

1. Details of Module and its structure

Module Detail	
Subject Name	Biology
Course Name	Biology 01 (Class XI, Semester - 1)
Module Name/Title	Structural Organisation in Animals – Part 2
Module Id	kebo_10702
Pre-requisites	Basic knowledge about Structural Organisation in Animals
Objectives	After going through this lesson, the learners will be able to understand the following: <ul style="list-style-type: none">• Structural Organisation in Earthworm<ul style="list-style-type: none">◦ Morphology◦ Anatomy• Structural Organisation in Cockroach<ul style="list-style-type: none">◦ Morphology• Anatomy
Keywords	Morphology, Anatomy, Organisation in Cockroach

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1. Introduction

The basic tissues organise to form organs which in turn associate to form organ systems in the multicellular organisms. Such an organisation is essential for more efficient and better coordinated activities of millions of cells constituting an organism. Each organ in our body is made of one or more type of tissues. For example, our heart consists of all the four types of tissues, i.e., epithelial, connective, muscular and neural.

We also notice, after some careful study that the complexity in organ and organ systems displays certain discernable trend. This discernable trend is called evolutionary trend. You are being introduced to morphology and anatomy of three organisms at different evolutionary levels to show their organisation and functioning. Morphology refers to study of form or externally visible features. In the case of plants or microbes, the term morphology precisely means only this. In case of animals this refers to the external appearance of the organs or parts of the body. The word anatomy conventionally is used for the study of morphology of internal organs in the animals. You will learn the morphology and anatomy of earthworm, cockroach and frog representing invertebrates and vertebrates.

2. Structural Organisation in Earthworm

Earthworm is a reddish brown terrestrial invertebrate that inhabits the upper layer of the moist soil. During day time, they live in burrows made by boring and swallowing the soil. In the gardens, they can be traced by their faecal deposits known as worm castings. The common Indian earthworms are *Pheretima* and *Lumbricus*.

2.1. Morphology

Taxonomic level of Earth worm:

Kingdom: Animalia

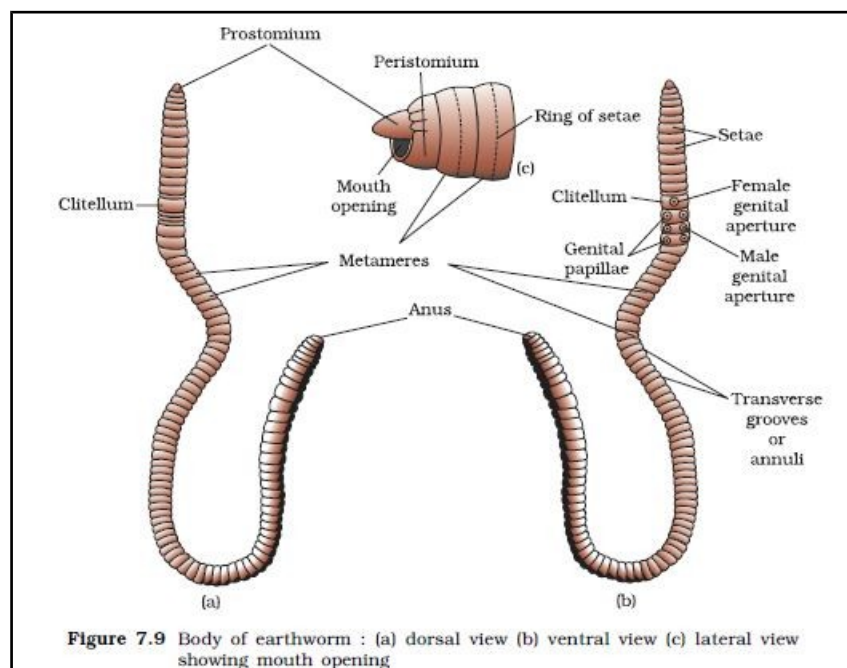
Phylum: Annelida

Class: Oligochaeta

Order: Megadrilacea

Earthworms have long cylindrical body. The body is divided into more than hundred short segments which are similar (metameres about 100-120 in number). The dorsal surface of the body is marked by a dark median mid dorsal line (dorsal blood vessel) along the longitudinal axis of the body. The ventral surface is distinguished by the presence of genital openings (pores). Anterior end consists of the mouth and the prostomium, a lobe which serves as a covering for the mouth and as a wedge to force open cracks in the soil into which the earthworm may crawl. The prostomium is sensory in function. The first body segment is called the peristomium (buccal segment) which contains the mouth. In a mature worm, segments 14-16 are covered by a prominent dark band of glandular tissue called **clitellum**. Thus the body is divisible into three prominent regions; preclitellar, clitellar and postclitellar segments (Figure 7.9).

