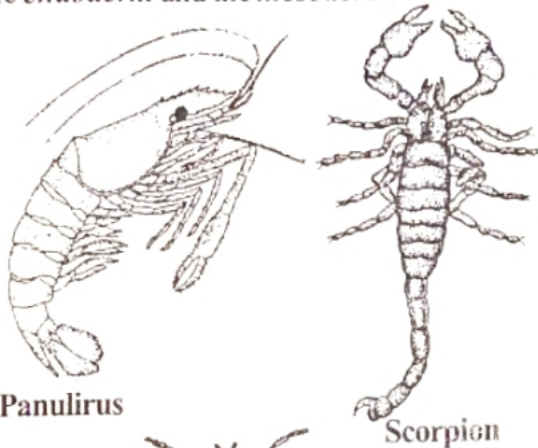


10. Arthropoda

General Characters

Arthropods are segmented animals with *jointed legs* and chitinous exoskeleton. It is the largest phylum comprising about 80% of the known species. This phylum is characterised by the following salient features:

1. All arthropods are *bilaterally symmetrical* animals.
2. The body wall is *triploblastic* consisting of three layers, namely the *ectoderm*, the *endoderm* and the *mesoderm*.



3. Coelom is a *haemocoel* filled with a blood-like *haemocoelic fluid*. True coelom is reduced to small cavities around the gonads.

4. The body is segmented (metamerism).
5. Arthropods exhibit *tagmatization*. Tagmatization means that the segments are func-

tionally modified and grouped into two or three divisions called *tagmata*.

6. A distinct *head* is present.
7. The body is covered by an exoskeleton formed of *chitin*.
8. The body bears paired *jointed appendages*.
9. They have the *organ system grade* of organization.
10. Respiration is by *gills* or *trachea* or *book lungs*.
11. The circulatory system is of an *open type*.
12. An *endocrine system* is developed.
13. Excretion is by *green glands* or *Malpighian tubules*.
14. They have *compound eyes*.
15. Sexes are separate in their case.
16. Gonads have *gonoducts*. Development is *direct* or *indirect*.

Eg. *Prawn, crab, cockroach, housefly, honey bees, ants, scorpion*, etc.

Classification

The phylum *Arthropoda* is classified into 7 sub phyla. They are the following:

1. *Onychophora*
2. *Tardigrada*
3. *Pentastomida (Linguatulida)*
4. *Trilobitomorpha*
5. *Chelicerata*
6. *Pycnogonida*
7. *Mandibulata*

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*.

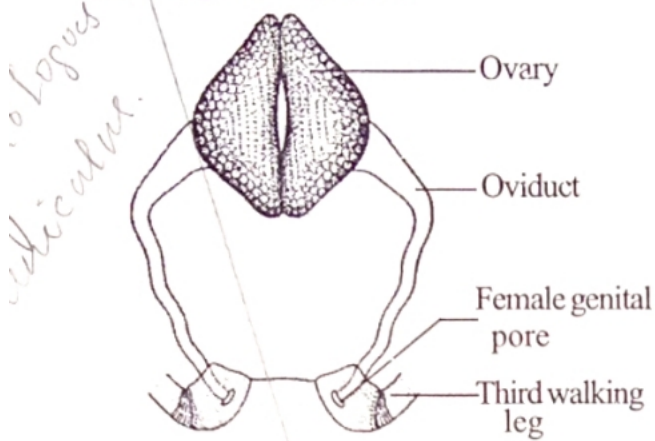


Fig.10.132:Palaemon; Female reproductive system.

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*.

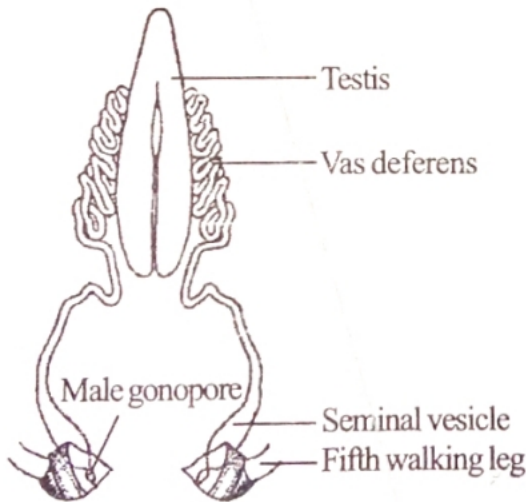


Fig.10.133:Palaemon; Male reproductive system.

The testes are elongated. They are located between the hepatopancreas and heart.

They are fused at the anterior ends. The testis is formed of numerous *seminiferous tubules*. Spermatozoa are formed here.

A long coiled tube called *vasdeferens* arises from the posterior end of each testis. It becomes much coiled. The vas deferens lead into a *seminal vesicle*. The seminal vesicle opens to the outside by a *male genital aperture* at the base of the 5th walking leg.

Life Cycle

Palaemon breeds during May, June, July. The male deposits sperms near the female genital aperture. The female releases egg. Fertilization is *external*. The female carries the eggs in the abdominal legs.

The development is *direct*. There is no larval stage. The eggs hatch into young prawns. The young prawns moult several times and become adults.

3. Cockroach (*Periplaneta americana*)

Phylum : Arthropoda
Class : Insecta
Order : Orthoptera

Cockroaches are widely distributed throughout the world except the polar regions. There are nearly 3000 species of cockroaches. The common Indian species are *Periplaneta americana* and *Blatta orientalis*.

Cockroaches are house - hold pests. They are found under stones, damp leaves, etc. They also inhabit kitchen, sewage channel, restaurants, godowns, store rooms, ships, fruit stalls, trains, etc. They are active and nocturnal animals, hiding in holes and crevices in day and emerge at night in search of food. They are usually found in place where there is warmth and food.

