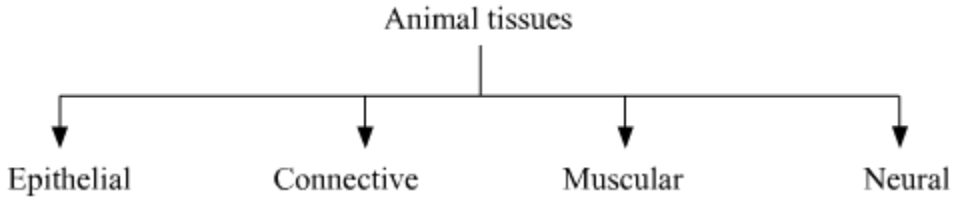
Structural Organisation in Animals

Epithelial Tissues

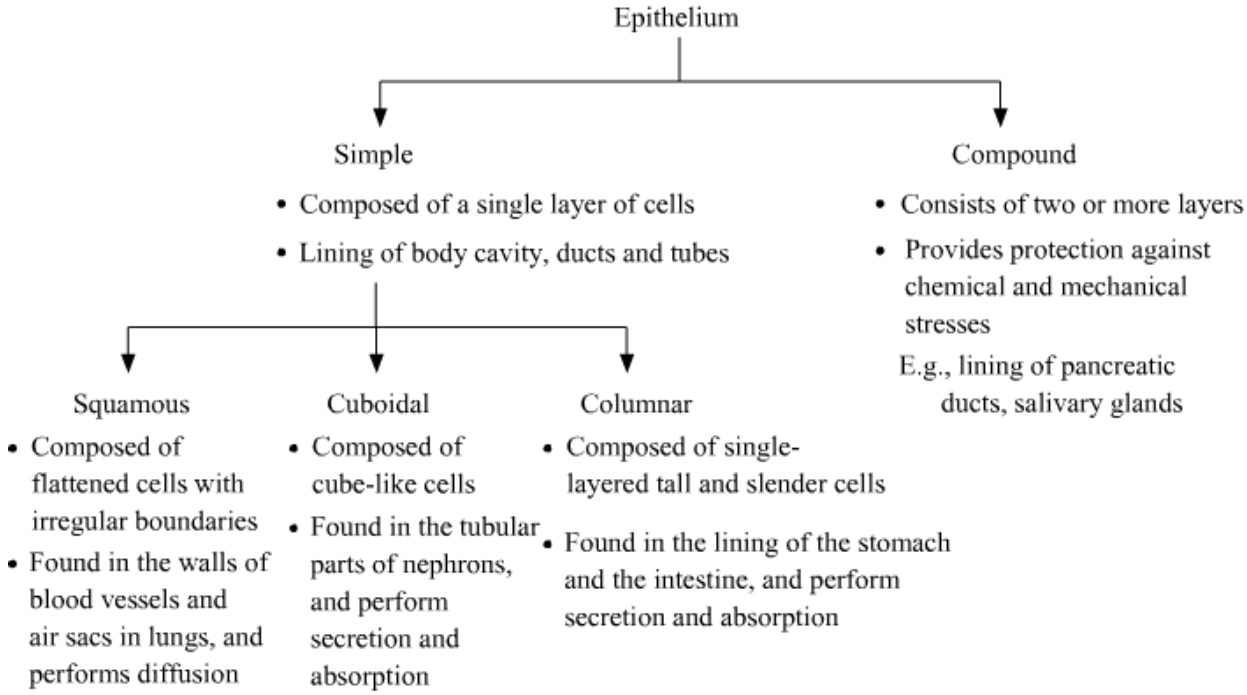
Animal Tissues

Can be classified broadly into:



Epithelial Tissues

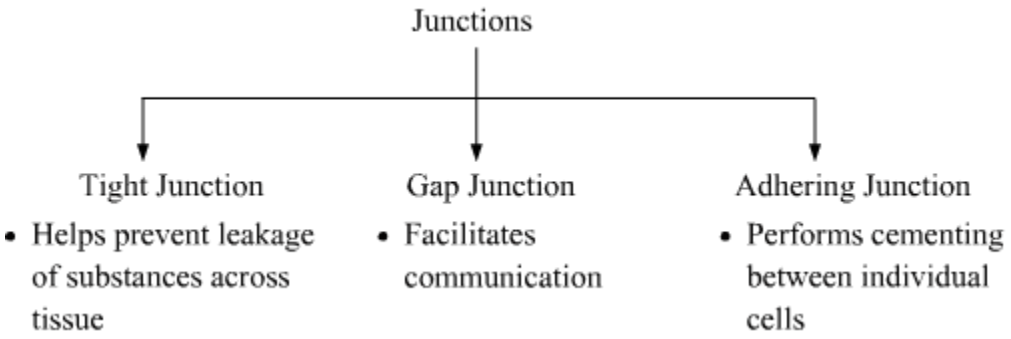
- Cells have free surface, compactly packed and with little intercellular matrix
- Free surface of the tissue faces either the body fluid or the outside environment, and provides covering for some parts of the body.



- **Ciliated epithelium:**
- Here, columnar/cuboidal cells bear cilia on their free surface.

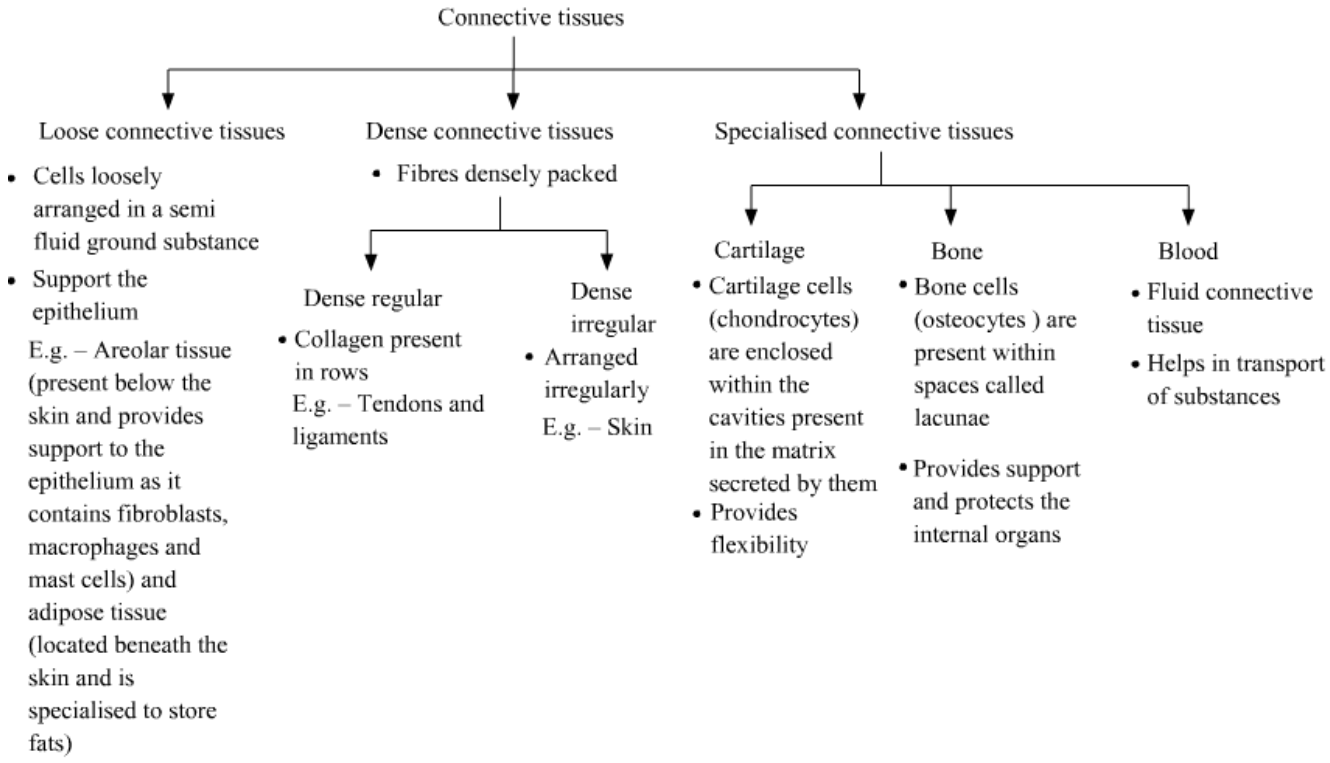
- They help in the movement of particles or mucus in a specific direction over the epithelium.
- Present in the inner surface of bronchioles and fallopian tubes
- **Glandular epithelium:**
- Here, columnar/cuboidal cells become specialised for secretion.
- Two types of glandular epithelium − unicellular (as in goblet cells of the alimentary canal) and multicellular (as in the salivary glands).
- Glands are of two types − endocrine (ductless) and exocrine (release products through ducts).

