

***Periplaneta americana*: The Common Cockroach**  
**[Cockroach: introduction \(YOUTUBE\)](#)**

Arthropods are incredibly diverse. They account for more than 83% of all animal species and out of that 80% are insects. Class Insecta of phylum Arthropoda is the largest in the Animal Kingdom, as there are more species of insects (about 80,000) than all other species of animals combined. Insects are air-breathing and usually flying arthropods. They are distinguished from other arthropods by the possession of 3 pairs of legs and usually 2 pairs of wings. They include familiar examples such as cockroaches, grasshoppers, house flies, honey bees, silkworms, etc. Cockroaches belong to the order Orthoptera. They are common pests of food industries, hotels, kitchens, warehouses, etc.

The word cockroach is derived from the Spanish 'Cucaracha'. Its four common species found in India are: (i) *Blattella germanica*, the German cockroach, (ii) *Blatta orientalis*, the Oriental cockroach, (iii) *Periplaneta americana*, the American cockroach, and (iv) *Periplaneta australasiae*, the Australian cockroach. The following text deals mainly with the biology of *P. americana*. There are about 30 species of cockroaches found in world.

***Periplaneta americana***

*Periplaneta americana* was originally named *Blatta americana* by Linnaeus (1758). De Geer (1773) called it *Blatta kakerlac*. The Its original home is supposed to be tropical Africa and not America, generic name *Periplaneta* was assigned to it by Burmeister (1838). as previously believed. Today, it exists in all parts of the world. It has become well established almost throughout India.

SYSTEMATIC POSITION

**[Cockroach: systematic position \(YOUTUBE\)](#)**

Phylum    Arthropoda

Class        Insecta

Subclass    Pterygota

Division    Exopterygota

Order       Orthoptera

Genus       *Periplaneta*

Species     *americana*

## **HABITS AND HABITAT (ECOLOGY)**

### **Cockroach: habits and habitat (YOUTUBE)**

Cockroaches are found in places where there is warmth, dampness, and plenty of organic food to devour. In warmer months, cockroaches are common outdoors, occurring in sewer, manholes, dumps, outbuildings, and wood piles. Indoors, they are a common pest in kitchens, latrines, hotels, restaurants, go downs, storerooms, board ships, etc. The Oriental cockroach prefers somewhat cooler places and hence it is commonly found in toilets and behind baths and sinks.

Cockroaches are nocturnal creatures. During daytime, they remain inactive and hiding. Their narrow and flattened body is adapted to slip into narrow crevices and crevices. During night, they show much activity and run here and there in search of food. They are cursorial insects, i.e., fast runners, and rarely resort to flight. It has been reported that, at 25°C, *Periplaneta* runs from 70-130 cm per second. Being omnivorous and scavengers in diet, they devour any animal or vegetable substance and even non-living materials like leather, paper, cloth, etc., causing great loss.

## **EXTERNAL MORPHOLOGY**

### **Cockroach : External Morphology (YOUTUBE)**

#### **[I] Shape, Size and Colour**

Body of cockroach is narrow elongated, bilaterally symmetrical and dorso-ventrally flattened. The adult measures from 28 to 44 mm in length and 8 to 10 mm in width. Colour is shining reddish- brown with a paler yellow area around the edge of tergum of pronotum of prothorax and two dark patches over it.

#### **[II] Exoskeleton or Cuticle**

The entire body is covered externally by a non- living brown-coloured, hard, jointed, and chitinous exoskeleton composed of several plates or sclerites. It is formed by the surface layer or cuticle of body wall and is secreted by the underlying hypodermis.

#### **[III] Divisions of Body**

Body of cockroach is distinctly divided into segments. These are grouped into 3 well-defined regions or tegmata: (i) Head, (ii) thorax and (iii) abdomen.

#### **[IV] Head**

Anterior region of body or head is small and roughly triangular or pear-shaped. It is held at right angles (perpendicularly) to the long axis of body and scarcely visible in dorsal view. It is formed by the fusion of 6 embryonic segments.

**1. Neck.** Head is attached to thorax anteriorly by a short and narrow neck or cervicum, which is supported by 4 small chitinous plates, 2 dorsal and 2 ventral. Head can be moved by neck muscles in different directions.

**2. Exoskeleton of head.** The whole head is covered by several chitinous plates or sclerites, constituting its exoskeleton or head capsule. Their fused margins are visible as lines, called sutures. Top or vertex of head is formed by two epicranial plates jointed in front by an inverted Y-shaped coronal or epicranial suture. The unpaired triangular frons lies between the arms of the epicranial suture. A broad rectangular clypeus forms the lower part of face. The two lateral sides of head below compound eyes are formed by the cheeks or genae.

**3. Appendages of head.** Head bears a number of jointed appendages. On each dorso-lateral side of head is a large reniform and black compound eye. Just in front of each eye is a long, slender and multi-segmented antenna. Inner

to the base of each antenna is a small, round and whitish area or fenestra, representing a simple eye or ocellus. Lower end of head bears the preoral cavity and mouth, surrounded by mouth parts. These consist of labrum, mandibles, maxillae, labium, and hypopharynx. Such a head with mouth parts directed downwards is called hypognathous.

## [V] Thorax

The middle region of body or thorax consists of 3 distinct segments called, from in front backwards, the prothorax, mesothorax and metathorax. Exoskeleton of each segment consists of a dorsal tergum or notum and a ventral sternum. Tergum of prothorax is the largest and called pronotum. It projects forwards to conceal the neck and head. Each thoracic segment bears ventrally a pair of 9 jointed walking legs. While mesothorax and metathorax each bear a pair of wings dorsally, except in the wingless female of *Blatta orientalis*. Two pairs of tracheal openings or spiracles are present on the lateral pleura of thorax.

## [VI] Abdomen

The posterior region of body is called abdomen. It is broader than thorax and dorso-ventrally flattened. Abdomen of adult consists of 10 segments while embryo has 11 segments. Not all segments are visible externally, the hinder segments remain somewhat concealed. 8 pairs of tracheal openings or spiracles are present on lateral pleura of first 8 abdominal segments.

**1. Exoskeleton of abdomen.** Exoskeleton of each abdominal segment consists of a dorsal tergum and a ventral sternum, united laterally by soft cuticle. Tergum of 7th segment overlaps those of 8th and 9th segments. 10th tergum projects behind freely as a deeply notched bifid plate. Anus lies below 10th tergum between 4 podical plates, a dorsal epiproct, a ventral hypoproct and two lateral paraprocts which may represent the vestiges of 11th embryonic segment.

**2. Abdominal appendages and sexual dimorphism.** 10th segment in both sexes bears a pair of small, filamentous and sensory anal cerci. They project laterally, one on either side, at the posterior end. They

probably represent the 11th segment. Each anal cercus is made of 15 segments. Terminal part of abdomen differs in two sexes.

In male, in addition to anal cerci, 9th sternum bears a pair of short, unjointed thread-like anal styles which are absent in female. The genital aperture of male is placed between 9th and 10th sternum, surrounded by complicated processes known as gonapophyses.

In female cockroach, abdomen is broader than in male. The genital aperture is located on 8th sternum surrounded by gonapophyses forming an ovipositor. 7th sternum of female forms a boat-shaped genital pouch and is split behind forming two gynovalvular plates. Frequently, an egg cocoon may be seen projecting from this.

## **APPENDAGES OF COCKROACH**

[Cockroach: appendages of cockroach \(YOUTUBE\)](#)

[Cockroach : Appendages \(YOUTUBE\)](#)

Main appendages include antennae and mouthparts on head, legs and wings on thorax, and external genitalia on abdomen.

### **[I] Antennae**

Antennae are a pair of long, slender, whip-like, and many-jointed movable appendages, found on head. They are embryologically preoral and hence homologous with the antennules of prawn (Crustacea). Male cockroach has longer antennae than female.

An antenna is attached close to the inner side of compound eye in a circular socket enclosed by a ring-like antennal sclerite, and freely articulating by a thin membrane. It consists of a large basal segment, the scape, followed by a short and cylindrical pedicel, and a long many-jointed flagellum. The antennae bear tactile and olfactory receptors and are sensitive to touch and smell.

### **[II] Mouth Parts**

Mouth parts are head appendages surrounding the mouth. These consist of the labrum or upper lip, a pair of mandibles, a pair of maxillae, the labium or lower lip and the hypopharynx. Mouth parts of cockroach have remained unspecialised due to its omnivorous habit. They are of the biting and chewing type, also known as of mandibulate type. They enable cockroach to bite and chew hard stuffs, consume soft stuffs and lap up liquids.

