



STRUCTURAL ORGANISATION IN ANIMALS

Chapter: - 7th



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STRUCTURAL ORGANISATION IN ANIMALS

Topics of the chapter: -

- Animal Tissues
- Organ and OrganSystem
- Earthworm
- Cockroach
- Frogs

1. Animal Tissues: -

The structure of the cells varies according to their function. Therefore, the tissues are different and are broadly classified into four types:

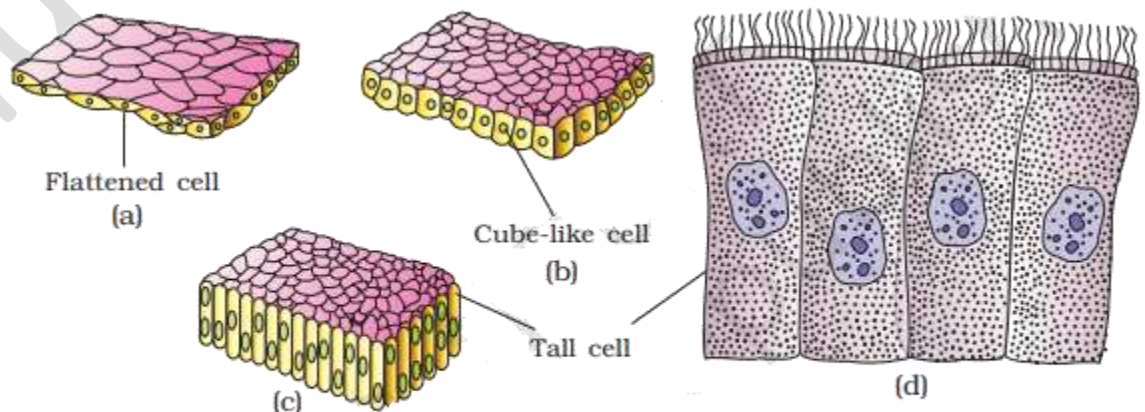
- (a) Epithelial
- (b) Connective
- (c) Muscular and
- (d) Neural.

I. Epithelial Tissue (Epithelium)

- Covering or lining for parts of the body.
- Compact cells; minimal intercellular matrix.
- Types:

1. Simple Epithelium:

- Single cell layer.
- Lining for cavities, ducts, tubes.
- Types based on structure:



Simple epithelium: (a) Squamous (b) Cuboidal (c) Columnar
(d) Columnar cells bearing cilia

a. Squamous:

- Single, thin layer; irregular boundaries.
- Found in blood vessels, air sacs of lungs.
- Function: diffusion boundary.

b. Cuboidal:

- Cube-like cells.
- Found in gland ducts, kidney nephrons.
- Functions: secretion, absorption.

c. Columnar:

- Tall, slender cells; nuclei at base.
- Found in stomach, intestine linings.
- Functions: secretion, absorption.

• **Special types:**

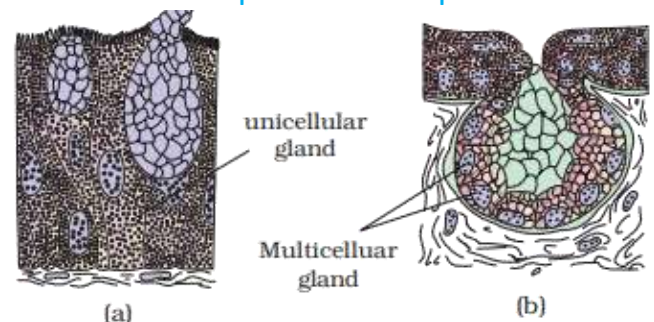
i. Ciliated: when columnar or cuboidal cells having cilia on their free surface or having hair like protoplasmic outgrowths on their surface. They are known as ciliated epithelium.

Function: Move particles/mucus; in bronchioles, fallopian tubes.

ii. Glandular: The cuboidal or columnar cells are specialised for secretion; either unicellular (goblet cells) or multicellular (salivary glands).

d. Glandular epithelium is a type of epithelial tissue that is specialized to produce and secrete substances. It is the epithelial component of glands. Here's a brief overview of the glandular epithelium:

Function: The primary function of the glandular epithelium is secretion. This secretion can be mucus, hormones, enzymes, or other products.

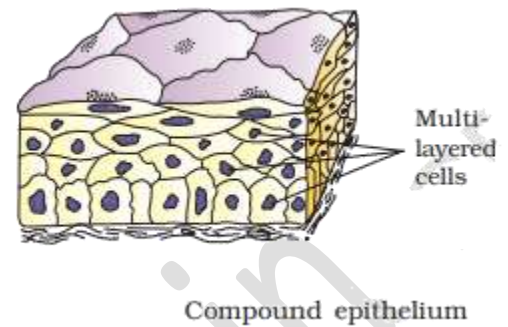


Glandular epithelium : (a) Unicellular
(b) Multicellular

- **Unicellular:** The most common example is the goblet cell, which secretes mucus. They are scattered among other types of cells within an epithelium.
- **Multicellular:** These are more complex and can be further classified based on the structure of their ducts and the morphology of their secretory units. For instance:
 - Tubular vs. Alveolar (or Acinar) based on the shape of the secretory unit.
 - Simple vs. Compound based on whether they have a single duct or a branching duct system.

2. Compound Epithelium:

- Multi-layered.
- Limited in secretion/absorption.
- Function: Protection (from chemical/mechanical stresses).
- Locations: Skin, buccal cavity, salivary & pancreatic ducts.
- Based on secretion mode:
Glands are divided into two categories: exocrine and endocrine.



1. Exocrine:

- Secretes products like mucus, saliva, enzymes.
- Released via ducts.

2. Endocrine:

- Secretes hormones.
- Directly into surrounding fluid; no ducts.

Cell Junctions

- Provide structural and functional links.
- Types:
 1. **Tight Junctions:** Prevent leakage across tissue.
 2. **Adhering Junctions:** Cement neighbouring cells together.
 3. **Gap Junctions:** These are the specialized structures that allow cells to communicate with each other. Connect cytoplasm for rapid transfer (ions, molecules).

II. Connective Tissue

- Primary function: Support and bind other tissues.
- Distinguished by a large amount of extracellular matrix compared to cell content.

Components:

1. Cells:

- **Fibroblasts:** Produce fibers and ground substance.
- **Macrophages:** Scavenger cells; immune defense.
- **Mast Cells:** Involved in inflammation.
- **Leukocytes:** White blood cells.
- **Plasma Cells:** Produce antibodies.
- **Adipocytes:** Store fat.

