11. Study of Animal Type - Cockroach

Can you recall?

1. How many different types of animals are present around us?
2. Can a person complete detailed study of each of those animals?
3. Which phylum is most diverse and populous?

11.1 Habit and habitat :

Cockroaches are omnipresent i.e. present everywhere, all over the world. It prefers damp and moist places, crevices to live. It is omnivorous, nocturnal and cursorial. *Periplaneta americana, Blatta orientalis* and *Blatta germanica* are the three common species of cockroach found in India.

11.2 Systematic Position :

Kingdom : Animalia (Cell wall absent, heterotrophic nutrition.)

Phylym : Arthropoda (Jointed appendages are present, segmented body, chitinous exoskeleton.

Class : Insecta (Two pairs of wings and three pairs of walking legs are present.)

Genus : *Periplaneta* (Nocturnal, straight wings.)

Species : *americana* (Origin is in Continent of America)

Curiosity box:

1. Why do insects need moulting?
2. What is the difference between simple and compound eyes?

11.3 External morphology :

Shape and size : Cockroach has an elongated, bilaterally symmetrical and dorso-ventrally flattened body. They are triploblastic, eucoelomate and truly segmented animals. Body cavity is called as haemocoel, filled with haemolymph.

Coloration : Cockroach is glistening brown or red brown in colour.

Exoskeleton : Body of cockroach is protected by hard, waxy, tough, non-living exoskeleton. Exoskeleton is formed by a nitrogenous polysaccharide-chitin that provides strength, elasticity and surface area for attachment of muscles. Each body segment of cockroach is covered by four chitinous plates (sclerites) namely, dorsal tergum, ventral sternum and two lateral pleurons.

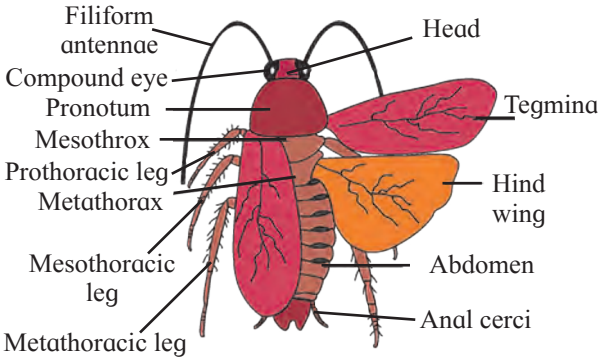

Fig. 11.1 Dorsal view

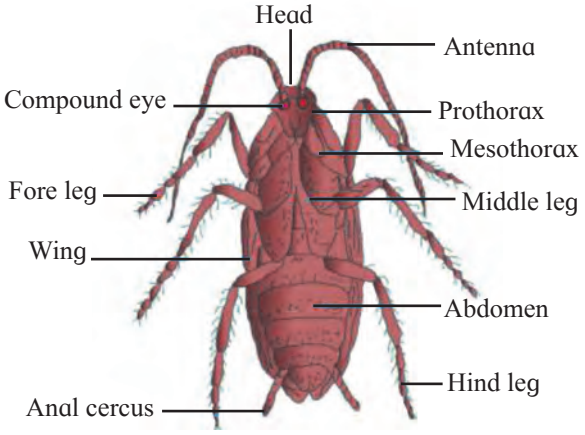

Fig. 11.2 Ventral view

Body Division : Body is divided into three regions namely head, thorax and abdomen. Head is attached at right angles to thorax by a thin, narrow, movable neck or cervix.

Head : It is formed by the fusion of six segments. It is triangular or ovate in shape. It is highly mobile due to flexible neck. It bears a pair of long antennae, a pair of compound eyes and mouth parts adapted for chewing and biting of food.

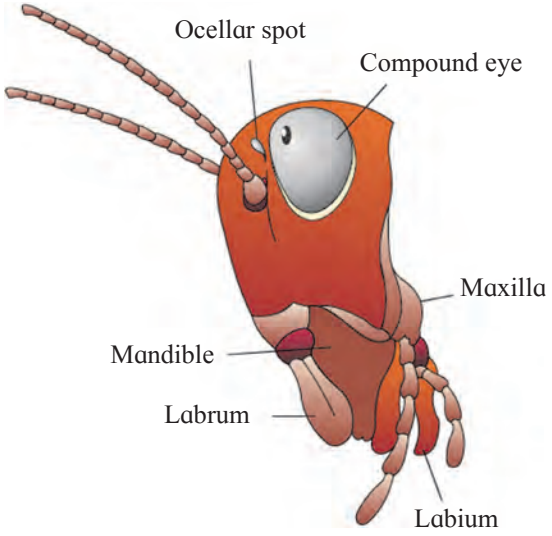

Fig. 11.3 Head

1. Antennae : Also called as feelers. There are filamentous, long, segmented structures that can be moved in all directions. They are lodged in membranous pits called antennal sockets. They are tactile (touch) as well as olfactory (smell) organs, useful in locating the food material in the vicinity.