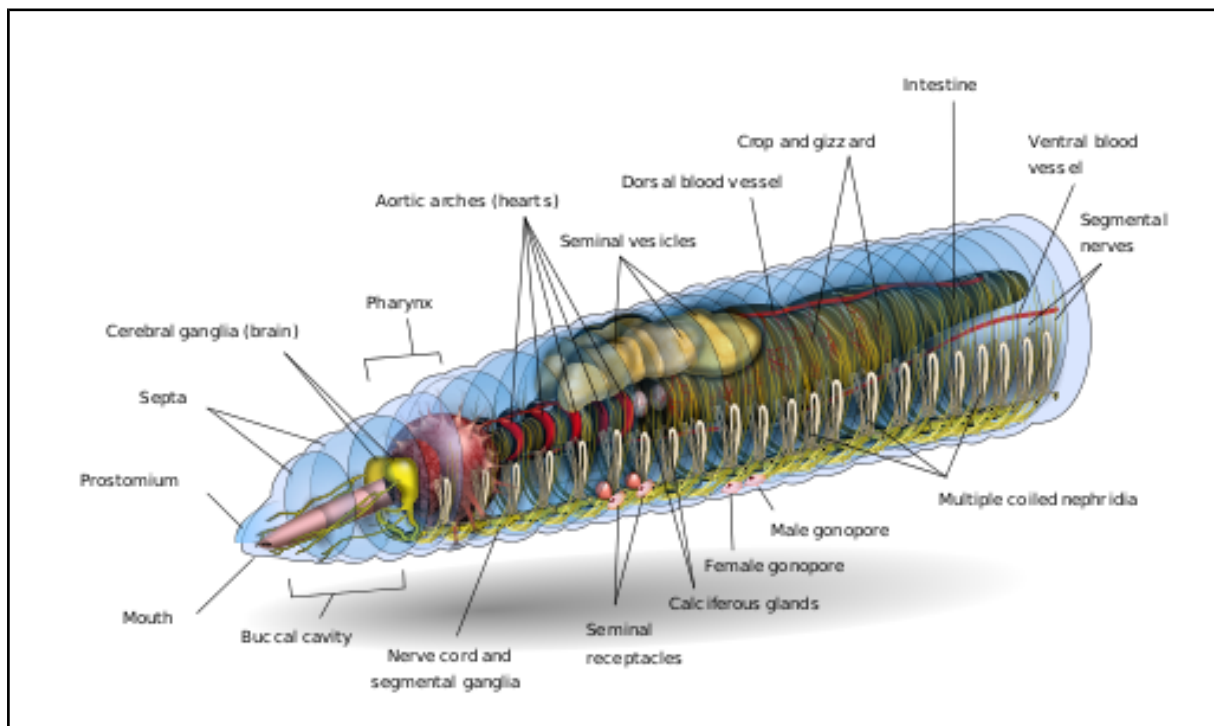
Four pairs of spermathecal apertures are situated on the ventro-lateral sides of the intersegmental grooves, i.e., 5th -9th segments. A single female genital pore is present in the mid-ventral line of 14th segment. A pair of male genital pores are present on the ventro-lateral sides



of the 18th segment. Numerous minute pores called nephridiopores open on the surface of the body. In each body segment, except the first, last and clitellum, there are rows of S-shaped **setae**, embedded in the epidermal pits in the middle of each segment. Setae can be extended or retracted. Their principal role is in locomotion.

2.2. Anatomy

The body wall of the earthworm is covered externally by a thin non-cellular cuticle below which is the epidermis, two muscle layers (circular and longitudinal) and an innermost coelomic epithelium. The epidermis is made up of a single layer of columnar epithelial cells which contain secretory gland cells. The alimentary canal is a straight tube and runs between first to last segment of the body. (Figure 7.10). A terminal mouth opens into the buccal cavity (1-3 segments) which leads into muscular pharynx. A small narrow tube, oesophagus (5-7 segments), continues into a muscular gizzard (8-9 segments). It helps in grinding the soil particles and decaying leaves, etc. The stomach extends from 9-14 segments.



https://upload.wikimedia.org/wikipedia/commons/8/8f/Earthworm_head.svg

The food of the earthworm is decaying leaves and organic matter mixed with soil. Calciferous glands, present in the stomach, neutralise the humic acid present in humus. Intestine starts from the 15th segment onwards and continues till the last segment. A pair of short and conical intestinal caecae project from the intestine on the 26th segment. The characteristic feature of the intestine between 26-35 segments is the presence of internal median fold of dorsal wall called **typhlosole**. This increases the effective area of absorption in the intestine. The alimentary canal opens to the exterior by a small rounded aperture called anus. The ingested organic rich soil passes through the digestive tract where digestive enzymes breakdown complex food into smaller absorbable units.

