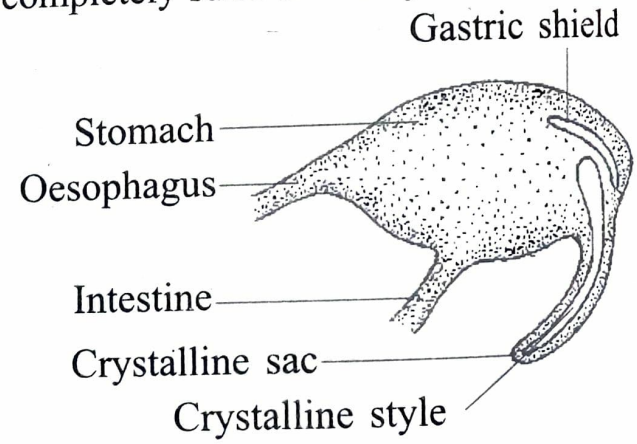


Fig.11.63: Stomach of freshwater mussel.

Crystalline style : The stomach is produced into an outgrowth called ***crystalline sac.*** The crystalline sac encloses a flexible gelatinous rod called ***crystalline style***. It is secreted by the ***crystalline sac.*** One end of the style projects into the stomach to meet with a plate called ***gastric shield*** located inside the ***stomach.*** The style rotates by the beating of the cilia of the style sac. When it is rotating, the style rubs on the gastric shield. This action sheds certain material from the gastric shield. This material dissolves and yields

an enzyme called ***amylase***. Again the rotation of the style mixes up the food and enzymes.

Intestine : The intestine starts from the floor of the stomach. It remains coiled inside the foot. It contains a pair of folds inside called ***typhlosoles.***

Rectum : It arises from the intestine. It runs horizontally on the dorsal part of the body. The typhlosole of the intestine continues into the rectum also. The rectum passes through the ventricle and opens into the ***cloaca*** through ***anus***. The cloaca opens to the outside by the exhalent siphon.

Digestive Glands

The digestive gland is formed of a pair of ***liver*** located around the stomach. They open into the stomach by several ducts. The liver has the following functions :

1. It secretes digestive enzymes.
2. It ingests and breaks solid food particles.
3. It digests fats and proteins intracellularly and
4. It absorbs carbohydrate.

Food

Freshwater mussel is an ***omnivore.*** It feeds on minute plants, animals and other organic debris.

Feeding

Bivalves collect their food from the water current created by the beating of the cilia. This type of feeding is called ***ciliary feeding***. The food materials are carefully filtered from the water current. Hence the mode of feeding is called ***filter feeding***. The filtered food particles are entangled in ***mucous***. This type of feeding is called ***mucous feeding***.

Mechanism of Feeding

The beating of the cilia of the gill filaments and the mantle creates a water current. This water current is drawn into the mantle cavity (infrabranchial chamber) through the inhalent siphon. The water current passes over the gills. The sand grains sink down to the bottom of the mantle cavity. From here they are sent out through the posterior end.

The gill filaments secrete ***mucous.*** The food particles are trapped in the mucous. The food laden mucous is passed ventrally to the ***food groove*** located at the lower edge of the gill lamina. Cilia of the food groove direct the food laden mucous forwards until it reaches the ciliated groove located between the labial palps of each side. The ciliated groove lying between the palps leads to the corners of the mouth. The larger particles are again ***dropped down*** from the palps and are sent out through the posterior end. The smaller particles are directed towards the mouth and are swallowed.

Digestion

In bivalves digestion is ***intracellular*** as well as ***intercellular***. The crystalline style liberates ***amylase*** into the stomach. It digests carbohydrate. This occurs inside the cavity of

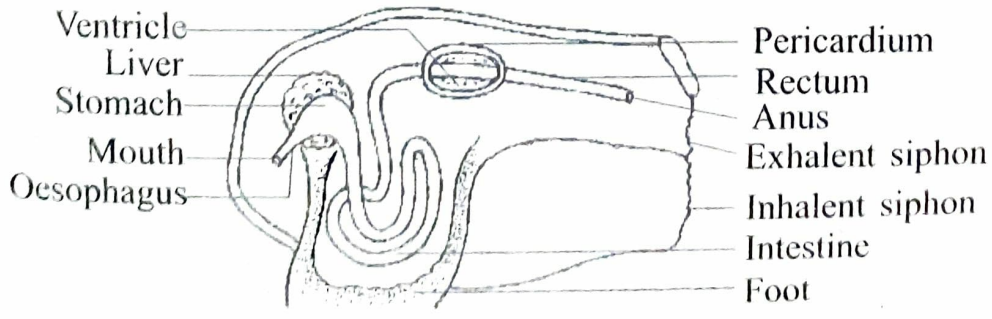


Fig. 11.64: Freshwater mussel - Digestive system.