2. Fenestrae are also called as ocellar spots situated at the base of each antenna and they appear as white spots.

3. Compound eyes : They are paired, dark, kidney shaped structures placed on lateral sides of the head and are made up of large number of ommatidia (singular ommatidium). **Ommatidia** are structural and functional units of compound eye, each forming an image of very small part of visual field. Collectively, compound eye produces a mosaic image.

4. Mouth parts : Cockroach has pre-oral cavity in front of mouth in which foods is received. It is bounded by chewing and biting type of mouth parts. These are movable, segmented appendages which assist in ingestion of food. Mouth parts of cockroach comprise of....

i. Labrum (Upper lip) : It is single flap-like movable part which covers the mouth from upper side. It forms an anterior wall of pre-oral cavity. It is useful in holding of the food during feeding.

ii. Mandibles (True jaws) : These are two dark, hard, chitinous structures with serrated median margins. They are present on either side, behind the labrum. They perform coordinated side-wise movements to cut and crush the food. This movement is effected with the help of adductor and abductor muscles

iii. Maxillae (Accessory jaws) : These are also called as first pair of maxillae. These are situated on the either side of mouth behind the mandibles. Each maxilla consist of sclerites like cardo, stipes, galea, lacinia and maxillary palps. Maxillary palps act as tactile organs. The maxillae hold food, help the mandibles for mastication. Maxillae are also used for cleaning the antennae and front legs.

iv. Labium (lower lip) : It is also called as second maxilla which covers the pre-oral cavity from ventral side and is firmly attached to the posterior part of head. It has labial palps which is three jointed and sensory in function. It is useful in pushing the chewed food in the pre-oral cavity and also prevents the loss of food falling from the mandibles during the chewing.

v. Hypopharynx (Tongue) : In front of the labium and between first maxillae, there is a some what cylindrical single structure called hypopharynx or lingua. A salivary duct opens at the base of this structure. Lingua bears comb-like plates called super-lingua on either side. It is useful in the process of feeding and mixing of saliva with food.

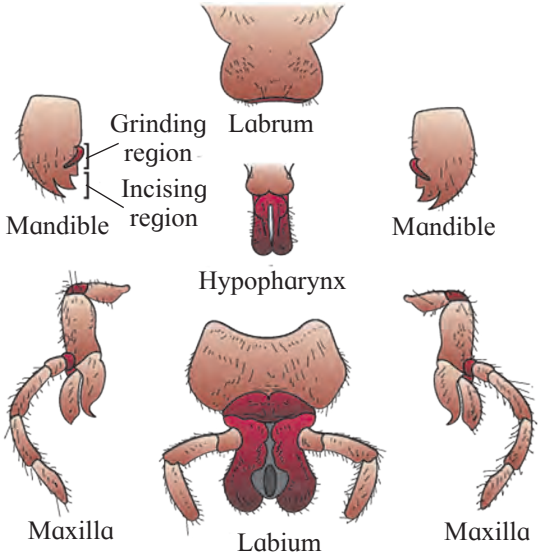

Fig. 11.4 Mouth parts

Thorax : Thorax is three segmented. Anterior segment is prothorax, middle mesothorax and posterior metathorax. Thorax bears three pairs of walking legs ventrally (one at each segment) and two pairs of wings dorsally (attached to mesothoracic and metathoracic segment).

Legs : Three pairs of walking legs are present on ventral side. Each leg has five podomeres namely coxa, trochanter, femur, tibia and tarsus. Tarsus is the last segment and is made up of five movable segments or tarsomeres. Last tarsomere bears a pair of claws and cushion-like arolium helpful in clinging.

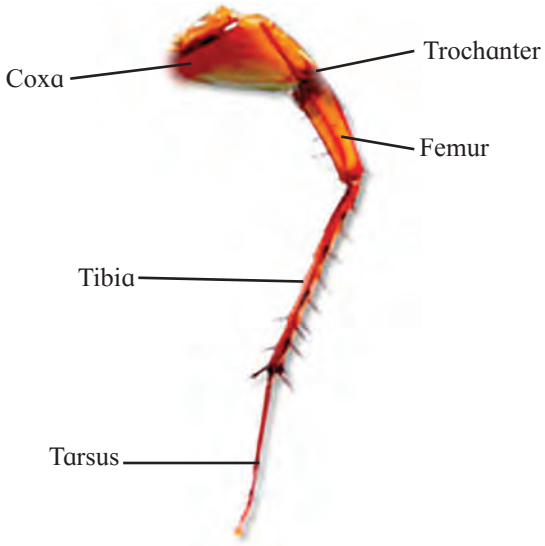

Fig. 11.5 Leg of cockroach

Wings : Two pairs of wings as forewings and hindwings are present on dorsal side. Forewings are first pair of dark, opaque, thick, leathery wings which are protective in function. Hindwings are thin, broad, membranous, delicate and transparent. These are attached to tergum of metathorax. These are helpful in flight and hence are also called as true wings.

