7

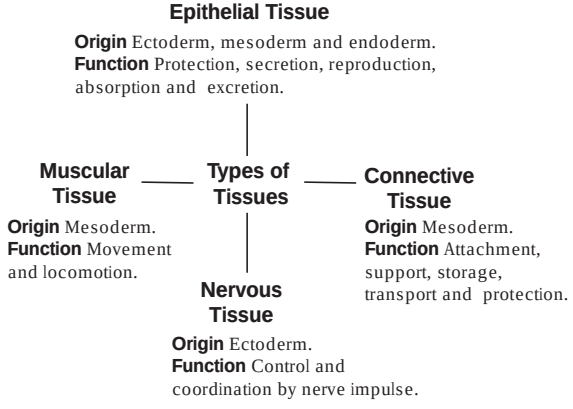
Structural Organisation in Animals

In unicellular organisms, all vital cellular functions like digestion, respiration, excretion, etc., are performed by a single cell. The multicellular animals have complex body organisation, **e.g., Hydra**.

Tissue (By Bichat; Father of Histology)

It is a group of one or more cell types and their intercellular substances that perform a particular function.

Based on structure, function and location, **animal tissues are of four types**



1. **Epithelial Tissue** (By Ruysch)

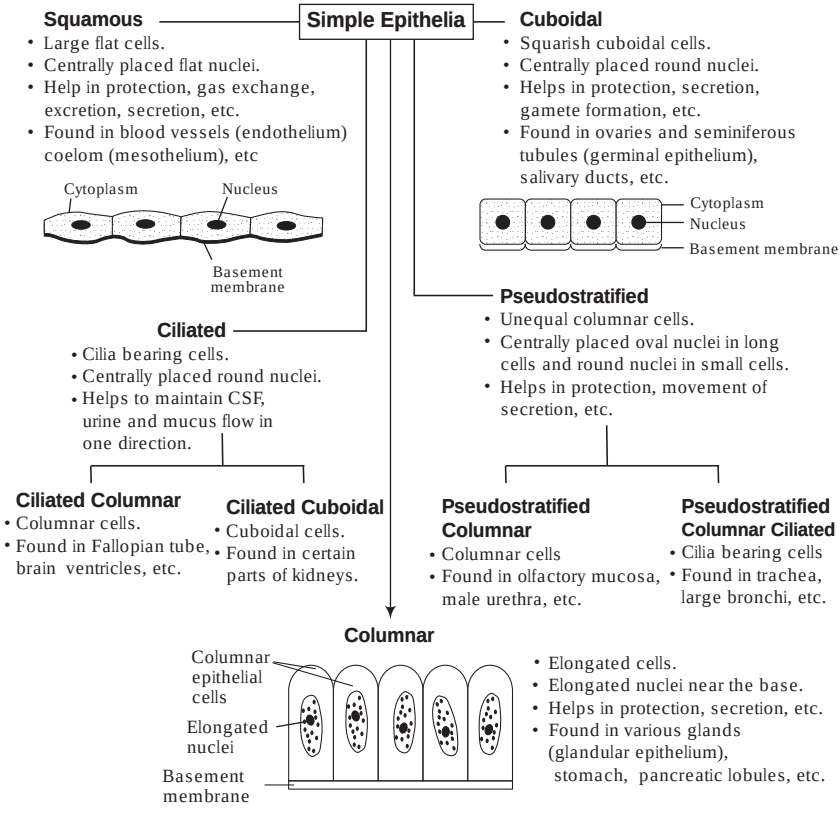
It consists of a sheet of tightly packed cells with the minimum of intercellular material and rest upon a non-cellular basement membrane or lamina propria.

Common junctions between epithelial cells include tight junctions, gap junctions, desmosomes, intercellular bridges and interdigitations. These occur at many points of cell to cell and cell to matrix junctions.

Epithelial tissues are of two types

(i) **Simple Epithelium**

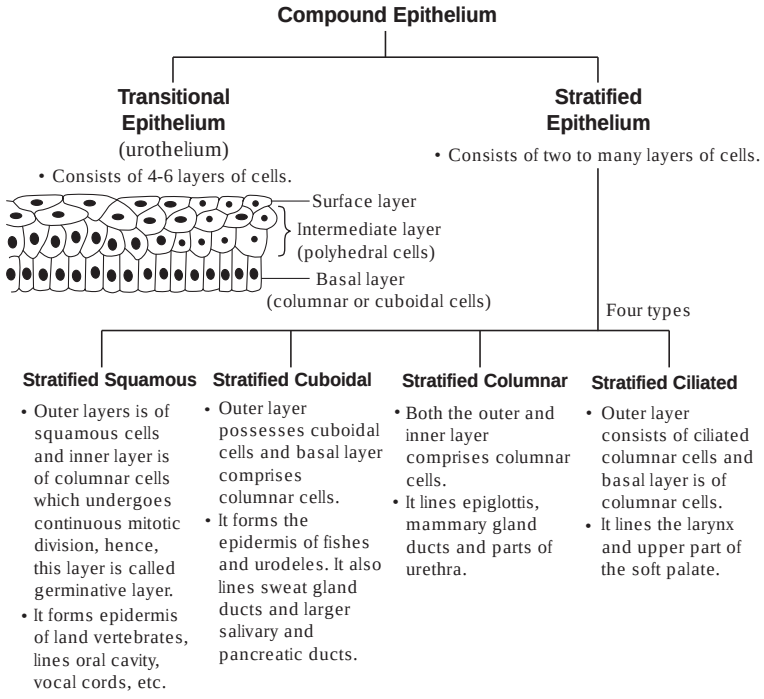
It consists of a single cellular layer and all the cells rest on the basement membrane. It covers the surface with little wear and tear activity. It performs secretory, absorptive and protective functions.



Types of simple epithelium

(ii) Compound Epithelium

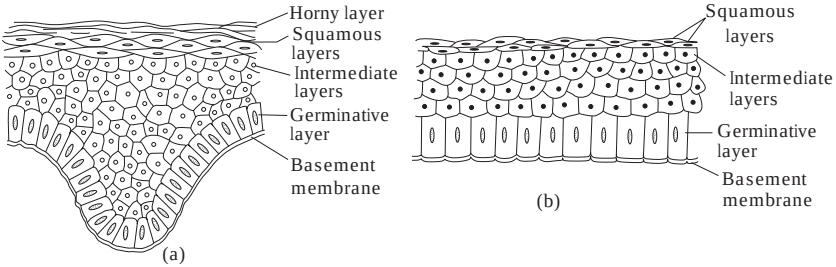
It consists of multicellular layers and the cells of deepest layer rest on the basement membrane. It covers the surfaces with maximum wear and tear activity. It performs protective functions.



Stratified squamous epithelium is further of two types

(a) **Keratinised Stratified Squamous Epithelium** Keratin is present in the dead superficial cells. It is impermeable to water and forms well protective covering against abrasions. It forms epidermis of skin of land vertebrates.

(b) **Non-keratinised Stratified Squamous Epithelium** Its superficial cells are living and keratin is absent. It is permeable to water and forms moderately protective covering against abrasions. It lines the buccal cavity, pharynx, oesophagus, etc.



(a) Keratinised epithelium (b) Non-keratinised epithelium

(III) Glandular Epithelium

Some of the columnar or cuboidal cells get specialised for secretion and form the glandular epithelium. **They are mainly of two types**

- **Unicellular** Consisting of isolated glandular cells, **e.g.,** goblet cells of the alimentary canal.
- **Multicellular** Consisting of cluster of cells, **e.g.,** salivary gland.

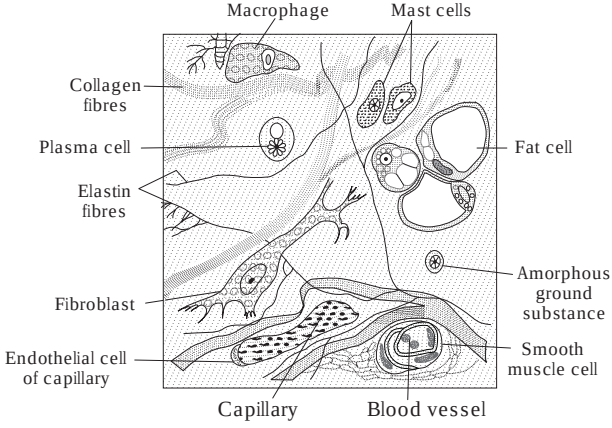
2. Connective Tissue

Most abundant and widely spread tissue, link and support other tissues of the body. **Basic components of connective tissue are**

(i) **Cells** embedded in the matrix including fibroblast, adipose cells, macrophages, mesenchyme cells, plasma cells, etc.