**1. Labrum.** Labrum or upper lip is the appendage of 3rd head segment. It is a broad and oblong plate, movably attached to the lower margin of clypeus and forms the anterior margin of mouth cavity. At its junction with clypeus, it bears a small sclerite, called tormae, on each inner side. Its inner surface also bears two rows of sensory (gustatory) setae, one on each side. Labrum overlaps the toothed portions of mandibles.

**2. Mandibles.** These are appendages of 4th head segment. These are small, triangular, and strongly sclerotised structures. They are attached with the sides of head capsule and articulate by means of a condyle with the gena of same side.

Inner margin of each mandible is made of two small cutting or serrated lobes, distal incisor and proximal molar, each bearing 3 tooth-like denticles of thickened cuticle. Proximal to molar lobe is a membranous lobe, the prosthema, that bears sensory hairs. Mandibles work like jaws.

Denticles act as the interlocking structures whereas smooth molar areas as masticatory surfaces. Both the mandibles show horizontal sideways movements brought about by the action of adductor and abductor muscles.

**3. Maxillae.** These are appendages of 5th head segment and known as first pair of maxillae. They lie beneath mandibles and articulate with the posterior surface of head capsule, one on either side. They are biramous in structure. The basal part or protopodite consists of a distal cylindrical stipes hinged to a proximal basal cardo at an obtuse angle. Stipes bears three processes: (i) inner lacinia which is sclerotised with a pair of sharp denticles and a blunt lacinula, (ii) middle galea which acts as a hood for lacinia and (iii) outer long maxillary palp, which is 5-segmented and sensory in nature. It is borne on a small basal sclerite, the palpifer. Maxillary palp represents exopodite while lacinia and galea on represent endopodite. Both maxillae act accessory jaws. They work sideways to masticate -labrum food and to convey food morsels into oral cavity. They also serve to clear antennae and forelegs.

**4. Labium.** Labium or lower lip is the appendage of 6th head segment. It is the posterior most of all mouth parts. It is formed by the fusion of two maxilla-like embryonic appendages or second pair of maxillae. Fused protopodite is 3-segmented consisting of a large proximal submentum, a small middle mentum and a distal prementum. The partially fused endopodites form a tongue-like ligula. Each half of ligula consists of an inner glossa and an outer paraglossa, corresponding with lacinia and galea respectively. Prementum bears, on each side, a 3-jointed sensory labial palp borne on a basal projection, the palpiger. Terminal segment of palp is covered thickly with sensory setae.

**5. Hypopharynx.** It lies between the maxillae and above the labium, inside the mouth cavity. It is a median somewhat cylindrical structure also known as lingua. Its distal end bears two comb-like plates, the superlingua. The common salivary duct opens at its front end.

### [III] Walking Legs

There are three pairs of walking legs, one pair attached ventrally to sternum of each of prothorax, mesothorax and metathorax and called for, mid- and hind legs, respectively. All the legs are similar, and each consisting of a linear series of 9-segments or podomeres. Leg is articulated with its thoracic segment by a stout flattened, basal coxa, followed by a smaller triangular trochanter. The latter is fused to a stout spiny femur, followed by a slender spiny tibia, which is the longest segment of leg. Finally, the tarsus is made of 5 very small movable podomeres or tarsomeres bearing fine hairs. Basal tarsomere is longer and called metatarsus while terminal tarsomere is named pretarsus. Inner edges of first four tarsomeres bear soft adhesive pads, the plantulae, Pretarsus ends in two lateral claws and between them a median, delicate hair-

covered porous pad, the arolium, which prevents it from slipping. All the legs are used for walking, running and climbing.

#### **[IV] Wings**

Cockroach has two pairs of wings. One pair of wings are attached dorso-laterally between tergum and pleuron of both mesothorax and metathorax. In *P. americana* wings reach up to the tip of abdomen in female, and a little beyond in male cockroach.

Each wing consists of two membranous layers of cuticle enclosing tubular tracheae. Chitin thickens around tracheae to form nervures or veins that strengthen the wings. Wing veins are of such constant pattern in each insect as to form a basis of their classification.

**1. Forewings.** Mesothoracic or forewings are heavily sclerotized. They are narrow, dark opaque and leathery in texture. They are not used in flight but serve to protect the hindwings at rest. Hence they are known as elytra, wing covers or tegmina.

**2. Hindwings.** Metathoracic or thin, membranous, hindwings are transparent, broad, delicate and used in flight. They are kept folded like a fan under the tegmina, when at rest. Movements are due to special muscles attached to wing bases and working at a very high speed.

#### **[V] External Genitalia**

Reproductive organs (such as testes and ovaries) concerned with production and transmission of gametes (ova and sperms) are collectively termed internal genitalia. While organs involved in sexual dimorphism, mating and deposition of eggs are known as external genitalia. In cockroach, these are appendages of the terminal segments of abdomen. Anal cerci and anal styles have already been described earlier. Whereas gonapophyses shall be dealt with the reproductive system of cockroach.

### **BODY WALL AND EXOSKELETON**

Body wall or integument consists of: (i) cuticle, (ii) hypodermis and (iii) basement membrane.

#### **[I] Cuticle (Exoskeleton)**

Entire body including appendages is covered externally by a thick, brown-coloured, non-living, hard and chitinous cuticle which forms the exoskeleton of insect. It is secreted by the hypodermis underneath.

**1. Structure of cuticle.** Cuticle or exoskeleton is principally made of chitin, a horny proteinous substance, chemically an amino- polysaccharide (C<sub>32</sub>H<sub>54</sub>N<sub>4</sub>O<sub>21</sub>), insoluble in water and resistant to most solvents. Cuticle of insects becomes hard not due to calcium salts as in some other classes, but due to certain proteins and chitin. Hardening of cuticle due to chitin is called sclerotization and its hardened plates are called sclerites. At the joints (sutures), sclerites are connected by soft and flexible arthroal membranes which

allow movements of body and appendages. Head armour is made of several plates as already described. In each thoracic and abdominal segment, there are 4 sclerites: a dorsal tergum, a ventral sternum and two very small lateral pleura.

Cuticle also lines the foregut, hindgut, tracheae and genital ducts. Numerous invaginations of cuticle form a sort of endoskeletons. That of head is called as tentorium while those of thorax and abdomen as apodemes. Further, the stiff, immovable bristles or spines covering the body and its appendages are in fact the outgrowths of cuticle.

**2. Histology of cuticle.** Histologically, cuticle is made of 3 distinct layers: epicuticle, exocuticle, and endocuticle, all secreted by the underlying hypodermis.

**(a) Epicuticle.** It is the outermost extremely thin layer 1 to 2  $\mu$  in thickness and without chitin. Its outer part is made of lipid or wax which is impermeable to water, while inner part is made of proteins and lipids. In some insects, a thin 'cement layer' occurs outside the waxy layer.

**(b) Exocuticle.** It is the middle layer 10 to 20  $\mu$  thick and containing chitin and melanin pigments.

**(c) Endocuticle.** It is the innermost, thickest, and laminated layer 20 to 30  $\mu$  thick. It contains chitin. Exocuticle and endocuticle together form the procuticle.

**(d) Pore canals.** Electron microscopic studies by Richards and Anderson have revealed presence of pore canals in exocuticle and endocuticle. These are hollow, spirally coiled tubes extending from hypodermis up to, but not into, the epicuticle. Their number is about 12,00,000 per sq. cm. Pore canals are probably filled with salt solution in ionic equilibrium with the hypodermal cells. Exact function of these canals is not known but they are supposed to influence the flexibility and permeability of cuticle.

**3. Functions of cuticle (exoskeleton).** Thick cuticle of arthropods is like steel to modern man, and is primarily responsible for their great success.

It is useful in many ways as follows:

- (1) Provides support, rigidity, and protection.
- (2) Waxy layer prevents loss of water due to evaporation, thus enabling insects to live in relatively dry environments.
- (3) Cuticular invaginations offer points of attachment for muscles.
- (4) Jointedness of cuticle of body segments and appendages makes accurate complicated movements possible.
- (5) Cuticular lining of fore and hind guts protects their epidermis from abrasions by passage of food.

(6) Melanin pigments within the cuticle provide protective colouration.