Spiracles : These are a series of slit-like openings on either side the body. In all, there are ten pairs - two on thorax and eight on abdomen. The spiracles let the air into and out of the tubes called trachea.

Abdomen : The abdomen is elongated and made up of ten segments. Each segment has a dorsal tergum and ventral sternum.

Laterally, tergum is jointed to sternum by soft cuticle called pleura. The posterior segments are telescoped in. Due to this, eighth and ninth terga get overlapped by the seventh. The tenth tergum projects backward. It is deeply notched. The tenth tergum also bears a pair of small, many jointed anal cerci. In the male, the abdomen is narrow and tapering than that in female. In male, the ninth sternum also bears a pair of short, unjointed anal style.

11.4 Body cavity : A body cavity or true coelom is present around the viscera. Because of the open type of circulation, the body cavity is filled up with blood. Hence, it is called haemocoel. In the haemocoel, fat bodies are seen. It is in the form of loose, whitish mass of tissue. The fat body is made up of large, polygonal cells which contain fat globules, proteins and sometimes glycogen.

11.5 Digestive system of cockroach :

Digestive system of cockroach consists of mouth parts, alimentary canal and a pair of salivary glands.

Alimentary canal is a long (6-7 cm) tube of different diameters and with two openings. Alimentary canal is divisible into three regions as Foregut (stomodaeum), Mid-gut (mesenteron) and Hindgut (proctodaeum).

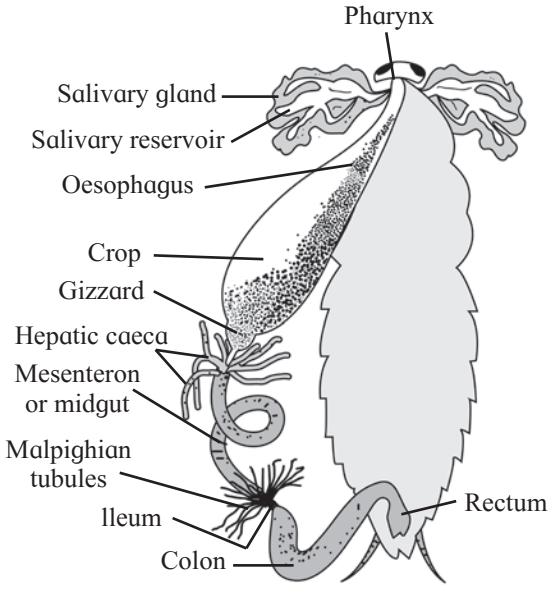

Fig. 11.6 Digestive system of Cockroach

Mouth : Mouth / pre-oral chamber is a narrow space bounded by mouth parts. Hypopharynx is present at the centre of mouth. Salivary duct opens at the base of hypopharynx. Mouth opens into foregut.

Fore-gut (Stomodaeum) :

Foregut consists of pharynx, oesophagus, crop and gizzard. Pharynx is very short, narrow but muscular tube. It contains taste sensillae. It leads to oesophagus.

Oesophagus is slightly long and narrow tube. It opens in crop. Crop is large, pear-shaped sac like organ. It temporarily stores the food and then sends it to gizzard.

Gizzard (Proventriculus) is small, spherical organ. Internally, it is provided with a circlet of six chitinous teeth and backwardly directed bristles. Teeth are responsible for crushing the food. Bristles help in filtering the food. Foregut ends with gizzard.

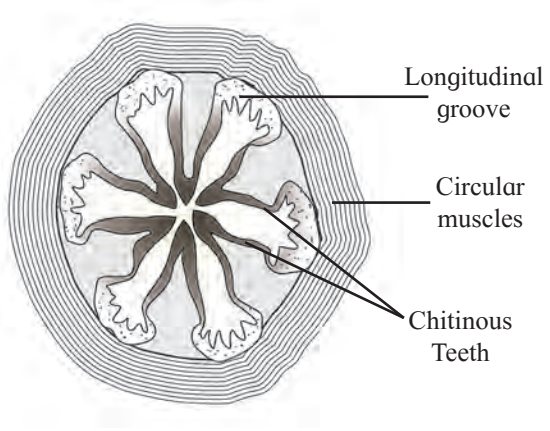

Fig. 11.7 T. S. of Gizzard

Mid-gut (Mesenteron) : Midgut consists of stomach and hepatic caecae. Stomach **(ventriculus)** is straight, short and narrow. It is lined by glandular epithelium. Which secretes digestive enzymes. Hence, stomach is mainly responsible for digestion and absorption. Hepatic caecae are thin, transparent, short, blind (closed) and hollow tubules. Hepatic caecae secrete digestive enzymes and thus help in digestion of food.