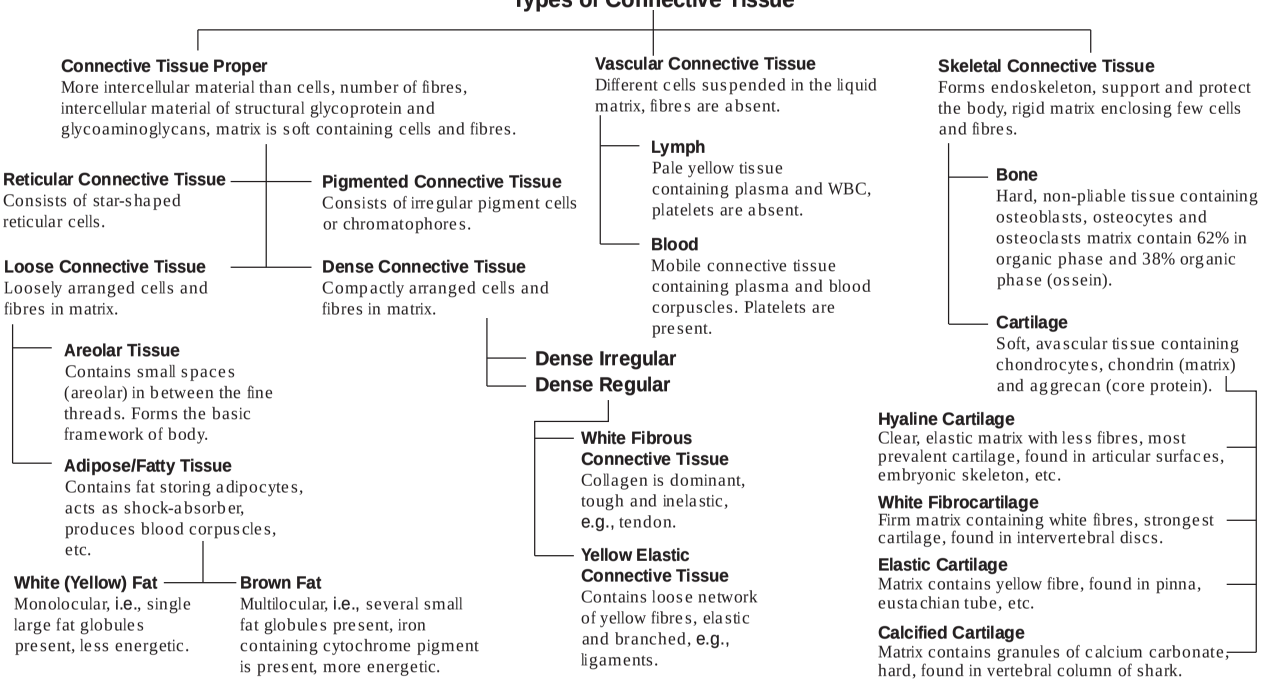
(ii) **Matrix** is a mixture of carbohydrates and proteins. The common mucopolysaccharide in matrix is hyaluronic acid.

(iii) **Fibres** including collagen fibres of white collagen protein, reticular fibres of reticulin protein and elastic fibres of yellow elastin protein.



Connective tissue (generalised)

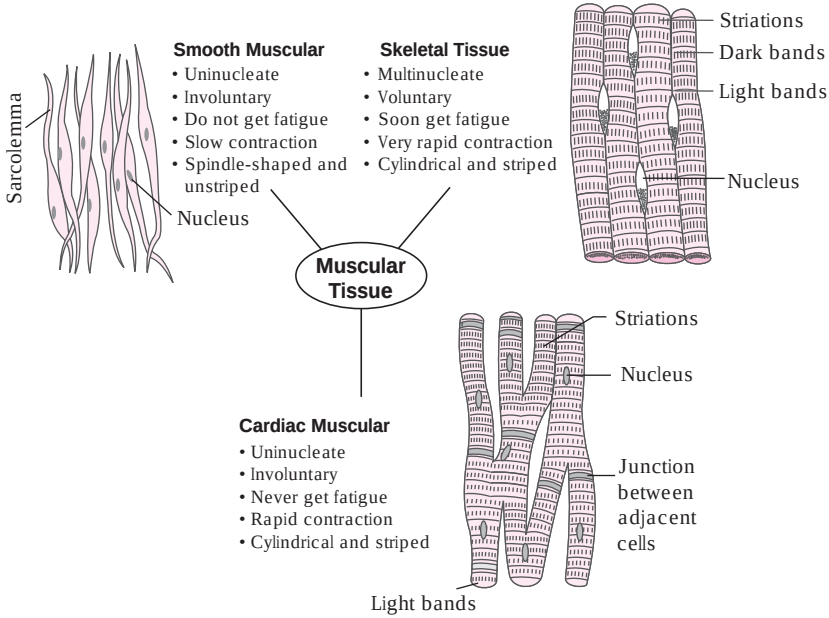
Types of Connective Tissue



3. Muscular Tissue

Contractile tissue containing numerous fine fibrils called **myofibrils** in the cytoplasm (sarcoplasm). Muscle cells (myocytes) develop from myoblasts. Muscles have the capacity to respond to a stimulus (irritability) by two basic phenomena, **i.e.,** response to a stimulus and conductivity.

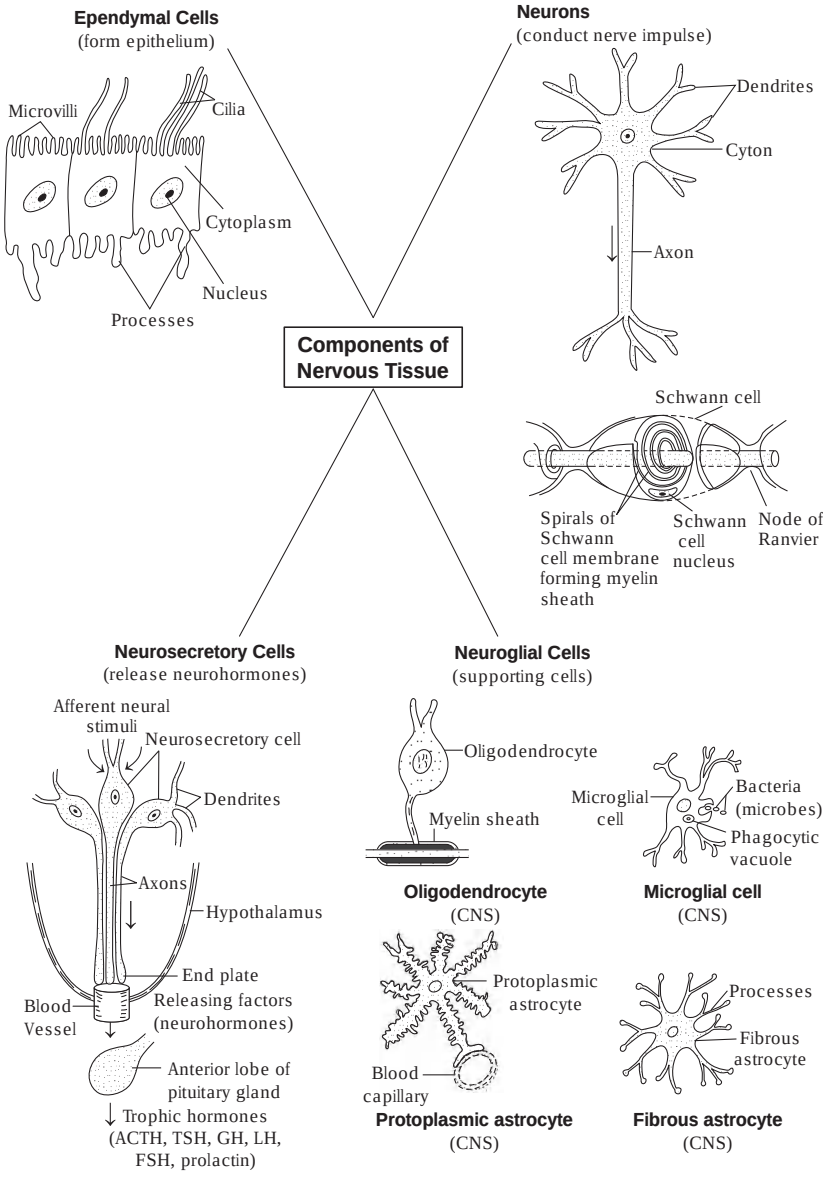
Muscular tissues are of following three types

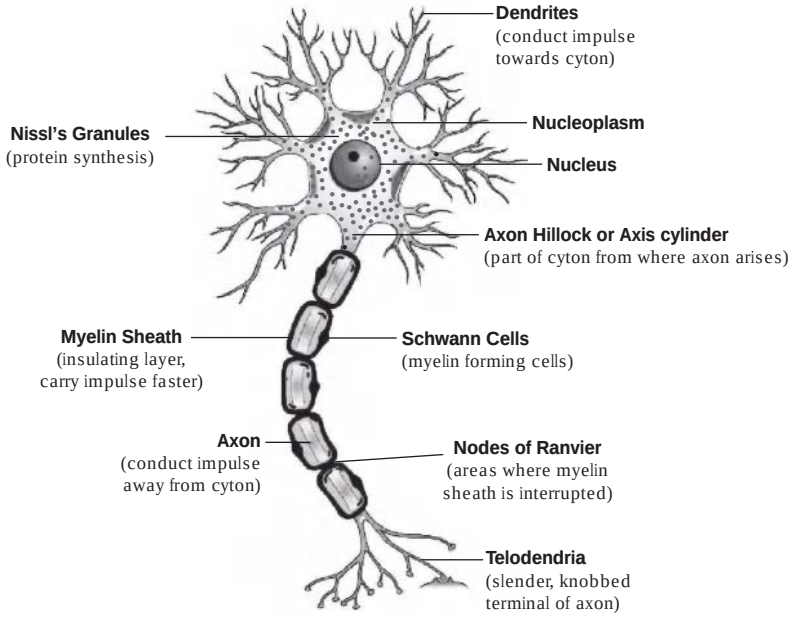


Types of muscles

4. Neural Tissue

This tissue is the second specialised tissue with the property of exicitability and conductivity. It consists of nerve cells and glial cells. Neurons are the structural and functional units of neural (nervous) tissue.