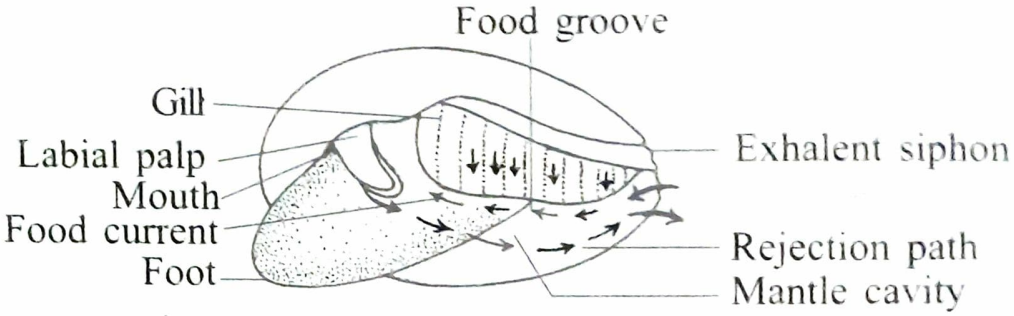


Fig.11.65: Movement of food particles.

the stomach. Hence it is called ***intercellular digestion***.

The entire alimentary canal contains ***amoeboid cells.*** These cells ingest and digest food particles. This type of digestion is called ***intracellular digestion.***

Intracellular digestion also occurs inside the liver. From the stomach, the small food particles enter the liver through the ***ducts***. Here they are engulfed by the epithelial cells for intracellular digestion. Digested food diffuses from the gland into the blood for distribution.

The undigested food particles are passed out from the stomach through the ***intestine, rectum, anus, cloaca*** and ***exhalent siphon.***

Circulatory System

The circulatory system of freshwater mussel is ***open type,*** because capillaries are absent from it. The system consists of ***blood, heart, arteries, sinuses*** and ***veins.***

Blood

The blood is formed of ***plasma*** and ***corpuscles***. It is ***blue*** in colour, because of the presence of a blue pigment called ***haemocyanin*** in the plasma. The corpuscles are colourless.

Heart

The heart is situated dorsally near the posterior end. It is covered by a membrane called ***pericardium.*** The pericardium encloses a cavity called ***pericardial cavity.*** This cavity represents true coelom in freshwater mussel.

The heart is formed of ***three chambers,*** namely a ***ventricle*** and two ***auricles***. The ventricle is ***tubular*** and surrounds the ***rectum.*** The auricles open into the ventricle by two openings called ***auriculo ventricular apertures.***

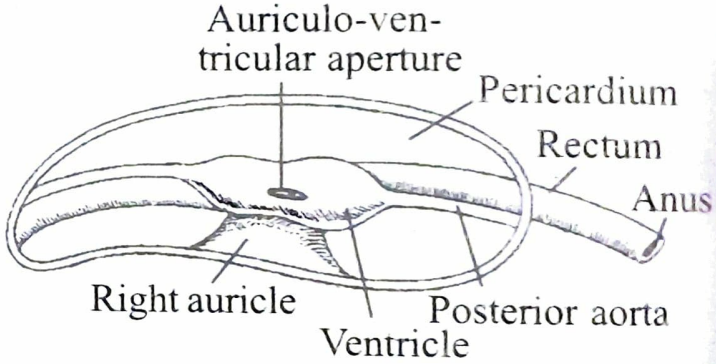


Fig.11.66: Heart of freshwater mussel.