Hind-gut (Proctodaeum) : **Hindgut** consists of **ileum**, **colon** and **rectum**. Ileum is short and narrow part of hind-gut. Malpighian tubules open in the anterior lumen of ileum, near the junction of mid-gut with hind-gut. Posterior region of ileum contains sphincter. Ileum sends nitrogenous wastes and undigested food towards colon.

Colon is longer and wider part of hind-gut. It sends the waste material towards rectum. It reabsorbs water from wastes as per need. Rectum is oval or spindle-shaped, terminal part of hind-gut. It contains six rectal pads along internal surface for absorption of water. Rectum opens outside by anus. Anus is present on ventral side of 10^{th} segment. Anus is last/ posterior opening of digestive system. It gives out undigested food.

Salivary Glands : Cockroach has a pair of salivary glands which secrete saliva. Each gland consists of two glandular lobes and one receptacle or reservoir. Glandular lobes consists of many irregular-shaped white lobules. These lobules secrete saliva. Each gland has a salivary duct. Both ducts unite together to form a common salivary duct. Receptacle of each gland is thin-walled, elongated, sac-like structure. Each receptacle has a duct. These ducts unite to form common reservoir duct. Both common ducts i.e. common salivary duct and common reservoir duct unite together to form common efferent salivary duct. Efferent salivary duct opens at the base of tongue or hypopharynx.

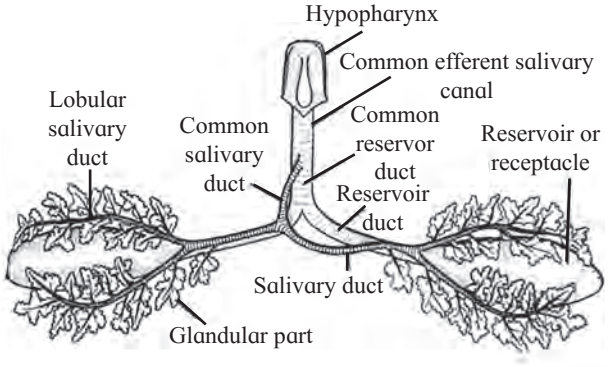

Fig. 11.10 Salivary glands of Cockroach

Food and digestion : Cockroach is omnivorous. It feeds upon plant and animal material. It has chewing and biting type of mouth parts, that chew the food and push it into alimentary canal. As food passes through the alimentary canal, it is digested and finally undigested food is eliminated through anus.

Do you know?

Cockroaches eat young cockroach. Such tendancy is called Cannibalism.

11.6 Circulatory system or blood vascular system:

Cockroach has open type of circulatory system that consists of colourless blood (haemolymph), a dorsal blood vessel (heart and dorsal aorta) and haemocoel.

A. Haemolymph : Haemolymph of cockroach is without any pigment; hence it is colourless. It consists of plasma and seven types of blood cells / haemocytes. Plasma consists of water with some dissolved organic and inorganic solutes. It is rich in nutrients and nitrogenous wastes like uric acid.

Use your brain power

Why body cavity of cockroach is called as haemocoel?

B. Haemocoel : Body cavity (coelom) of cockroach is divided into three sinuses due to two diaphragms i.e. dorsal and ventral diaphragm.

Dorsal and ventral diaphragms are thin fibromuscular septa (sing.—septum). It remains attached to terga along lateral sides at intermittent points.

Dorsal diaphragm has 12 pairs (2 thoracic and 10 abdominal) of fan like alary muscles. Alary muscles are triangular with pointed end attached to terga at lateral side and broad end lies between heart and dorsal diaphragm. Ventral diaphragm is flat and present just above the ventral nerve cord. Laterally, it is attached to sterna at intermittent points.

Sinuses : Coelom of cockroach is gets divided into three sinuses as pericardial, perivisceral and perineural sinus. Pericardial sinus is dorsal, very small and contains dorsal vessel. Perivisceral sinus is middle and largest. It contains fat bodies and almost all major visceral organs of alimentary canal and reproductive system. Perineural sinus is ventral, small and contains ventral nerve cord. It is continuous into legs. All the three sinuses communicate with each other through pores present between two successive points of attachments of diaphragms.

Dorsal blood vessel : This is present in pericardial sinus, just below the tergum. It is divisible into posterior heart and anterior aorta (dorsal aorta / cephalic vessel). Heart is about 2.5cm long, narrow, muscular tube that is open anteriorly and closed posteriorly. It starts from 9th abdominal segment and extends anteriorly upto 1st thoracic segment. It is divisible into thirteen chambers. Ten chambers are in abdominal region and three are in thoracic region. Each chamber has a pair of vertical slit like incurrent aperture / opening called ostium (pl. - ostia). Ostia are present along lateral side in posterior region of first 12 chambers.