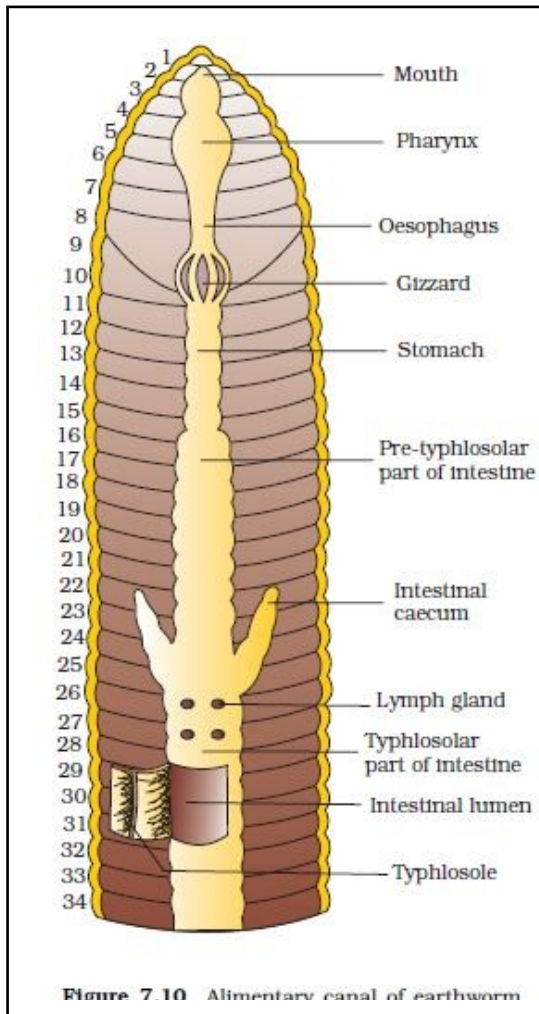


Figure 7.10 Alimentary canal of earthworm

These simpler molecules are absorbed through intestinal membranes and are utilised. *Pheretima* exhibits a closed type of blood vascular system, consisting of blood vessels, capillaries and heart. (Figure 7.11). Due to closed circulatory system, blood is confined to the heart and blood vessels. Contractions keep blood circulating in one direction.

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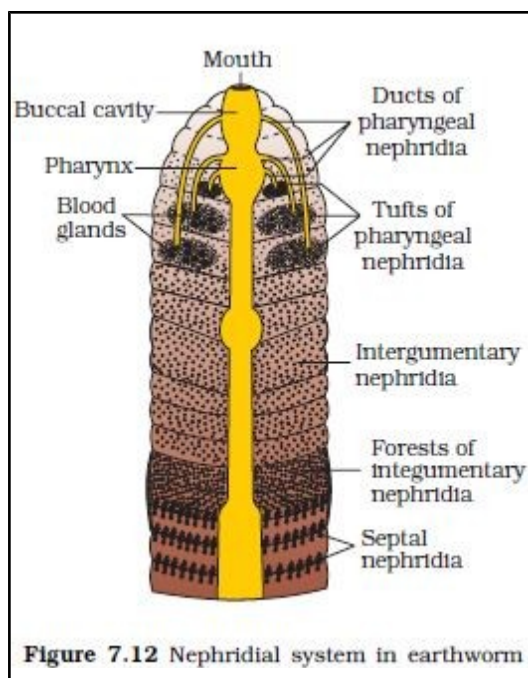
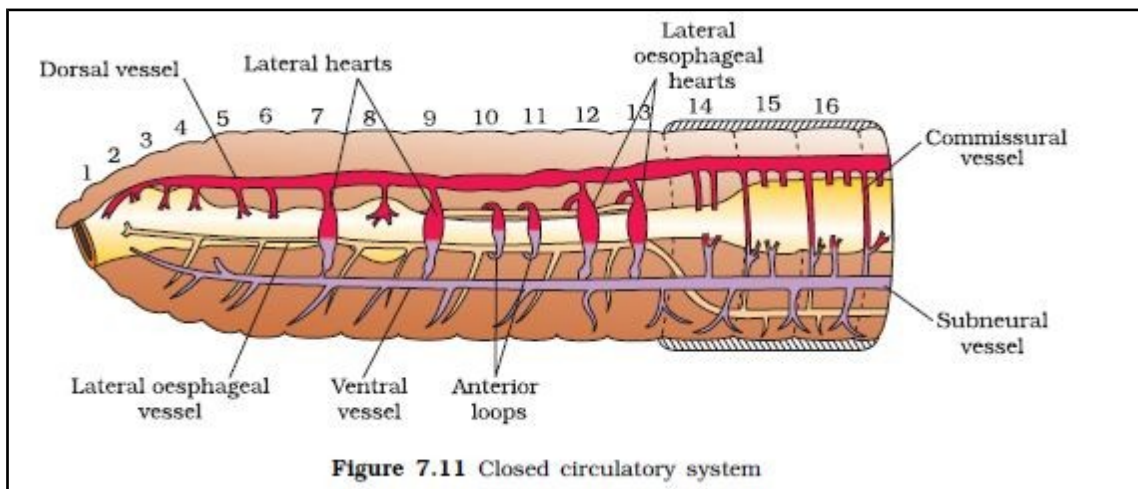