The body is flat, broad and *bilaterally symmetrical*. The body is reddish brown

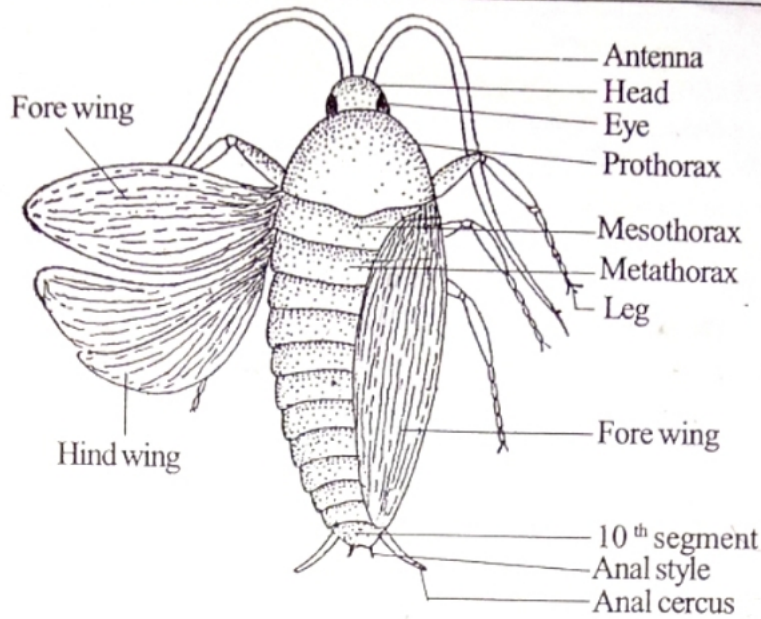


Fig.10.134: *Periplaneta americana*.

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 vestigial. 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.

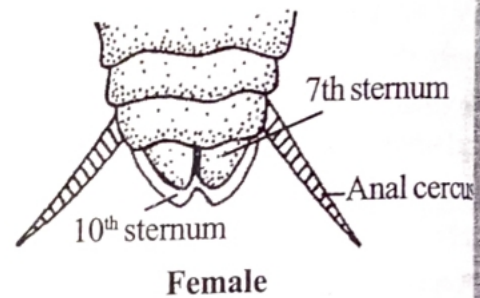
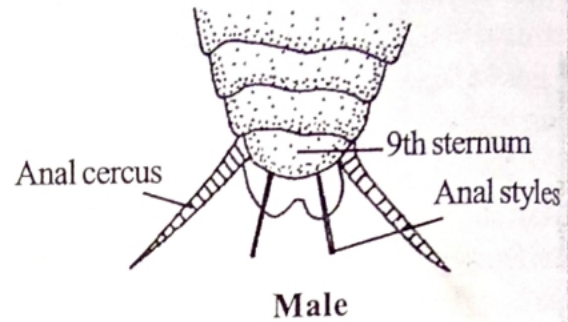


Fig.10.135: Abdomen of Cockroach.

Head Capsule

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

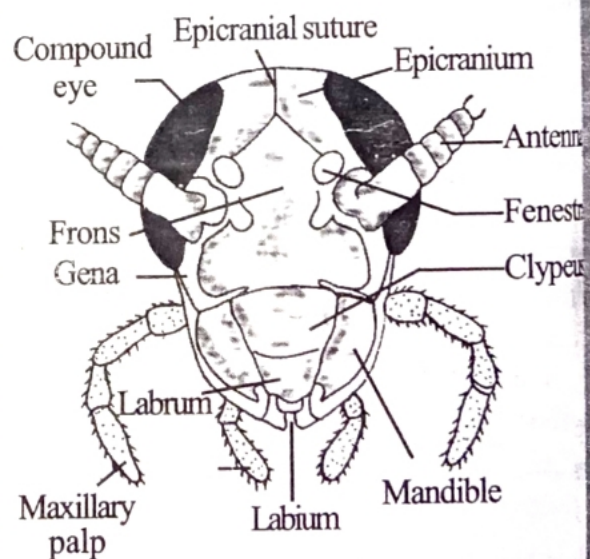


Fig.10.136: Cockroach-Head.

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**,

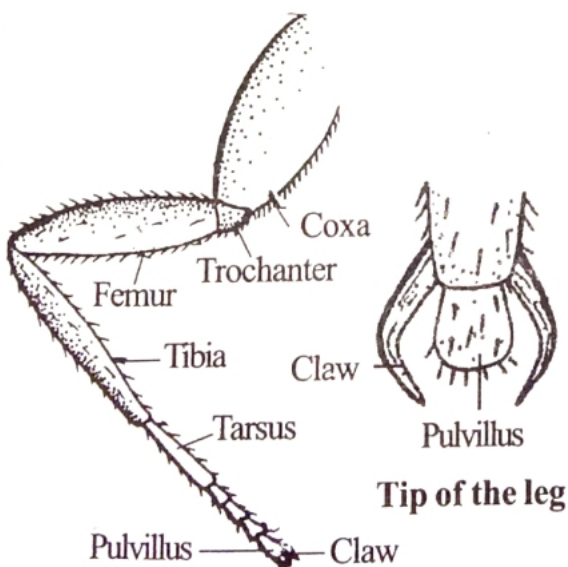


Fig.10.137: Cockroach; a leg.

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 pushing the masticated food into the preoral cavity.