Each ostium has lip-like valves that allow flow of blood from sinus to heart only. Heart is continued by a short, thin walled vessel called as dorsal aorta. It lies in head region and opens in the haemocoel.

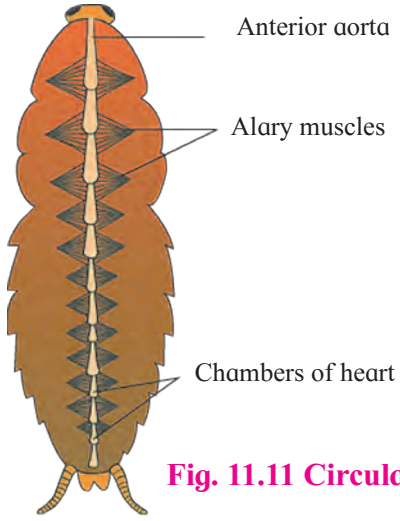

Fig. 11.11 Circulatory System

Blood circulation in cockroach :

Blood circulates between sinuses and heart due to contraction and relaxation of heart and alary muscles. Heart alternately contracts (systole) and relaxes (diastole). After diastole, there is a third phase in the heart cycle known as diastasis. Heart remains in expanded state during diastasis.

During diastole, alary muscles contract, making the dorsal diaphragm flat. As a result blood passes from perivisceral to pericardial sinus through fenestrae and finally to the heart through ostia. During systole, contraction starts at posterior end and wave of contraction passes anteriorly. Due to this, blood is pushed towards cephalic vessel i.e. dorsal aorta. During systole, ostia remain closed with the help of valves. As a result of systole, blood is flushed into head region from where it goes to perivisceral and perineural sinus.

Alary muscles are relaxed during systole. Due to this, dorsal diaphragm becomes convex, reducing the volume of pericardial sinus. This makes the blood to move from pericardial sinus to perivisceral sinus through fenestrae.

11.7 Respiratory system or tracheal system :

Cockroach has an internal respiratory system of air tubes called tracheal system, by which air is brought into the body and is in contact with every part of body. It allows exchange of gases directly between the air and tissues without the need of blood.

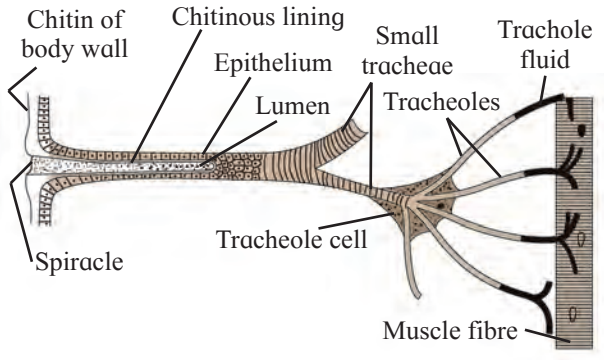

Fig. 11.12 Respiratory System

Spiracles : Spiracles are respiratory openings. They are paired, present on ventro-lateral side of body, in pleural membrane. Cockroaches have two pairs of thoracic and eight pairs of abdominal spiracles. The spiracles open into a series of air sacs from which the tubes called trachea arise.

Trachea : The trachea form a definite pattern of branching tubes arranged transversely as well as longitudinally. They are about 1mm thick and have spiral or annular thickening of chitin. The inner lining of chitin prevents the trachea from collapsing. Each trachea branches into number of smaller tubes called tracheoles.

Tracheole : These are fine intracellular tubes that penetrate deep into tissues. They are thin and not lined with chitin. They end blindly in the cells. Each tracheole at the blind end is filled with a watery fluid through which exchange of gases takes place. The content of this fluid keeps changing. At high muscular activity, a part of fluid is drawn into the tissues to enable more and rapid oxygen intake. The rhythmic movements of thoracic and abdominal muscles renew the air in the tracheal system. The body fluid does not distribute the gases but simply acts as a stationary medium for diffusion.

11.8 Excretory System :

Malpighian tubules are main excretory organs of cockroach. They are attached to the alimentary canal between the midgut and hindgut. They are thin, yellow coloured, ectodermal thread-like structures hanging freely in the haemocoel. They are about 150 in number.

Malpighian Tubule : Each Malpighian tubule is lined with a single layer of glandular epithelial cells having microvilli. Their distal portion is secretory and proximal part is absorptive in function. They extract water and nitrogenous wastes from the haemocoel and convert them into uric acid and pass them into ileum. As the cockroach excretes uric acid, it is said to be uricotelic. In addition, the fat bodies, nephrocytes and uricose glands (in male cockroach only) also help in excretion.