(7) Many of the cuticular outgrowths form sensory receptors.

### **[II] Hypodermis**

Hypodermis (or epidermis) lies beneath the cuticle which it secretes. It is a highly organised epithelium made of a single layer of columnar cells resting on a basement membrane and anchored to it by hemidesmosomes. Besides secreting cuticle, hypodermis resorbs endocuticle before each moult or ecdysis.

**1. Glands.** Dermal glands found in hypodermis are of two kinds. They are concerned with the production of cement layer and different kinds of cuticle. They probably also secrete pheromones and some hormones. Swollen body of glands lie in hypodermis while their ducts run through cuticle to open on its surface.

**2. Oenocytes.** In adult cockroach large irregular cells, more than 100  $\mu$  in diameter, appear between hypodermal cells and basement membrane. They probably secrete wax or lipids (Kramer and Wigglesworth) that is transmitted to the surface of cuticle.

**3. Trichogen cells.** Specialized, movable and hair-like sensory setae, projecting above the surface of cuticle, are secreted by special trichogen cells of hypodermis.

### **[III] Basement Membrane**

A typical stout and continuous basement membrane bounds the inner surface of hypodermis. It consists of an amorphous granular material, probably a mucopolysaccharide.

## **COELOM AND BODY CAVITY**

The large perivisceral body cavity of cockroach, enclosing alimentary canal and other viscera, is not a coelom as found in earthworm. It is a haemocoel containing blood, and shall be described with the circulatory system. True coelom in cockroach is much reduced and represented only by the cavities of gonads.

### **[I] Digestive System**

[Cockroach: Digestive system \(YOUTUBE\)](#)  
[Cockroach: physiology of digestion \(YOUTUBE\)](#)

It is the most conspicuous organ system in the body. It includes the mouth parts already described, a long alimentary canal and a pair of salivary glands.



## [III] Alimentary Canal

It is a long and somewhat coiled tube of uneven diameter and divisible into three regions: foregut, midgut and hindgut. Foregut and hindgut are ectodermal and lined with a thin cuticle secreted by ectoderm. Whereas midgut is endodermal, devoid of cuticular lining and capable of absorbing digested food.

### A. Foregut or stomodaeum

It includes mouth cavity, pharynx, oesophagus, crop and gizzard.

**1. Mouth cavity.** Mouth cavity or preoral chamber is a small, ill-defined space outside mouth, surrounded by mouth parts. Hypopharynx divides preoral cavity into a posterior part, called salivarium, into which common salivary duct opens, and an anterior part or cibarium, which leads towards mouth as a narrow food passage. Food is crushed and acted upon by the salivary secretion or saliva in mouth cavity.

**2. Mouth.** True mouth is a small opening at the base of preoral cavity and leads into pharynx.

**3. Pharynx.** It is short and tubular and its cuticular lining is more folded posteriorly.

**4. Oesophagus.** From pharynx arises a long, straight narrow and laterally compressed tube, the oesophagus. It passes through the nerve collar, runs through the neck and enters thorax to merge with crop.

**5. Crop.** It is large, thin-walled, a pear-shaped sac, which extends well up to the third or fourth abdominal segment. It is the largest part of foregut. Its internal epithelial and cuticular lining is very much folded. Its outer surface is covered by a network of tracheae. Crop serves as a reservoir for storing food.

**6. Gizzard.** Crop leads behind into a small, cone-shaped, muscular and thick-walled chamber, the gizzard or proventriculus, which marks the end of foregut. It consists of two parts, an anterior armarium and a posterior stomodaeal valve.

**(a) Armarium.** The armarium possesses internally six longitudinal folds that greatly reduce its lumen. Longitudinal folds alternate with six longitudinal grooves which also bear small secondary folds. Cuticular lining of each longitudinal fold forms, (i) in the anterior part, a thick plate produced centrally into strong, sharp teeth or denticles, (ii) in the posterior part, a thin plate. Behind each longitudinal fold the cuticular lining of the gizzard forms a soft cushion-like lobe, the pad or pulvillus, with long, backwardly directed hairs which act as strainers and allow only finer food particles to pass into midgut.

**(b) Stomodaeal valve.** Behind pads, the posterior end of gizzard extends into the lumen of midgut as a spout-like narrow tube, the stomodaeal valve. The latter folds back on itself, and is thus double-walled. Stomodaeal valve prevents regurgitation of food from midgut into gizzard.

## **B. Midgut or mesenteron**

Midgut is the short and narrow tube-like middle part of alimentary canal also known as ventriculus or mesenteron. It is internally lined by glandular epithelium and forms the true stomach serving mainly for digestion and absorption.

**1. Hepatic caeca.** Opening into the anterior end of midgut are 7 or 8 short, narrow, blindly ending hollow tubes, called enteric or hepatic caeca. These are internally lined by epithelium and secrete digestive enzymes.

**2. Malpighian tubules.** From the junction of midgut and hindgut arise 80 to 90 very narrow, thread-like, yellow-coloured projecting freely into haemocoel. These are called Malpighian tubules after the great Italian anatomist Malpighi. In fact these tubules arise from hindgut and are excretory in function. In Periplaneta, these have been shown to contain certain intracellular enzymes (E. Schlottke, 1937).

## **C. Hind gut or proctodaeum**

The posterior 1/3 part of the alimentary canal forms the hindgut. It is divided into three regions : ileum, colon and rectum.

**1. Ileum.** Ileum is a narrow and short tube and its posterior end is characterised by the possession of six tiny triangular lobes internally, bearing spicules and acting as a sort of sphincter.

**2. Colon.** Colon is longer and wider and with an irregular shape.

**3. Rectum.** Rectum is an oval or spindle- shaped sac with external ridges alternating with internal longitudinal thickenings called rectal pads or rectal papillae. These are 6 in number and also known as rectal glands. Rectum opens to outside by anus. Lining of hindgut is also cuticular, but is more pervious to water than that of foregut.

## **[III] Salivary Apparatus**

Lying in thorax, on either dorso-lateral side of oesophagus, is a pair of bipartite, diffuse and whitish salivary glands. Each gland consists of several secreting lobules or acini in grape-like clusters and connected by fine tubules. Acini contain two types of cells, described by Day as zymogenic cells and ductule-containing cells. Both types of cells secrete saliva, that consists of an enzyme zymase and mucoid substance. Ductules from ductule-containing cells open into an intercalary duct, that leaves acinus to join similar ducts of other acini, to form a larger duct. Associated with each gland is an elongated, sac-like, thin-walled reservoir or receptacle for the storage of saliva.

Ducts from the two salivary glands unite to form a single common glandular duct. Similarly, ducts from two reservoirs unite with each other forming a common reservoir duct. Both common ducts then join to form a common efferent salivary duct that opens at the base of hypopharynx in the salivarium of preoral cavity.

## [IV] Nutrition

**1. Food.** Cockroach is omnivorous, feeding on any kind of animal or vegetable matter, including wood, book-bindings, cloth, leather, paper, pastes, glues, hair, and even its own cast cuticle. It usually feeds at night.

**2. Feeding.** Food is searched by the sweeping antennae tasted by maxillary and labial palps, and seized by the forelegs, labrum and labium. During eating, mandibles (and maxillae) undergo a sideways movement brought about by the action of the adductor and abductor muscles, and masticate the food into finer particles.

**3. Digestion.** In the salivarium of mouth cavity, crushed food mixes with salivary secretion. Mucus of saliva lubricates food while its digestive enzyme zymase hydrolyses the starchy matter of food. Lubricated food is then pushed into pharynx through mouth with the help of labium. Food now starts moving through alimentary canal by peristalsis. Most of digestion occurs in crop by saliva and digestive secretions from hepatic caeca and midgut. Upon entering proventriculus, food is subjected to further mastication by internal denticles worked upon by longitudinal and annular muscles. Hair on pulvilli act as a filter, allowing only finer particles to move ahead. In midgut, partly digested food is mixed with enzymatic secretions of epithelial secretory cells of enteric caeca and midgut itself. These secretions contain: (i) a trypsin-like enzyme and peptidases that break down proteins, (ii) amylase that completes the breaking down of starches, and (iii) lipase that breaks down fats. A thin transparent chitinous peritrophic membrane lines the midgut internally in the form of a tube. This membrane is secreted by the stomodaeal valve of gizzard. It protects the delicate lining of midgut from abrasion by the hard indigestible components of food. It is, however, permeable to enzymes as well as digested food and, therefore, does not hinder their normal course of digestion and absorption.