- All tissues have specialised junctions which provide structural and functional links to individual cells.



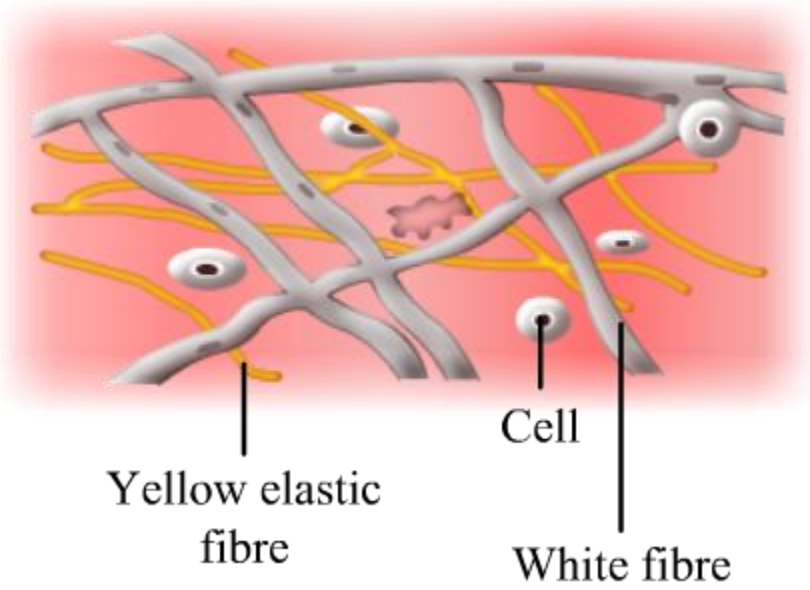
Connective Tissues

- Most abundant tissues present in the human body
- They link or connect other tissues.
- Examples: cartilage, bone, adipose, blood, etc.



Areolar Tissue

It is the most widely distributed connective tissue in the animal body. It consists of transparent, jelly-like matrix which contains numerous fibres and cells.



Mainly two types of fibres are found in the areolar tissue.

- **White fibres:** Very abundant; have very fine and wavy, unbranched structure; made up of collagen protein; inelastic in nature.

- **Yellow fibre:** Fewer in number, are thicker than white fibre and are branched, made up of elastin protein; elastic in nature

Major cells found in areolar tissue are:

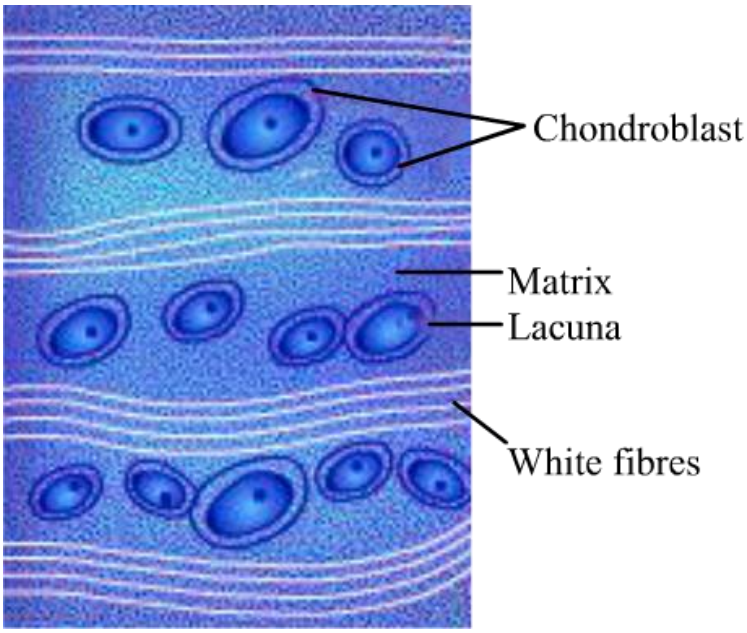
- **Fibroblasts:** These are the principal cells of the areolar tissue. They are usually large, flat, spindle shaped cells with oval nucleus. They are responsible for secreting materials that make up the fibres. The inactive fibroblasts are known as fibrocytes.

- **Macrophages/Histiocytes:** These are large, irregular shaped cells with ovoid nuclei. They are almost as numerous in number as fibroblasts. They play major role in immune system as they engulf the foreign particles, pathogens, and damaged body cells.

- **Mast cells:** These are small oval cells that have large granules in their cytoplasm. They produce important chemicals, heparin and histamine. Heparin helps in preventing blood clotting, while histamine is involved in allergic and inflammatory reactions.

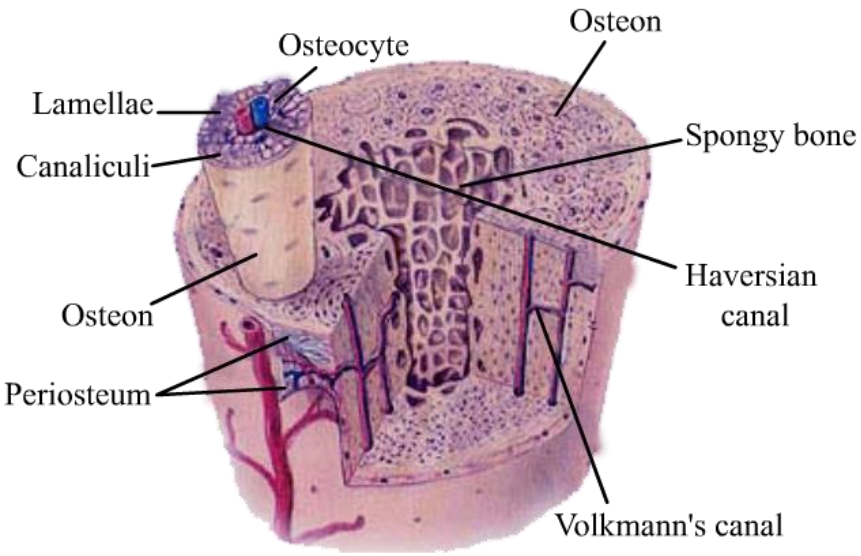
Cartilage

It is a solid, semi-rigid connective tissue, that contains a rubbery matrix of chondrion sulphate. This matrix is secreted by cartilage cells, or chondroblasts. The matrix also contain fibrous layers of white collagen fibres. The chondroblasts are oval shaped cells that contain large nuclei and extensive system of endoplasmic reticulum. A chondroblast lies in a fluid-filled space in the matrix, known as cartilage lacuna.