Ependymal Cells
(form epithelium)
Microvilli
Cilia
Cytoplasm
Nucleus
Processes
Neurons
(conduct nerve impulse)
Dendrites
Cyton
Axon
Components of Nervous Tissue
Schwann cell
Spirals of Schwann cell membrane forming myelin sheath
Schwann cell nucleus
Node of Ranvier
Neurosecretory Cells
(release neurohormones)
Afferent neural stimuli
Neurosecretory cell
Dendrites
Axons
Hypothalamus
End plate
Blood Vessel
Releasing factors (neurohormones)
Anterior lobe of pituitary gland
Trophic hormones (ACTH, TSH, GH, LH, FSH, prolactin)
Neuroglial Cells
(supporting cells)
Oligodendrocyte
Myelin sheath
Oligodendrocyte
(CNS)
Microglial cell
Bacteria (microbes)
Phagocytic vacuole
Microglial cell
(CNS)
Protoplasmic astrocyte
Blood capillary
Protoplasmic astrocyte
(CNS)
Processes
Fibrous astrocyte
Fibrous astrocyte
(CNS)



Structure of a neuron

Types of Neurons

On the basis of structural nature, **neurons are of following four types, i.e.,**

(i) **Apolar Neurons**, **i.e.,** neurons without polarity. Here, the fibres of neuron are not differentiated into axon and dendrites. All the fibres are of same nature and can carry information towards or away from the cell body, **e.g.,** neurons of **Hydra**.

(ii) **Unipolar Neurons**, **i.e.,** neurons with unidirectional flow of information. These have one axon or one dendrite only. Most sensory neurons are unipolar. These are common in invertebrate and vertebrate embryos.

(iii) **Bipolar Neurons**, **i.e.,** neurons with unidirectional flow of information, but with one dendron and one axon at opposite poles. These occur in the retina of eyes, olfactory epithelium, etc.

(iv) **Multipolar Neurons**, **i.e.,** neurons with unidirectional flow of information, but with one axon and many dendrites. They occur in the nervous system of adult vertebrates.

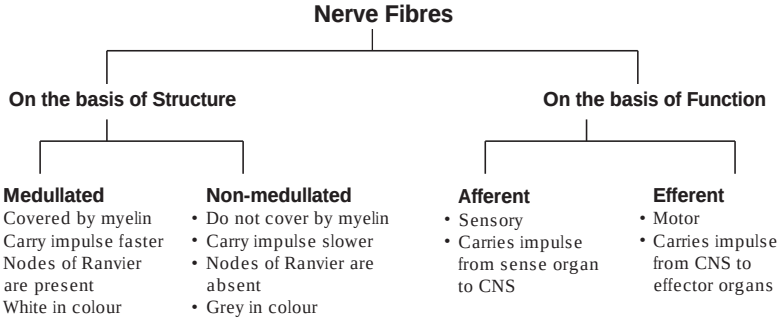
Neurons can also be classified according to their functions as

(i) **Sensory or Afferent neurons**, **i.e.,** these connect sensory or receptor cells or organs to the CNS and conduct sensory impulses. Branched or unbranched and naked or encapsulated free endings of numerous sensory neurons found scattered in skin epidermis. These serve as cutaneous sense organs or **exteroceptors**. Similar endings scattered in skeletal muscles, bone joints, ligaments and tendons serve as **interoceptors**.

(ii) **Motor or Efferent neurons**, **i.e.,** these connect the CNS to effectors (muscles and glands) and conduct motor impulses.

(iii) **Internuncial or Interneurons** These occur only in the CNS and serve to connect two or more neurons for distant transmission of impulses.

Similarly, nerve fibres can be categorised as

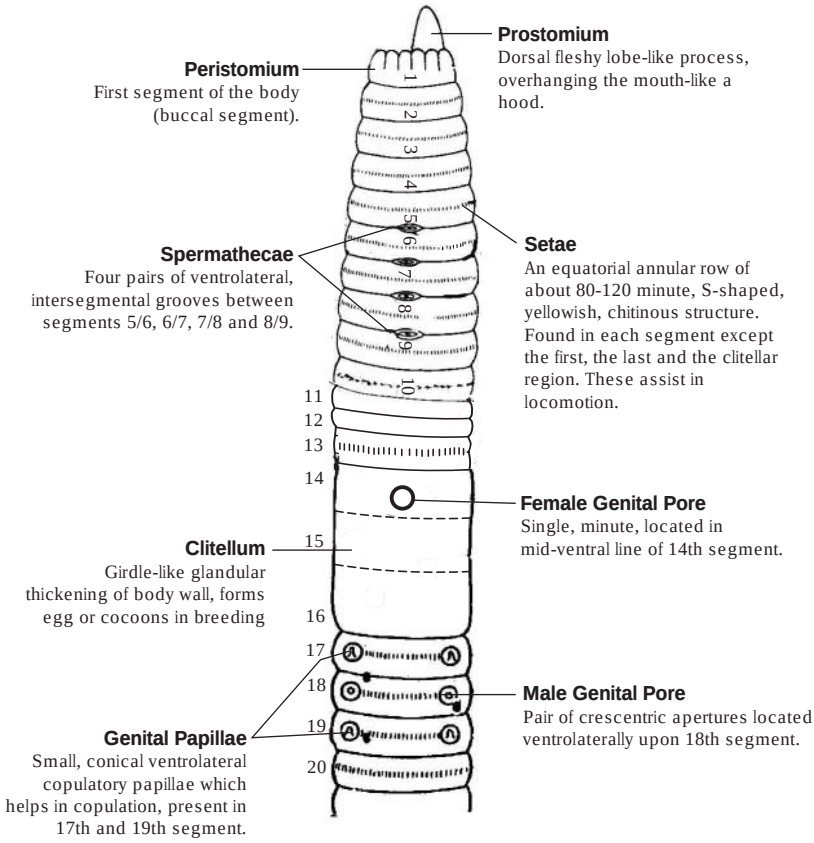


Earthworm

It is a reddish-brown terrestrial invertebrate that inhabits the upper layer of the moist soil. The common Indian earthworms are **Pheretima** and **Lumbricus**.

Morphology

Bilaterally symmetrical with elongated, narrow and cylindrical body. It appears brown due to the presence of porphyrin pigment in the body wall. Dorsal body surface is demarcated by the ventral surface due to the presence of dark mid-dorsal line. Their body is metamerically segmented.



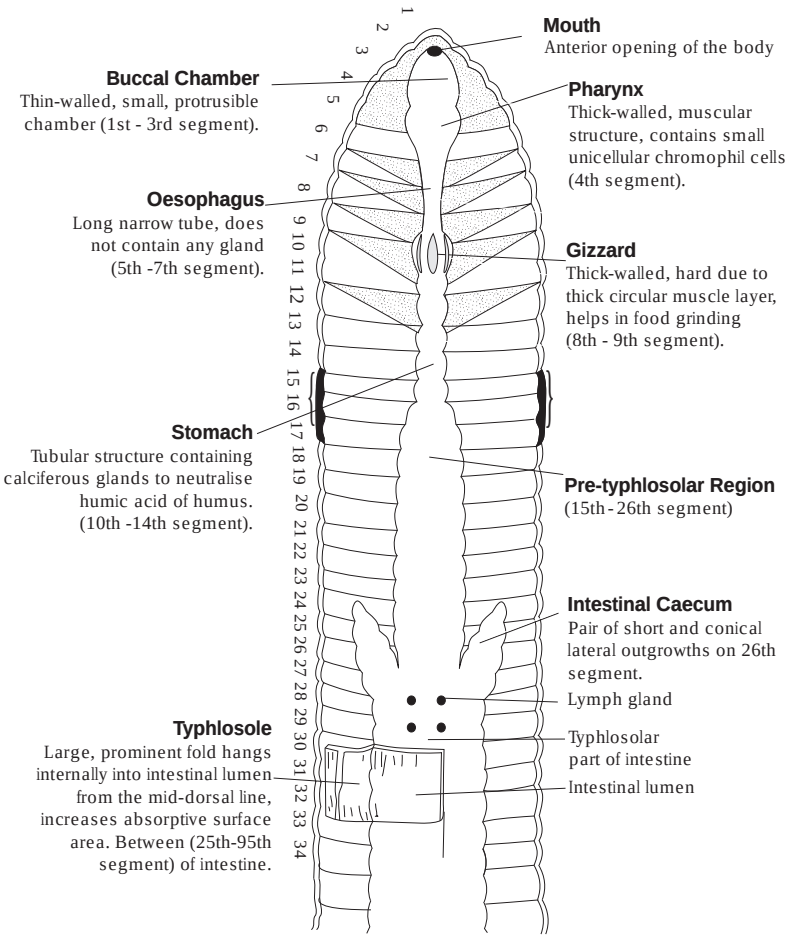
External structure of an earthworm

Metamerism

It is the repetition of organs and tissues at intervals along the body of an animal, thus dividing the body into a linear series of similar parts or segments (metamers). It is an internal mesodermal phenomenon and helps in more efficient locomotion.