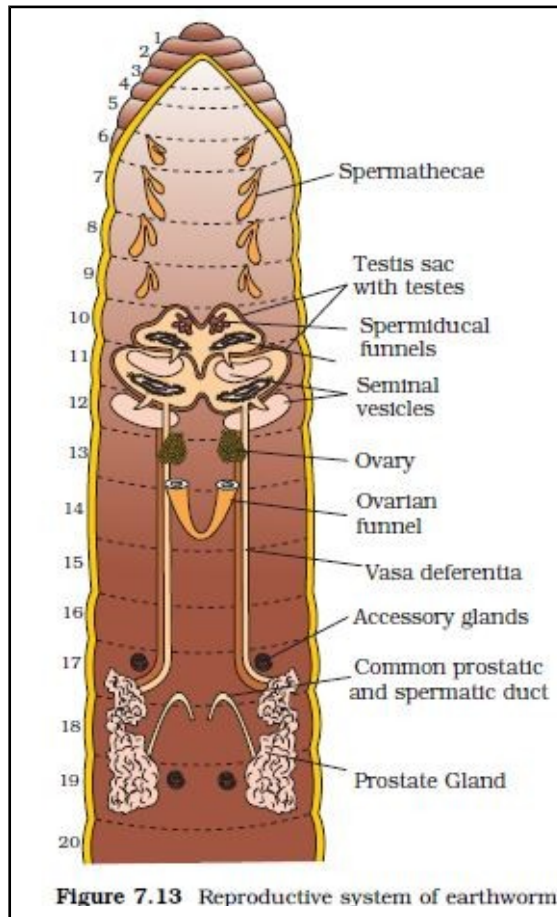
Figure 7.12 Nephridial system in earthworm

Smaller blood vessels supply the gut, nerve cord, and the body wall. Blood glands are present on the 4th, 5th and 6th segments. They produce blood cells and haemoglobin which is dissolved in blood plasma. Blood cells are phagocytic in nature. Earthworms lack specialised breathing devices. Respiratory exchange occurs through moist body surface into their blood stream.



The excretory organs occur as segmentally arranged coiled tubules called nephridia (sing.: *nephridium*). They are of three types: (i) septal nephridia, present on both the sides of intersegmental septa of segment 15 to the last that open into intestine, (ii) integumentary nephridia, attached to lining of the body wall of segment 3 to the last that open on the body surface and (iii) pharyngeal nephridia, present as three paired tufts in the 4th, 5th and 6th segments (Figure 7.12). These different types of nephridia are basically similar in structure. Nephridia regulate the volume and composition of the body fluids. A nephridium starts out as a funnel that collects excess fluid from coelomic chamber. The funnel connects with a tubular part of the nephridium which delivers the wastes through a pore to the surface in the body wall into the digestive tube.

Nervous system is basically represented by ganglia arranged segment wise on the ventral paired nerve cord. The nerve cord in the anterior region (3rd and 4th segments) bifurcates, laterally encircling the pharynx and joins the cerebral ganglia dorsally to form a nerve ring. The cerebral ganglia alongwith other nerves in the ring integrate sensory input as well as command muscular responses of the body.



Sensory system does not have eyes but does possess light and touch sensitive organs (receptor cells) to distinguish the light intensities and to feel the vibrations in the ground. Worms have specialised chemoreceptors (taste receptors) which react to chemical stimuli. These sense organs are located on the anterior part of the worm.

Earthworm is hermaphrodite (bisexual), i.e., testes and ovaries are present in the same individual (Figure 7.13). There are two pairs of testes present in the 10th and 11th segments. Their vasa deferentia run up to the 18th segment where they join the prostatic duct. Two pairs of accessory glands are present one pair each in the 17th and 19th segments. The common prostatic and spermatic duct (*vasa deferentia*) opens to the

exterior by a pair of male genital pores on the ventro-lateral side of the 18th segment. Four pairs of spermathecae are located in 6th-9th segments (one pair in each segment). They receive and store spermatozoa during copulation. One pair of ovaries is attached at the inter-segmental septum of the 12th and 13th segments. Ovarian funnels are present beneath the ovaries which continue into oviduct, join together and open on the ventral side as a single median female genital pore on the 14th segment.

A mutual exchange of sperm occurs between two worms during mating. One worm has to find another worm and they mate juxtaposing opposite gonadal openings exchanging packets of sperms called spermatophores. Mature sperm and egg cells and nutritive fluid are deposited in cocoons produced by the gland cells of clitellum.

Fertilisation and development occur within the cocoons which are deposited in soil. The ova (eggs) are fertilised by the sperm cells within the cocoon which then slips off the worm and is deposited in or on the soil. The cocoon holds the worm embryos. After about 3 weeks, each cocoon produces two to twenty baby worms with an average of four. Earthworms development is direct, i.e., there is no larva formed.