Bone

Bone is a strong and non-flexible connective tissue. It has a calcified matrix, which makes it the hardest tissue in the body. It is the chief constituent of the skeleton of an animal. It also anchors the muscles and supports the main organs of the body. Its matrix (ossein) is hard due to the presence of inorganic salts of calcium and phosphorus. The osteoblasts (bone cells) are found embedded in this matrix.



Muscular and Neural Fibres

Muscle Fibres

- Each muscle is made of long, cylindrical fibres arranged in parallel arrays, which in turn are composed of fine fibrils called myofibrils.
- Play an important role in movement. They contract in response to stimulation and then relax to return to their original state.

Types of Muscle Fibres

- Skeletal muscle fibre:
- Attached to the skeletal bones and are voluntary
- Skeletal muscle fibres are striated and are bundled together in a parallel manner by a sheath of tough connective tissues.
- Smooth muscle fibres:

- Present in the walls of internal organs such as blood vessels, stomach, etc., and are involuntary
- Smooth muscle fibres are fusiform (taper at both ends) and non- striated. They are held together by cell junctions and are bundled together in a sheath of connective tissues.
- Cardiac muscle fibres:
- Present only in the heart. Contractile in nature and are involuntary.
- Plasma membranes of cardiac cells are fused together by cell junctions, and hence, the cells stick together. Communication junctions present as intercalated discs facilitate the contraction of cardiac cells as a unit.

Neural Fibres

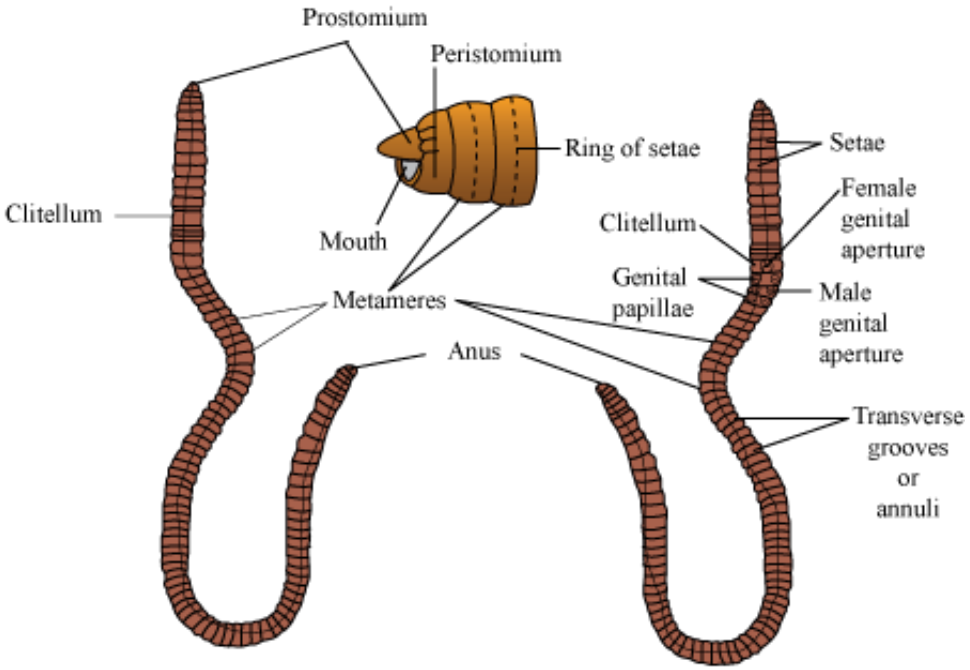
- Nervous system consists of neurons and neuroglial cells.
- Neurons are the basic units of the neural system. These are excitable cells.
- Neuroglial cells protect and support the neurons.
- Electrical disturbance is generated on the stimulation of a neuron. This disturbance travels along the plasma membrane of the neuron.
- When the disturbance reaches the neuron endings, events causing stimulation or inhibition of adjacent neurons are triggered.

Morphologyof the Earthworm

Earthworm

- Reddish brown, terrestrial invertebrate
- Inhabits the upper layer of moist soil
- Lives in burrows made by boring and swallowing the soil
- Can be traced by its worm castings (faecal deposits)
- Common Indian earthworms are *Pheretima* and *Lumbricus*

Morphology



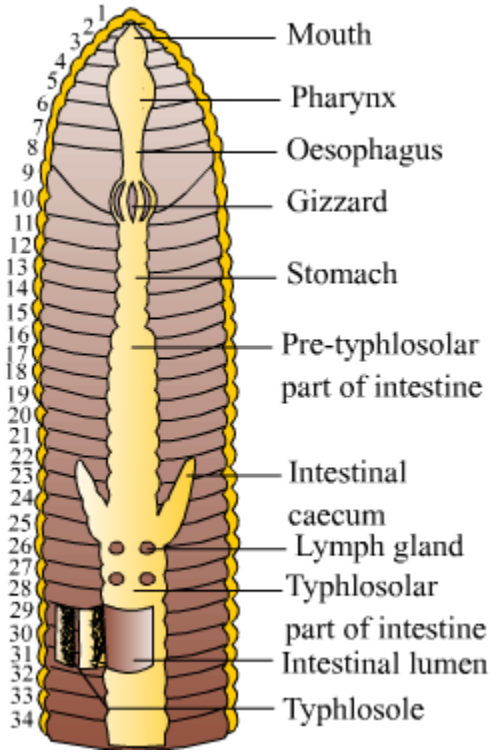
- Long cylindrical body
- Body divided into a number of (100−120) similar short segments called **metameres**.
- Dorsal surface has dark, median, mid dorsal line (dorsal blood vessel) along the longitudinal axis
- Ventral surface has genital pores
- Anterior end has the mouth and **prostomium** (covers the mouth and helps to break soil); prostomium is sensory in function
- **Peristomium**: First body segment, consisting of the mouth
- **Clitellum**: Dark band of glandular tissue that covers segments 14 to 16 of the earthworm. It divides the body into three distinct segments −
- **Preclitellar**: 1st to 14th segments. In this portion, 5th to 9th segments have four pairs of spermathecal apertures.
- **Clitellar**: 14th to 16th segments. This portion is characterised by the presence of a single female genital pore in the 14th segment.
- **Postclitellar**: 17th segment onwards. This portion has a pair of male genital pores in the 18th segment.

- Each segment—except the 1st segment, the 14th to 16th segments and the last segment—has rows of **setae** (S-shaped), which can be extended or retracted; used in locomotion
- Numerous minute pores called **nephridiopores** are present all over the body surface.