2. Fibers:

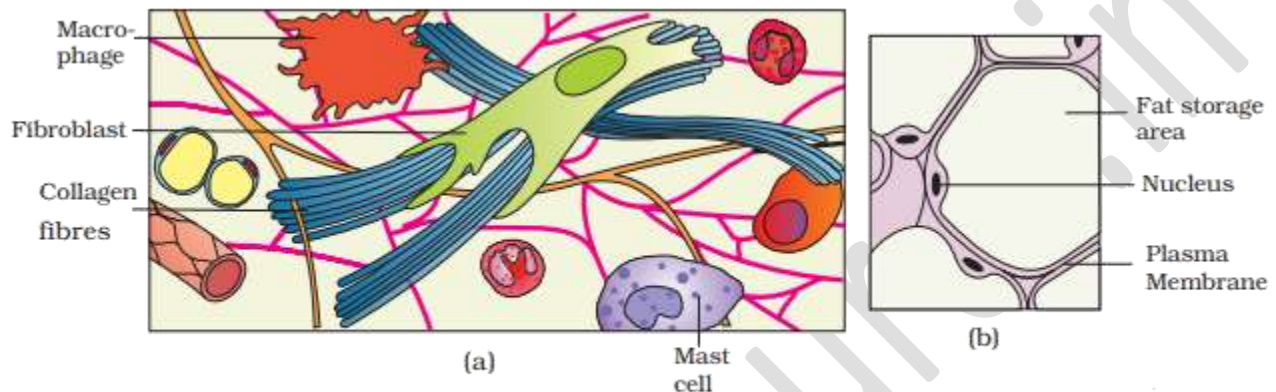
- **Collagen Fibers:** Strongest and most abundant; provides tensile strength.
- **Elastic Fibers:** Long, thin fibers that allow stretch.

- **Reticular Fibers:** Fine, short collagen fibers; branch forming networks.
3. **Ground Substance:** Unstructured material that fills spaces between cells and fibers.

Types of Connective Tissue:

a. Loose Connective Tissue:

It consists of cells and fibres which are loosely arranged in a semifluid ground substance. For example:



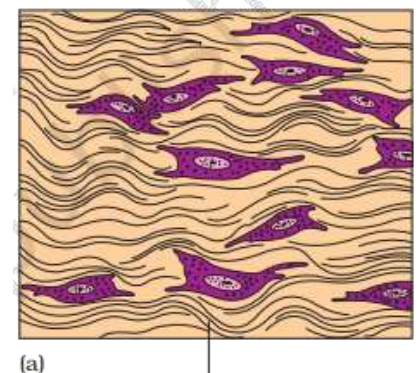
Loose connective tissue : (a) Areolar tissue (b) Adipose tissue

- **Areolar:** Supports and binds tissues; contains fibroblasts, macrophages, mast cells.
- **Adipose:** Stores fat; insulates and cushions.
- **Reticular:** Provides framework for lymphatic tissues.

b. Dense Connective Tissue:

It contains compactly packed fibres and fibroblasts.

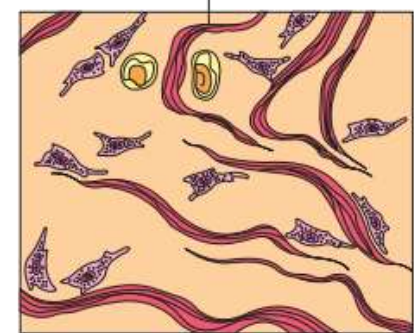
- **Dense Regular:** Tightly packed, parallel collagen fibers; found in tendons and ligaments.
- **Dense Irregular:** Randomly arranged collagen fibers; provides strength in multiple directions; found in dermis of skin.
- **Elastic:** Dense with high proportion of elastic fibers; found in the walls of large arteries and airways.



(a)

Collagen fibre

skin.



(b)

Dense connective tissue:
(a) Dense regular
(b) Dense irregular

(i) **Types:** There are three primary types of cartilage:

- **Hyaline Cartilage:** This is the most common type found in the

body. It's smooth and translucent and is found in areas like the tip of the nose, trachea, larynx, and the ends of bones where they form joints.

- **Fibrocartilage:** This type of cartilage is tougher and contains more collagen fibers. It's found in areas that need to withstand pressure and tension, such as the intervertebral discs and the menisci in the knee.
- **Elastic Cartilage:** This cartilage is more flexible than the other types and contains elastin fibers. It's found in the external ear and the epiglottis.

(ii) **Functions:** Cartilage has several functions in the body:

- **Support:** Provides support to bodily structures while being less rigid than bone.
- **Friction and Cushioning:** Found at joint surfaces, cartilage reduces friction between bones and absorbs shocks.
- **Growth and Development:** During development, bones often start as cartilage and are replaced by bone in a process called endochondral ossification.

d. **Bones: -**

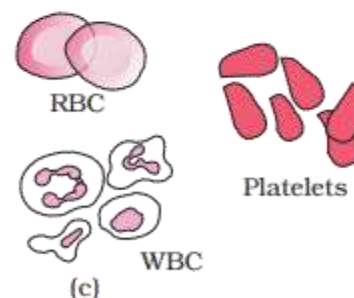
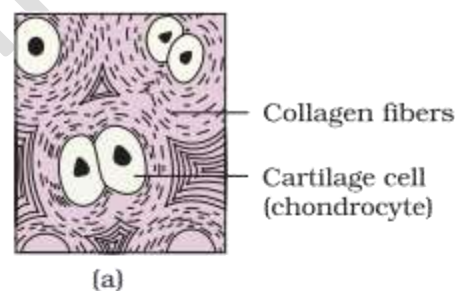
Composition: Bones are composed of both organic and inorganic components. The organic component consists mainly of collagen fibers, which provide flexibility and tensile strength. The inorganic component is primarily hydroxyapatite, a mineral compound of calcium and phosphate, which gives bones their hardness.

1. **Types of Bones:** There are two primary types of bone tissue:

- **Compact Bone:** This is the dense outer layer of bone that forms a protective and supportive structure. It is hard and provides strength.
- **Spongy (Cancellous) Bone:** Found inside compact bone, spongy bone is porous and consists of a network of trabeculae. It is less dense and provides space for bone marrow and blood vessels.

2. **Functions:**

- **Support:** Bones provide the framework and structural support for the body, allowing us to stand, move, and maintain our shape.



Specialised connective tissues : (a) Cartilage (b) Bone (c) Blood

- **Protection:** Bones protect vital organs. For example, the skull protects the brain, and the ribcage protects the heart and lungs.
 - **Movement:** Muscles attach to bones via tendons, allowing the contraction of muscles to produce movement at joints.
 - **Storage:** Bones act as a reservoir for minerals such as calcium and phosphorus, which can be released into the bloodstream when needed for various bodily functions.
 - **Blood Cell Production:** The bone marrow, found in the cavities of certain bones, is responsible for producing red blood cells, white blood cells, and platelets in a process called hematopoiesis.
- e. **Blood:** Red & white blood cells in a fluid matrix (plasma); transports respiratory gases, nutrients, and wastes.
- f. **Lymph:** Contains white blood cells; drains into the veins of the cardiovascular system.

Functions:

- Physical protection (bones, skull).
- Support and structural framework (skeleton).
- Binding of structures (ligaments bind bone to bone, tendons bind muscle to bone).
- Storage (bones store calcium and fat).
- Transport (blood carries oxygen, nutrients, and waste).
- Immune protection (white blood cells, antibodies).

Connective tissues provide a wide range of functions and are integral to the structure and function of the body. They vary greatly in vascularity, from the avascular cartilage to the highly vascularized bone. The fibers and cells embedded in the ground substance give each type of connective tissue its unique properties.