Earthworms are known as 'friends of farmers' because they make burrows in the soil and make it porous which helps in respiration and penetration of the developing plant roots. The

process of increasing fertility of soil by the earthworms is called vermicomposting. They are also used as bait in game fishing.

3. Structural Organisation in Cockroach

Taxonomic level:

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Blattodea

Cockroaches are brown or black bodied animals that are included in class Insecta of Phylum Arthropoda. Bright yellow, red and green coloured cockroaches have also been reported in tropical regions. Their size ranges from 0.5 inches to 3 inches (0.6-7.6 cm) and have long antenna, legs and flat extension of the upper body wall that conceals head. They are nocturnal omnivores that live in damp places throughout the world. They have become residents of human homes and thus are serious pests and vectors of several diseases.

3.1. Morphology

The adults of the common species of cockroach, *Periplaneta Americana* are about 34-53 mm long with wings that extend beyond the tip of the abdomen in males. The body of the cockroach is segmented and divisible into three distinct regions – head, thorax and abdomen (Figure 7.14).

The entire body is covered by a hard chitinous

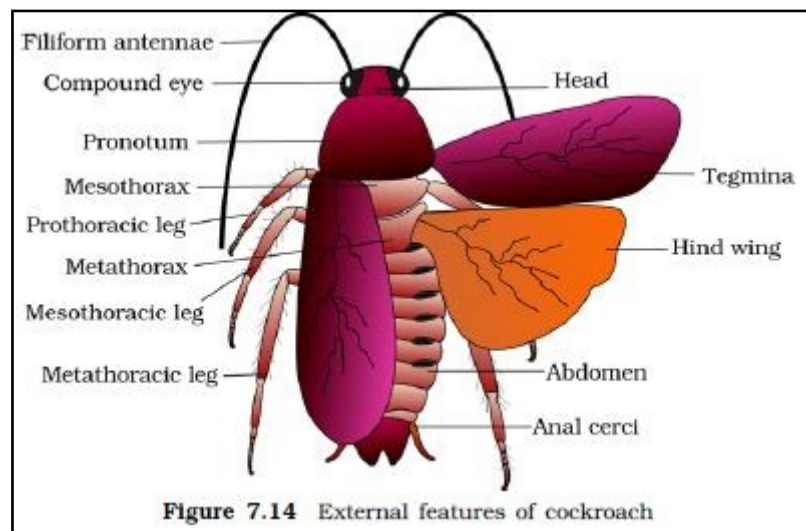


Figure 7.14 External features of cockroach

exoskeleton (brown in colour). In each segment, exoskeleton has hardened plates called sclerites (tergites dorsally and sternites ventrally) that are joined to each other by a thin and flexible articular membrane (arthrodial membrane).

Head is triangular in shape and lies anteriorly at right angles to the longitudinal body axis. It is formed by the fusion of six segments and shows great mobility in all directions due to flexible neck (Figure 7.15).