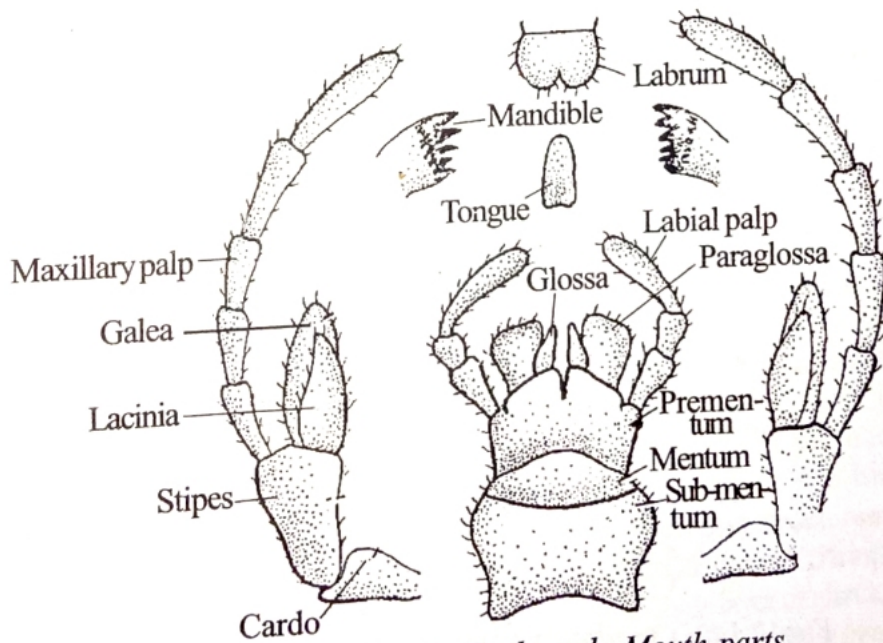


Fig.10.138: Cockroach; Mouth-parts.

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, whereas 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.

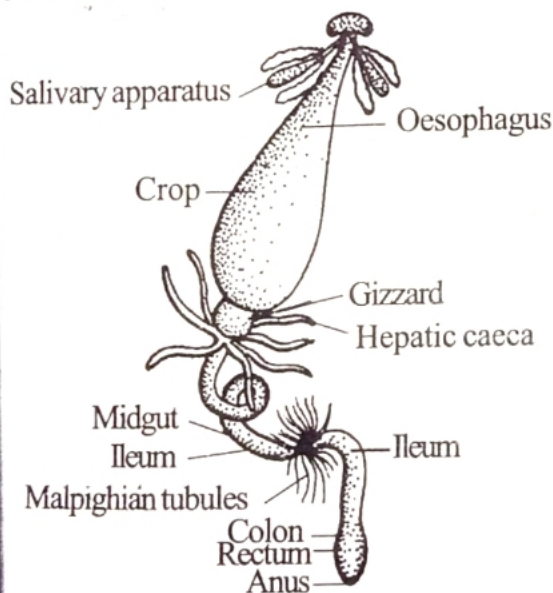


Fig.10.139: Cockroach; Digestive system.

The crop opens into a *gizzard*. It is a round 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*.

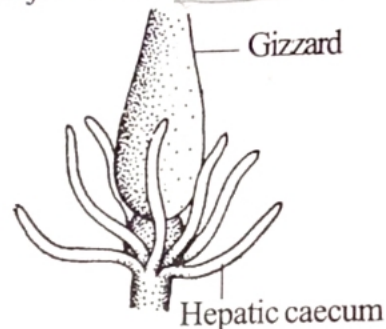


Fig.10.140: Hepatic caeca.

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*.

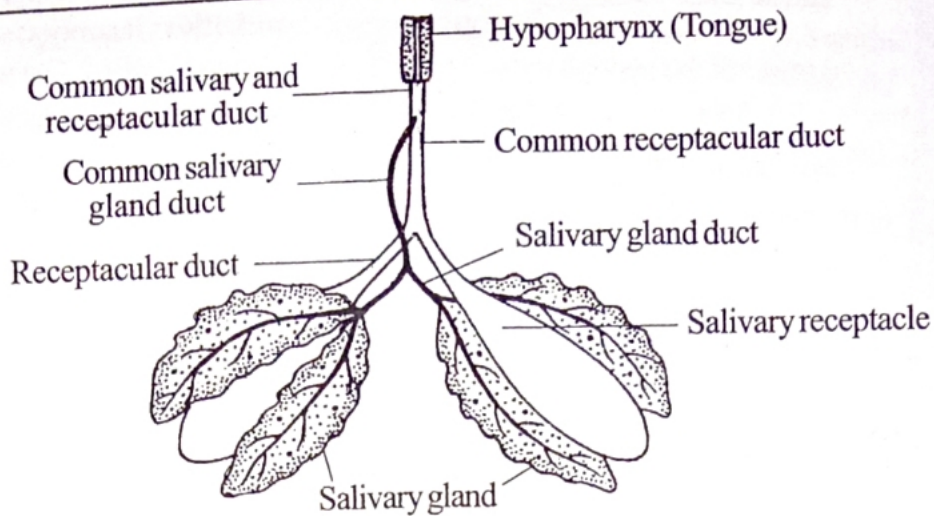


Fig.10.141: Salivary apparatus.

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**.

The heart consists of **thirteen chambers**, each communicating by a valvular opening with the one in front of it. The chambers communicate to the pericardial sinus by paired lateral openings called **ostia**. Ostia are also valvular allowing the entry of blood from the pericardial sinus into the heart. The heart is closed behind.

Aorta

The heart is continued in front as a short tube the **aorta** which opens into the haemocoel on the head.

Haemocoel

The blood filled spaces are called **haemocoel** or **blood sinuses**. Cockroach has **four blood sinuses**. They are **head sinuses**, **pericardial sinus**, **middle sinus** and **ventral sinus**. The middle sinus is also called **perivisceral sinus**.