III. Muscle Tissue

Major Characteristics:

1. **Excitability:** Ability to respond to a stimulus.
2. **Contractility:** Ability to shorten and generate force.
3. **Extensibility:** Ability to be stretched or extended.
4. **Elasticity:** Ability to return to its original shape after being stretched.

Types of Muscle Tissue:

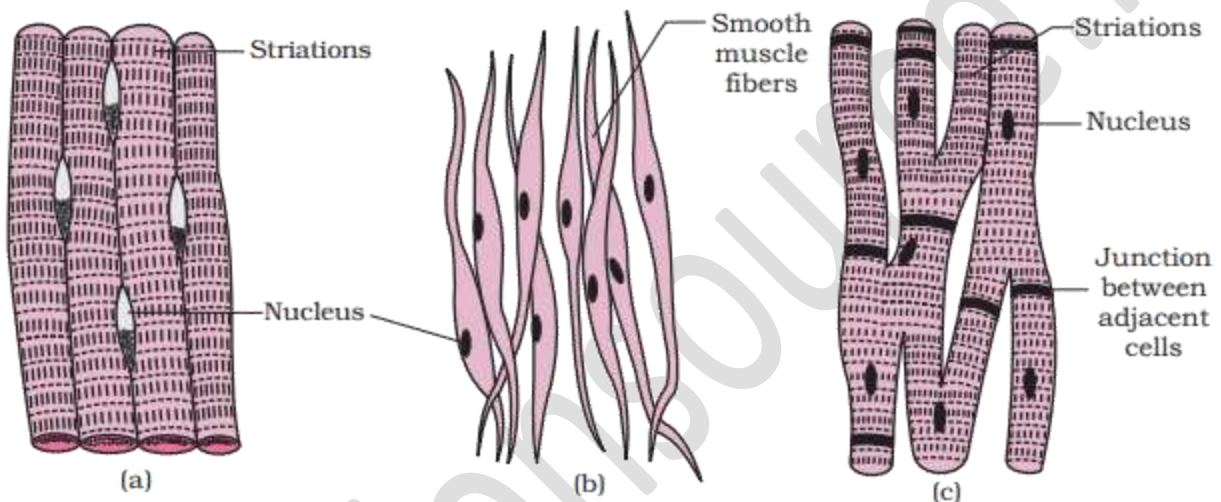
1. Skeletal Muscle:

- **Location:** Attached to bones by tendons.

- **Structure:** Long, cylindrical cells (fibers) with multiple nuclei; visible striations (bands).
- **Function:** Produces voluntary movements; controlled consciously.
- **Other features:** Contracts rapidly, tires easily, and can exert great force.

2. Smooth Muscle:

- **Location:** Walls of hollow organs (e.g., stomach, blood vessels, intestines).
- **Structure:** Spindle-shaped cells with a single nucleus; no striations.
- **Function:** Involuntary control; propels substances (e.g., food, urine) along internal passageways.
- **Other features:** Can sustain prolonged contractions and doesn't tire easily.



Muscle tissue : (a) Skeletal (striated) muscle tissue (b) Smooth muscle tissue
(c) Cardiac muscle tissue

3. Cardiac Muscle:

- **Location:** Walls of the heart.
- **Structure:** Branching cells with a single nucleus, striations, and intercalated discs (unique junctions).
- **Function:** Pumps blood; involuntary control.
- **Other features:** Contracts at a steady rate set by the heart's pacemaker, influenced by neural and hormonal controls.

Functions of Muscle Tissue:

- Movement:** Allows for both gross and fine movements.
- Maintaining Posture:** Enables us to stay upright or seated.
- Stabilizing Joints:** Tendons prevent bones from dislocating.
- Heat Generation:** Muscle contractions produce heat which helps maintain body temperature.

Muscle Tissue Components:

- a. **Muscle Fibers (Cells):** Individual muscle cells.
- b. **Myofilaments:** Protein filaments (actin and myosin) within muscle fibers responsible for muscle contraction.
- c. **Connective Tissue Wrappings:** Hold together and support muscle fibers.
- d. **Blood Vessels:** Deliver necessary nutrients and oxygen to muscles.
- e. **Nerve Fibers:** Control muscle contractions.

Muscle tissue is dynamic and plays a vital role in almost every action carried out by the body, from the blinking of eyes to the beating of the heart to the movements of fingers and limbs.

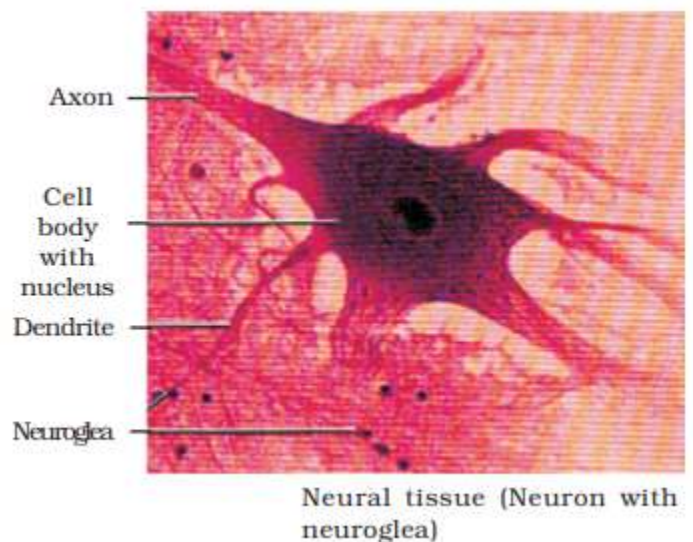
IV. Neural (Nervous) Tissue

Major Characteristics:

1. **Excitability:** Ability to respond to stimuli.
2. **Conductivity:** Ability to transmit an impulse.

Major Components:

1. **Neurons (Nerve Cells):** Principal cells that transmit electrical impulses.
 - **Dendrites:** Receive stimuli or impulses from other neurons and convey them toward the cell body.
 - **Axon:** Conducts impulses away from the cell body.
 - **Cell Body (Soma):** Contains the nucleus and other organelles; metabolic center of the neuron.
 - **Synapse:** Junction between a neuron and another neuron or effector cell, where signals are transmitted.
2. **Neuroglia (Glia):** Support cells for neurons; they nourish, insulate, and replenish neurons and remove excess neurotransmitters. They outnumber neurons in the nervous system.
 - **Types in the Central Nervous System (CNS):**
 - **Astrocytes:** Maintain blood-brain barrier, provide nutrients to neurons.
 - **Oligodendrocytes:** Produce myelin sheaths around axons in the CNS.
 - **Microglia:** Act as phagocytes, removing debris and pathogens.
 - **Ependymal Cells:** Line brain ventricles; produce cerebrospinal fluid.



- **Types in the Peripheral Nervous System (PNS):**
 - **Schwann Cells:** Produce myelin sheaths around axons in the PNS.
 - **Satellite Cells:** Surround and support neuron cell bodies in the PNS.