The most remarkable feature of the circulatory system of *Lamellidens* is that the rectum passes through the ***ventricle*** and ***pericardium.***

Arteries

From the ventricle two blood vessels arise. These are called ***anterior aorta*** and ***posterior aorta***. The anterior aorta arises from the anterior end of the ventricle. It divides into many arteries and they supply blood to the anterior regions of the body. The posterior aorta arises from the posterior end of the heart and it supplies blood to the posterior regions of the body.

The mantle receives two pallial arteries, namely an ***anterior pallial artery*** from the anterior aorta and a ***posterior pallial artery*** from the posterior aorta.

Detailed Study of Types

1. 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.

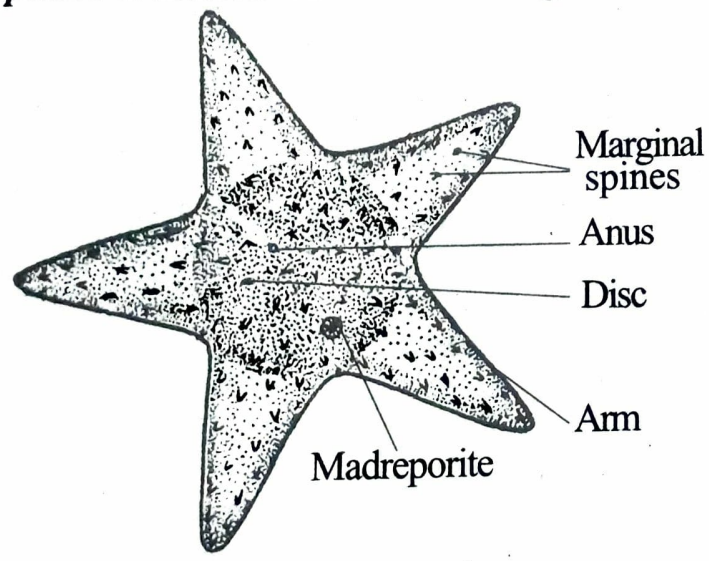


Fig.12.28: Starfish; Aboral view.

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.***

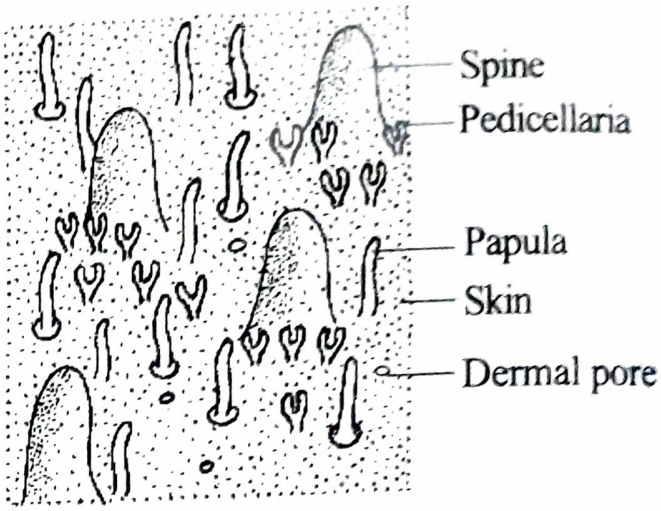


Fig.12.29: Skin; Aboral view.

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***.

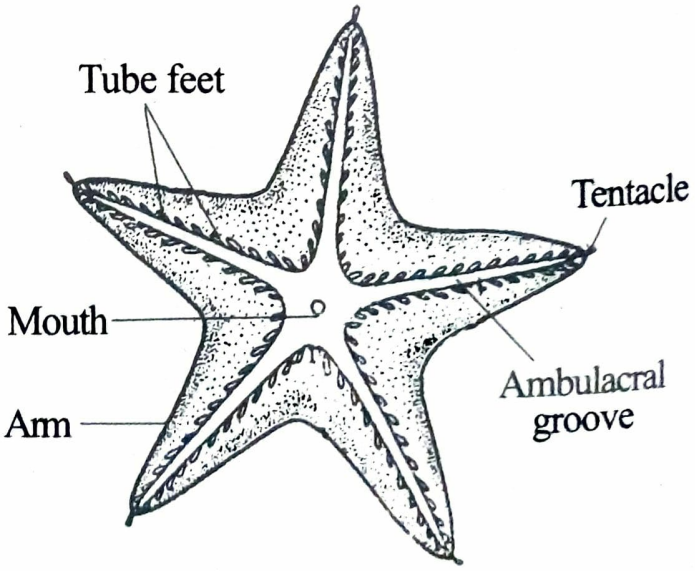


Fig.12.30: Starfish; Oral view.