Blood

The blood is **colourless** and is called **haemolymph**. It contains **plasma** and different kinds of colourless cells the **haemocytes**. There are two types of haemocytes, one is called the **plasmocyte** and the other one is known as **cytocyte**.

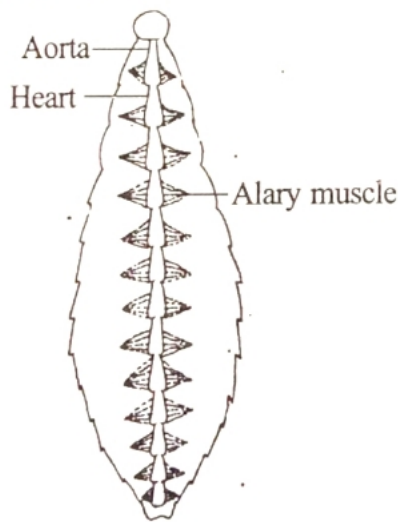


Fig.10.142: Circulatory system.

The blood serves as the distributing and collecting medium for food and water. It also acts as a reservoir of water. It helps in the transmission of hydrostatic pressure from one end of the body to the other. The haemocytes are responsible for phagocytosis, coagulation and for healing the wound.

Mechanism of Circulation

The contraction of the alary muscles enlarges the pericardial sinus, so that the blood flows into it from the underlying haemocoel. When the alary muscles relax, the blood is forced through the ostia into the heart.

The heart and the aorta contract from behind forwards, driving the blood anteriorly into the head.

From the head the blood flows backwards and fills up the body cavity bathing the organs contained in it.

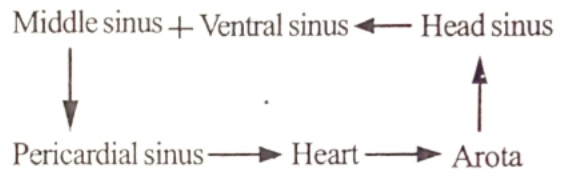


Fig.10.143: Course of circulation.

The blood absorbs the nutrient material from the alimentary canal and carries it to all the parts of the body.

Respiratory System

Cockroach exhibits **aerial respiration**. The respiratory system is formed of a system of air-filled tubes called **tracheal system**. The tubes of the tracheal system are called **tracheae**.

There are 6 large longitudinal tubes called **tracheal trunks**. Of these, two are **ventral**, two **dorsal** and two **lateral**. They are interconnected by **transverse commissures**.

The lateral tracheal trunks open to the exterior by 10 pairs of openings called **spiracles** or **stigmata**. Of these two pairs are located in

the thorax and eight pairs in the abdomen.

The spiracle opens into a wide chamber called **atrium**. The atrium has a **filtering apparatus** and a **valve**. The spiracle can be opened or closed by the muscles.

The tracheal trunks branch and rebranch to form a network of fine tubes called **tracheoles**. The tracheoles end blindly in and around cells and tissues.

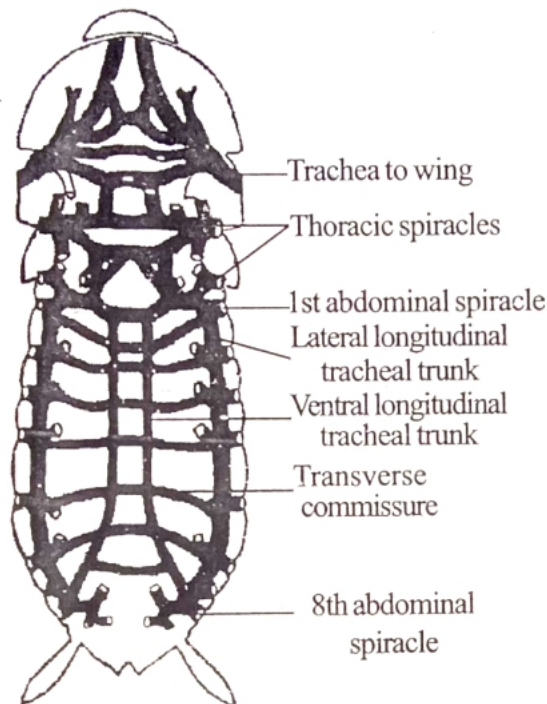


Fig.10.144: Cockroach ; Tracheal system in dorsal view.

In some insects like grasshoppers, house flies, bees, etc. bulb-like **air-sacs** are attached to the tracheal system.

Each trachea has a lumen and is covered by two layers. The inner layer is called **intima** and the outer layer is called **epithelium**. The intima is formed of **chitin** and it is in the form of closely set spirals called **taenidia**. The taenidia prevent the collapsing of tracheae. They are absent from tracheoles.

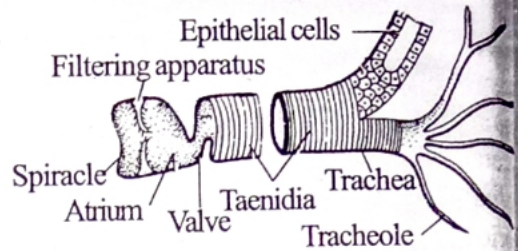


Fig.10.145: Cockroach; Spiracle and a portion of tracheal system.

Mechanism of Respiration

Air enters the tubes through spiracle. It is called **inspiration**. The inspired air reaches the tracheoles. The terminal ends of the tracheoles are filled with a fluid. O_2 of the inspired air dissolves in the fluid.

Owing to active work, the fluid in the tissues becomes **hypertonic**. As a result the fluid containing fluid of the tracheoles diffuses into the tissues. This helps the inspired air to reach the tip of the tracheoles. Now exchange of O_2 and CO_2 takes place. After this the impure air goes out through the spiracle. This is called **expiration**. Inspiration and expiration are brought about by **abdominal movements**.