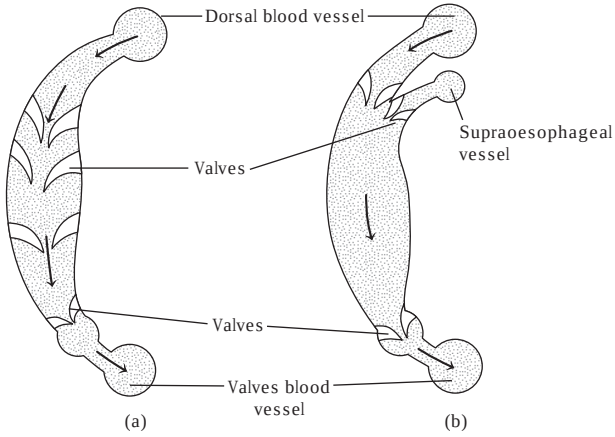
Anatomy and Physiology

- The body wall of the earthworm is covered externally by a thin non-cellular cuticle below which is epidermis, two muscular layers and an innermost coelomic epithelium. The epidermis is made up of a single layer of columnar epithelial cells which contain secretory gland cells.
- **Locomotion** It is brought about by a coordinated contraction and relaxation of circular and longitudinal muscles of body wall, assisted by setae, mouth and the hydrostatic pressure of coelomic fluid.
- **Digestive System** Earthworm possesses a straight alimentary canal from mouth to anus. The canal is differentiated into six regions–buccal chamber, pharynx, oesophagus, gizzard, stomach and intestine.



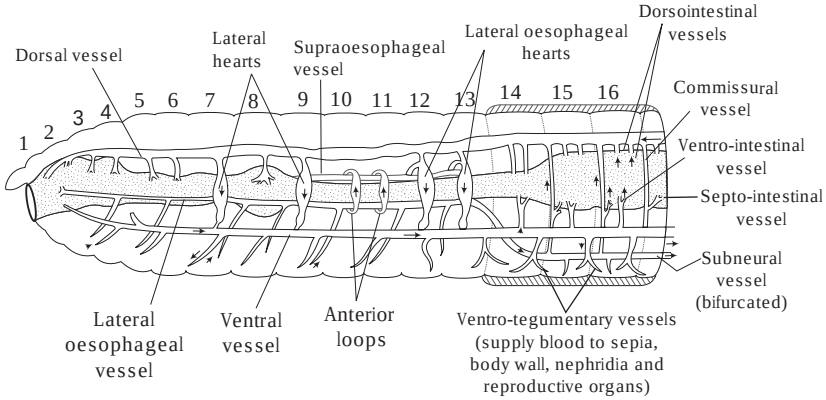
Alimentary canal of an earthworm

Circulatory System Closed circulatory system, **haemoglobin** or erythrocruorin dissolved in blood plasma. Three main blood vessels in body are dorsal, ventral and sub-neural. **Dorsal blood vessel** is the largest blood vessel of the body. **Blood glands** are present on the 4th, 5th and 6th segments and they produce blood cells and haemoglobin. Blood cells are phagocytic in nature. Their heart do not have any kind of pulsative activity.

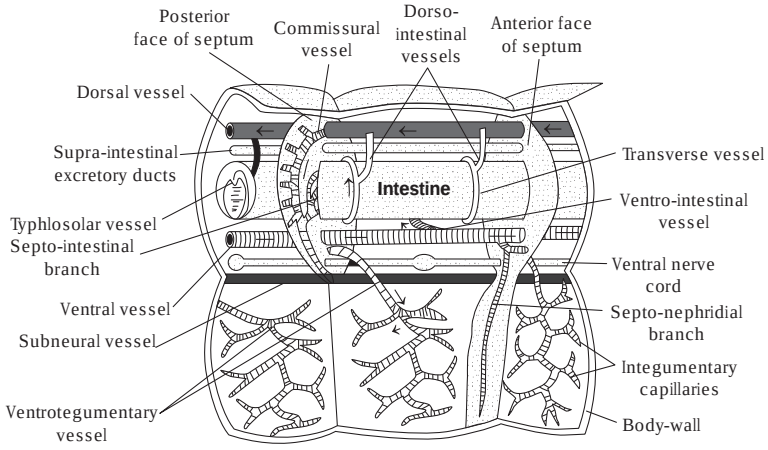


Heart of Pheretima : (a) Lateral heart (7th and 9th segments) (b) Lateral oesophageal heart (12th and 13th segments)

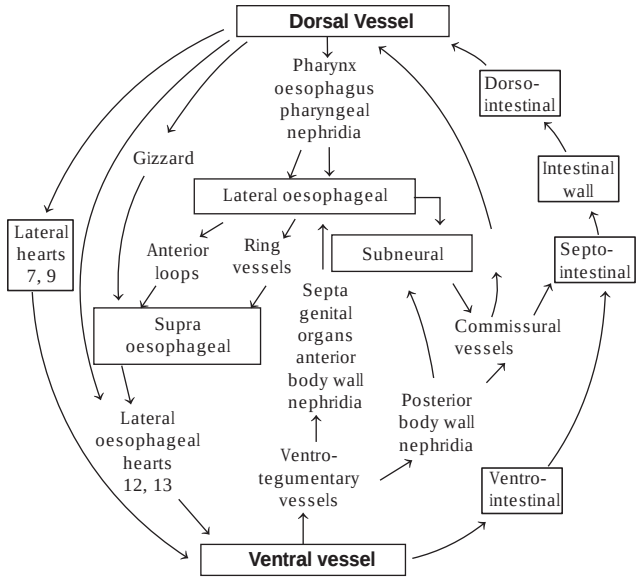
The number, nature and arrangement of blood vessels are very different in the first 13th segments from that in the rest of the body.



Pattern of blood vascular system in first 13th segments

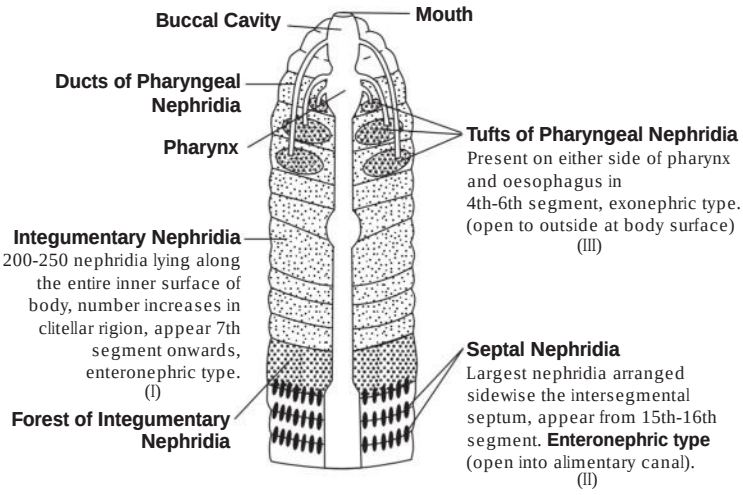


Pattern of blood vascular system behind 13th segment



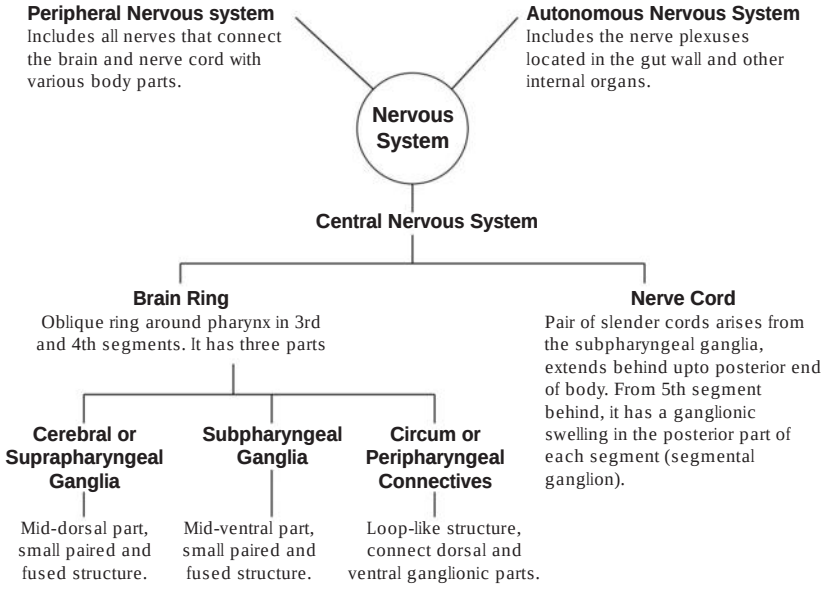
Complete circulation plan of earthworm

- **Respiratory System** The animal is aerobic and gaseous exchange takes place through general body surface.
- **Excretory System** It is made up of segmentally arranged **nephridia** of **three types**.