Anatomy of the Earthworm

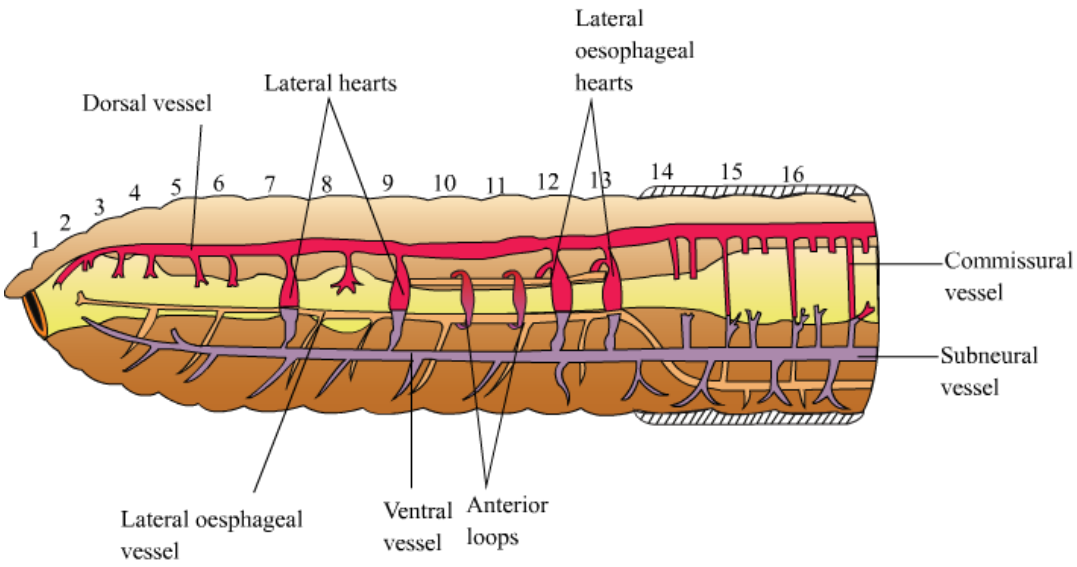
- Body wall is covered by an **external cuticle**
- Below the cuticle is the:
- Epidermis (single layer of columnar epithelium; contains secretory gland cells)
- Two muscle layers (circular and longitudinal)
- Innermost coelomic epithelium

Digestive System of the Earthworm



Food	Decaying leaves, organic matter mixed with soil
Mouth	Terminal
1st - 3rd segments	Muscular Pharynx and Buccal cavity
5th - 7th segments	Oesophagus
8th - 9th segments	Muscular gizzard grinds the food
9th - 14th segments	Stomach (calciferous glands in the stomach neutralise humic acid of humus)
15th segment to the last segment	Intestine
26th segment	A pair of short conical intestinal caecae
26th - 35th segments	Typhlosole (median fold of the dorsal wall); increase the surface area for effective absorption
Last segment	Anus

Circulatory System



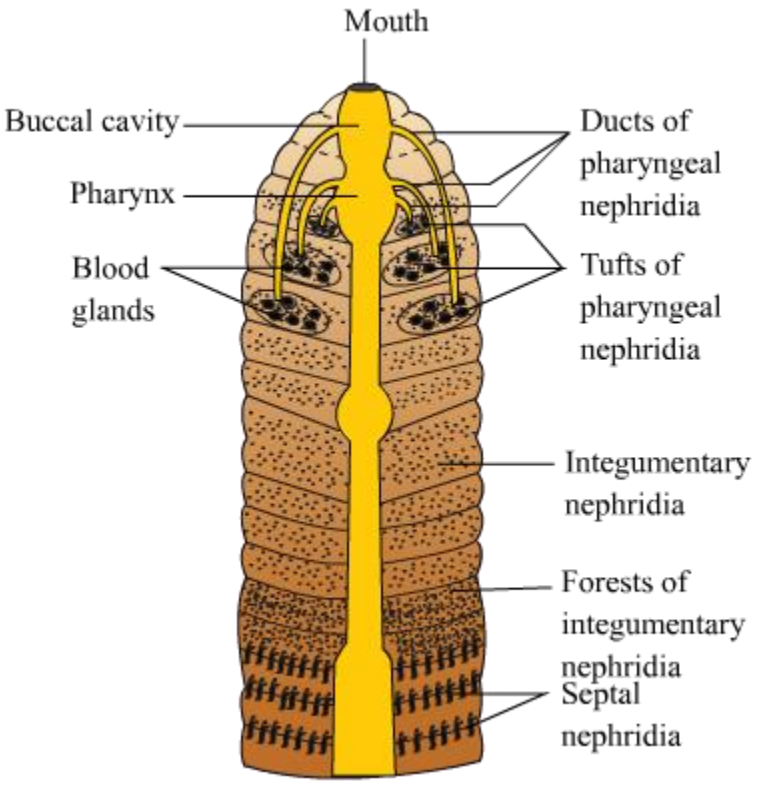
- **Closed type** of circulatory system

- Contractions of blood vessels keep the blood circulating in one direction.
- Smaller blood vessels supply blood to the gut, nerve cord and body wall.
- The 4th, 5th and 6th segments have **blood glands** (produce blood cells and haemoglobin).
- Blood cells are phagocytic in nature.

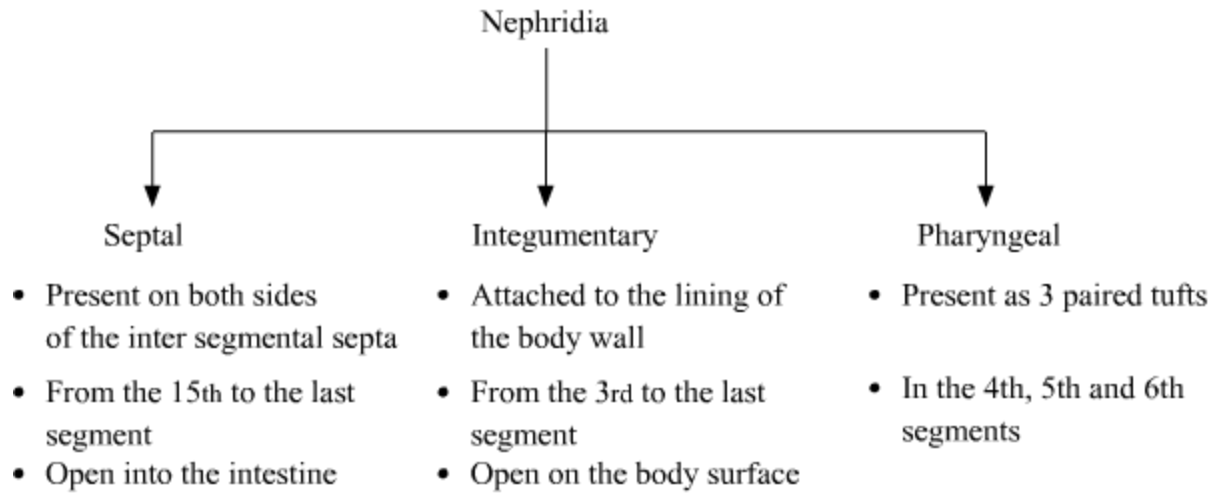
Respiratory System

- Earthworm **lacks specialised organs** for gaseous exchange.
- Exchange takes place through the moist body surface.