Functions:

1. **Sensory Input:** Sensory receptors detect internal and external stimuli.
2. **Integration:** Interpretation of sensory input in the brain and spinal cord.
3. **Motor Output:** Activation of effector organs (muscles and glands) to produce a response.

Divisions of Neural Tissue:

1. **Central Nervous System (CNS):** Comprises the brain and spinal cord. It is the main control center, interpreting incoming sensory information and issuing outgoing instructions.
2. **Peripheral Nervous System (PNS):** Includes all the nerves branching off from the brain and spinal cord. It serves as a communication line, linking the CNS to the rest of the body.

Neural tissue plays a crucial role in the functioning of the body, responsible for everything from reflex actions to complex decision-making processes and emotional responses. It's the primary medium for communication and control in the body.

2. Organ

- **Definition:** A collection of tissues grouped together based on a common function.
- **Characteristics:**
 - Contains two or more types of tissues.
 - Performs specific functions.
 - Has recognizable shapes (e.g., heart, liver, kidney).

Examples of Organs:

1. **Heart:** Pumps blood throughout the body.
2. **Lungs:** Facilitate gas exchange.
3. **Liver:** Detoxifies and produces bile.
4. **Kidneys:** Filter blood and produce urine.
5. **Brain:** Central control organ for the body.

Organ System

- **Definition:** A group of organs that work together to perform major functions or meet physiological needs of the body.

Examples of Organ Systems and Their Functions:

1. Circulatory System (Cardiovascular System)

- Organs: Heart, Blood vessels (arteries, veins, capillaries)
- Function: Transports nutrients, oxygen, and waste products throughout the body.

2. Respiratory System

- Organs: Lungs, Trachea, Bronchi, Diaphragm
- Function: Facilitates gas exchange (oxygen and carbon dioxide).

3. Digestive System

- Organs: Mouth, Esophagus, Stomach, Small and Large Intestines, Liver, Pancreas
- Function: Breaks down food, absorbs nutrients, and excretes waste.

4. Nervous System

- Organs: Brain, Spinal Cord, Peripheral Nerves
- Function: Processes and transmits information; controls body functions.

5. Muscular System

- Organs: Skeletal muscles, Smooth muscles, Cardiac muscles
- Function: Allows movement and provides support.

6. Skeletal System

- Organs: Bones, Joints, Cartilage
- Function: Supports body, protects organs, facilitates movement, and stores minerals.

7. Endocrine System

- Organs: Pituitary Gland, Thyroid Gland, Adrenal Glands, Pancreas
- Function: Regulates bodily processes through hormones.

8. Urinary System

- Organs: Kidneys, Ureters, Urinary Bladder, Urethra
- Function: Removes waste products and maintains electrolyte balance.

9. Reproductive System

- Organs: Ovaries, Fallopian Tubes, Uterus, Vagina (in females); Testes, Vas Deferens, Prostate Gland, Urethra (in males)
- Function: Produces offspring.

10. Integumentary System

- Organs: Skin, Hair, Nails, Sweat Glands
- Function: Protects the body, regulates temperature, and provides sensory information.

11. Lymphatic System

- Organs: Lymph nodes, Lymphatic vessels, Thymus, Spleen
- Function: Drains excess tissue fluid, defends against pathogens.

12. Immune System

- Organs and Components: White blood cells, Antibodies, Complement proteins, Lymph nodes
- Function: Protects against disease and pathogens.

Each organ system is essential in maintaining homeostasis and ensuring the overall health and functioning of the body. They often work together, illustrating the interconnectedness and complexity of the human body.

3. 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*.

I. Earthworm Morphology

a. General Body Structure:

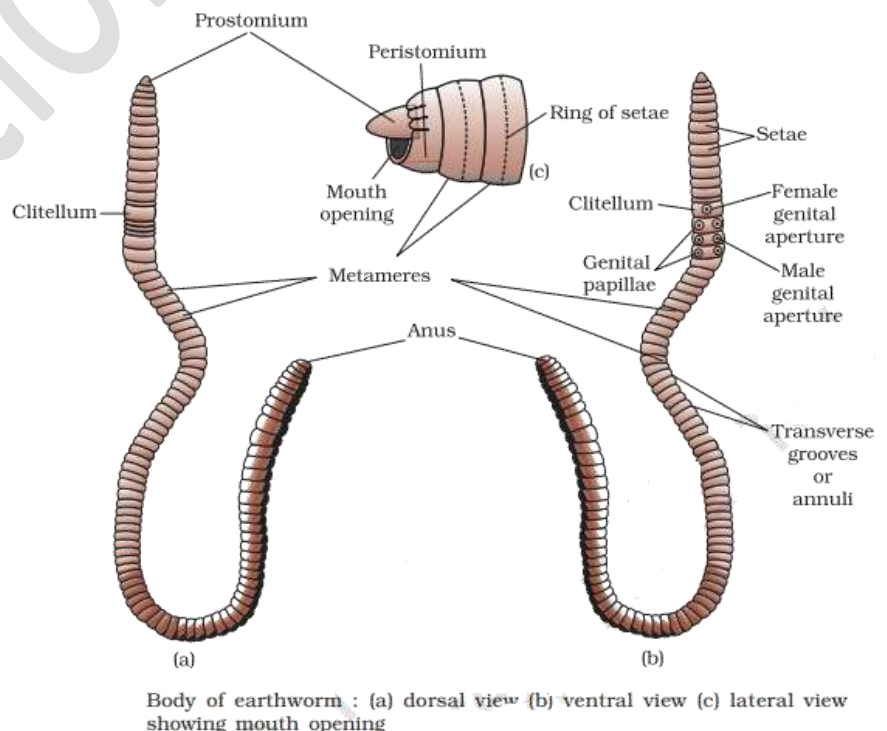
- Shape: Long and cylindrical.
- Segmentation: Body divided into 100-120 similar segments called metameres.
- Dorsal Surface: Features a dark median mid-dorsal line (dorsal blood vessel).
- Ventral Surface: Contains genital openings.

b. Anterior End Features:

- **Prostomium:** A lobe covering the mouth, used to force open soil cracks. It has sensory functions.
- **Peristomium (Buccal Segment):** The first body segment, housing the mouth.

c. Clitellum:

- A prominent dark band of glandular tissue on segments 14-16.
- Body divisions based on clitellum:



- Preclitellar
- Clitellar
- Postclitellar

d. Genital Features:

- **Four pairs of spermathecal apertures:** Located on the ventro-lateral sides of the 5th-9th segments.
- **Female genital pore:** Positioned on the mid-ventral line of the 14th segment.
- **Pair of male genital pores:** Found on the ventro-lateral sides of the 18th segment.
- **Nephridiopores:** Minute pores distributed across the body surface.