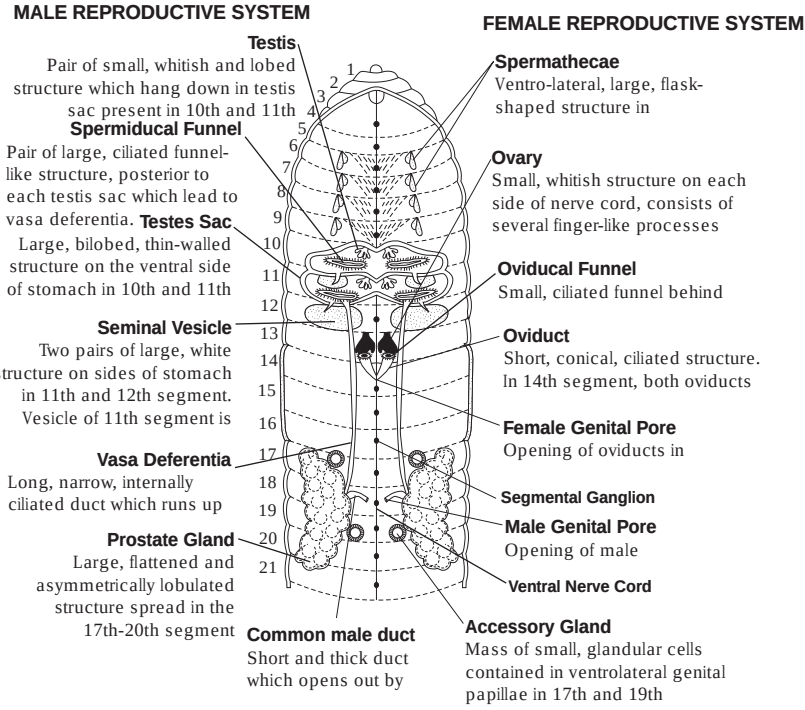


Types of nephridia

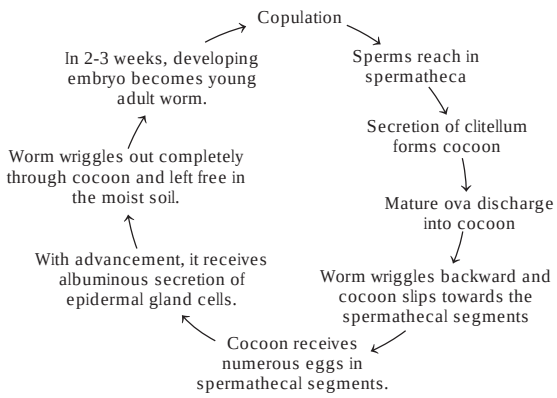
Nervous System Metamerically segmented, divisible into three sections, **viz.,** central, peripheral and autonomic. All nerves are mixed, having both sensory and motor fibres.



Reproductive System Earthworm is hermaphrodite (bisexual) and reproduces only sexually.



Reproductive system of earthworm



Events of reproduction in earthworm

Economic Importance of Earthworm

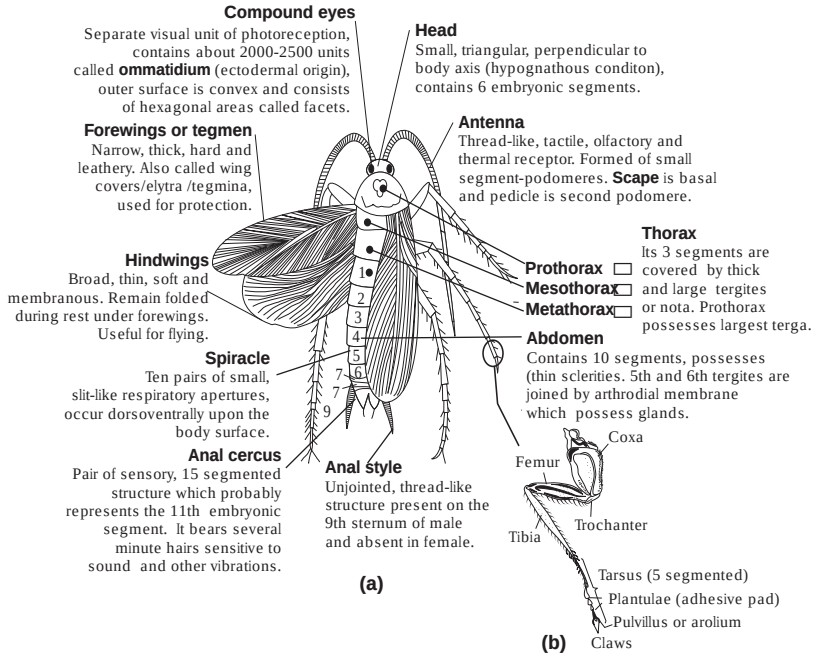
- They are used as bait for fishing.
- Their burrowing habit increases the fertility of soil. This is called vermicomposting.
- Their burrows cause the loss of water by seepage from ditches in irrigated lands.
- They are easily obtained and are of convenient size for dissections in laboratories.

Cockroach

They are brown or black-bodied animals that are included in class–Insecta of phylum–Arthropoda. The most common species of cockroaches in India is **Periplaneta americana**.

Morphology

Nocturnal, bilateral symmetrical invertebrate, distinctly segmented and covered by a shining brown exoskeleton. Their dorsal body surface is covered by dark brown wings. When wings are removed, the three regions of the body–head, thorax and abdomen become visible.



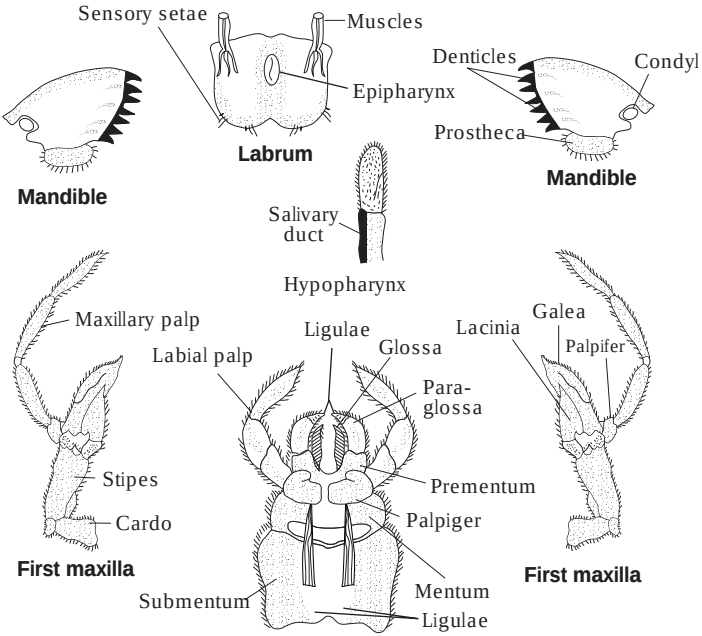
External features of cockroach : (a) Complete body (b) One walking leg

- **Sclerites** Small plate-like structures, which forms the exoskeleton. These structures are joined together by soft, intersegmental, flexible membrane called **arthrodial membrane**.

  The dorsal sclerites are called **tergites**, ventral one are **sternites**, while the lateral ones are called **pleurites**.

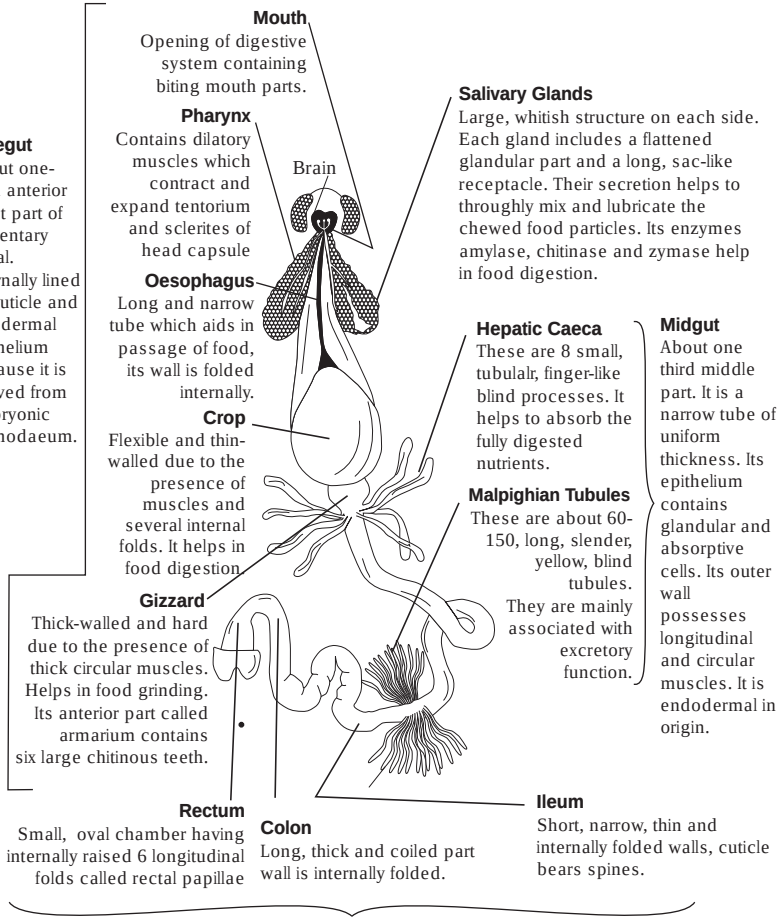
Anatomy and Physiology

- **Body Wall** The body wall contains cuticle, epidermis and basement membrane.
- **Body Cavity** Cockroaches are coelomate animals. But, true coelom occurs only in embryonic stage. In adults, it is found in small cavities only around the gonads.
- **Endoskeleton** Certain processes of exoskeleton extend into the body and form endoskeletal elements. These provide attachment to the muscles and hence called apodemes.
- **Locomotion** Cockroaches are good runners, but poor fliers as the muscles associated with the jointed legs are much more developed than those associated with the wings.
- **Digestive System** The mouth in animal is surrounded by well-defined appendages, which can be seen as



Mouth parts of cockroach

Alimentary canal is complete and well-differentiated in accordance with omnivorous mode of feeding. **It is divisible into following parts**



Digestive system of cockroach

- **Respiratory System** Every tissue of body is in direct communication with atmospheric air due to the absence of respiratory pigment in the blood.