Excretory System

Cockroach is an **uricotelic** animal as it excretes **uric acid**. The removal of the nitrogenous waste material is carried out by **malpighian tubules**, **fat body cells**, **nephrocytes**, **uricose gland**, **cuticle**, etc.

Malpighian tubules

These are fine, yellow thread-like processes which open into the anterior end of the ileum. They are arranged in six groups, each group consisting nearly 10 to 12 tubules. They float freely in the haemocoel. They are outgrowths of the hindgut and they are **endodermal** structures. Each tube is nearly 25mm long and 0.05 mm in diameter. It is formed of a single layer of glandular ciliated **epithelium** with a characteristic **brush border**.

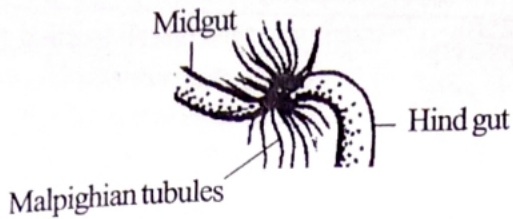


Fig. 10.146: Malpighian tubules.

The distal portion of the tubule separates the nitrogenous wastes *urates* and *uric acid* from the blood and *pour* them in the lumen. The proximal portion of the tubule reabsorbs the water and inorganic base in the form of bicarbonates. The water and bicarbonates are conserved and used over and over again. The semisolid waste then passes into the hindgut and from it, it is eliminated along with the undigested food materials through the anus. The elimination of the nitrogenous waste materials through the alimentary canal is an adaptation for conserving water by reabsorption in the rectum.

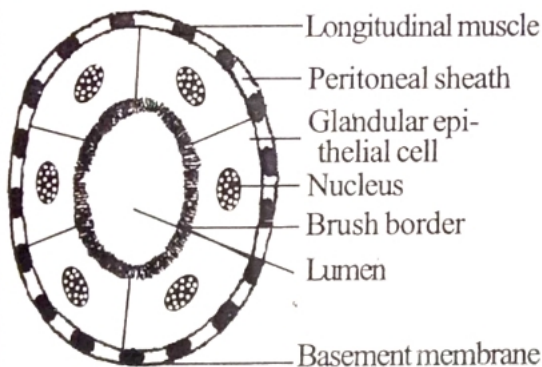


Fig. 10.147: Cockroach-T.S. of Malpighian tubule.

Fat body

The fat body cells fill up the greater part of the haemocoel. These cells consist of many lobes. They store the products of digestion in the form of fat, glycogen and protein. They also separate waste materials and store in them in the form of uric acid and urates. This mode of excretion is called *storage excretion*.

Nephrocytes

Groups of special cells called *nephrocytes* are found in the pericardial cavity around the heart. They remove the waste materials from the blood and store in them.

Cuticle

Nitrogenous waste is removed through the cuticle during moulting.

Uricose glands

These are long blind tubules found at the periphery of *mushroom*-shaped gland in males. They also store uric acid and discharge them during the time of copulation.

Nervous System

The nervous system comprises three parts, the *central nervous system*, *peripheral nervous system* and *autonomic* or *sympathetic nervous system*.

Central Nervous System

The central nervous system consists of a *brain*, a *ventral nerve cord* and *ganglia*.

The brain is the *supra-oesophageal ganglion*. It is a large, white bilobed mass and it lies in the head above the oesophagus. It is formed by the fusion of three pairs of ganglia.

Below the oesophagus there is another ganglion, the *sub-oesophageal ganglion*. It is also formed by the fusion of three pairs of ganglia.

The brain and the sub-oesophageal ganglion are connected on either side of the oesophagus by a nerve called *circum oesophageal connective*.

A *double ventral nerve cord* starts from the sub-oesophageal ganglion and runs backwards along the midventral line of thorax and abdomen.

It bears *nine ganglia*. The first three are called *thoracic ganglia* and the remaining six are called *abdominal ganglia*. The three

thoracic ganglia are found in the pro, meso and metathorax and are called **prothoracic ganglion**, **mesothoracic ganglion** and **metathoracic ganglion** respectively.

The last abdominal ganglion is the largest one. It is formed by the fusion of a number of ganglia.

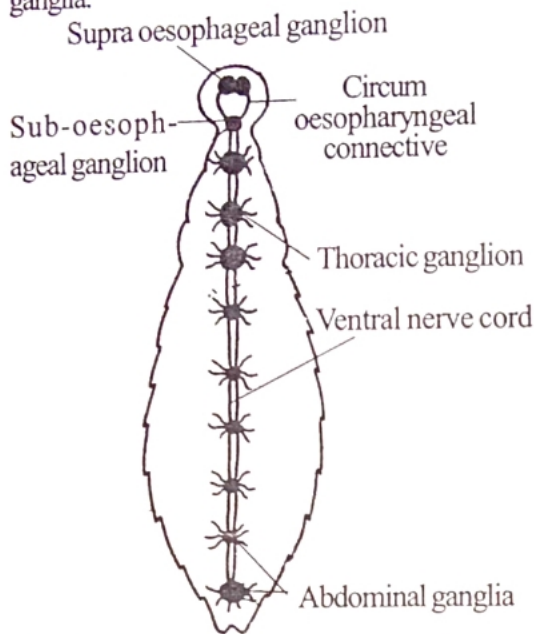


Fig.10.148: Cockroach; Nervous system.