In cockroach, urate cells (nephrocytes) associated with fat bodies and cuticle are also believed to be excretory in function. The nephrocytes are cells present along with the fat bodies or present along the heart and store nitrogenous wastes. The excretory products later are removed in the haemocoel. Some nitrogenous wastes are deposited on the cuticle and eliminated during moulting.

11.9 Nervous system :

The nervous system of cockroach consists of Central Nervous System (CNS), Peripheral Nervous System (PNS), and Autonomus Nervous System (ANS). Nervous system of cockroach is ventral, solid and ganglionated.

A. Central Nervous System (CNS):

CNS consists of nerve ring and ventral nerve cord. **Nerve ring** is made up of supra-oesophageal ganglia, circum-oesophageal connective and sub-oesophageal ganglion. A pair of supra-oesophageal / cerebral ganglia is collectively known as brain. Brain is present in head, above the oesophagus and between antennal bases. Each cerebral ganglion is formed by fusion of three small ganglia- protocerebrum, deutocerebrum and tritocerebrum.

Sub-oesophageal ganglion is bilobed; present below the oesophagus in head. It is also formed by fusion of 3 pairs of ganglia.

Cerebral ganglia are connected to sub-oesophageal ganglion by a pair of lateral nerves called as circum-oesophageal connectives. Connectives arise from cerebral ganglia.

Ventral nerve cord (VNC) : It arises from sub-oesophageal ganglion. It is present along mid-ventral position, in perineural sinus. It is double nerve cord and consists of nine segmental, paired ganglia. First three pairs of segmental ganglia are large and known as thoracic ganglia. Six pairs of segmental ganglia are in abdomen. Sixth abdominal ganglion is largest and it is present in 7th abdominal segment. There is no ganglion in 6th segment.

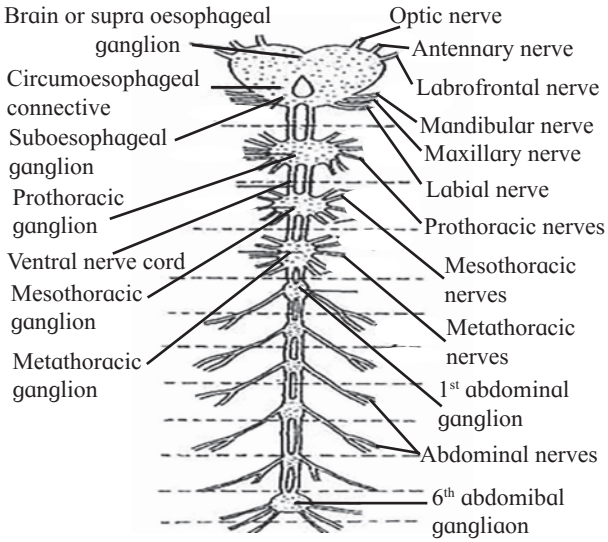

Fig. 11.13 Central Nervous System

B. Peripheral Nervous System (PNS):

Peripheral nervous system consists of nerves arising from various ganglia of CNS. Six pairs of nerves arise from cerebral ganglia. They go to eyes, antennae and labrum. Nerves arising from sub-oesophageal ganglion go to mandibles, maxillae and labium. Nerves arising from thoracic ganglia go to the wings, legs and internal thoracic organs. Nerves from abdominal ganglia go to the abdominal organs of respective abdominal segments.

C. Autonomous Nervous System (ANS):

It consists of four ganglia and a retrocerebral complex. These ganglia are as follows.

1. Frontal ganglion : It is present above the pharynx and in front of brain.

2. Hypocerebral ganglion : It is present on the anterior region of oesophagus.

3. Ingluvial ganglion : It is present on crop. It is also called as visceral ganglion.

4. Ventricular ganglion : It is present on gizzard.

Sense organs :

Collect the information and complete the chart:

Sense Organ	Location	Function
1. Antennae		
2. Eyes		
3. Maxillary palp		
4. Labial palp		
5. Anal Cerci		

Knowledge Enhancer : Compound eyes are present in the cockroach, situated on the dorsal surface of the head. Each eye consists of about 2000 hexagonal ommatidia (singular : Ommatidium). Each ommatidium is like a simple eye, forming image independently, hence with the help of several ommatidia, a cockroach receives several images of an object. Compound eye gives mosaic or hazy vision, but the animal is able to detect even a slightest movement of the object. This kind of vision is with more sensitivity but less resolution.

11.10 Reproduction system :

Cockroach is dioecious organism i.e. male and female individuals are separate.