It consists of following components

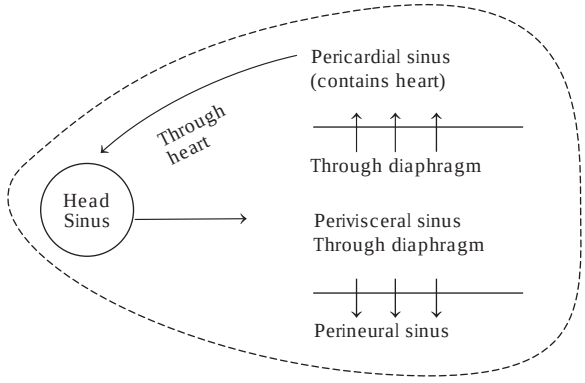
(a) **Trachea or Air Tubes** Numerous, shiny, transparent, branched tubes formed by extensive invagination of the hypodermis of skin (ectodermal in origin). There are six longitudinal tracheal tubes (2 dorsal, 2 ventral and 2 lateral) which are interconnected by transverse commissures.

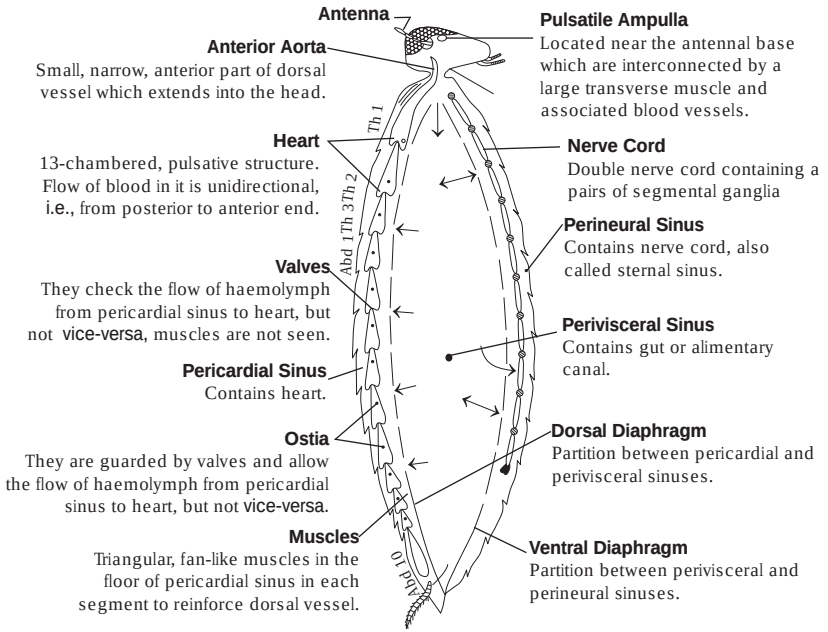
(b) **Spiracle or Stigmata** Ten pairs of slit-like apertures through which air enters and escapes from the trachea, located on lateral side of body, surrounded by a ring-like peritreme.

There are 2 thoracic pairs (larger than abdominal spiracle) and 8 abdominal pairs (first pair is dorso-lateral upon tergite and rest seven are upon the pleurites of 2nd - 8th segments).

- **Circulatory System** Cockroach possesses open type of circulatory system with blood flowing in the blood spaces or lacunae. The blood is without respiratory pigment and called haemolymph (possesses plasma and haemocytes). Body consists of three sinuses mainly with one head sinus.

The flow of blood within the body looks like





Circulatory system of cockroach

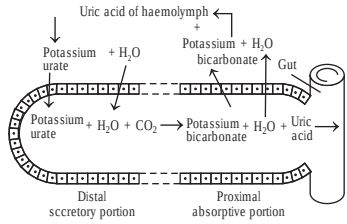
Excretory System The animal is uricotelic and excretion occurs through the following structures

Fat Body
It has urate cells, which obtain nitrogenous waste from haemolymph and stores it in the form of uric acid. Mycetocyte cells of fat body contain symbiotic bacteria which decompose uric acid into protein during protein deficiency.

Cuticle
Helps in removing excess salt and nitrogenous wastes probably at the time when cuticle is removed during moulting.

Excretory System

Malpighian Tubules



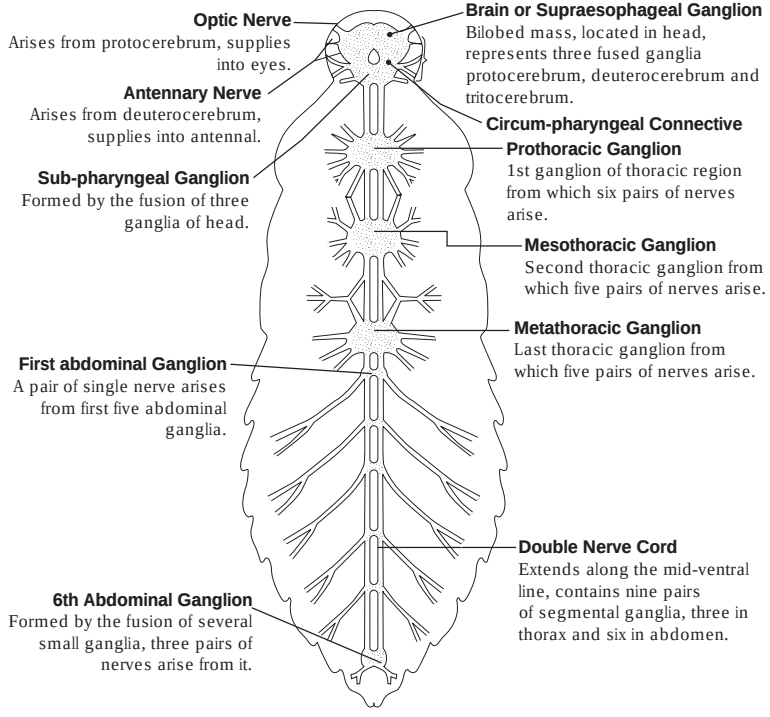
Mushroom Glands
These are long tubules, i.e., uricose gland in male cockroach. They store and discharge uric acid over the spermatophore during copulation.

Excretory system in cockroach

Nervous System It is well-developed and divided into following three types

(i) **Central Nervous System** It includes a brain, one suboesophageal or subpharyngeal ganglion and a doublet ventral nerve cord.

(ii) **Peripheral Nervous System** It includes the nerves that connect the various ganglia of CNS to different body parts.



Central and peripheral nervous system of cockroach

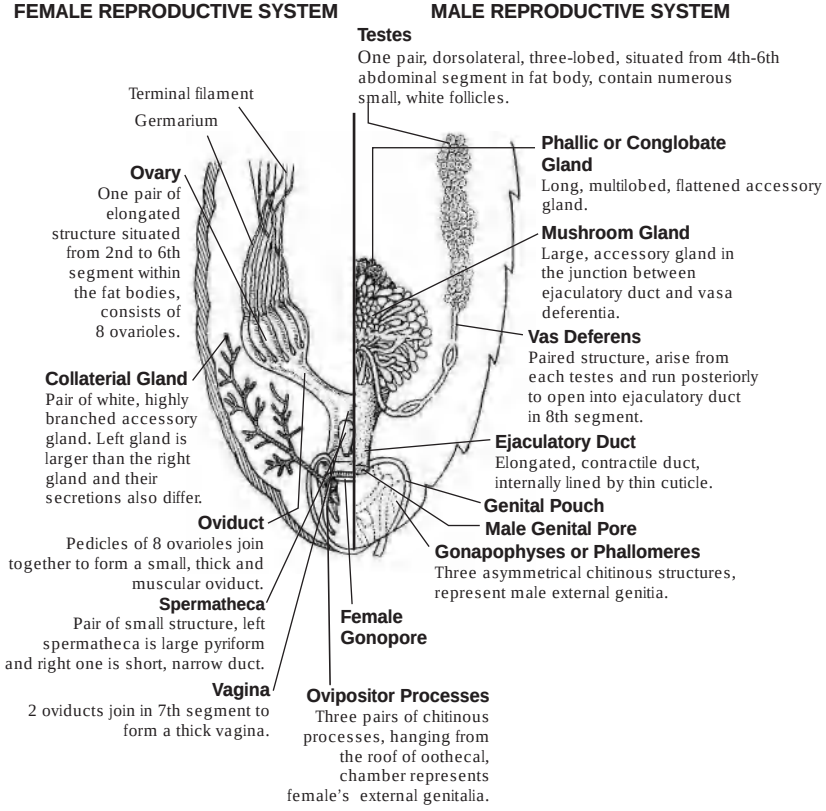
(iii) **Autonomic Nervous System** It is of sympathetic type and also called **visceral nervous system**. It performs both nervous and endocrine functions.

It is divided into three parts

1. **Caudal NS** Includes certain fine nerves that arise from last abdominal ganglion and innervate hindgut, reproductive organs and anal appendages.
2. **Spiracular NS** Includes certain fine paired nerves which arise from the ganglia of nerve cord and innervate the spiracles.
3. **Somatogastric NS** Includes certain fine nerves which arise from five ganglia and innervate the anterior parts of the gut.