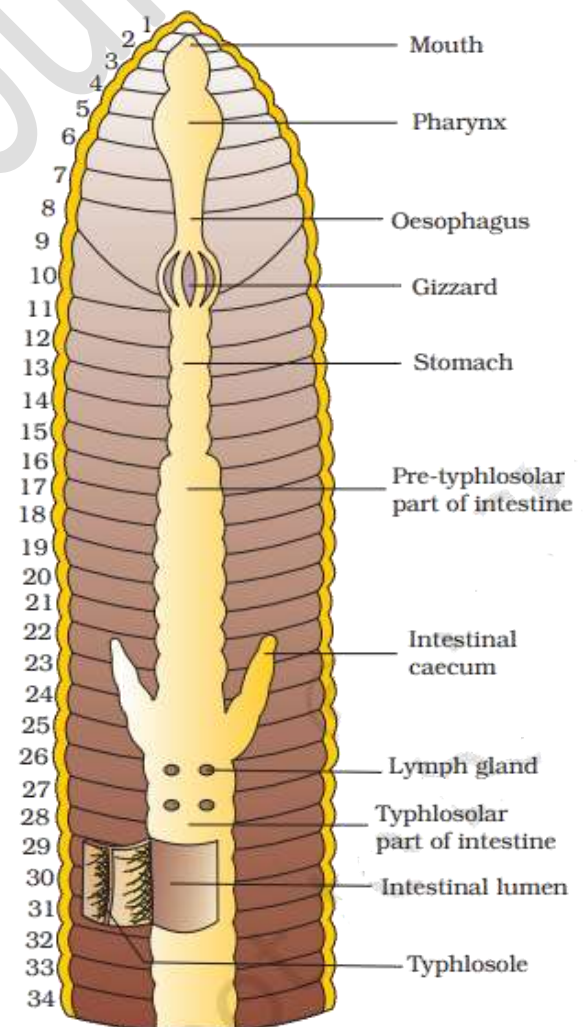
e. Setae:

- S-shaped structures found in rows in almost every segment, excluding the first, last, and those with clitellum.
- Embedded in epidermal pits located at the segment's center.
- Play a crucial role in locomotion; can be extended or retracted.

II. Anatomy of Earthworm

a. Alimentary Canal:

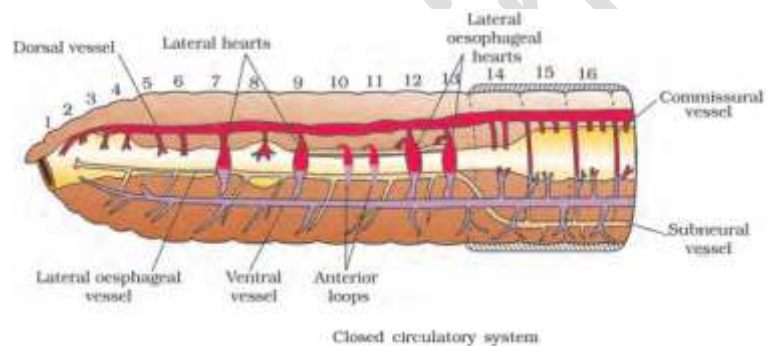
- **Mouth:** Beginning of the canal; located in the first segment.
- **Pharynx:** Swallowing happens here; spans the segments 2-4.
- **Oesophagus:** A short, narrow tube in segments 5-7.
- **Crop:** Storage area; a wider chamber located in segments 8-9.
- **Gizzard:** A muscular structure in segments 10-14; helps in grinding the soil particles.
- **Intestine:** Starts from the 15th segment and continues till the last segment. The dorsal side of the intestine has a fold called **typhlosole** which increases the surface area for absorption.



Alimentary canal of earthworm

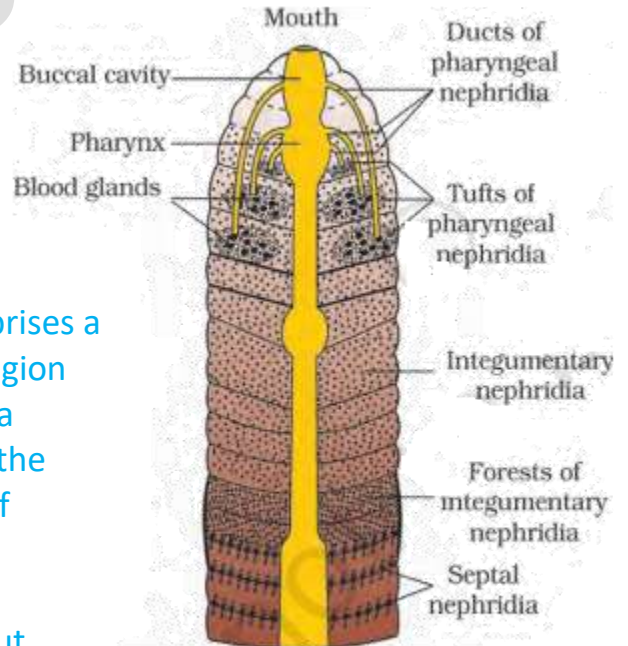
b. Blood Vascular System:

- Earthworms possess a closed circulatory system.
- **Dorsal Blood Vessel:** Main vessel that runs along the length of the worm, transporting blood from the back (posterior) end forward.
- **Ventral Blood Vessel:** Transports blood from the front (anterior) end to the back.
- **Aortic Arches (Heart):** Five pairs present, responsible for pumping blood.



c. Excretory System:

- Comprised of **nephridia**. They are segmentally arranged excretory organs.
- Three types based on their location:
 - **Prostomial nephridia:** Located in the first segment.
 - **Septal nephridia:** Located on the walls of segmental partitions.
 - **Integumentary nephridia:** Attached to the body wall.



d. Nervous System:

- **Central Nervous System (CNS):** Comprises a pair of cerebral ganglia in the head region (acts as a simple brain) connected to a ventral nerve cord, which runs along the body's length. The cord has a series of ganglia in each segment.
- **Peripheral Nervous System (PNS):** Comprises nerve fibers that branch out from the CNS.

e. Reproductive System:

- Earthworms are hermaphroditic (both male and female reproductive organs in one individual).

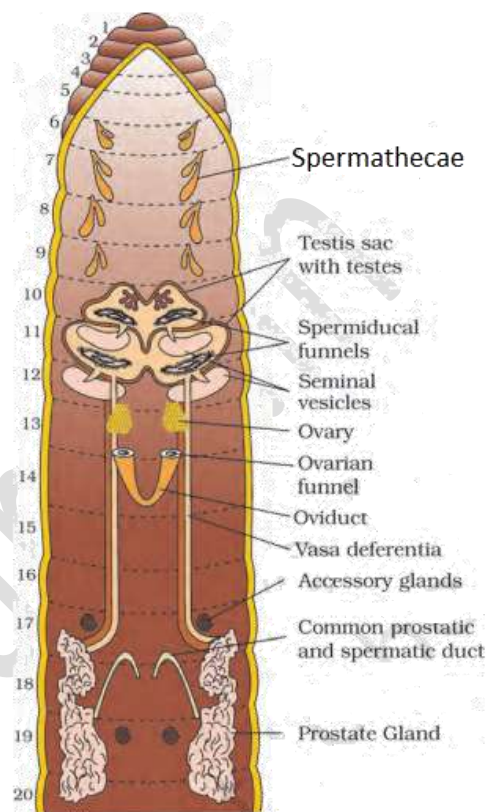
- **Male Reproductive System:** Includes a pair of testes, testes sacs, and vasa deferentia.
- **Female Reproductive System:** Consists of a pair of ovaries and oviducts.
- **Accessory glands:** Several present, aiding in the reproductive process.

f. Respiratory System:

- Earthworms do not have distinct respiratory organs.
- Gaseous exchange occurs through the moist body surface directly.

g. Integumentary System:

- The skin secretes a slimy substance to keep the body moist, aiding in respiration.
- The epidermis contains glands that secrete mucus, which helps in movement and copulation.