**4. Absorption.** Epithelial cells of enteric caeca and midgut are also absorptive. They absorb digested food which is stored in the diffuse fat bodies. According to Abbott (1926), large quantities of fat are absorbed by the epithelial cells of crop.

**5. Egestion.** Undigested food is passed first into ileum and then into colon. In rectum, the rectal pads absorb water and the faeces is eliminated to outside through anus as dry pellets.

## CIRCULATORY SYSTEM

Cockroach has an open or lacunar circulatory system as blood, also called haemolymph, flows freely within the body cavity or haemocoel. There is a heart and aorta but no capillaries and veins.

### [I] Haemocoel

Body cavity of cockroach is called haemocoel (Gr., haima, blood + koila, cavity), as it is filled with blood or haemolymph.

**1. Diaphragms.** Haemocoel is divided by a dorsal and ventral diaphragm into three sinuses: (i) dorsal pericardial, (ii) middle perivisceral and (iii) ventral perineural. Diaphragms are provided with pores or fenestrae to permit flow of haemolymph from one sinus to another. Ventral diaphragm also extends into each leg as a septum dividing its cavity into two sinuses, one for the outward and the other for inward flow of haemolymph.

**2. Dorsal pericardial sinus.** It encloses heart and aorta and paired fan-shaped (triangular) alary muscles, one pair in each segment, one on either side of heart. Apices of these muscles are attached to the terga and their broad bases to the dorsal diaphragm.

**3. Perivisceral sinus.** Middle or perivisceral sinus contains the alimentary canal. It is mostly occupied by a whitish mass of tissue or fat body. It consists of several types of cells. Trophocytes store reserve food in the form of fat globules, protein globules and glycogen. The latter is used during starvation. Urate cells are excretory in nature. Oenocytes produce wax while myocytes contain intracellular symbiotic bacteria.

**4. Perineural or sternal sinus.** It encloses the ventral nerve cord.

## **[II] Heart and Aorta**

Enclosed by dorsal pericardial sinus is the heart. It lies mid-dorsally beneath the terga of thorax and abdomen. It is a long narrow tube with anterior end open and posterior end closed. It consists of 13 funnel-shaped chambers or segments, each communicating by a valvular opening with the one in front of it. Hinder end of each chamber has a pair of minute lateral openings, the ostia. These allow flow of haemolymph from pericardial sinus into heart only and not in a back gear. The anterior narrow and tubular part of heart is called anterior aorta. It is without ostia and forwards into the head sinus,

## **[III] Haemolymph**

The haemolymph or blood of cockroach consists of a clear colourless plasma rich in amino acids, uric acid, and numerous different types of cells, called haemocytes. According to Wigglesworth (1965), there are seven types of such cells. Some cells transfer, by ingestion, the food material from blood to the tissues, while others act as phagocytes in removing the metabolic wastes from tissues. Haemolymph is devoid of a respiratory pigment and hence does not assist in respiration.

## **[IV] Blood Circulation**

Blood or haemolymph circulates by the contraction and relaxation of heart assisted by the paired fan-shaped alary muscles. Contraction of these muscles enlarges the pericardial sinus so that blood flows into it from the underlying perivisceral sinus. When the muscles relax, blood is forced through ostia into the heart. Heart and aorta contract peristaltically from behind forwards driving blood into head sinuses and then backwards into the perivisceral and sternal sinuses. The rate of heart beat in *Periplaneta* is 49/min.

From head sinuses, haemolymph is also sent into antennae by the pumping activity of two small ampullae, located in head. In case of wings, small pulsatile organs at their bases cause haemolymph to flow through the veins of fore and hindwings.

## RESPIRATORY SYSTEM

### [I] Respiratory Organs

Respiratory system of cockroach is well-developed to compensate the poorly developed circulatory system. It consists, as in other insects, of tracheae, tracheoles and spiracles.

**1. Tracheae.** Haemocoel contains a network of elastic, closed and branching air tubes or tracheae. There are three pairs of large, parallel, longitudinal tracheal trunks, one dorsal, one ventral and one lateral in position, which are connected together by transverse commissures. Tracheae are formed as invaginations of outer integument, hence they are made of an outer epithelial wall lined by an inner chitinous cuticle. The cuticular lining is spirally thickened forming intima or taenidia which prevents the tracheal tubes from collapsing. When cockroach is dissected under water, the tracheae, filled with air, presents a glistening appearance.

**2. Tracheoles.** The profusely branching tracheae anastomose and penetrate to all parts of body. The ultimate finer branches of tracheae are called tracheoles which encounter the individual body cells. They have a diameter of only 1 micron. Their cavities are intracellular, that is, each tracheole is made of a single cell. Their walls are very thin and devoid of cuticular spiral thickening, instead they are lined by a protein called trachein. They are permeable to water. Their tips are usually filled with a fluid in which oxygen dissolves and diffuses to the tissues. However, some zoologists think that tracheoles end blindly and remain without fluid. Thus, the elaborate tracheal system carries oxygen directly to all the body cells. This very well compensates for the inability of blood to transport oxygen due to absence of a respiratory pigment.

**3. Spiracles.** The main tracheal trunks open to the exterior on body surface through 10 pairs of segmentally arranged apertures termed spiracles or stigmata. Two pairs of spiracles are thoracic, one between pro- and mesothorax and the other between meso- and metathorax. Eight pairs of spiracles are abdominal, one pair in each of the first eight abdominal segments. They are present laterally in the soft cuticle between terga and sterna. A spiracle is guarded by bristles or hair to keep out dirt. It is surrounded by an annular sclerite, the peritreme. It has a closing device in the form of a simple valve which prevents undue loss of water and can be closed or opened to regulate the flow of air. Each spiracle internally leads into a short tracheal chamber or atrium from which arises a main tracheal trunk.

### [II] Respiratory Mechanism and Gaseous Exchange

Alternate contraction and relaxation of the abdominal muscles (tergo-sternal muscles) cause rhythmic contraction and expansions of abdomen. Such movements cause change in diameter of tracheae and force air in and out of tracheal tubes through spiracles. 1st and 3rd pairs of spiracles always remain open while the remaining eight pairs open only during inspiration. Respiratory movements depend on the activity of insect and temperature. Greater the muscular activity, the more vigorous is the pumping in-and-out of air. Respiratory movements are coordinated and regulated by nerve centres in thoracic ganglia which are stimulated by low O<sub>2</sub> and higher CO<sub>2</sub> concentrations in tissue fluids.

Gaseous exchange occurs by simple diffusion between air in tracheae and dissolved gases in blood or tracheolar fluid which has been shown to rise and fall. When insect is resting, the tips of tracheoles remain filled with fluid so that O<sub>2</sub> diffuses slowly through fluid into body cells and tissues. When the metabolic activity is greater, fluid from tracheoles is withdrawn into surrounding tissue due to a rise in osmotic pressure of cells. This exposes more surface walls of tracheoles to oxygen, so that more oxygen is supplied to the surrounding tissues. O<sub>2</sub> entering the tissues brings about oxidation of energy-rich food molecules with the release of energy and production of CO<sub>2</sub> and water. Some of the CO<sub>2</sub> leaves the body through tracheae and spiracles. But major part of CO<sub>2</sub> leaves through the cuticular covering of body because it can diffuse more readily through chitin than O<sub>2</sub>.

## **EXCRETORY SYSTEM**

Excretory system regulates the amounts of nitrogenous material, inorganic salts and water in blood or haemolymph. As a result of the protein metabolism, nitrogen is produced in excess which is excreted as uric acid. The main structures that play the role of excretion are: (i) Malpighian tubules, (ii) fat body cells, (iii) uricose glands, and (iv) cuticle,

### **[I] Malpighian Tubules**

These are attached to the alimentary canal at the extreme anterior end of hindgut. These are fine, long, unbranched, yellowish and blind tubules lying freely in the haemolymph. There are between 60 to 150 in number and are arranged in 6-8 bundles. Each tubule is about 16 mm long and 0.5 mm in diameter and is lined by glandular epithelium with a characteristic brush border.