Excretory System



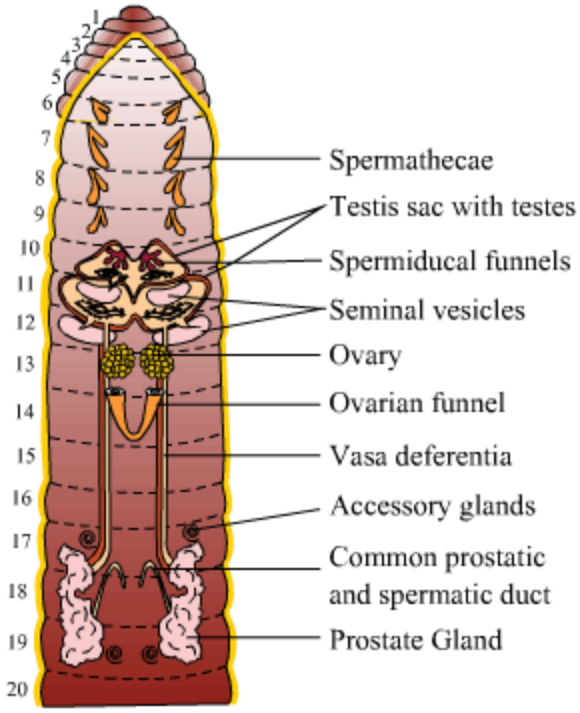
- Segmentally arranged coiled tubules called **Nephridia** (start as funnels and collect excess fluid) are present as excretory organs.
- Regulate volume and composition of body fluids



Nervous System

- Represented by **ganglia**, which are arranged segmentwise on the ventral-paired nerve cord
- The **nerve cord** in the anterior region (3rd and 4th segments) bifurcates and joins the cerebral ganglia to form a **nerve ring**.
- Cerebral ganglia and other nerves:
- Integrate sensory input
- Command muscular responses of the body
- Earthworms lack eyes, but do posses light and touch-sensitive organs.
- Have specialised chemoreceptors (taste receptors) which react to chemical stimuli
- Sense organs are located on the anterior part of the body.

Reproductive system



Reproductive system of Earthworm

6th and 9th segments	Receive and store spermatozoa during copulation; have 4 paris of spermathecae
10th and 11th segments	Two pairs of testes
11th and 18th segments	Vasa deferentia; join the prostatic duct
17th and 19th segments	Two pairs of accessory glands
18th segment	common prostatic and spermatic duct; a pair of genital pores present on the ventro-lateral side

Female Reproductive System

12th and 13th segments	A pair of ovaries
12th and 14th segments	Ovarian funnels present below the ovaries continue into oviduct
14th segment	Oviduct opens on the ventral side as a single median female genital pore

Reproduction

Mating	Mutual exchange of sperms between two worms
Fertilisation	External; takes place inside the cocoon; sperm and egg deposited inside the cocoon
Development period	About 3 weeks; cocoon produces 2 to 20 worms; development is direct, i.e., no larval stage

Vermicomposting

- The process of increasing fertility of soil by the earthworms is called vermicomposting.
- Earthworms are called “friends of farmers”.
- Make burrows in soil
- Make the soil porous, thereby helping the developing plant root to respire, and penetrate the soil
- Hence, increases the fertility of soil

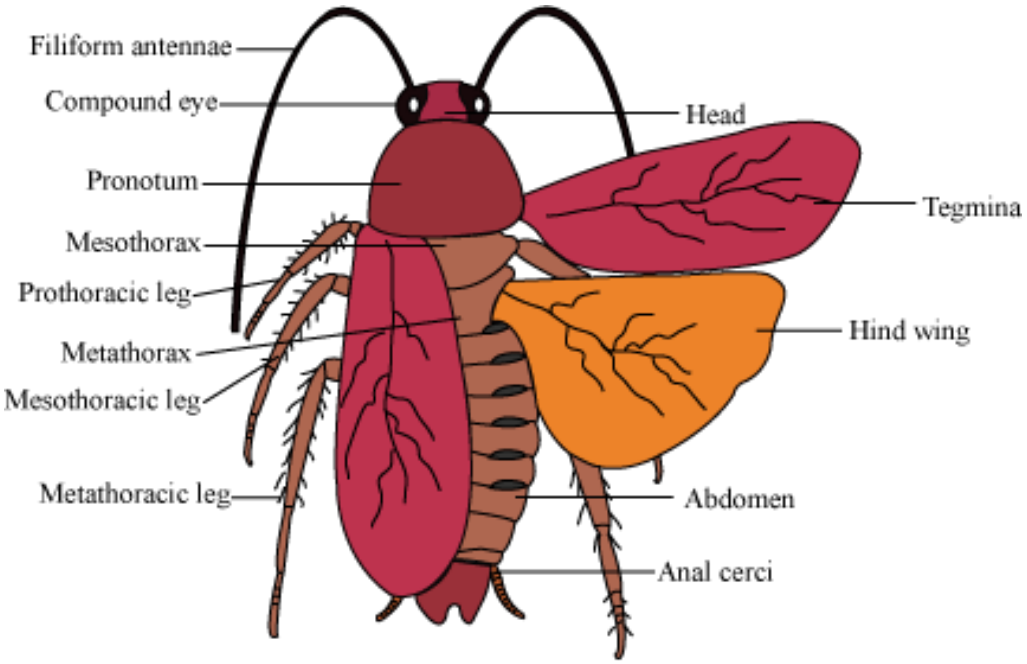
Morphology of the Cockroach

Belongs to:

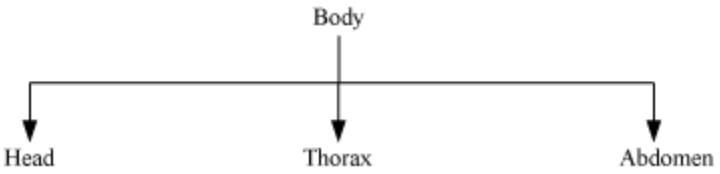
Phylum	Arthropoda
Class	Insecta
Genus	*Periplaneta*
Species	*americana*

- Brown or black-bodied animals.
- Size ranges from 0.6 cm to 7.6 cm
- Nocturnal; omnivores; live in damp places
- Have long antennae; flat extension of upper body wall that conceals the head
- Serious pests and vectors of several diseases

Morphology



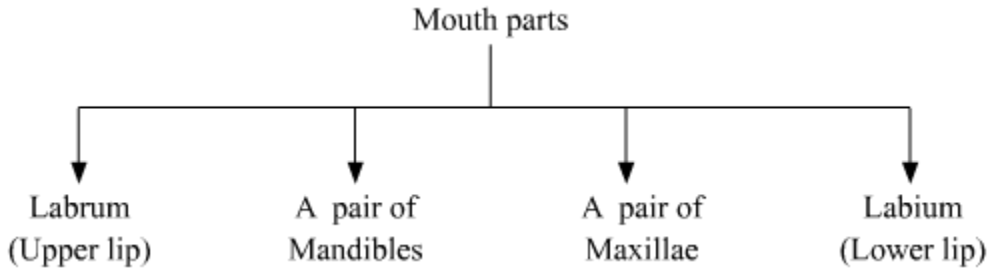
- Adults 34−53 mm long; wings extend beyond the tip of the abdomen in males
- **Body segmented**; covered by **chitinous exoskeleton** (brown-coloured)
- At each segment, the exoskeleton has **sclerites** (hardened plates). Sclerites are called **tergites** dorsally and **sternites** ventrally.
- Sclerites are joined by arthrodial membrane (thin and flexible articular membrane)