Reproductive system of earthworm

4. Cockroach: - 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 $\frac{1}{4}$ 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.

I. Morphology of Cockroach:

a. Body Size and Shape:

- Oval and flat-bodied.
- Segmented body divided into three main parts: head, thorax, and abdomen.

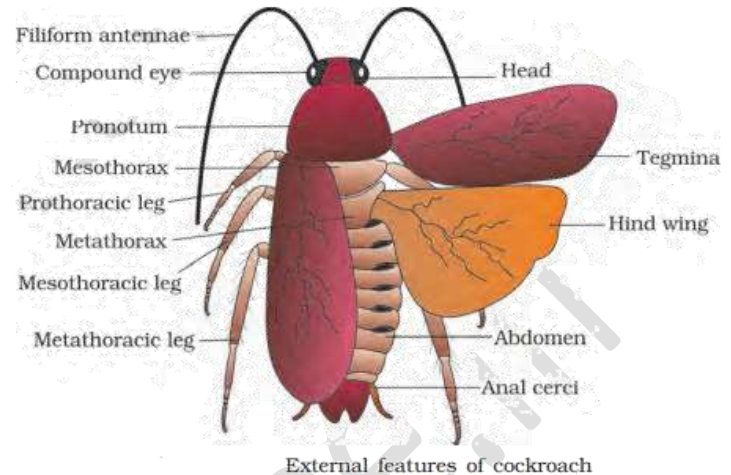
b. Head:

- Triangular and tilted downward, almost concealed from view by the thorax.
- **Antennae:** Long, hair-like structures that are segmented and used for touch and smell.

- **Eyes:** Two large compound eyes for vision.
- **Mouthparts:** Adapted for biting and chewing. It includes a labrum (upper lip), mandibles (jaws), maxillae (secondary jaws), and labium (lower lip).

c. Thorax:

- Divided into three segments: prothorax, mesothorax, and metathorax.
- Each segment has a pair of legs.
- **Legs:** Cockroaches have spiny legs which are adapted for running. Each leg consists of coxa, trochanter, femur, tibia, and tarsus.
- **Wings:** Most species possess two pairs of wings, though not all are good fliers.
 - **Forewings (Tegmina):** Thick, leathery, and dark. When at rest, they lie flat on the body and cover the more delicate hind wings.
 - **Hindwings:** Thin, membranous, and used for flight.

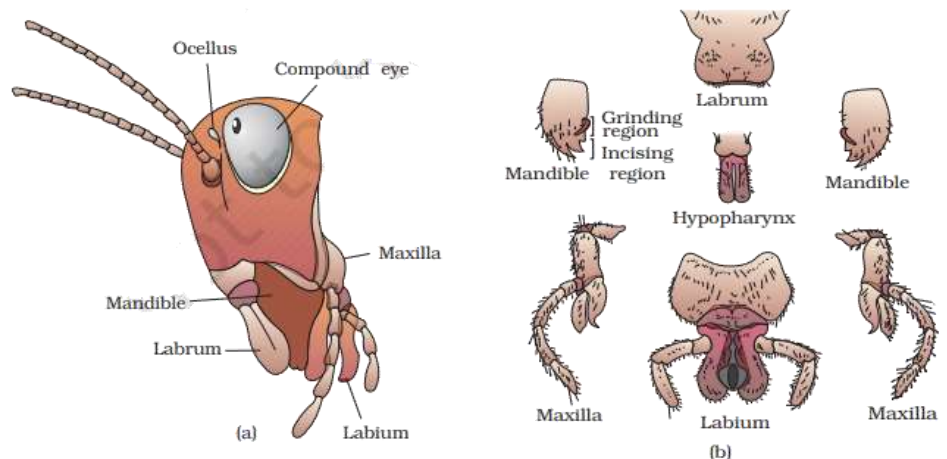


d. Abdomen:

- Comprises ten segments. The terminal segments are modified for reproductive purposes.
- **Male Cockroach:** The last segments are rounded and ventrally carry a pair of short, jointed anal styles.
- **Female Cockroach:** The seventh sternum is boat-shaped, and the ovipositor is present, which is involved in egg-laying.
- **Cerci:** Paired, long, thread-like structures at the end of the abdomen, sensitive to touch and air currents.

e. External Structures:

- **Spiracles:** Small openings on the sides of the body for respiration. Cockroaches possess ten



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

pairs of spiracles (two thoracic and eight abdominal).

- **Tergites:** The dorsal plates of the segments.
- **Sternites:** The ventral plates of the segments.

f. Coloration:

- Typically, brown or black, though colors can vary depending on the species.

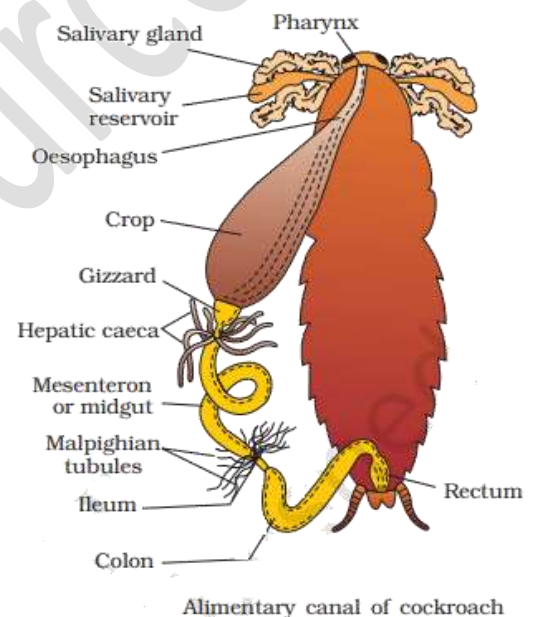
g. Sexual Dimorphism:

- Males and females can be differentiated by examining their abdomen's structure and size. Males typically have a narrower and more pointed abdomen than females.

II. Anatomy of Cockroach:

1. Digestive System:

- **Mouth:** Beginning of the alimentary canal.
- **Pharynx:** Short tube that leads to the esophagus.
- **Esophagus:** Leads to the crop.
- **Crop:** Stores food.
- **Gizzard:** Thick-walled and muscular, helps in grinding food. It also has "teeth" that break down the food.
- **Intestine:** Long and coiled; divided into a small and large intestine.
- **Rectum:** Ends in the anus, where waste is expelled.
- **Digestive Glands:** Salivary glands produce saliva which helps in digestion.



2. Respiratory System:

- **Tracheae:** Network of tubes for gas exchange. Air enters the tracheae through spiracles.
- **Spiracles:** Small openings on the lateral sides of the body. Ten pairs are present (two thoracic and eight abdominal).