A Malpighian tubule has two functional parts. Glandular cells of distal secretory part extract nitrogenous wastes (mostly in the form of salts of uric acid, e.g., potassium urate) and water from haemolymph forming a solution called urine. The urine flows towards the proximal absorptive part of tubule which reabsorbs certain salts, such as bicarbonate, and some as potassium water resulting in precipitation of uric acid. Uric acid already present in haemolymph combines with reabsorbed potassium bicarbonate and water to form the relatively soluble potassium urate which again becomes available to be actively transported from haemolymph into the lumen of distal portion of Malpighian tubule. From Malpighian tubule uric acid moves into ileum by gentle peristaltic waves. More water is reabsorbed in colon and rectum so that more or less solid uric acid is eliminated with faeces through anus.

### **[II] Fat Body Cells**

Fat body, filling up the greater part of haemocoel is a lobed white tissue. It consists of many different types of cells, but only urate cells are associated with excretion. These cells accumulate, produce and store uric acid and urate granules throughout life. This mode of excretion is termed storage excretion.

Some other important types of cells in the fat body are: (i) Trophocytes that store reserves of fat, glycogen and protein, (ii) Oenocytes that are believed to produce lipoprotein (wax) for formation of new epicuticle at moulting, and (iii) Mycetocytes that are filled with bacteroids (symbiotic intracellular bacteria). Henry and Block have shown that these bacteroids contribute in the synthesis of amino acids. Further, Keller is of the opinion that these bacteroids can breakdown uric acid to remobilise its nitrogen.

### **[III] Uricose Glands**

The mushroom gland of male cockroach possesses long, blind tubules at its periphery, called uricose glands or utriculi majores. These tubules store uric acid (storage excretion) and discharge it over the spermatophore during copulation. Thus they serve as 'storage excretory organs' between matings and as active excretory organs' during copulation (Roth and Dateo).

### **[IV] Cuticle**

Cuticle also acts as a site where nitrogenous waste material is deposited and then eliminated with its shedding at each moult.

## **NERVOUS SYSTEM**

### **Cockroach: nervous system (YOUTUBE)**

Nervous system comprises the central, peripheral and sympathetic or stomatogastric nervous systems.

#### **[I] Central Nervous System**

It consists of the brain and ventral nerve cord with its ganglia.

**1. Brain.** Brain or supra-oesophageal ganglion is a large and bilobed mass located in head above oesophagus. It represents 3 pairs of ganglia of head region fused together. It is divided into three parts : protocerebrum, deutocerebrum and tritocerebrum. Remaining three pairs of ganglia of head fuse to form the sub-oesophageal ganglion which lies below oesophagus. Brain and sub-oesophageal ganglion are connected together, on either side of oesophagus, by a circumoesophageal commissure.

**2. Ventral nerve cord.** From sub-oesophageal ganglion runs posteriorly a double ventral nerve cord along the mid-ventral line of thorax and abdomen. It bears 9 ganglia, 3 in thorax and 6 in abdomen. The last abdominal ganglion is the largest, representing many fused ganglia of the posterior abdominal segments.

#### **[II] Peripheral Nervous System**

The nerves, given off from ganglia to all parts of body, constitute the peripheral nervous system. Protocerebrum of brain gives off paired optic nerves to eyes, deutero-cerebrum gives off paired antennary nerves to antennae, and tritocerebrum supplies nerves to frons and labrum. Sub-oesophageal ganglion supplies mandibular, maxillary and labial nerves to the mandibles, maxillae and labium, respectively. Nerves from thoracic ganglia innervate thoracic muscles, mainly those of wings and legs. First 5 abdominal ganglia send nerves to the dorsal and ventral muscles of body wall, spiracles and heart, whereas the last abdominal ganglion supplies nerves to muscles of last three abdominal segments, reproductive organs, copulatory appendages, and anal cerci.

### **[III] Sympathetic or Stomatogastric Nervous System**

It comprises four ganglia and a retro-cerebral complex,

(i) A frontal ganglion lies above pharynx, in front of brain. It sends nerves to pharynx, clypeus and labrum. It is connected to protocerebrum of brain by a median nervous connectives and to tritocerebrum by a pair of frontal connectives. Frontal ganglion is also connected, by a median unpaired recurrent nerve, with (ii) a hypocerebral ganglion on oesophagus. It sends an oesophageal nerve, to (iii) an ingluvial ganglion located on crop. Branches from oesophageal nerve innervate the salivary glands and their ducts. From ingluvial ganglion arise two nerves, one dorsal and other ventral to crop, that run posteriorly and get connected with (iv) a proventricular ganglion on the surface of proventriculus.

Retro-cerebral complex is located above the hypocerebral ganglion. It is formed of two paired masses, the corpora cardiaca and corpora allata, and related connectives. Corpora cardiaca is neuro-secretory and regulates the heart-beats and peristalsis of foregut. Corpora allata produces hormones which assist in reproduction and metamorphosis.

## **SENSE ORGANS**

All the major senses (touch, smell, hearing, sight, etc.) are found in cockroach, as found in most of other.

### **[I] Photoreceptors or Eyes**

Visual receptors or eyes are of two types, compound eyes and ocelli.

**1. Compound eyes.** Of all the organs of special senses, the most important are a pair of large, sessile, compound eyes in the form of black, kidney-shaped organs on lateral sides of head. Each consists of about 2,000 visual elements or units, called ommatidia, similar in structure to those already described for the prawn. The same may be referred to for details.

Compound eye of cockroach and other insects is a very elaborate structure. In complexity, it challenges the eyes of vertebrates, but falls far behind in efficiency. The pigment does not seem to be retractable in the eyes of cockroach. Owing to its form and permanently extended pigment sheath, the only light rays which reach the retinular cells are those nearly parallel to its long axis. Thus, the image seen by the whole eye is



made up of many spots of light, each contributed by one ommatidium. This is known as a mosaic or apposition image. Compound eyes are specially adapted to perceive movements of objects.

**2. Ocelli.** At the base of each antenna is a fenestra which represents a simple eye or ocellus. Each comprises of a single corneal facet. It is mainly concerned with light-collecting rather than image-forming. Probably it enhances the sensitivity of compound eyes.

### **[II] Sensillae**

Sense organs, other than eyes and ocelli, are

scattered all over the body, but are especially numerous on antennae, mouth parts, legs and wings. These sense organs or receptors are called sensillae (Sing, sensillum) Which are isolated or collective modifications of epidermal cells. A simple sensillum comprises a sensory cell connected with the fibre of a sensory nerve. Sensillae take different forms and perform various functions.

**1. Thigmoreceptors.** These are tactile hair sensitive to touch which are present on body surface, antennae, bristles of legs and maxillary palps. They help in searching food.

**2. Chemoreceptors.** These are organs of taste and smell, mainly confined to the tips of maxillary palps, labial palps, labium and hypopharynx.

**3. Auditory receptors.** Hair sensillae present on anal cerci respond to the air or earth-borne sound vibrations.

**4. Proprioceptors.** Campaniform sensillae, present on the joints of maxillary palps and legs, perceive strains set up in the cuticle during feeding and movement.

## **REPRODUCTIVE SYSTEM**

Cockroach is dioecious, i.e., the sexes are separate. Sexual dimorphism is evident in the internal reproductive organs as well as external morphology.

### **[I] Male Reproductive System**

#### **[Cockroach: Male reproductive system \(YOUTUBE\)](#)**

Male reproductive organs include testes, vasa deferentia, ejaculatory duct, mushroom gland, seminal vesicles, phallic gland, genital pouch and external genitalia, all located in abdomen.

**1. Testes.** Male gonads are a pair of testes, lying embedded in fat body, one on either dorso- lateral side of 4th to 6th abdominal segments. Each testis is three-lobed and consists of numerous (30-40) small whitish transparent follicles arranged in a longitudinal series around a narrow, delicate vas deferens, into which they discharge their products (sperms) In adult cockroach testes become non-functional and greatly reduced in size.

**2. Vasa deferentia.** The paired vasa deferentia, one from each testis, run posteriorly and downwards to open into the ejaculatory duct.

**3. Ejaculatory duct.** It is a single, median and muscular duct that extends posteriorly and opens into the genital pouch through the male genital pore, lying immediately below anus and between 9th and 10th sterna. The glandular wall of ejaculatory duct secretes the middle layer of spermatophore.

**4. Mushroom gland.** The junction of two vasa deferentia and ejaculatory duct is surrounded by an elaborate mushroom gland consisting of numerous compact, finger like blind tubules arranged in two distinct groups, and opening into the anterior part of ejaculatory duct.