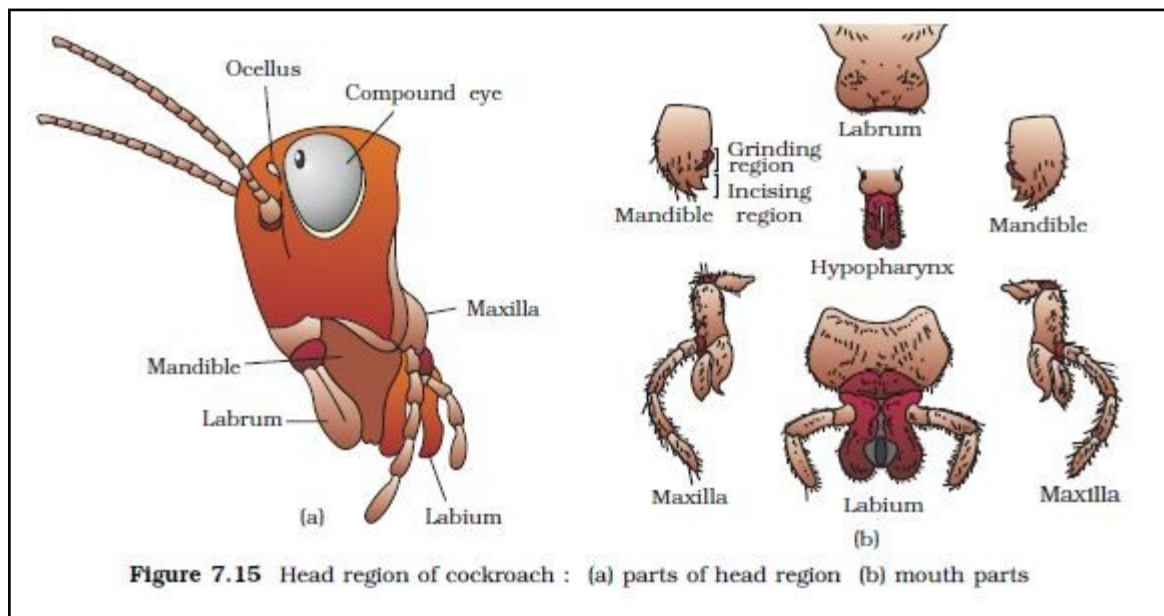


Figure 7.15 Head region of cockroach : (a) parts of head region (b) mouth parts

The head capsule bears a pair of compound eyes. A pair of thread like antennae arise from membranous sockets lying in front of eyes. Antennae have sensory receptors that help in monitoring the environment. Anterior end of the head bears appendages forming biting and chewing type of mouth parts. The mouthparts consisting of a labrum (upper lip), a pair of mandibles, a pair of maxillae and a labium (lower lip). A median flexible lobe, acting as tongue (hypopharynx), lies within the cavity enclosed by the mouthparts (Figure 7.15b). Thorax consists of three parts ñ prothorax, mesothorax and metathorax. The head is connected with thorax by a short extension of the prothorax known as the neck. Each thoracic segment bears a pair of walking legs. The first pair of wings arises from mesothorax and the second pair from metathorax. Forewings (mesothoracic) called tegmina are opaque dark and leathery and cover the hind wings when at rest. The hind wings are transparent, membranous and are used in flight.

The abdomen in both males and females consists of 10 segments. In females, the 7th sternum is boat shaped and together with the 8th and 9th sterna forms a brood or genital pouch whose anterior part contains female gonopore, spermathecal pores and collateral glands. In males, genital pouch or chamber lies at the hind end of abdomen bounded dorsally by 9th and 10th terga and ventrally by the 9th sternum. It contains dorsal anus, ventral male genital pore and gonapophysis. Males bear a pair of short, threadlike anal styles which are absent in females. In both sexes, the 10th segment bears a pair of jointed filamentous structures called anal cerci.

3.2. Anatomy

The alimentary canal present in the body cavity is divided into three regions: foregut, midgut and hindgut (Figure 7.16). The mouth opens into a short tubular pharynx, leading to a narrow tubular passage called oesophagus.

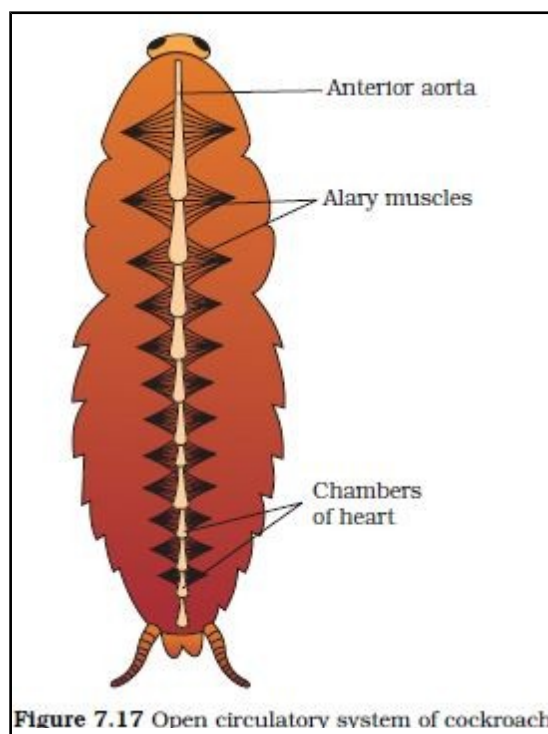
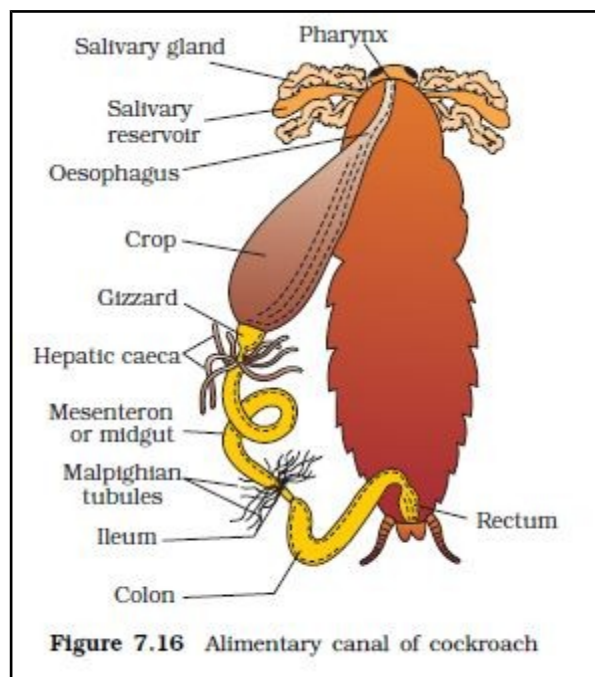
This in turn opens into a sac like structure called crop used for storing of food. The crop is followed by gizzard or proventriculus. It has an outer layer of thick circular muscles and thick inner cuticle forming six highly chitinous plate called teeth. Gizzard helps in grinding the food particles. The entire foregut is lined by cuticle. A

ring of 6-8 blind tubules called hepatic or gastric caecae is present at the junction of foregut and midgut, which secrete digestive juice. At the junction of midgut and hindgut is present another ring of 100-150 yellow coloured thin filamentous **Malpighian tubules**. They help in removal of excretory products from haemolymph. The hindgut is broader than midgut and is differentiated into ileum, colon and rectum. The rectum opens out through anus.