Peripheral Nervous System

The peripheral nervous system comprises the nerves which arise from the central nervous system and go to various parts of the body. From the brain arise, three pairs of nerves which are known as **optic**, **antennary** and **labro-frontal** nerves. Optic nerves innervate the compound eyes, whereas the antennary nerves innervate the antennae. The third one innervate the labrum.

The sub-oesophageal ganglion supplies **mandibular**, **maxillary** and **labial** nerves to the mandibles, maxillae and labium respectively.

The thoracic and abdominal ganglia supply several pairs of nerves to the appendages, muscles and the organs connected with their

segments. The last abdominal ganglion give off nerves to the muscles of the seventh, eighth and ninth segments, reproductive organs, copulatory appendages and cerci.

Autonomic or Sympathetic Nervous System

It includes few ganglia and connectives. A **frontal ganglion** is lying on the oesophagus just in front of the brain. It is connected to the brain by a nerve called **frontal connective**. It sends nerves to pharynx, clypeus and labrum. There is a ganglion called **hypocerebral ganglion** present on the oesophagus. It is connected to the frontal ganglion by a median nerve termed as **recurrent nerve**.

A third ganglion is located on the crop and it is known as **ingluvial ganglion**. It is connected to the hypocerebral ganglion by a median nerve.

The fourth ganglion called **proventricula ganglion** is lying on the gizzard. It is connected by two nerves to the ingluvial ganglion. All these ganglia are connected to the brain by connectives. Nerves arise from the sympathetic system and innervate the muscles, alimentary canal, spiracles and other organs and control their activities.

Sense Organs

The cockroach is sensitive to light, sound, taste, smell and touch and it possesses sense organs for all these senses.

The epidermal cells are modified to form **sensillae**. A sensilla consists of a bipolar sensory cell associated with a pointed seta. The seta is secreted by a large epidermal cell called the **richogen**. It is provided with a nerve fibre.

The receptors of touch, taste and smell have isolated into simple sensillae, whereas those of heat and sight have aggregations of sensillae which form elaborate organs.

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Tactile (sense of touch) *sensillae* are found mainly on antennae, palps, legs, body and cerci.

Olfactory (sense of smell) sensillae are located chiefly on antennae.

The **gustatory** (sense of taste) sensillae are found on maxillae.

Auditory (sense of hearing) sensillae are found in the cerci.

Compound Eyes

Prawn has two black *compound eyes* placed at the tip of a movable jointed *stalk*. Each compound eye is formed of many simple eyes called *ommatidia* or *ocelli*.

Ommatidium

Ommatidium is a single unit of the compound eyes present in Arthropoda. The ommatidia are radially arranged.

The compound eye is covered by a thin transparent and biconvex cuticle called *cornea*. The cornea is divided into a large number of squares. Below each square lies an ommatidium.

Above each ommatidium, the corneal square thickens to form a *lens*. Two *corneagen cells* lie beneath the lens. These cells secrete new cornea when the old one is cast off in moulting. Four *cone cells* are present below the corneagen cells. These cells surround a *crystalline cone*.

The cone cells rest on a spindle-shaped rod called *rhabdome*. The rhabdome is secreted and surrounded by seven *retinal cells*.

These cells rest on a *basal membrane*. The retinal cells are connected with the nerve fibres of the optic ganglia which are connected with the brain by the *optic nerve*.

The adjacent ommatidia are separated by dark *pigment cells* which are arranged in two series, an outer one and an inner one. The outer

series lies along the cone cells and is called *iris pigment*. The inner series lying along the retinal cells is called *retinal pigment*. The retinal pigments exhibit amoeboid movement and take up different positions.

The outer region of the eye, from the lens to the inner ends of cone cells, is called *dioptrical region* which focuses the light towards the inner region of the eye. The inner region of the eye is called *receptor region*.

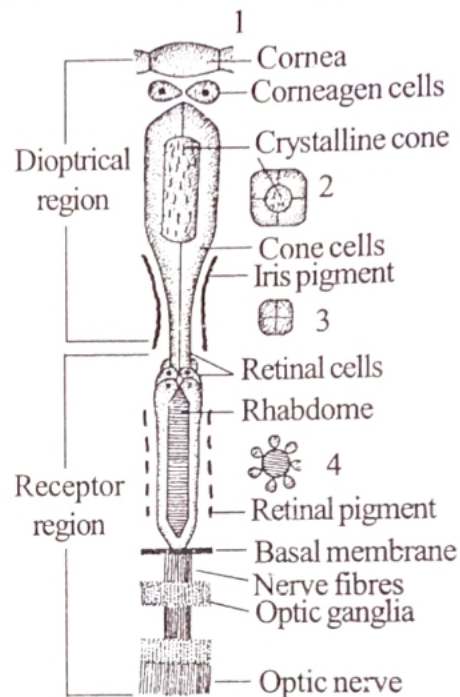


Fig.10.149: Ommatidium.

Vision

Each ommatidium is able to produce a separate image of a small part of the object seen. As there are several ommatidia the image of the object consists of several pieces. Thus the image appears like a mosaic pattern. This type of vision is called *mosaic vision*. This type of vision is peculiar to all arthropods provided with compound eyes.

Reproductive System

The sexes are separate and the *sexual dimorphism* is well marked.

Male Reproductive System

A pair of *testes* is situated dorsoventrally in the fourth and fifth abdominal segments. Each testis is a three lobed structure. From the hind end of each testis arises a thin duct called *vas deferens*.

The two vasa deferentia run backwards and inwards to open into a median duct known as *ejaculatory duct*.

The junction of the vasa deferentia and ejaculatory duct is surrounded by a large structure called *mushroom gland*.

The gland is made up of numerous compact finger-like blind tubules. The base of the mushroom gland has several *seminal vesicles*.