**(a) Utriculi majores.** These are long, slender and peripheral tubules. Their secretion forms the inner layer of spermatophore.

**(b) Utriculi breviores.** These are short tubules forming the bulk of mushroom gland. Their secretion nourishes the sperms.

**5. Seminal vesicles.** Present on the ventral surface of anterior part of ejaculatory duct are two groups of numerous small glistening white sacs constituting the seminal vesicles meant for storage of sperms. Seminal vesicles can be distinguished from utriculi breviores of mushroom gland by their slightly larger size and more opaque whiteness.

**6. Phallic or conglobate gland.** It is a large, beaded multilobed, leaf-like or club-shaped gland present ovariole below the ejaculatory duct and reaching anteriorly up to 5th abdominal segment. Its narrow duct ovariole opens into the genital pouch by the side of male genital pore. Phallic gland secretes the outer layer formation of spermatophore.

The mushroom and phallic glands form apical en accessory reproductive glands.

**7. Genital pouch.** Genital pouch or chamber of male cockroach lies at the hind end of abdomen bounded dorsally by 9th and 10th terga and ventrally by 9th sternum. It contains the dorsal anus, ventral male genital pore and gonapophyses.

**8. External genitalia or gonapophyses.** In attached to the genital pouch, surrounding the male genital pore, are present the phallic organs or gonapophyses which help in copulation. These consist of 3 small irregular chitinous plates (right, left and ventral) known as phallomeres.

**(a) Right phallomere.** It consists of two horizontal opposing plates, a sickle-shaped hook and a serrated lobe terminating in two prongs.

**(b) Left phallomere.** It is made of a broad base from which arise 4 lobes of sclerites. Outer most is the short pseudopenis with a broad hammer-like head. To its left is a long, slender titillator with a curved hook.

Inner most is the acutobolus with a large curved hook. Outer to this is the serrated asperate. Opening of phallic gland lies between acutobolus and asperate lobes.

(c) **Ventral phallomere.** It is simple, broad, and brown plate without lobes and lying beneath the right phallomere. Opening of ejaculatory duct lies at its base in an intromittent muscular region, called phallus or edeagus.

## [II] Female Reproductive System

### [Cockroach: reproductive system - female \(YOUTUBE\)](#)

Female reproductive organs include ovaries, oviducts and vagina, spermatheca, collateral gland, genital pouch and external genitalia, all confined to abdomen.

**1. Ovaries.** A pair of yellow-coloured ovaries lie in 2nd to 6th abdominal segments, one on either side of hindgut, and embedded in fat bodies. Each ovary consists of 8 elongated, tapering and beaded blind tubes called ovarian tubules or ovarioles. Each ovariole contains a linear series of ova in various stages of development. Each ovariole consists of anterior region or germarium, containing immature ova in early stages of egg-formation, and a posterior region of vitellarium containing maturing eggs. The anterior tapering apical ends or terminal filaments of the ovarioles of each ovary unite to form a single thread or suspensory ligament which is lost in the fat body.

**2. Oviducts and vagina.** Posteriorly, all the ovarioles of an ovary unite to form a short and wide lateral oviduct. The two lateral oviducts in their turn unite in 7th segment to form a very short median common oviduct. Its posterior wider part is called vagina which is formed as an invagination of body wall. It opens into a large genital pouch by a vertical slit-like vulva or female genital pore on the 8th sternum.

**3. Spermatheca.** A spermatheca or receptaculum seminis, consisting of a left sac-like and a right filamentous caecum, opens by a median aperture in the dorsal wall of genital pouch on 9th sternum, at the tip of a small spermathecal papilla. In a fertile female, spermatheca is found filled with spermatozoa, received during copulation, from the male.

**4. Collateral gland.** A pair of much branched accessory or collateral glands lies behind and above the ovaries. Left gland is opaque and more developed, while the right one is transparent and less developed. The two open into the genital pouch through two separate openings, lying close together, a little behind and above the spermathecal opening. Secretion of two collateral glands forms the hard egg-case or ootheca around groups of eggs.

**5. Genital pouch.** It is located at the hind end of abdomen. 7th sternum is large, boat-shaped and split behind into two apical lobes or gynovalvular plates. These plates form the lateral, ventral and posterior limits of genital pouch, whose anterior and dorsal limits are formed respectively by the 8th and 9th sterna. Genital pouch can be divided into two parts. Smaller anterior part containing female gonopore and pores of spermatheca and collateral glands is termed genital atrium. While its larger posterior part in which ootheca is formed is called vestibulum.

**6. External genitalia.** A sclerite around female genital pore is called valvular plate. Besides, three pairs of plate-like chitinous gonapophyses are present between the female genital pore and anus. Of these one pair arises laterally from 8th sternum (I basivalvulae), while the other two pairs (valvifers and II basivalvulae) from 9th sternum. These form the three pairs of ovipositor valves. These assist in copulation, in laying eggs and in the formation of ootheca. A median sclerite of 8th sternum forms a spermathecal papilla on which opens the spermathecal pore.

## **LIFE HISTORY**

### **[I] Copulation**

Sexually mature male and female cockroaches generally mate during night from March to September. During copulation, the male transfers its spermatozoa in the form of packets, called spermatophores, directly into the female genital pouch. According to Roth and Willis (1952), the mature female cockroach emits a specific odorous volatile chemical, a pheromone or sex attractant, which is detected by the antennal chaemoreceptors of male. In response, the sexually excited male raises its tegmina (fore wings) by 45° to 90° and rapidly flutters its hindwings. In mating, first the male gets under female, extends his left hooked phallomere to insert into female genital chamber, clasping a small sclerite in front of ovipositor and then moves from beneath her. Both now gain an end-to-end position. The process of copulation lasts an hour or more after which the male and female separate.

### **[II] Spermatophore Formation and Insemination**

Spermatozoa produced by testes get stored in seminal vesicles of male. At the time of copulation these pass into the ejaculatory duct where they immediately get mixed with a nourishing fluid secreted by utriculi breviares. At the same time utriculi majores pours its secretion that hardens to form the inner layer of spermatophore. As this one-layered spermatophore passes backwards, glandular wall of ejaculatory duct secretes around it another (middle) layer. During copulation, the two-layered spermatophore is deposited into the female genital pouch on the spermathecal papilla. Here the secretion of phallic or conglobate gland forms its third (outer) layer.

Fully formed spermatophore is a three-layered, tough and pear-shaped capsule about 1.5 mm long. Its central chamber contains spermatozoa in a spermatic fluid. Its capsule has a simple opening that comes in close contact with the female spermathecal opening. Within 24 hours, sperms enter the spermatheca where they remain stored until required, while empty spermatophore drops down.

### **[III] Ootheca Formation and Fertilization**

Ripe eggs are elongate oval. 16 eggs, one from each ovariole usually descend together through vulva into vestibulum of genital pouch. As they are laid they become fertilized by sperms ejected simultaneously from spermatheca. A sperm enters through a minute pore, called micropyle, of egg shell and fertilizes the egg inside. Fertilized eggs become surrounded by the secretion of collateral glands, which hardens to form an egg case or ootheca. 16 eggs are arranged in two rows in one ootheca, assisted by ovipositor valves, very much like cigarettes packed in a cigarette case. Complete formation of an ootheca requires about two days during which it is protruding behind from her abdomen. A total of about 15 oothecae are laid by the female cockroach.

An ootheca is about 8 mm long. It is shaped like an oblong bag fringed with a dorsal serrated keel and each lateral wall raised into 8 elongated areas due to 16 enclosed eggs. An ootheca is moulded into its characteristic shape by the action of ovipositor valves and the inner configuration of walls of genital pouch. Colour of ootheca is first white, but later turns to pink or chocolate brown. Ootheca contains no chitin, but protein hardened by quinone, both secreted by collateral glands.

#### **[IV] Laying of Ootheca**

The female cockroach carries the ootheca, protruding from tip of her abdomen, for several days, till it is deposited in a warm, sheltered, and dark place.

#### **[V] Embryonic Development**

Fertilized eggs are slightly curved, concave on one side and convex on the other. Each contains a diploid nucleus and sufficient yolk, providing enough food for embryonic development. Each egg undergoes superficial cleavage characteristic of insects, resulting in a blastula followed by a gastrula. Gastrula is differentiated into embryo which gets separated from blastoderm by an amniotic cavity. Its three germ layers (ectoderm, mesoderm and endoderm) form the various parts of the nymph.