Head

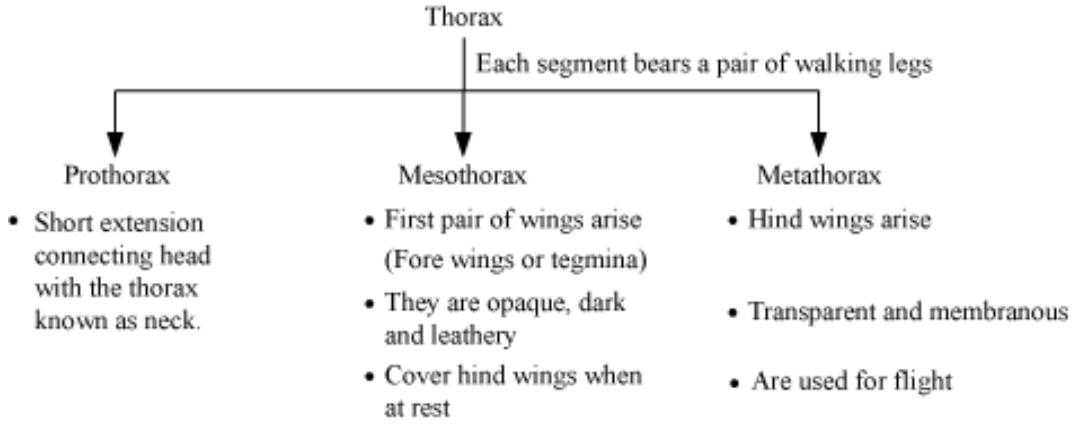
- Triangular shape
- Lies anteriorly at right angles to the body axis

- Formed by the fusion of 6 segments
- Shows great mobility in all directions due to a flexible neck
- Head capsule contains:
- A pair of thread-like **antennae** (sensory)
- A pair of **compound eyes**
- Biting and chewing type of mouthparts are formed by appendages present on the anterior part of the head.



- Tongue (hypopharynx) lies within the cavity enclosed by the mouth parts.

Thorax



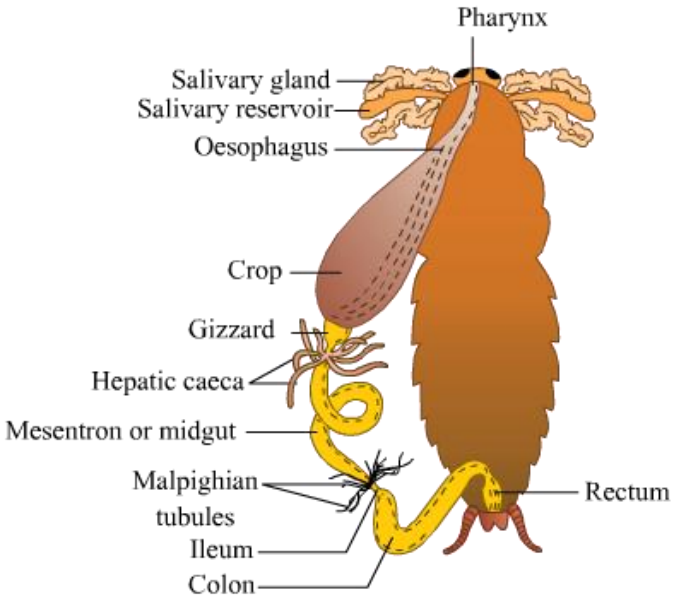
Abdomen

- Present in both males and females; contains 10 segments
- In females:
- 7^{th} sternum; boat-shaped
- The 7^{th}, 8^{th} and 9^{th} sterna form the **genital pouch** (brood).

- Anterior part of genital pouch contains gonopore, spermathecal pores and collateral glands.
- In males:
- Genital pouch lies at the hind part of the abdomen
- Genital pouch is bounded dorsally by the 9th and 10th terga, and ventrally by the 9th sternum.
- Genital pouch contains dorsal anus, ventral male genital pore and gonapophysis.
- Bear a pair of short, thread-like **anal styles** which are not present in females
- In both sexes, the 10th segment has a pair of jointed, filamentous **anal cerci**.

Anatomy of the Cockroach

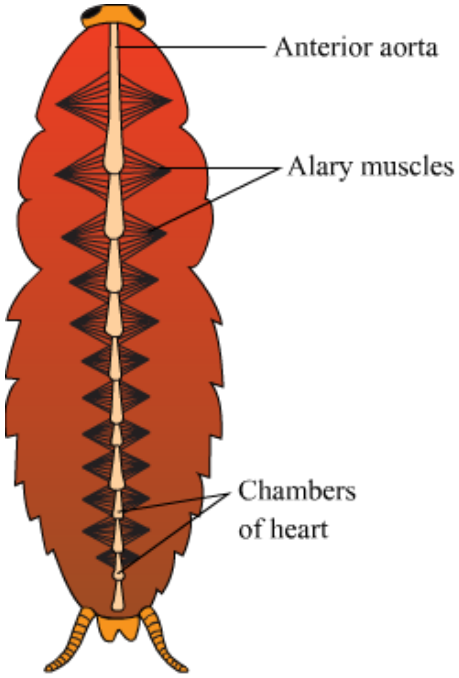
Digestive System



- The alimentary canal is divided into:
- Foregut
- Midgut
- Hindgut

- Foregut:
- Is lined by a **cuticle**
- Consists of a mouth which opens into the tubular pharynx, leading into the oesophagus, which further opens into a sac-like **crop** that stores the food
- The crop leads to a **gizzard** (proventriculus). The gizzard helps in grinding food as it has an inner layer with six chitinous teeth.
- The junction of the foregut and midgut has rings of 6 to 8 blind tubules called **hepatic or gastric caecae**, which secrete digestive juices.
- The hindgut is broader than the midgut, and consists of:
- Ileum
- Colon
- Rectum (opens out through the anus)

Circulatory System



- Cockroach has an **open type** of circulatory system.
- Poorly developed blood vessels which open into the **haemocoel**

- Organs located in the haemocoel bathed by blood (**haemolymph**)
- Haemolymph = Colourless plasma + Haemocytes
- Heart consists of an elongated muscular tube along the mid-dorsal line of the thorax and the abdomen.
- Differentiated into funnel-shaped chambers, with ostia on each side

Flow of Blood: Sinuses → Ostia → Heart → Sinuses

Respiratory System

- Consists of a network of trachea, which opens through 10 pairs of small holes called **spiracles**
- Spiracles are present on the lateral side of the body.
- Opening of the spiracles is regulated by sphincters.
- Tracheal tubes are subdivided into tracheoles which carry oxygen to all parts.
- Exchange takes place in the tracheoles by **diffusion**.

Excretory System

- Excretion: Performed by yellow-coloured **Malpighian tubules** (100−150)
- Location: At the junction of the hindgut and the midgut
- Each tubule is lined by glandular and ciliated cells.
- Cockroach is **uricotelic**.
- Fat body, nephrocytes and urecose glands also help in excretion.