Reproductive System Sexes are separate and sexual dimorphism is also seen

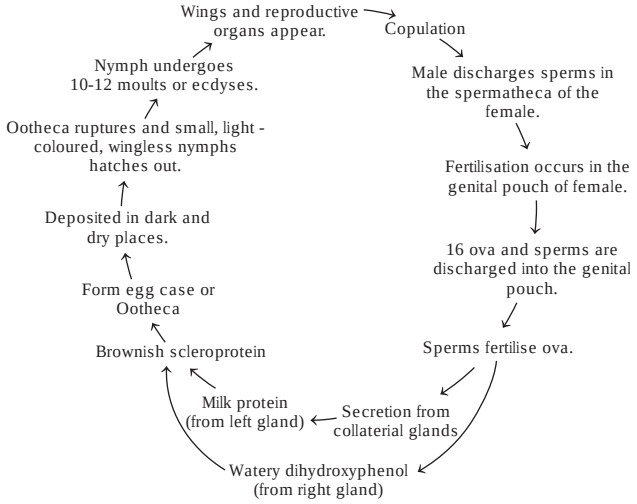
Female Cockroach	Male Cockroach
Body relatively larger and thicker.	Body relatively smaller and more flattened.
Abdomen has seven distinct segments.	Abdomen has nine distinct segments.
Hind end of abdomen is blunt and boat-shaped.	Hind end of abdomen is somewhat pointed.
Seventh sternite is divided.	Seventh sternite is undivided.
Anal styles are absent.	A pair of anal styles is articulated with 9th abdominal sternite.
Wings are smaller, extend only up to the hind end part of body.	Wings are relatively large, extend somewhat beyond the hind end of body.



Reproductive system of cockroach

- **Suspensory Filament** Thin, thread-like terminal filament formed of a syncytial chord of cytoplasm. It is terminally inserted upon dorsal body wall and serves to suspend the ovarioles into the perivisceral sinus.
- **Germarium** A small, multicellular structure in which oogonia forms and matures into oocytes.
- **Vitellarium** A long and narrow structure which receives the actively growing oocytes from germarium. It appears beaded due to gradually growing sizes of contained oocytes.
- **Egg Chamber** A small, thick and elliptical structure which contains, at a time, a single, large, mature ovum.
- **Pedicel** A small, hollow structure which unites to form oviduct.
- **Spermatophore** It is a three-layered, pear-shaped, tough structure which centrally contains spermatozoa in the nourishing fluid secreted by small tubules or utriculi breviores of male's mushroom gland.

Physiology of Reproduction



Process of reproduction in cockroach

Economic Importance of Cockroach

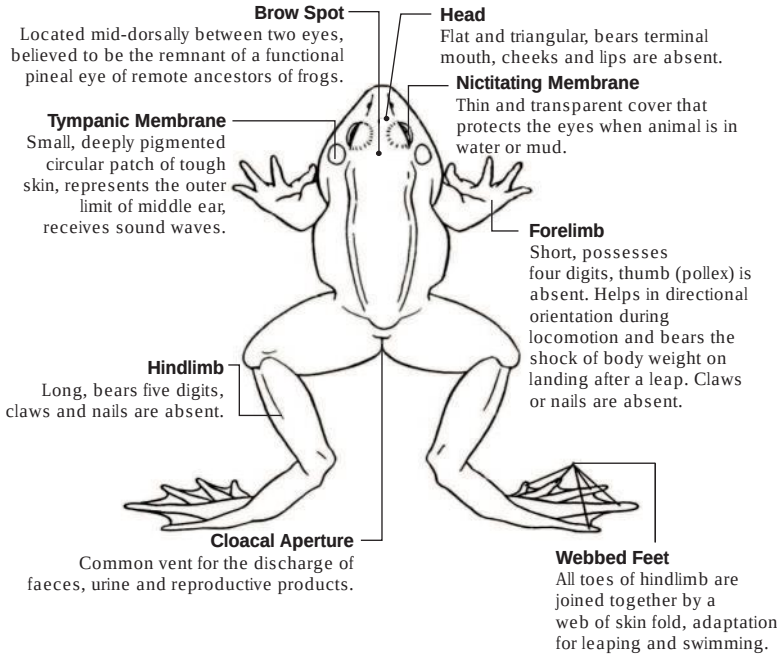
- They can be used as tools for the research of insect physiology and toxicology.
- They do not sting or bite, transport human pathogens.

Frog

They are called amphibians because they can live both on land and in freshwater. The most common species of frog is **Rana tigrina**.

Morphology

Frog is a dorsoventrally flattened and streamlined animal, adapted for an amphibious mode of life. Its body is divisible into head and trunk.



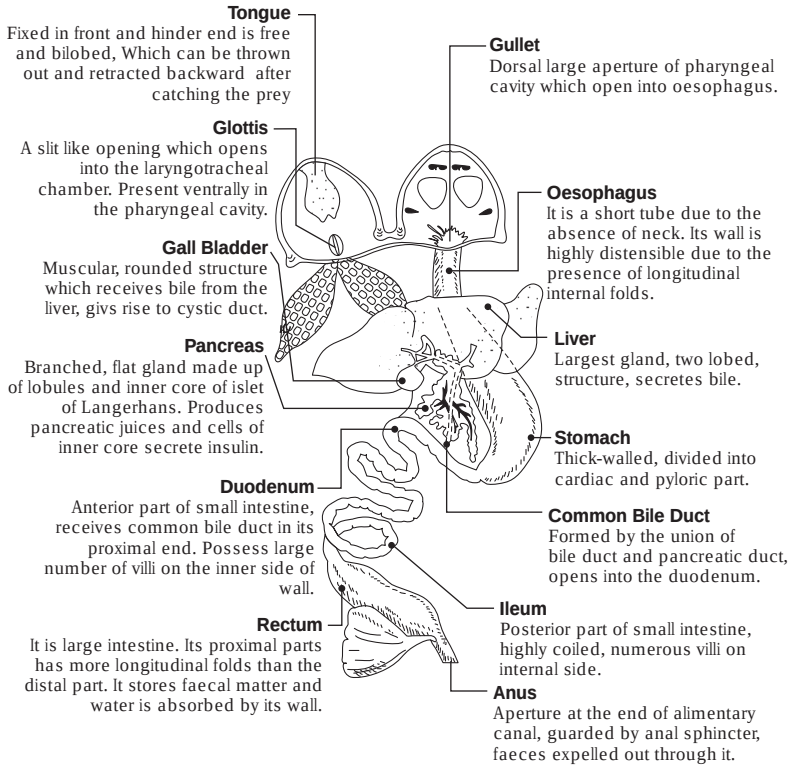
External structure of frog

- **Croaking** During the rainy season or breeding season, frogs make peculiar sound with the help of their vocal cords to attract females for mating. The male frogs croak louder than the females.

- **Metachrosis** It is the capability of frog to change its body colour with the change in its surroundings and climatic conditions.
- **Nuptial Pad** It is a dark swelling on the inner finger of the male frog which helps the male frog in mating.

Anatomy and Physiology

- **Digestive System** Frogs are holozoic and carnivorous. Their alimentary canal is short, **coiled tube consisting of following structures**



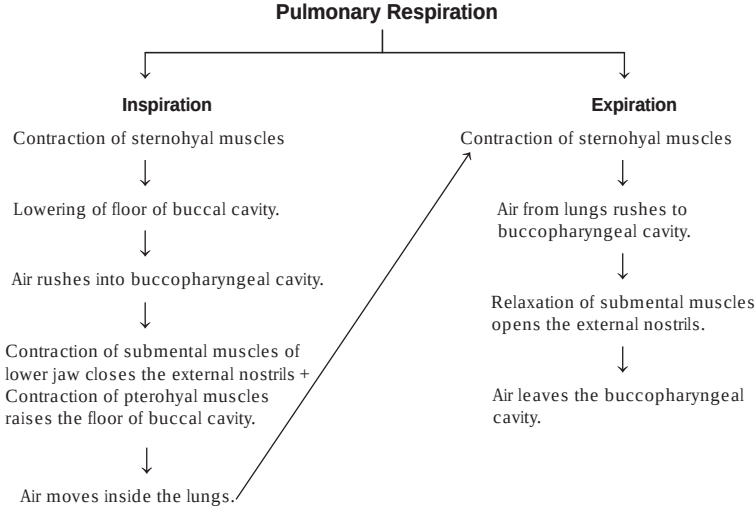
Digestive system of frog

- **Respiratory System Respiration in frog occurs through three modes**

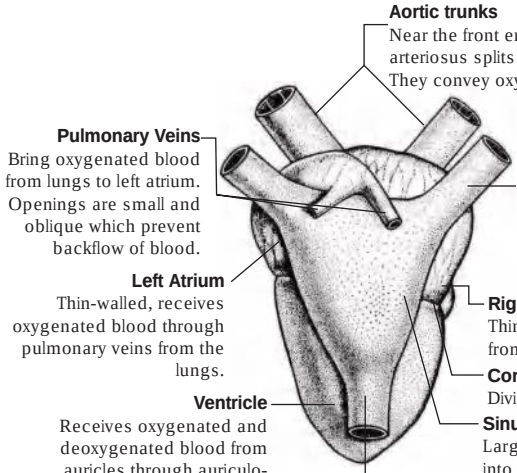
(a) **Cutaneous Respiration** Frog's skin is ideally adapted for the process of gaseous exchange. It is without exoskeleton, highly vascularised skin, always remain moist due to the secretions of mucous glands. It is most common mode, especially during hibernation and aestivation.