#### **[VI] Hatching**

When hatching occurs, the dorsal keel of ootheca splits and the young cockroaches or nymphs emerge out leaving their egg membranes behind. Freshly-hatched nymphs are delicate, transparent and almost colourless creatures with black eyes. They possess nearly all adult characters but differ in size and colouration, in being sexually immature and lacking wings.

#### **[VII] Metamorphosis**

Immediately after hatching, the nymphs undergo first moulting or ecdysis and then 6 or 7 successive moults follow. As nymphal development proceeds, the wing pads arise, body increases in size, colouration becomes darker and ultimately the adult takes its form with fully developed wings and genitalia. Thus development of cockroach is simple and direct and includes incomplete or gradual metamorphosis which is known as paurometaboly.

## IMPORTANT QUESTIONS

### ►► Long answer type questions

1. Describe the mouth parts of cockroach and add a note on its feeding mechanism
2. Give an account of the digestive system of *Periplaneta americana*
3. Describe the respiratory organs and mechanism of respiration of the cockroach.
4. Describe the reproductive organs of any cockroach studied by you.
5. Give an account of the life history of common cockroach.
6. Write short notes on: i) Malpighias tubules, (ii) Nymph, (iii) Ootheca, (iv) Salivary apparatus, (v) Spermatophore.

### ►► Short answer type questions

1. What is the name of the rings that strengthen the trachea?
2. How do the cockroach feed?
3. Describe the compound eye of *Periplaneta* and clearly mention its adaptation for bright and dim-light
4. Draw neatly labelled diagrams of the T.S. through the abdomen of cockroach
5. Draw male and female reproductive organs of cockroach. Label them How is ootheca formed in it?
6. Cockroach and scorpion are both terrestrial forms. Why should then cockroach have a tracheal system which supplies oxygen directly to the tissues for respiration and scorpion have book lungs functioning differently. Answer within 30 words
7. Compare the organs of respiration in cockroach and scorpion.
8. Distinguish between a trachea and tracheole.

9. Write the names of external genitalia or gonapophyses of male cockroach and give the function of each.

►► **Fill in the blanks**

1. The type of image that falls on ommatidia is called .....
2. Spiracles are also called as.....
3. Hard cuticle prevents evaporation of water; loss of water takes place through.....
4. Body cavity of cockroach is called as.....
5. Heart of cockroach has ..... funnel-shaped chambers.
6. Uricose glands of male cockroach is an ..... organ and stores .....
7. Metamorphosis in cockroach is of ..... type.

►► **Multiple choice questions**

1. Generic name of cockroach *Periplaneta* was assigned by:

- (a) Linnaeus (1758) (b) De Beer (1973)  
(c) Burmerister (1838) (d) Bentham (1664)

2. The function of spermatheca in *Periplaneta* is:

- (a) to help in copulation  
(b) to store eggs  
(c) to secrete musky fluid  
(d) to store sperms

3. Egg case of cockroach is known as:

- (a) embryophore  
(b) ootheca

(c) gonophore

(d) female gamete

4. Periplaneta belongs to the phylum:

(a) Annelida

(b) Platyhelminthes

(c) Molluscs

(d) Arthropoda

(e) Onychophora

5. Male and female cockroach can be identified by

(a) anal cerci

(b) anal styles

(c) antennae

(d) compound eyes

6. Anal styles are found in:

(a) male cockroach (b) housefly

(c) male mosquito (d) female cockroach

7. The skeleton of cockroach is formed of

(a) chitin

(b) cuticle

(c) cartilage

(d) amino acid

8. Vision of cockroach is:



- (a) monocular
- (b) binocular
- (c) mosaic
- (d) all

9. The part of head of cockroach between and behind the eyes is:

- (a) gena
- (b) ocellus
- (c) clypeus
- (d) epicranium

10. Dorsal surface of an abdominal segment of cockroach is:

- (a) sternum
- (b) pleuron
- (c) tergum
- (d) none of these

11. The out border of tergum in cockroach bends downwards to attach with :

- (a) pleuron
- (b) sternum
- (c) mesenteries
- (d) muscles

12. The number of thoracic segments in cockroach are:

- (a) 2
- (b) 4

(c) 3

(d) 5

13. The two pairs of wings in cockroach are situated in the segments:

(a) prothorax and mesothorax

(b) prothorax and metathorax

(c) mesothorax and metathorax

(d) none of these

14. The chambers in the heart of cockroach are:

(a) 13

(b) 9

(c) 12

(d) 15

15. The egg of cockroach is:

(a) Isolecithal

(b) Telolecithal

(c) Microlecithal

(d) Centrolecithal

16. Conglobate glands are found in the reproductive organs

(a) male cockroach

(b) female cockroach

(c) frog

(d) earthworm

17. The respiratory passage in cockroach during inspiration:

- (a) spiracle trachea
- (b) longitudinal respiratory tube
- (c) air chamber
- (d) trachea

18. Palpiger is a portion of:

- (a) labrum
- (b) labium
- (c) maxilla
- (d) mandible

19. Lacunar type of circulatory system is present in:

- (a) *Periplaneta americana* (b) *Blatta orientalis*
- (c) *Blatella germanica* (d) All of the above

20. Corpora cardiaca are:

- (a) an endocrine organ in insects
- (b) another name of salivary gland of bugs
- (c) a part of nervous system of insects
- (d) excretory organ of a insect

21. Function of the colleterial gland in cockroach is to:

- (a) store sperms
- (b) secrete the egg-case
- (c) keep vagina moist

(d) store eggs

22. The respiratory pigments in cockroach is absent. Hence in cockroach:

(a) O<sub>2</sub> diffuses directly in the tissues

(b) colleterial respiration takes place

(c) respiration occurs by book lungs

(d) none of the above

23. Ootheca of cockroach is secreted by:

(a) mushroom glands

(b) conglobate glands

(c) collateral glands

(d) genital pouch of female

24. The excretory waste of cockroach and other insect is:

(a) ammonia

(b) uric acid

(c) urea

(d) guanine

25. Malpighian tubules in cockroach are used for:

(a) respiration

(b) excretion

(c) reproduction

(d) digestion

26. The body cavity of cockroach is:

- (a) coelom
- (b) pseudocoel
- (c) haemocoel
- (d) coelenteron

27. The Nymph grows into a cockroach by:

- (a) incomplete metamorphosis
- (b) complete metamorphosis
- (c) no metamorphosis
- (d) two of the foregoing

28. The male cockroach can be distinguished from the female in having:

- (a) anal cerci (b) anal styles (c) large antenna (d) large wings

29. The chitinous structures found around the genital aperture of cockroach are:

- (a) gonapophyses (b) odontoid processes
- (c) anal cerci (d) sternum

30. The salivary gland of cockroach secretes:

- (a) ptyalin
- (b) amylase
- (c) trypsin
- (d) pepsin

31. How many teeth are present in the gizzard of cockroach?

- (a) 6 (b) 4 (c) 3 (d) none

32. Number of segments in leg of cockroach is:

(a) 3 (d) 9 (b) 5 (c) 6

33. In cockroach, the outer border of a tergum turns downwards to become attached with:

(a) sternum. (c) muscles

(b) pleuron (d) mesenteries

34. Class of cockroach is:

(b) Arachnida

(a) Insecta

(c) Gastropoda

(d) Arthropoda

35. One common feature in the trachea of cockroach and the trachea of rabbit is that:

(a) their inner lining is ciliated

(b) their walls are strengthened by hard structures

(c) both start in the head region

(d) both are paired

36. Mouth parts of cockroach are:

(a) cutting and chewing

(b) sucking

(c) piercing

(d) all these

37. Wings are vestigial in:

(a) female Periplaneta

(b) male Periplaneta

(c) Blatta

(d) Housefly

38. Plantulae are found in:

(a) parapodia of Nereis (b) maxilla of cockroach (c) leg of cockroach (d) proboscis of housefly

39. Alary muscles are present in connection with:

(a) wing of cockroach (b) ovary of cockroach (c) heart of cockroach (d) tracheae of cockroach