3. Circulatory System:

- **Open circulatory system:** Blood is not enclosed in vessels but fills body cavities.

- **Heart:** Tubular structure that pumps blood. It runs the length of the body dorsally.
- **Hemolymph:** Blood equivalent in cockroaches, which bathes the organs directly.

4. Excretory System:

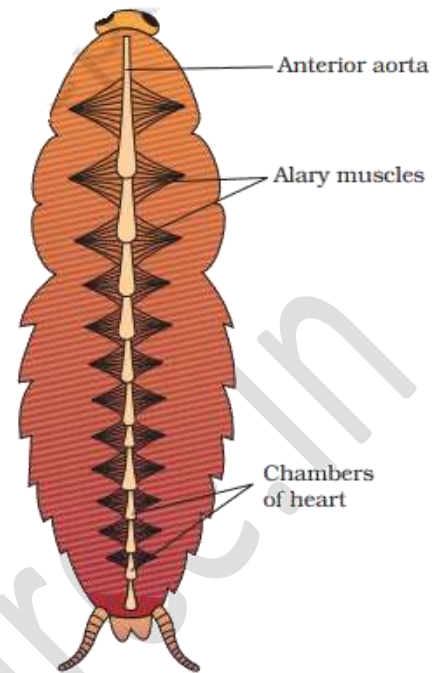
- **Malpighian Tubules:** Primary organs for excretion. They remove nitrogenous waste from the hemolymph and release it into the intestine to be expelled with feces.

5. Nervous System:

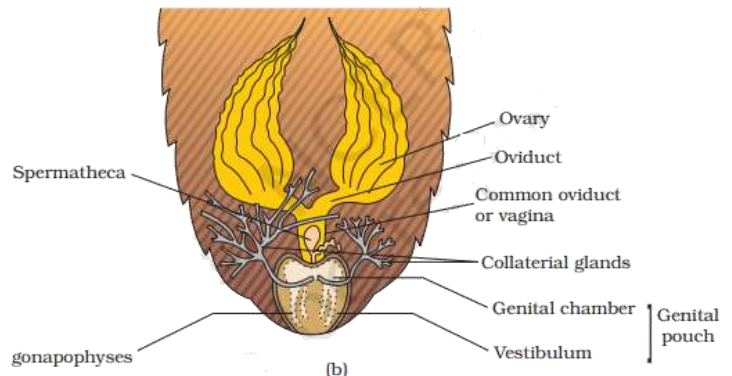
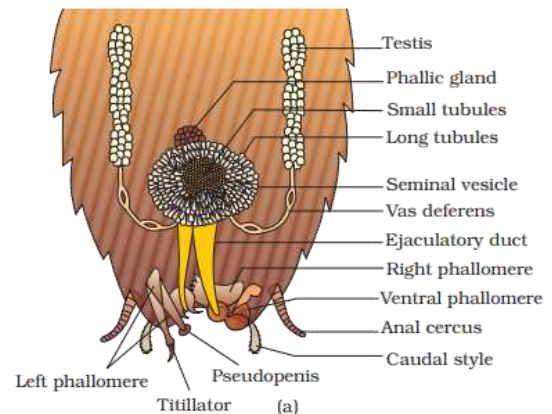
- **Supraesophageal ganglion or "Brain":** Located above the esophagus, responsible for receiving and processing information.
- **Subesophageal ganglion:** Located below the esophagus, sends nerve impulses to mouthparts and other areas.
- **Double Ventral Nerve Cord:** Runs the length of the body with segmental ganglia, connecting the various parts of the body.

6. Reproductive System:

- **Male:**
- **Testes:** Produce sperms.
- **Vas deferens:** Tubes that carry sperm from the testes.
- **Accessory glands:** Produce seminal fluid to nourish and transport sperm.
- **Male genital pore:** Where the vas deferens opens,



Open circulatory system of cockroach



Reproductive system of cockroach : (a) male (b) female

used to transfer sperm.

- **Female:**

- **Ovaries:** Produce eggs.
- **Oviduct:** Transports eggs.
- **Spermathecae:** Stores sperm after mating.
- **Female genital pore:** Where the oviduct opens, used for laying eggs.

7. Endocrine System:

- Contains various endocrine glands and structures that produce hormones, like corpora allata and prothoracic gland.

8. Sensory Organs:

- **Antennae:** Main organs of touch and smell.
- **Eyes:** Compound eyes for vision. Some species also have simple eyes (ocelli).
- **Tympanum:** Equivalent to the eardrum, for hearing.

9. Muscular System:

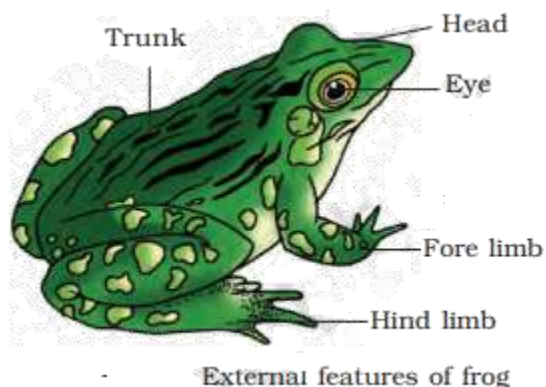
- Contains muscles that allow the cockroach to move, fly (in some species), and perform other actions.

5. FROGS: - Frogs can live both on land and in freshwater and belong to class Amphibia of phylum Chordata. The most common species of frog found in India is *Rana tigrina*.

I. Morphology of Frog:

a. Body Division:

- **Head and Trunk:** Frogs lack a distinct neck and tail, so the body appears as a fused head and trunk.
- **Snout:** Pointed anterior end of the head.
- **Eyes:** Large, bulging eyes with nictitating membranes that can move over the eye for protection and to keep them moist.
- **Tympanum (Tympanic Membrane):** The eardrum situated behind the eyes; involved in hearing.
- **Mouth:** Wide and equipped with small, sharp teeth in the upper jaw. The lower jaw lacks teeth.



- **Tongue:** Attached at the front of the mouth, highly elastic and protrusible, used to capture prey.
- b. Limbs:**
- **Forelimbs:** Shorter with four web-less digits. Adapted mainly for holding and pushing.
 - **Hindlimbs:** Much longer and muscular compared to forelimbs, adapted for leaping and swimming. They end in five digits, which are webbed to aid in swimming.
- c. Skin:**
- Moist and glandular, with mucous glands that keep it wet. This helps in cutaneous respiration.
 - Contains chromatophores, which allow frogs to change color to some extent to match their surroundings.
 - Some species might have specialized granular glands that produce toxins as a defense mechanism.
- d. Cloacal Aperture:**
- A common opening for the digestive, excretory, and reproductive systems located at the base of the thighs.
- e. Sexual Dimorphism:**
- **Male Frogs:**
 - Typically, smaller than females.
 - Have vocal sacs (not always visible unless inflated) which they use to produce mating calls.
 - Have nuptial pads (rough patches) on their forelimbs to grasp females during mating.
 - **Female Frogs:**
 - Generally larger and bulkier than males, especially during the breeding season when their bodies are full of eggs.
- f. Dorsal Side:** Generally darker to blend with the surroundings when viewed from above.
- g. Ventral Side:** Lighter in color, which provides camouflage from underwater predators looking upwards.