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

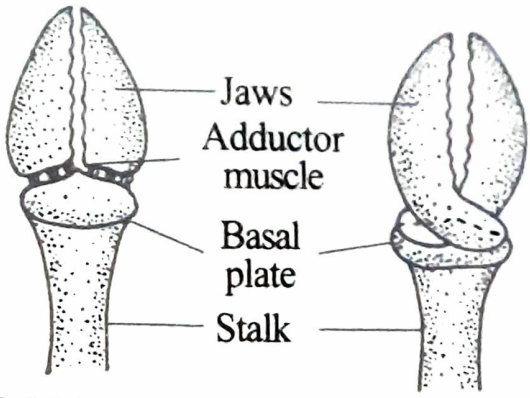
Pedicellariae are microscopic pincer-like structures embedded in the skin of echinoderms. They are the modified spines. They are found at the bases of the spines both on the oral and aboral sides. Pedicellariae are peculiar to echinoderms and they are not formed in other animal groups.

Structure of a Typical Pedicellaria

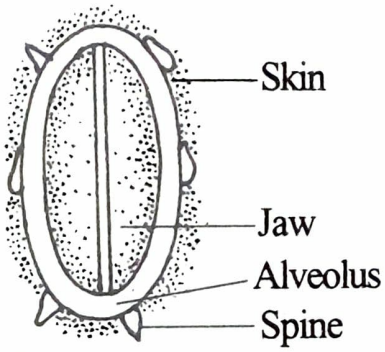
A pedicellaria consists of a ***stalk*** and ***3 ossicles*** (calcareous plates). The stalk is flexible. One end of the stalk is embedded and attached in the skin. The free end of the stalk bears 3 ossicles. Of these 3 ossicles, one lies horizontally at the apex of the stalk and it is called ***basal 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.***

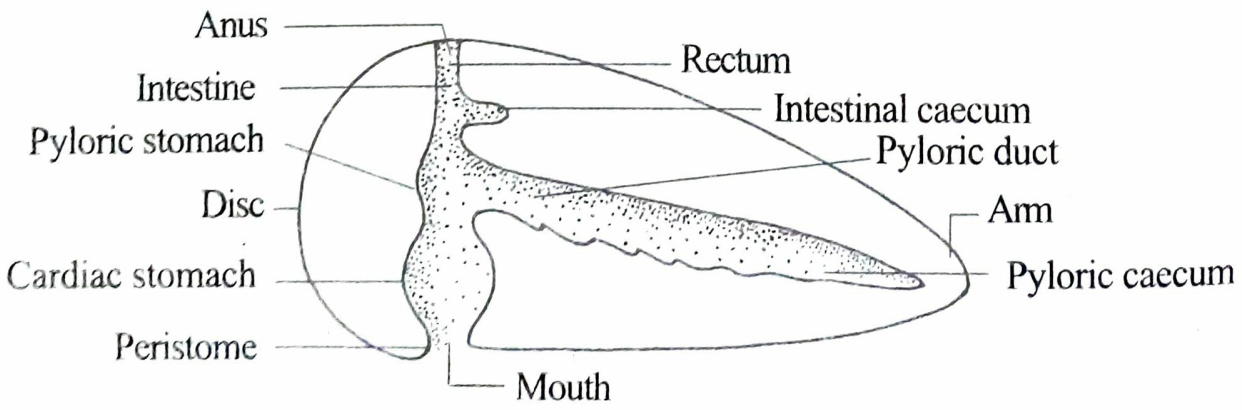


Fig.12.32: Star fish-Vertical section of the disc and arm showing the digestive system.