A long, flat sac-like *conglobate gland* is present beneath the ejaculatory duct. It tapers posteriorly to form a *conglobate duct* which opens near the male genital aperture, into the genital pouch.

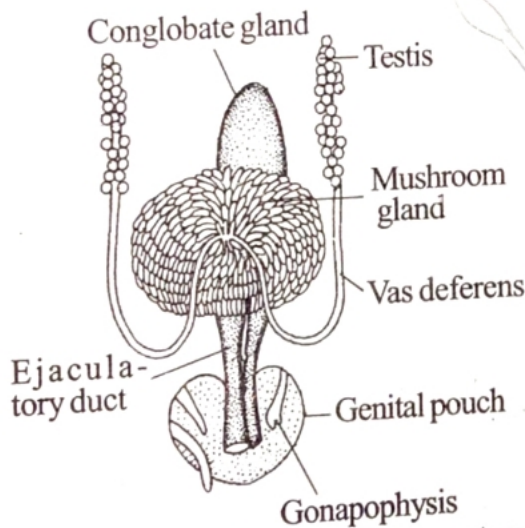


Fig.10.150: Male reproductive system.

The male aperture is surrounded by irregular chitinous processes called *gonapophyses*. They help in *copulation*.

The testes produce spermatozoa and they are brought into the seminal vesicles by the vasa deferentia. The spermatozoa in the seminal vesicles

stick together to form a *spermatophore*. It is *pear-shaped* and its wall has three layers.

Female Reproductive System

A pair of *ovaries* are situated beneath the fourth, fifth and sixth abdominal terga one on each side. They are light yellow in colour and embedded in the fat body.

Each ovary is formed of eight *ovarian tubules*. Each ovarian tubule is developing eggs in a row. In each ovariole, its anterior region or *germarium* contains immature eggs, where as its posterior region or *vitellarium* contains the maturing eggs.

The ovarian tubules of each ovary taper anteriorly and unite to form a single thread.

Posteriorly they join to form a short and wide *oviduct*. The two oviducts then unite to form a median tube the *vagina* or *common oviduct* which runs backwards and opens into the *genital pouch* by a slit-like female genital aperture or *vulva*.

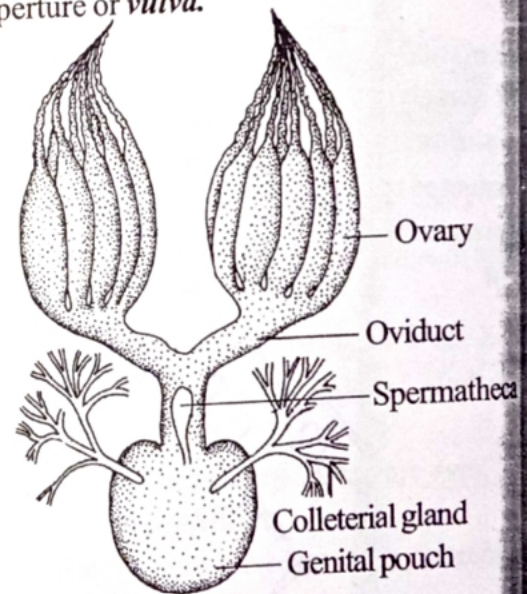


Fig.10.151: Female reproductive system.

There are two club-shaped sacs called *spermathecae* of unequal size. The two spermathecae open by a common duct into the genital pouch on a small *spermathecal papilla*.

A pair of much branched *colleterial glands* is present behind and above ovaries. The left gland is larger and opaque, while the right gland is smaller and transparent. The ducts of the colleterial glands open into the genital pouch. The secretion of these glands provides material for the formation of the egg case the *ootheca*.

The genital pouch is distinguished into two parts. The smaller anterior portion of the genital pouch is called *genital chamber*. It contains the female genital aperture, spermathecal pore and colleterial pores. The larger posterior portion is known as *vestibulum*. The ootheca is formed in the vestibulum.

The genital pore is surrounded by three pairs of symmetrically arranged duct-like chitinous processes, the *gonapophyses*. They help in copulation and in depositing the eggs.

The ova are formed in the upper part of ovarian tubules. As they pass down, yolk is deposited in them and they come to lie in a line giving the appearance of a string of beads.

Life History

Copulation and Formation of Ootheca

When sexually mature, the male and female cockroaches pair, during night. During copulation, the tip of the abdomen of the male is inserted into the genital pouch of the female. So the spermatozoa from the male reach the genital pouch of the female and they are stored in spermathecae of the female.

After pairing the female begins to lay eggs. Sixteen mature eggs pass into the common oviduct from the right and left ovaries alternately. They enter the genital chamber. In the genital chamber, they are fertilized by the sperms shed from the spermathecae.

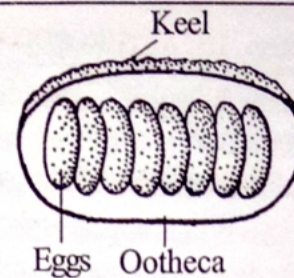


Fig.10.152: Ootheca of Cockroach.

The colleterial glands pour on the fertilized egg their secretion, which hardens to form the egg case, *ootheca*.

The ootheca is moulded and shaped by the *ovipositor* (It is formed by the gonapophyses) and the walls of the oothecal chamber.

Ootheca is 10-12 mm in length and dark brown in colour. It is a *purse-like* capsule with a keel on its outer dorsal fringe. It contains sixteen eggs arranged vertically in two rows of eight each. The formation of ootheca is completed within a day. The female carries the ootheca for several days and deposits it in a warm dark and suitable place. The mother takes care of the eggs and the progeny.

Development

The fertilized eggs are rich in yolk which provides enough food for development. When fully developed, the young comes out, rupturing the egg case.