Nervous System

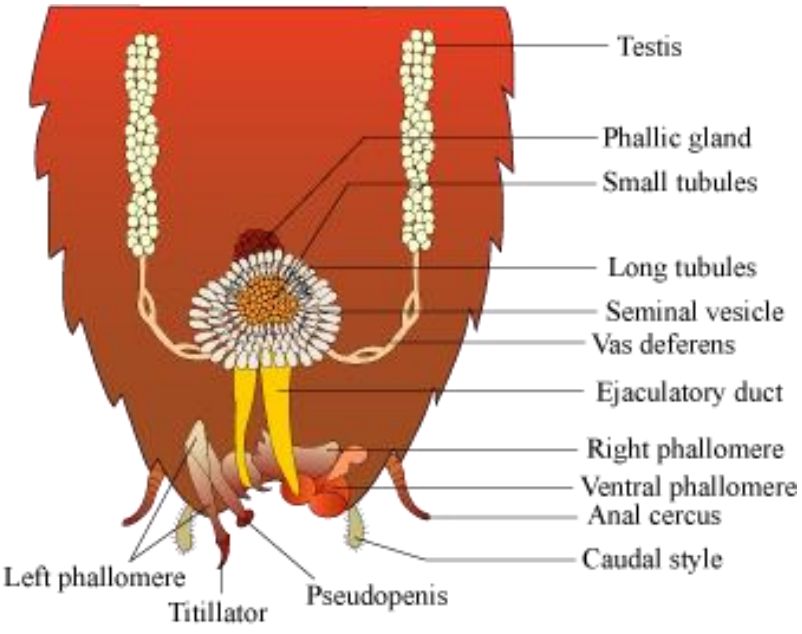
- Consists of a series of fused segmentally arranged **ganglia** (joined by paired longitudinal connectives on the ventral side).
- Three ganglia lie in the thorax and six in the abdomen
- Spreads throughout the body, with the head holding just a bit of the nervous system

- In the head, the **brain** is represented by the **supra-oesophageal ganglion** which supplies nerves to the antennae and the compound eyes.
- Sense organs:
- Compound eye − composed of 2000 hexagonal **ommatidia** (cockroach has **mosaic vision** and is nocturnal)
- Antennae
- Maxillary palps
- Labial palps
- Anal cerci

Reproductive System

- Cockroaches are **dioecious**
- Both sexes have well-developed reproductive organs

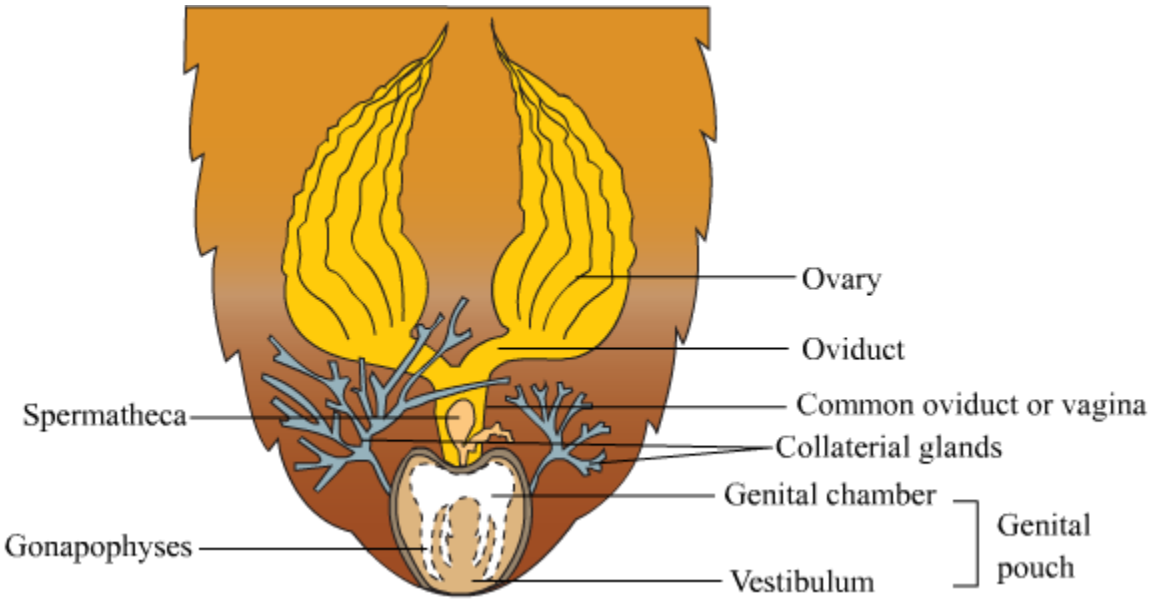
Male Reproductive System



- Consists of:
- A pair of testes; one each on the lateral side of the 4th, 5th and 6th abdominal segments

- Vas deferens arises from each testis.
- Vas deferens opens into the ejaculatory duct through the seminal vesicle.
- Ejaculatory duct opens into the male gonopore.
- A characteristic accessory reproductive gland (mushroom-shaped) is present in the 6th to 7th abdominal segments.
- The male **gonapophysis** represents the external genitalia.
- Sperms are stored in the seminal vesicles; glued together in bundles called spermatophores and discharged during copulation

Female Reproductive System



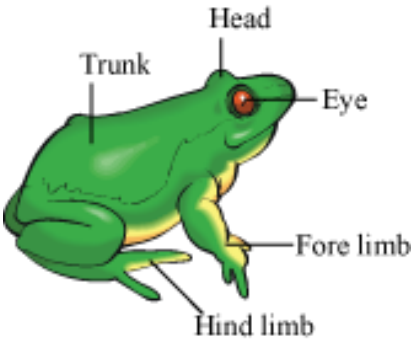
- Consists of:
- Two large ovaries − formed by a group of 8 **ovarioles**; contain chains of developing ova
- Ovary lies laterally in the 2nd to 6th abdominal segments.
- Oviducts of each ovary unite into a single median oviduct (vagina).
- Vagina opens into the genital chamber.
- A pair of spermathecae is present in the 6th segment.

- Fertilisation
- Sperms are transferred through spermatophores.
- Fertilised egg is encased in capsules called **oothecae** (Dark brown in colour)
- Female produces 9−10 oothecae with 14−16 eggs.
- Development is **paurometabolous** (means passing through nymphal stage). Nymphs look like adults and grow up to 13 times by moulting to reach the adult form.

Morphology of the Frog

Belongs to:

Phylum	Chordata
Class	Amphibia
Genus	*Rana*
Species	*tigrina* (in India)

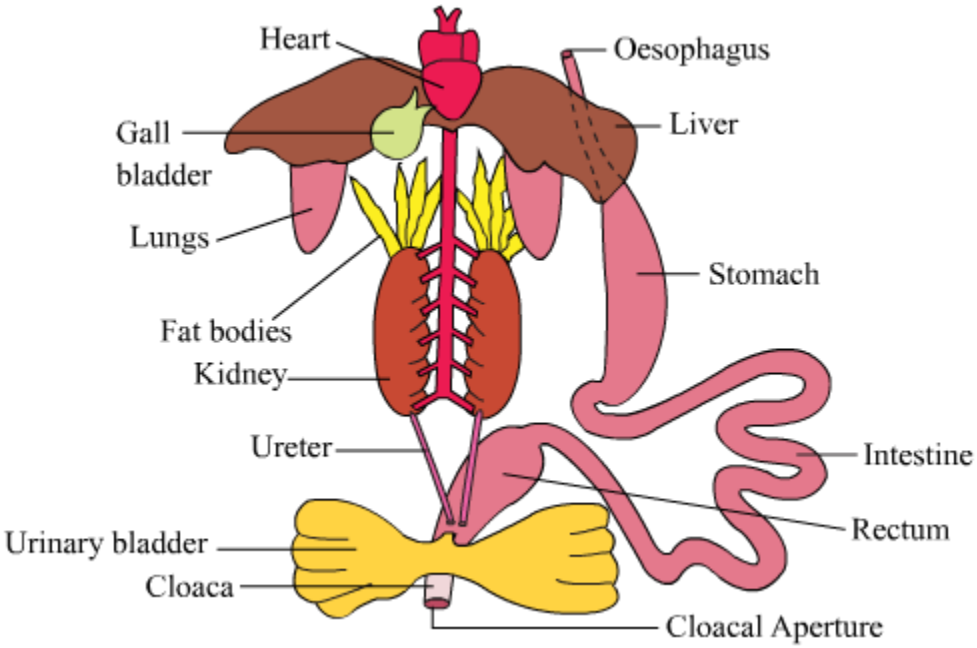


- Body of a frog is divisible into **head** and **trunk.**
- Neck and tail are not present in adults.