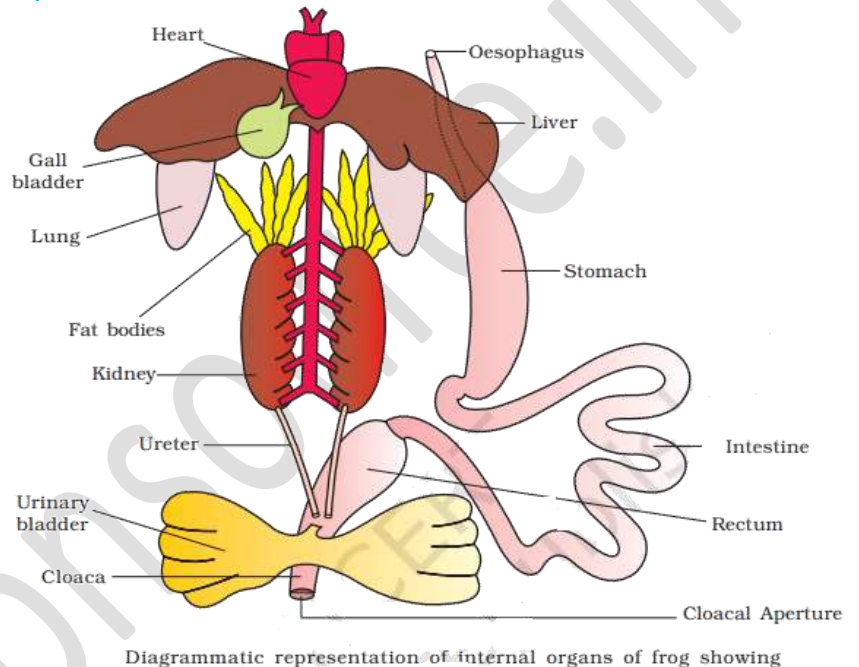
II. Anatomy of Frog:

a. Digestive System:

- Begins with the **mouth**, equipped with small teeth in the upper jaw.
- The **esophagus** is a short tube leading to the **stomach**, a site for the breakdown of food.
- **Small intestine** where most digestion and absorption occur.
- **Large intestine** leading to the **cloaca**, the common chamber and exit for the intestinal, urinary, and reproductive tracts.

b. Respiratory System:

- **Nostrils** (external nares) for air intake, which then passes through internal nares into the oral cavity.
- **Lungs:** Two sac-like structures for breathing on land.
- The moist **skin** also plays a significant role in gas exchange (cutaneous respiration).



Diagrammatic representation of internal organs of frog showing

c. Circulatory System:

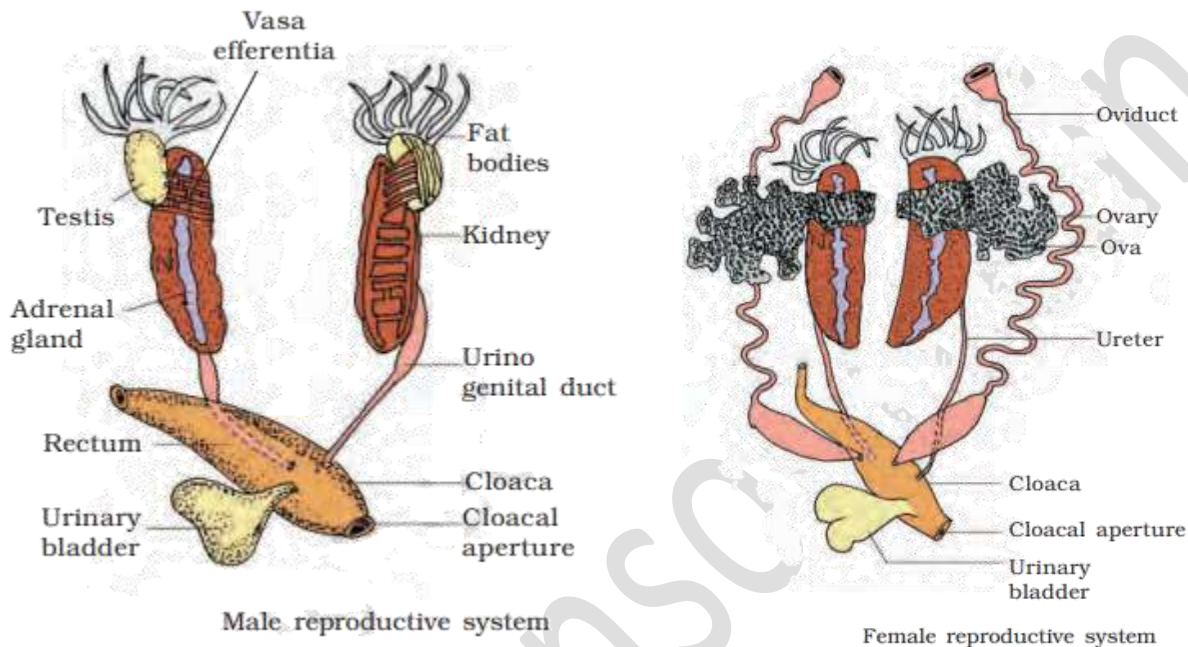
- **Three-chambered heart** with two atria and one ventricle.
- Blood from the heart is pumped to lungs (pulmonary circulation) and to the rest of the body (systemic circulation).
- **Sinus venosus** and **conus arteriosus** are additional structures present in the frog's heart, aiding in blood flow.

d. Excretory System:

- **Kidneys:** Primary organs for filtration of blood and urine formation.
- **Ureters** transport urine from kidneys to the urinary bladder, and then it's expelled via the cloaca.
- Frogs also have structures called **fat bodies** which store lipids and are associated with the kidneys.

e. Reproductive System:

- **Male:** Testes produce sperm, which travel through vasa efferentia to the kidneys, then through ureters mixed with urine, and exit the body via cloaca.
- **Female:** Ovaries produce eggs which travel down the oviducts. Eggs are released through the cloaca.



f. Nervous System:

- **Brain** consists of olfactory lobes, cerebrum, diencephalon, cerebellum, and medulla oblongata.
- A **spinal cord** that runs down the back and transmits nerve signals.
- **Nerves** branch from the brain and spinal cord.
- **Sense Organs:** Eyes with a nictitating membrane and a tympanum (eardrum) for hearing.

g. Skeletal System:

- Made up of bones and cartilages. Frogs have a **urostyle**, a unique elongated bone, formed from fused vertebrae, which provides rigidity to the spine.
- The limb bones of the frog are adapted for leaping and swimming.

h. Endocrine System:

- Contains endocrine glands like the pituitary, thyroid, and adrenal glands, which produce hormones for regulation of various body functions.

i. Muscular System:

- Muscles are arranged in pairs (one to stretch a joint, its partner to bend that joint), allowing for movement.

j. Immune System:

- Includes the thymus, spleen, and white blood cells, protecting the frog from diseases.

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