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

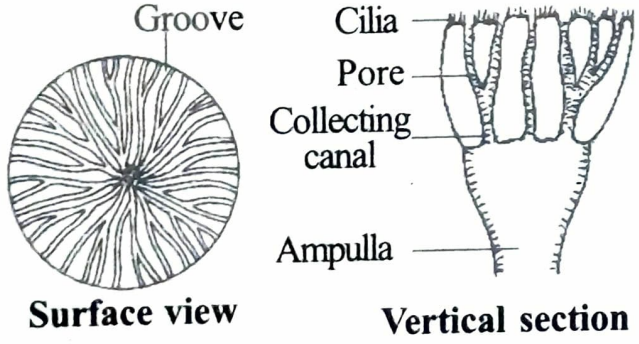


Fig.12.35: Madreporite.

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.***

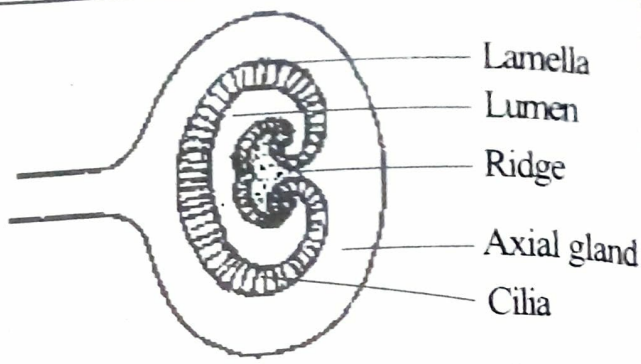


Fig.12.36: T.S. of stone canal.

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

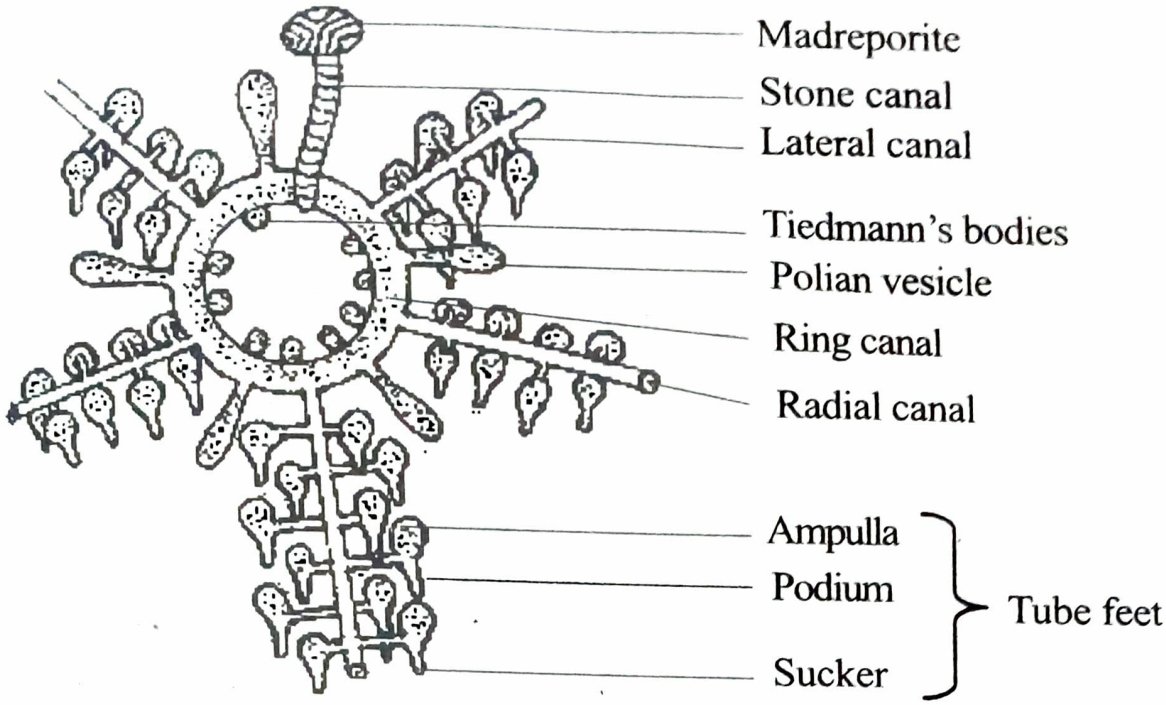


Fig.12.37: Star fish: Water vascular system.

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.