- A pair of nostrils is present above the mouth.
- Eyes are bulged and covered by **nictitating membrane**.
- **Tympanum** represents the ear.
- The limbs help in walking, leaping, burrowing and swimming.
- The hind limb (having 5 digits) is larger than the fore limb (having 4 digits).
- **Male** frog has sound producing **vocal sacs** and also a **copulatory pad** on the first digit of the fore limbs (not present in the female).
- Skin is always moist due to the presence of mucus. Frog never drinks water, but absorbs it through its skin.

Anatomy of the Frog

Digestive System



- The mouth opens into the buccal cavity; food is captured by the bilobed tongue.
- Leads into the oesophagus, through the pharynx
- Oesophagus is short and opens into the stomach.

- Liver secretes bile, and pancreas secretes pancreatic juice containing digestive enzymes.
- Digestion starts in the stomach by the action of HCl.
- Partially digested food (chyme) is passed on to the duodenum where it is acted upon by bile juices and pancreatic juices, and further broken down into simpler substances.
- Digested food is absorbed by the numerous finger-like folds called villi and microvilli in the inner wall of the intestine.
- The undigested solid waste moves into the rectum, and passes out through the cloaca.

Respiratory System

- Frogs can respire on land as well as in water.
- In water, they respire through the skin by diffusion (**cutaneous respiration**)
- On land, the buccal cavity, skin and lungs act as respiratory organs. (**pulmonary respiration**)
- The lungs are a pair of pink-coloured, sac-like organs present in the upper part of the trunk region (thorax).
- Air enters through the nostrils, passes into the buccal cavity, and then into the lungs.
- During aestivation and hibernation, respiration is cutaneous.

Circulatory System

- **Closed** and well developed
- It has a **lymphatic system also**; consisting of lymph, lymphatic vessels and lymph nodes
- The heart is **three-chambered** (2 atria and 1 ventricle). It is covered by pericardium.
- **Sinus venosus**: Triangular structure that joins the right atrium and receives blood through the major veins called the vena cava
- **Conus arteriosus**: Sac-like structure in which ventricle opens
- Circulatory system consists of separate arterial system and venous system.

- Special **venous connections** are also present between different parts of the body:
- Hepatic portal system − connects liver and intestine
- Renal portal system − connects kidney and lower parts of the body
- The blood is composed of RBCs, platelets, plasma and WBCs.
- Circulation is achieved by the pumping action of the heart.

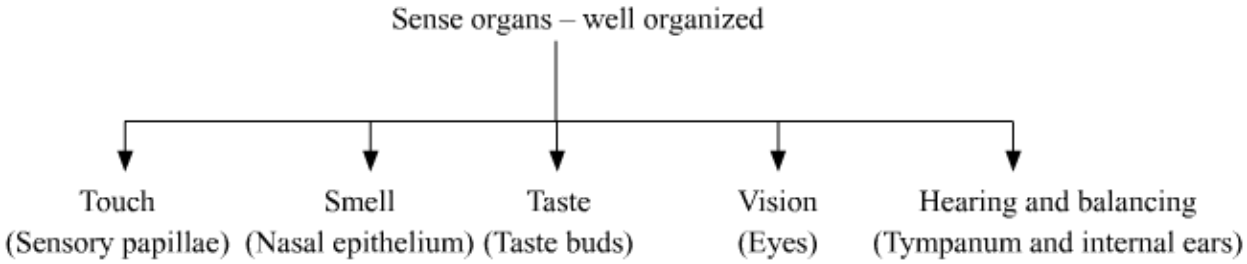
Excretory System

- Consists of:
- A pair of **kidneys**; composed of **uriniferous tubules** (nephrons)
- **Ureters** arise from the kidneys; in males ureters act as urinogenital ducts, opening into the **cloaca**
- **Urinary bladder** present ventral to the rectum which also opens in the cloaca
- In females, the ureters and oviduct open separately into the cloaca
- Frogs are **ureotelic** since they excrete urea.

Nervous System

- Nervous system is organised into:
- Central nervous system (brain and spinal cord)
- Peripheral nervous system (cranial and spinal nerves)
- Autonomic nervous system (sympathetic and parasympathetic)
- There are **10 pairs of cranial nerves** arising from the brain
- Brain is enclosed in the **brain box (cranium)**.
- Brain is divided into:
- **Forebrain** − Olfactory lobes, paired cerebral hemispheres and unpaired diencephalon
- **Mid brain** − A pair of optic lobes

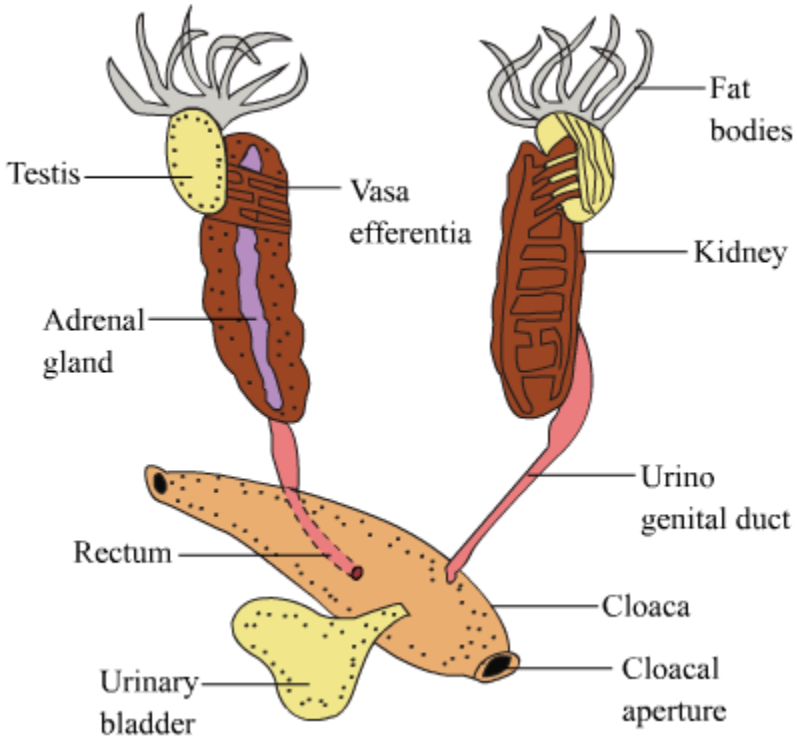
- **Hind brain** − Cerebellum and medulla oblongata (continues into the spinal cord; enclosed in the vertebral column)



Reproductive System

- Have well-organised male and female reproductive systems

Male Reproductive System



- Consists of a pair of yellowish, ovoid testes
- Testes adhered to the kidneys by **mesorchium** (double fold of peritoneum)
- Vasa efferentia (10−12) arise from the testes, enter the kidney on their side, and open into **Bidder's canal**.

- Bidder’s canal opens into the cloaca; passes out faecal matter, urine and sperms to the exterior

Female Reproductive System

- Includes a pair of ovaries, situated near the kidneys
- A pair of oviduct arises from the ovaries and opens into the cloaca separately.
- A mature female produces 2500−3000 ova at a time.
- **Fertilisation is external** and takes place in water.
- **Development is indirect** (passes through the larval stage called the tadpole)