The young hatching from the ootheca is called *nymph*. It resembles the adult both in structure and mode of life, but devoid of wings and the gonads are immature. It is smaller in size and white in colour.

It feeds and grows. Its outer exoskeleton is cast off. This process of shedding of the skin is known as *moulting* or *ecdysis*. Moulting is due to a moulting hormone.

The nymph undergoes six or seven moults to become an adult in about a year.

The intermediate stages between successive moults are known as *instars*. The stage

immediately after hatching from the egg is the **first instar**. The last is the fully developed adult form which is known as **imago**.

Wings appear at the end of the last moult. Body size increases and the colour becomes darker in the adult.

The metamorphosis from the nymph to adult takes about 6 to 8 months and requires eleven moults in male and twelve moults in female.

The development of cockroach is gradual without much changes. So this is called **incomplete metamorphosis** or **heterometabolous metamorphosis**.

4. Grasshopper

- Phylum : Arthropoda
- Class : Insecta
- Sub class : Pterygota
- Order : Orthoptera
- Family : Aerididae
- Genus : Poeciloceris
- Species : Pictus

Grasshopper is an **insect**. It has **joined** appendages. Hence it is included in the phylum **Arthropoda**. It has 6 legs and two pairs of wings and hence it is included in the class

Insecta. It is included in the order **Orthoptera** and family **Aerididae**.

Poeciloceris pictus is the **ak** grasshopper. It is the grasshopper living on **Calotropis** plant.

Grasshoppers live on grasslands and green vegetation. They are **diurnal** insects. They feed on vegetation. They can crawl, leap and fly. There are males and females. They lay eggs. The eggs hatch into **nymphs** which develop into adults.

The grasshopper is **bilaterally symmetrical**. The body is **segmented**. The body is covered by an **exoskeleton** formed of **cuticle**.

The body is cylindrical and elongated. It consists of a **head**, a **thorax** and an **abdomen**.

Head

The head consists of a **head capsule**, a pair of **compound eyes**, three **ocelli**, two **antennae**, **mouth** and **mouth parts**.

Thorax

The thorax is the middle portion of the body. It consists of three segments namely a **prothorax**, a **mesothorax** and a **metathorax**.

Each thoracic segment is protected by four sclerites, namely a dorsal **tergum**, a ventral **sternum** and two lateral **pleura**

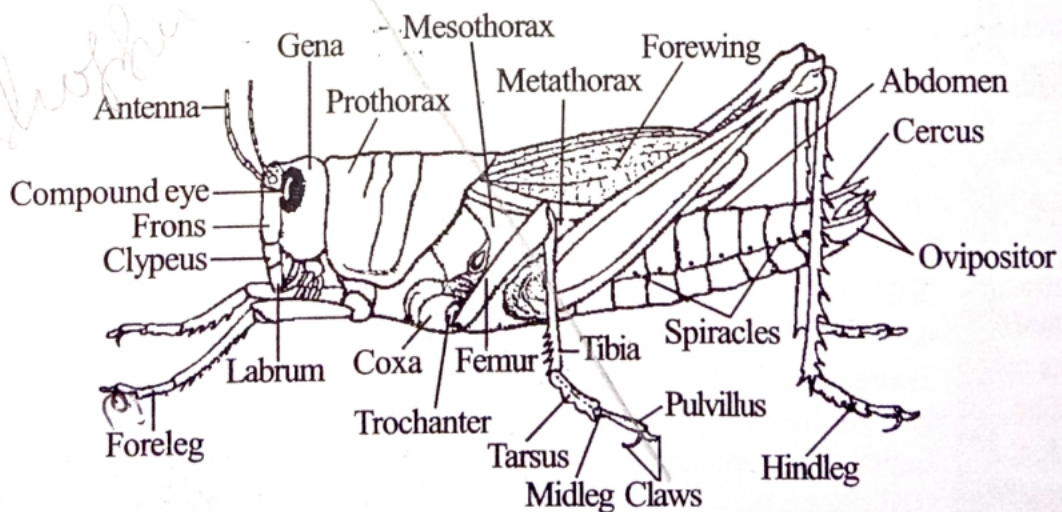


Fig.10.153: Grasshopper.

11. 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*.

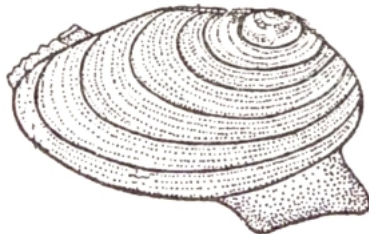


Fig.11.1: Freshwater mussel.

- 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 *gills* or *pulmonary chambers*.

- ⑩ The digestive system is well developed. It contains a *radula* and a *hepatopancreas*.



Fig.11.2: Radula.

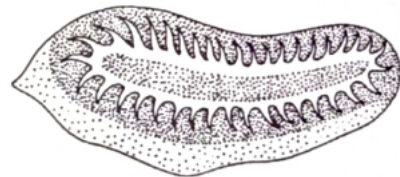


Fig.11.3: Osphradium.

- 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 several *classes*. They are the following:

12. 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.

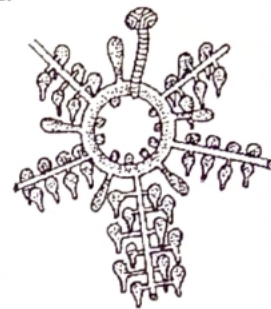


Fig.12.2: Water vascular system.

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.

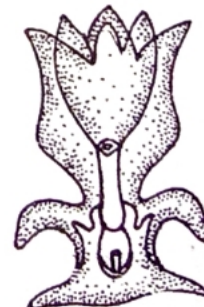


Fig.12.4: Bipinnaria.