1. Male Reproductive System : Male reproductive system consists of primary and secondary reproductive organs. Primary sex organs (male gonads) are called testes which are paired and located in the 4th to 6th abdominal segments. They produce sperms which are carried by vasa deferentia. It is a pair of thin tubular structure arising from the testes and opening into the ejaculatory duct through seminal vesicle. They carry sperms to the ejaculatory duct. Ejaculatory duct opens into male gonopore situated ventral to anus.

Mushroom shaped gland or Utricular gland is accessory reproductive gland. It is present in the 6th to 7th abdominal segments.

Male gonapophyses or phallomere are external genitalia of male. These are three asymmetrical chitinous structures surrounding the male gonophore.

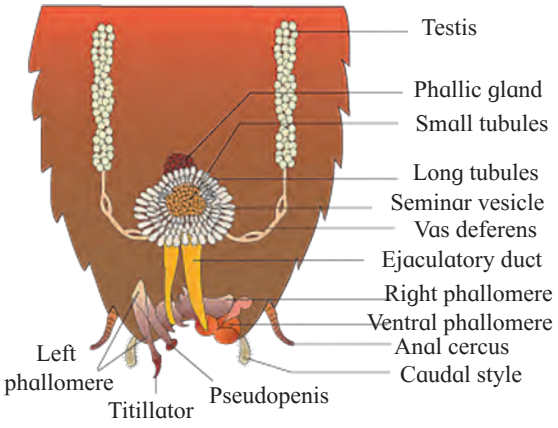

Fig. 11.14 Male Reproductive System

The sperms produced by the testes are stored in seminal vesicles and are glued together in the form of bundles called spermatophores. These spermatophores are deposited in female reproductive tract during copulation.

2. Female Reproductive System : Female reproductive system consists of primary and secondary reproductive organs. Primary reproductive organs are ovaries. There is a pair of large ovaries, lying laterally in the 2nd to 6th abdominal segments. Each ovary is formed of a group of 8 ovarian tubules or ovarioles, containing a chain of developing ova.

All ovarioles of an ovary open in lateral oviduct of respective side. Both lateral oviducts unite to form common oviduct or vagina. Common oviduct or vagina opens into the genital chamber (bursa copulatrix), the female organ of copulation.

A sperm storing structure called spermatheca is present in the 6th segment that open into the genital chamber. Besides, paired accessory glands-collaterial glands are also present that open in genital chamber.

Female gonapophyses consist of six chitinous plates surrounding the genital pore.

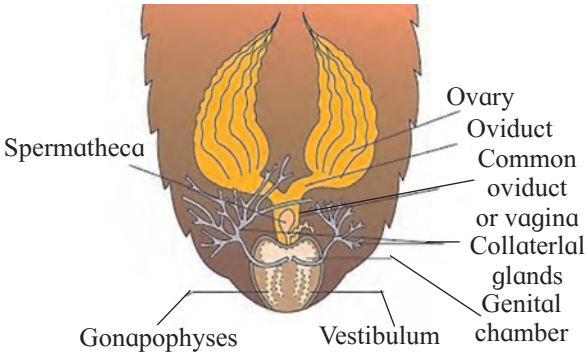

Fig. 11.15 Female Reproductive System

Fertilization and formation of ootheca :

Male and female cockroaches come together by their posterior ends and with the help of phallomeres. The spermatophores are transferred to the genital chamber of female cockroach.

The sperms are released from spermatophore and they reach the spermatheca. The eggs are discharged from both the ovaries alternately into the common oviduct and pass into the genital chamber where they are fertilized by the sperms coming from the spermatheca. The process of fertilization is internal.

Ootheca : The secretion of collaterial glands forms a capsule around them is called as ootheca or egg case. Ootheca is dark reddish to blackish brown capsule about 8 mm long, containing 14 to 16 fertilized eggs in two rows. Ootheca are dropped or glued to a suitable surface like a crack or crevice of good humidity near the food source. On an average, a female produces 9 to 10 oothecae.

Development of Eggs : The development of *Periplaneta americana* is paurometabolous i.e. there is development through nymphal stage. Embryonic period varies as per temperature and humidity. At 24°C, duration is about 58 days and at 30°C, the duration is about 32 days.

Fertilized egg ⟶ Nymph ⟶ Adult

The nymph looks like the adult but far smaller and is sexually immature. After sufficient growth, nymph undergoes moulting and enters into next instar (a stage between two successive moults).