(b) **Buccopharyngeal Respiration** Mucosa of buccopharyngeal cavity is highly vascularised which aids in gaseous exchange. By showing oscillatory movements of the floor of buccal cavity and keeping the mouth, gullet and glottis closed, breathing process is carried out. **Sternohyal** and **pterohyal** muscles help in the oscillatory movements. It is carried out in water and on land.

(c) **Pulmonary Respiration** It involves the lungs, which are positive pressure type with hollow, highly distensible walls. They are endodermal in origin. Inspiration and expiration involves **gulping movements** in between oscillatory motion of buccopharyngeal respiration.



Circulatory System It consists of blood vascular system of closed type which represents the incomplete double circulation. **i.e.,** both oxygenated and deoxygenated blood enters the heart and get mixed in the ventricle. Blood vascular system comprises blood, heart and blood vessels. Their heart is myogenic.



Aortic trunks
Near the front end of the atrium, conus arteriosus splits into right and left aortic trunks. They convey oxygenated blood to the whole body.

Pulmonary Veins
Bring oxygenated blood from lungs to left atrium. Openings are small and oblique which prevent backflow of blood.

Anterior Vena Cava
Vein with large diameter carries deoxygenated blood from the upper half of the body to the right atrium.

Left Atrium
Thin-walled, receives oxygenated blood through pulmonary veins from the lungs.

Right Atrium
Thin-walled, receives mixed blood from sinus venous.

Coronary Sulcus
Divides atrium and ventricle.

Ventricle
Receives oxygenated and deoxygenated blood from auricles through auriculo-ventricular aperture.

Sinus Venosus
Large, triangular, thin-walled, opens into right atrium, three thick veins open into it, two precaval veins and postcaval vein. It is a chamber in which blood from the various parts of body collected first. In higher animals (like mammals), it is incorporated as SA node (pacemaker) within the right auricle. The origin of pulse is attributed to this structure.

Posterior Vena Cava
Large vein that carries deoxygenated blood from the lower half of the body into the right atrium.

Circulatory system of frog

(i) **Conus or Truncus Arteriosus** This accessory chamber is present towards the ventral side. It contains a spiral valve inside because of which its cavity is divided into cavum pulmocutaneum and cavum aorticum.

(ii) **Pylangium** The proximal, more muscular and longer portion of conus arteriosus. It is also called as **bulbus arteriosus**. It contains pulsative cardiac muscles.

(iii) **Synangium** The distal, less muscular portion of conus arteriosus. It is also called as **ventral aorta**.

(iv) **Columnae Carneae** These are the major muscle columns of ventricle. These columns are connected with the flaps of valves through elastic chords of fibres called **chordae tendineae**.

Mixed blood is pumped by frog's heart due to incomplete double circuit (**i.e.**, due to the presence of only one ventricle).

Lymphatic system It consists of lymphatic capillaries, sinuses, lymph hearts and lymph.

(i) **Lymph** Mobile connective tissue containing plasma with less number of proteins and corpuscles, containing numerous leucocytes, but no erythrocytes.

(ii) **Lymph sinuses** Thin-walled spaces around the tissues and between the organs. Subcutaneous and subventral sinuses are most common.

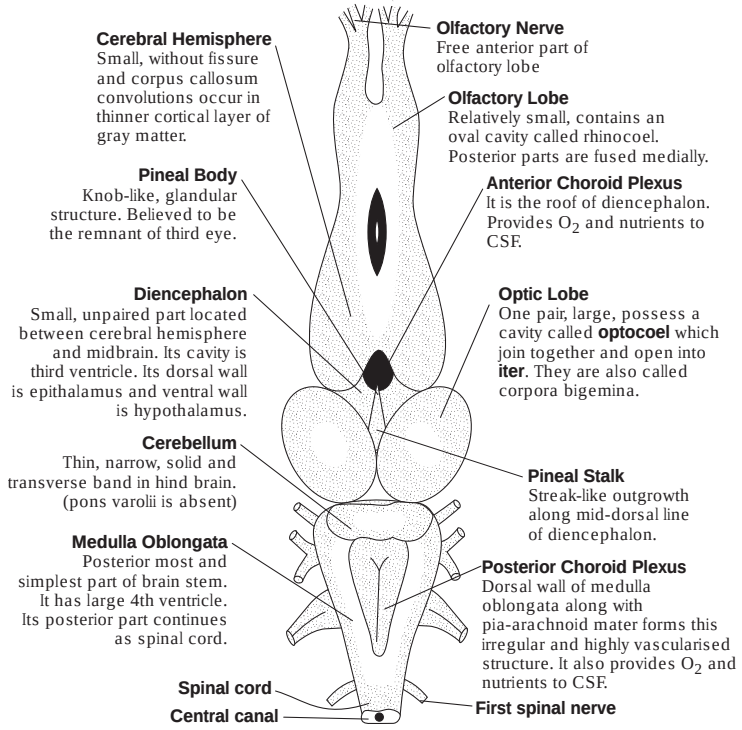
(iii) **Lymph hearts** Two pairs of thin-walled and muscular structure.

(iv) **Lymph capillaries** They end blindly in contact with the body cells and tissue spaces. Thin-walled, irregular and permeable to colloids, water and crystalloids.

- **Excretory System** It consists of two kidneys, ureter, urinogenital ducts and urinary bladder. The kidneys are of **mesonephric type**, **i.e.,** it develops from the middle part of intermediate mesoderm. The nephron is not much differentiated. In embryonic conditions, **nephrostomes** are functional and in adults, they get replaced by **glomerulus**. Frog is **ureotelic**.

- **Nervous System** It comprises CNS, PNS and ANS

(i) **Central nervous system** It comprises brain and spinal cord. Brain is enveloped by two membranous meninges, **i.e.,** Pia arachnoid (inner, soft, highly vascularised) and Dura mater (outer, tough, collagen fibre covering).



Nervous system of frog

Exceptions to frog's brain as compared to humans are

- Rhincnceptialon is anterior in position, but not in humans.
- Optic lobes are one pair, whereas they are two pairs in humans.
- Corpus striatum is present upon the floor of cavities of cerebral hemisphere in frog.
- Hippocampi, corpus callosum and pons Varolii are absent in frogs.
- Frog's vision is monolocular and it is binocular in humans.

(ii) **Peripheral Nervous System** It is represented by cranial and spinal nerves.

There are 10 pairs of cranial nerves in frog.

Spinal accessory nerves and hypoglossal nerves are absent in it.

The number of spinal nerves in frog is 10 pairs, **i.e.,** 20.

(iii) **Autonomic Nervous System** It controls the involuntary activities such as homeostasis. **It comprises two antagonistic parts**

(a) **Sympathetic NS** It generally acts to stimulate the body to cope with stress. Its nerve endings are cholinergic and adrenergic.

(b) **Parasympathetic NS** It functions to calm the body. Its nerve endings are cholinergic.

(iv) **Endocrine system** Endocrine glands secrete hormones for chemical coordination of various organs of body. The prominent endocrine glands found in frog are pituitary, thyroid, parathyroid, thymus, pineal body, pancreatic islets, adrenals and gonads.

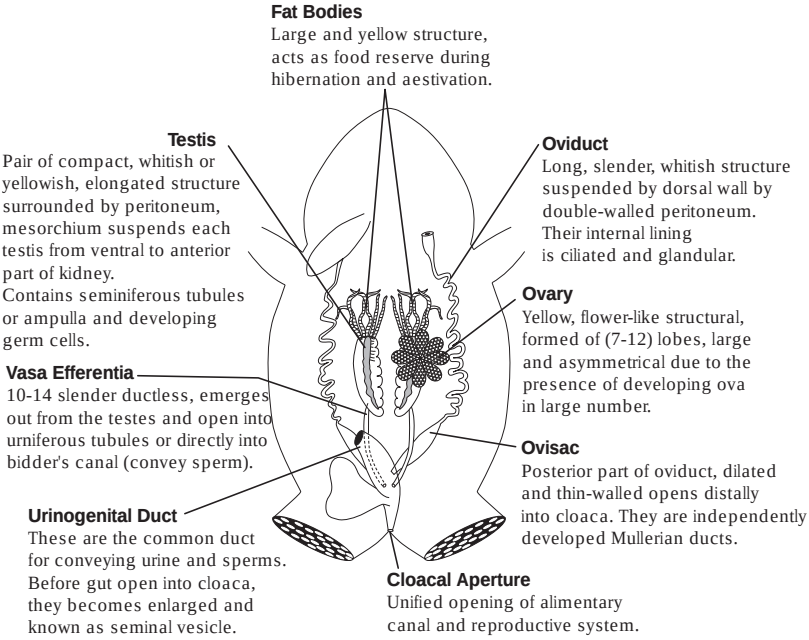
(v) **Skeletal system** In frog, exoskeleton is absent. the endoskeleton has two parts

(a) **Axial skeleton** includes skull in the head and vertebral column in trunk.

(b) **Appendicular skeleton** indudes limb bones in the arms and legs and girdles that connect the limb bones with vertebral column.

(vi) **Reproductive System** Sexes are separate and sexual dimorphism can be seen. The vocal sacs and nuptial pad can be observed in male frogs in breeding season.

Reproductive System



Reproductive system in frog

Economic Importance of Frog

- They control bugs and help keep the ecosystem in balance.
- They maintain the balance in food chain and food web by acting as consumers.