40. Phallic glands in cockroach:

(a) secrete ootheca

(b) secrete outer covering of spermatophore

(c) store excretory products

(d) secrete ecdysone

41. Common salivary duct of cockroach opens at base of:

(a) hypopharynx (b) mandibles

(c) second maxillae (d) labrum

42. Egg of cockroach is:

(a) centrolecithal (b) telolecithal

(c) microlecithal (d) megalecithal

43. The two sexes are externally demarcated in:

(a) earthworm (c) Amoeba

(b) cockroach (d) Hydra

44. Fixed number of body segments are found in:

- (a) cockroach
- (b) earthworm
- (c) Taenia
- (d) none of these

45. Number of segments that constitute thorax of cockroach is:

- (a) 6 (b) 3 (c) 8 (d) 2

46. The broadest segment in the leg of cockroach is:

- (a) femur
- (c) trochanter
- (b) coxa
- (d) tibia

47. Each ovary of cockroach is made of ovarioles, number is:

- (a) 4 (b) 30 (c) 8 (d) 16

48. Mandibles of cockroach are:

- (a) long (b) short with teeth
- (c) short without teeth (d) syringe like

49. Colleterial glands of cockroach are to help:

- (a) secretion of ootheca
- (b) secretion of genital chamber
- (c) oviposition
- (d) fertilization



50. The common feature among cockroach, scorpion and centipede:

- (a) compound eyes
- (b) thorax
- (c) tracheae
- (d) jointed legs

51. The common feature between a cockroach and earthworm

- (a) nephridia
- (b) moulting
- (c) larva
- (d) ventral nerve

52. Number of paired spiracles in cockroach are:

- (a) 3
- (b) 10
- (c) 6
- (d) 2

53. Dorsal plate in an abdominal segment of cockroach is termed:

- (a) tergum
- (b) pleurite
- (c) sternite
- (d) none of these

54. Outer part of a tergite bends downwards in cockroach and it is attached with:

- (a) sternite

(b) pleurite

(c) both

(d) none of this day time are called:

55. Animals active during

(a) nocturnal

(b) diurnal

(c) carnivorous

(d) herbivorous

56. Rhabdome is found in eyes of:

(a) mollusc

(b) frog

(c) man

(d) insects

57. Image chiefly formed by compound eyes of insects is:

(a) superposition

(b) apposition

(c) both

(d) monocular

58. Chief excretory wastes of insects is

(a) urea

(b) ammonia

(c) uric acid

(d) amino acids

59. The portion of head in between and behind the eyes. in cockroach is:

- (a) epicranium
- (b) gene
- (c) clypeus
- (d) frons

60. Vision in cockroach is called:

- (a) binocular
- (b) monocular
- (c) mosaic
- (d) stereoscopic

61. Wings of cockroach usually help the insect in:

- (a) escaping from enemies
- (b) oviposition
- (c) copulation
- (d) feeding

62. Both cockroach and housefly have:

- (a) two pairs of wings
- (b) compound eyes
- (c) liquid diet
- (d) pupa stage

63. Both male and female cockroach do not have:

- (a) anal styles

(b) anal cerci

(c) three segmented thoraxes

(d) biting mouth parts

64. Skeleton of cockroach and other insects is made of:

(a) spicule (c) coral

(b) fluid (d) chitin

65. Cockroach has chitinous teeth for grinding in its:

(a) gizzard

(b) mandible

(c) both

(d) pharynx

66. Salivary glands of cockroach secrete:

(a) amylase

(b) Chitinase

(c) Cellulase

(d) All of these

67. Alary muscles of cockroach are related with:

(a) nutrition

(b) circulation

(c) respiration

(d) all of these

68. Heart of cockroach is:

(a) multichambered (b) single (c) longitudinally beaded (d) all of these

69. Blood of cockroach has:

(a) haemoglobin

(b) no pigment

(c) R.B.C.

(d) oxygen

70. Malpighian tubules of cockroach are for:

(a) excretion

(b) osmoregulation

(c) both

(d) digestion

71. Ommatidium is:

(a) structural unit of compound eye

(b) visual unit

(c) both

(d) false

72. Ootheca of cockroach contains:

(a) one zygote

(b) 16 zygotes and is secreted by colleterial gland

(c) 16 zygotes

(d) a larva

73. Nymph grows into an adult cockroach by:

- (a) complete metamorphosis
- (b) incomplete metamorphosis
- (c) less than 7 moults
- (d) less than 12 moults

74. The tracheal system in *Periplaneta* communicates to the outside by:

- (a) 10 pairs of spiracles (b) 12 pairs of spiracles
- (c) 8 pairs of spiracles (d) 6 pairs of spiracles

75. The function of the phallic gland in *Periplaneta* is to secrete:

- (a) a secretion which helps the sperms in the spermatophore to stick together
- (b) the innermost layer of the wall of the spermatophore
- (c) the middle layer of the wall of the spermatophore
- (d) the outermost layer of the wall of the spermatophore

76. Which one of the following regions of the alimentary canal in *Periplaneta* is characterised by the presence of a peritrophic membrane?

- (a) Ileum
- (b) Mesenteron
- (c) Crop
- (d) Gizzard

77. The oxygen carrying pigment in the blood of cockroach is:

- (a) haemocyanin
- (b) haemoglobin
- (c) xanthophyll
- (d) not present at all

78. Number of ganglia located over ventral nerve cord of cockroach is:

- (a) 6 thoracic and 3 abdominal
- (b) 3 thoracic and 6 abdominal
- (c) I thoracic and I abdominal
- (d) I thoracic and 8 abdominal

79. Metamorphosis in cockroach is regulated by:

- (a) corpora allata (c) food
- (b) temperature (d) brain

80. Body is covered by:

- (a) cuticle
- (b) chitin
- (c) sclerites
- (d) suberin

81. Gloss and paraglossa are collectively called:

- (a) tergum
- (b) natum
- (c) lingula
- (d) pleura

82. Respiratory pigment in *Periplanata*:

- (a) haemoglobin
- (b) haemocynin
- (c) both

(d) none

83. Excretory system of cockroach:

(a) trophocytes (c) oenocytes

(b) mycetocytes (d) urate cell

(e) all the above

84. Juvenile hormone secreted by:

(a) corpora allata

(b) intracerebral gland

(c) prothoracic gland

(d) none the above

85. The period between two mould is:

(a) stadium

(b) incubation

(c) latent

(d) zero

86. Each ovary contain how many ovarioles:

(a) 4

(b) 6

(c) 8

(d) 10

87. Number of chromosomes in male:



(a) 33

(b) 34

(c) 32

(4) 30

88. The blood of cockroach contains no respiratory pigment. It means that:

(a) cockroach does not respire

(b) respiration is anaerobic

(c) oxygen goes into tissues by intracellular capillary system

(d) oxygen goes directly into tissues through tracheal system

89. Biggest phylum with reference to number of species

(a) Insecta

(b) Arthropoda

(c) Chordata

(d) Platyhelminthes

90. The type of antenna in cockroach is

(a) Aristotle

(b) Filiform

(c) Clubbed

(d) Plumose

## Answers

### ►► Fill in the blanks

1. Mosaic or apposition 2. Stigmata, 3. Spiracle valve, 4. Haemocoel, 5. 13, 6. Excretory organ/ uric acid.  
7. Incomplete type

### ►► Multiple choice questions

1. (c)

2. (d)

3. (b)

4. (d)

5. (b)

6. (a)

7. (a)

8. (c)

9. (a)

10. (c)

11. (b)

12. (c)

13. (c)

14. (a)

15. (c)

16. (a)

17. (a)

18. (b)

19. (d)

20. (a)

21. (b)

22. (a)

23. (c)

24. (b)

25. (b)

26. (c)

27. (a)

28. (b)

29. (a)

30. (b)

31. (a)

32. (d)

33. (a)

34. (a)

35. (b)

36. (a)

37. (a)

38. (c)

39. (c)

40. (b)

41. (a)

42. (a)

43. (b)

44. (a)

45. (b)

46. (b)

47. (c)

48. (b)

49. (a)

50. (d)

51. (d)

52. (b)

53. (a)

54. (a)

55. (b)

56. (d)

57. (b)

58. (c)

59. (d)

60. (c)

61. (a)

62. (b)

63. (a)

64. (d)

65. (a)

66. (a)

67. (b)

68. (a)

69. (b)

70. (a)

71. (b)

72. (b)

73. (b)

74. (a)

75. (d)

76. (b)

77. (8)

78. (b)

79. (a)

80. (c)

81 (c)

82 (d)

83. (e)

84. (a)

85. (a)

86. (c)

87. (a)

88. (d)

89. (b)

90. (b)