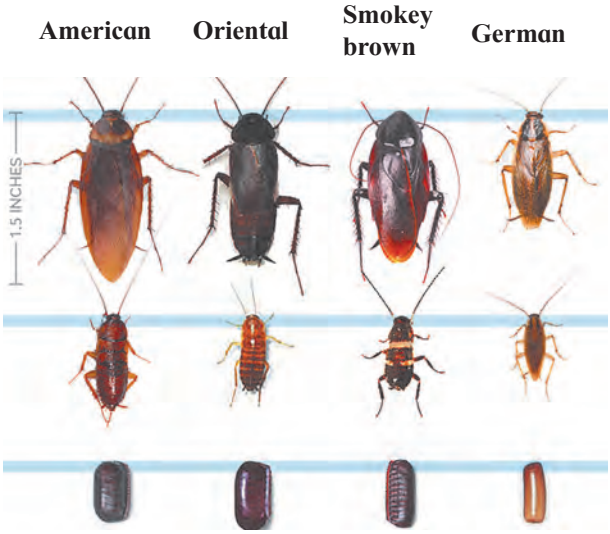

Fig. 11.16 Cockroach Development stages

Cockroach may undergo moulting for about 13 times before reaching the adult stage. The nymphal stages have wing pads but only adult cockroaches have wings.

11.11 Interactions with mankind :

1. Cockroach causes damage to the household materials like clothes, shoes, paper etc. They also eat and destroy the food stuff.
2. They contaminate food which gives typical smell and make it unpalatable.
3. As they live in sewage pipes and gutter holes, they carry with them harmful pathogens causing diseases like cholera, diarrhoea, tuberculosis, typhoid, etc.
4. Cockroach serves as a part of food chain also. Many amphibians, birds, lizards and rodents prey upon them making them a part of food chain. They are eaten by certain groups of people in South America, China and Myanmar.
5. Cockroach is used as experimental animal in laboratories and for biological research, as they can be obtained easily without causing damage to ecological balance.

Control Measures : As cockroach is economically harmful organism it must be controlled in an efficient way. Some of the measures are as follows :

1. Good Sanitation : Dark and humid places of kitchen, cupboards, trolleys must be cleaned regularly. Cracks and crevices and such areas must be filled. There should not be any place in a home, where accumulation of garbage may take place.

Cockroaches frequently enter home by migrating up from sewer connections if the drain trap is dry. So always keep the drain trap filled with water.

2. Chemical control : Organophosphates, carbamates, pyrethroids and boric acid are efficient poisons of cockroaches, various types of their formulations are available in market, under various brand names.

Do you know ?

Cockroaches are considered as bio-indicators! Their presence indicate unhygienic conditions.

Internet my friend

Collect the information about techniques and objectives of rearing the cockroaches in countries like China and make a powerpoint presentation including video clips.

Interesting information :-

Different insects feed upon different types of food materials. Ex : Butterflies feed upon nectar, mosquito (female) and bedbugs on human blood, mantis on other animals, etc.

Depending upon nature of food and feeding habits, different insects have different types of mouthparts. Collect images of different mouthparts and paste in appropriate boxes.

Siphoning mouth parts (Butterfly)

Sponging mouthpart (Housefly)

Piercing and sucking mouthpart (female mosquito)

Piercing and sucking (bed bug)

Chewing and biting (praying mantis)

Chewing and lapping (honey bee)

Exercise

1. Choose correct option

A. Chemical nature of chitin is .....
   a. protein. b. carbohydrate.
   c. lipid. d. glycoprotein.

B. Cockroach has ..... type of mouthparts.
   a. sponging
   b. chewing and biting
   c. piercing and Sucking
   d. lapping

C. Spiracle is a part of ..... system of cockroach.
   a. circulatory b. respiration
   c. reproductive d. nervous

D. ..... is a part of digestive system.
   a. Trachea b. Hypopharynx
   c. Haemocyte d. Seminal vesicle

E. ..... is also called as brain of cockroach.
   a. Supra-oesophageal ganglion
   b. Sub-oesophageal ganglion
   c. Hypo-cerebral ganglion
   d. Thoracic ganglion

2. Answer the following questions

A. Describe the digestive system of cockroach.

B. Give an account on tracheal system of cockroach?

C. Describe nervous system of cockroach.

D. With help of neat labelled diagram, describe female reproductive system of cockroach.

E. With help of neat labelled diagram, describe the digestive system of cockroach.

F. A student observed that the cockroaches are killed for dissection by simply putting them in soap water. He inquired whether soap is so poisonous. Teacher said it is due to its peculiar respiratory system. How?

G. Describe the cirulatory system of cockroach.

3. Answer the following questions

A. How will you identify male or female cockroach?

B. Write a note on : Gizzard of cockroach.

C. Give the systematic position of cockroach.

D. What would have happened if cockroach did not had gizzard?

E. What is the functional difference between eyes of cockroach and human being?

F. What is the functional difference between respiratory systems of cockroach and human being?

4. Explain the following in short

A. What are anal cerci?

B. What is the ganglion?

C. What is the role of hypopharynx?

D. What is mesenteron?

E. Location of turgum.

F. What is ootheca?

G. How many chambers are present in heart of cockroach?

Practical / Project :

Visit to nearest sericulture farm and study the life cycle of silk worm.