Blood vascular system of cockroach is an open type (Figure 7.17). Blood vessels are poorly developed and open into space (haemocoel). Visceral organs located in the haemocoel are bathed in blood (haemolymph). The haemolymph is composed of colourless plasma and haemocytes. Heart of cockroach consists of elongated muscular tube lying along mid dorsal line of thorax and abdomen.

It is differentiated into funnel shaped chambers with ostia on either side. Blood from sinuses enter heart through ostia and is pumped anteriorly to sinuses again.

The respiratory system consists of a network of trachea, that open through 10 pairs of small holes called spiracles present on the lateral side of the body. Thin branching tubes (tracheal tubes subdivided into tracheoles) carry oxygen from the air to all the parts. The opening of

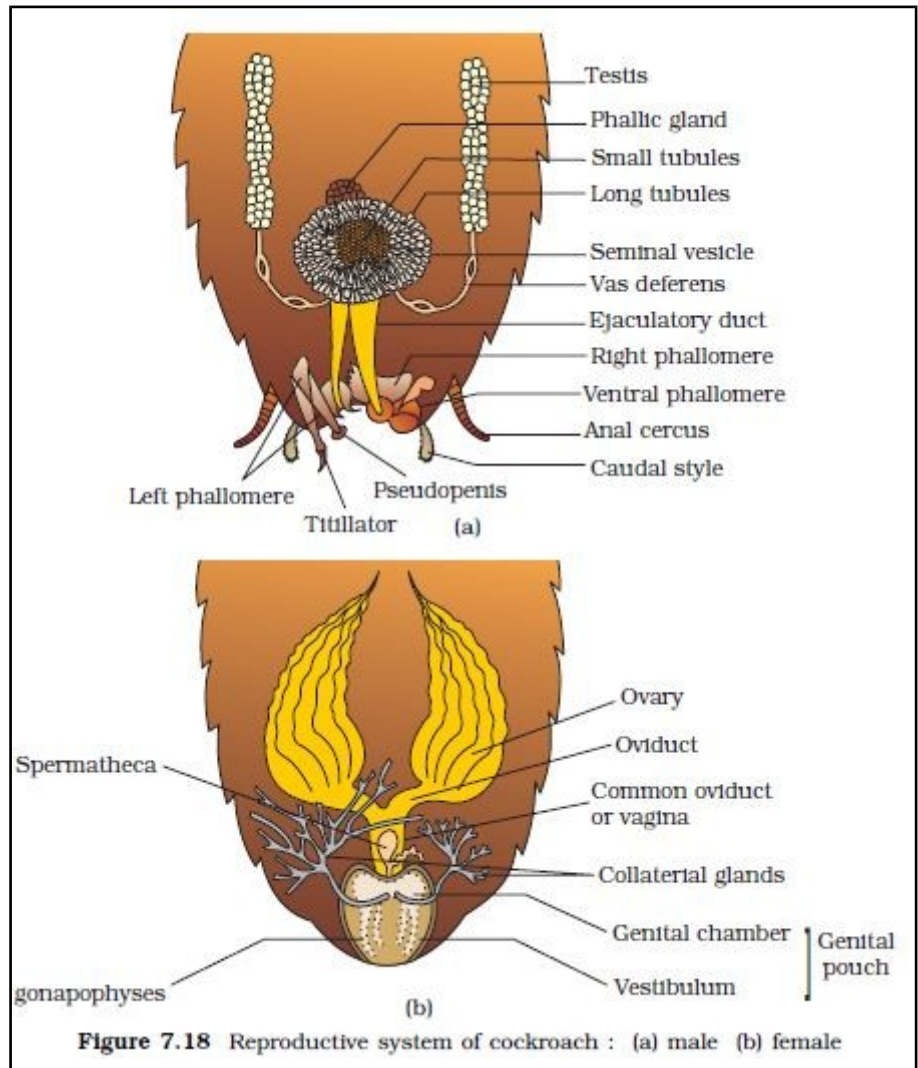


the spiracles is regulated by the sphincters. Exchange of gases take place at the tracheoles by diffusion.

Excretion is performed by Malpighian tubules. Each tubule is lined by glandular and ciliated cells. They absorb nitrogenous waste products and convert them into uric acid which is excreted out through the hindgut. Therefore, this insect is called **uricotelic**. In addition, the fat body, nephrocytes and urecose glands also help in excretion. The nervous system of cockroach consists of a series of fused, segmentally arranged ganglia joined by paired longitudinal connectives on the ventral side. Three ganglia lie in the thorax, and six in the abdomen. The nervous system of cockroach is spread throughout the body. The head holds a bit of a nervous system while the rest is situated along the ventral (belly-side) part of its body. So, now you understand that if the head of a cockroach is cut off, it will still live for as long as one week. In the head region, the brain is represented by supra-oesophageal ganglion which supplies nerves to antennae and compound eyes. In cockroach, the sense organs are antennae, eyes, maxillary palps, labial palps, anal cerci, etc. The compound eyes are situated at the dorsal surface of the head. Each eye consists of about 2000 hexagonal ommatidia (sing.: *ommatidium*). With the help of several ommatidia, a cockroach can receive several images of an object. This kind of vision is known as mosaic vision with more sensitivity but less resolution, being common during night (hence called nocturnal vision).

Cockroaches are dioecious and both sexes have well developed reproductive organs (Figure 7.18). Male reproductive system consists of a pair of testes one lying on each lateral side in the 4th -6th abdominal segments. From each testis arises a thin vas deferens, which opens into ejaculatory duct through seminal vesicle. The ejaculatory duct opens into male gonopore situated ventral to anus. A characteristic mushroomshaped gland is present in the 6th-7th abdominal segments which functions as an accessory reproductive gland. The external genitalia are represented by male gonapophysis or phallomere (chitinous asymmetrical structures, surrounding the male gonopore). The sperms are stored in the seminal vesicles and are glued together in the form of bundles called spermatophores which are discharged during copulation. The female reproductive system consists of two large ovaries, lying laterally in the 2nd ñ 6th abdominal segments. Each ovary is formed of a group of eight ovarian tubules or ovarioles, containing a chain of developing ova. Oviducts of each ovary unite into a single median oviduct (also called vagina) which opens into the genital chamber. A pair of spermatheca is present in the 6th segment which opens into the genital chamber.

Sperms are transferred through spermatophores. Their fertilised eggs are encased in capsules called oothecae. Ootheca is a dark reddish to blackish brown capsule, about 3/8" (8 mm) long. They are dropped or glued to a suitable surface, usually in a crack or crevice of high relative humidity near a food source. On an average, females produce 9-10 oothecae, each containing 14-16 eggs. The development of *P. Americana* is paurometabolous,



meaning there is development through nymphal stage. The nymphs look very much like adults. The nymph grows by moulting about 13 times to reach the adult form. The next to last nymphal stage has wing pads but only adult cockroaches have wings.

Many species of cockroaches are wild and are of no economic importance. A few species thrive in and around human habitat. They are pests because they destroy food and contaminate it with their smelly excreta. They can transmit a variety of bacterial diseases by contaminating food material.

4. Summary

Earthworm, Cockroach and Frog show characteristic features in body organisation. In *Pheretima posthuma* (earthworm), the body is covered by cuticle. All segments of its body are alike except the 14th, 15th and 16th segment, which are thick and dark and glandular, forming clitellum. A ring of S-shaped chitinous setae is found in each segment. These setae help in locomotion. On the ventral side spermathecal openings are present in between the grooves of 5 and 6, 6 and 7, 7 and 8 and 8 and 9 segments. Female genital pores are present

on 14th segment and male genital pores on 18th segment. The alimentary canal is a narrow tube made of mouth, buccal cavity, pharynx, gizzard, stomach, intestine and anus. The blood vascular system is of closed type with heart and valves. Nervous system is represented by ventral nerve cord. Earthworm is hermaphrodite. Two pairs of testes occur in the 10th and 11th segment, respectively. A pair of ovaries are present on 12 and 13th intersegmental septum. It is a protandrous animal with crossfertilisation. Fertilisation and development take place in cocoon secreted by the glands of clitellum. The body of Cockroach (*Periplaneta americana*) is covered by chitinous exoskeleton. It is divided into head, thorax and abdomen. Segments bear jointed appendages. There are three segments of thorax, each bearing a pair of walking legs. Two pairs of wings are present, one pair each on 2nd and 3rd segment. There are ten segments in abdomen. Alimentary canal is well developed with a mouth surrounded by mouth parts, a pharynx, oesophagus, crop, gizzard, midgut, hindgut and anus. Hepatic caecae are present at the junction of foregut and midgut. Malpighian tubules are present at the junction of midgut and hindgut and help in excretion. A pair of salivary gland is present near crop. The blood vascular system is of open type. Respiration takes place by network of tracheae. Trachea opens outside with spiracles. Nervous system is represented by segmentally arranged ganglia and ventral nerve cord. A pair of testes is present in 4th-6th segments and ovaries in 2nd-6th segments. Fertilisation is internal. Female produces 9-10 ootheca bearing developing embryos. After rupturing of single ootheca sixteen young ones, called nymphs come out.