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Introduction

Overview

- Unicellular organisms perform all life functions in a single cell.
- Multicellular organisms have specialized groups of cells performing specific functions.
- A tissue is a group of similar cells with common origin and function.

Memory Aids

- Tissue = group of similar cells + intercellular substance + common function.

Quick Checkpoints

- What defines a tissue in multicellular organisms?
- How do unicellular and multicellular organisms differ in function execution?

Animal Tissues

Types and Classification

- Four basic tissue types: Epithelial, Connective, Muscular, Neural.
- Each tissue type has distinct origin and function.
- Epithelial: protection, secretion, absorption, excretion, reproduction.
- Connective: support, attachment, storage, protection, transport.
- Muscular: movement and locomotion.
- Neural: control and nerve impulse transmission.

	Type	Origin	Function
(i)	Epithelial tissue	Ectoderm, endoderm, mesoderm	Protection, secretion, absorption, excretion, reproduction
(ii)	Connective tissue	Mesoderm	Attachment, support, storage, protection, transport
(iii)	Muscular tissue	Mesoderm	Movement of body parts and locomotion
(iv)	Nervous tissue	Ectoderm	Control and coordination by nerve impulse

Memory Aids

- Remember: Epithelial = covering; Connective = support; Muscular = movement; Neural = control.

Quick Checkpoints

- List the four basic animal tissues.
- What are the main functions of connective tissue?

Epithelial Tissue

Structure and Types

- Epithelium has a free surface facing body fluid or environment.
- Cells are tightly packed with minimal intercellular matrix.
- Two main types: Simple (single layer) and Compound (multiple layers).
- Simple epithelium subtypes: Squamous, Cuboidal, Columnar.
- Squamous: thin, flat cells; found in blood vessels and lungs; functions include protection and gas exchange.
- Cuboidal: cube-shaped cells; found in gland ducts and kidney tubules; functions include secretion and absorption; may have microvilli.
- Columnar: tall cells with basal nuclei; found in stomach, intestine; may have microvilli (brush border) or cilia.
- Ciliated epithelium moves mucus, urine, eggs, cerebrospinal fluid.
- Compound epithelium protects against mechanical and chemical stress; found in skin, mouth lining, ducts.
- Glandular epithelium specialized for secretion; unicellular (goblet cells) or multicellular (salivary glands).
- Glands classified as exocrine (ducts) or endocrine (ductless, secrete hormones).
- Heterocrine glands have both exocrine and endocrine parts (e.g., pancreas).
- Cell junctions: Tight (prevent leakage), Adhering (cement cells), Gap (communication).

Types of Epithelial Tissue

Simple epithelium

- Composed of a single layer of cells
- Functions as a lining for body cavities, ducts and tubes

Compound epithelium

- Consists of two or more cell layers
- Protective in function

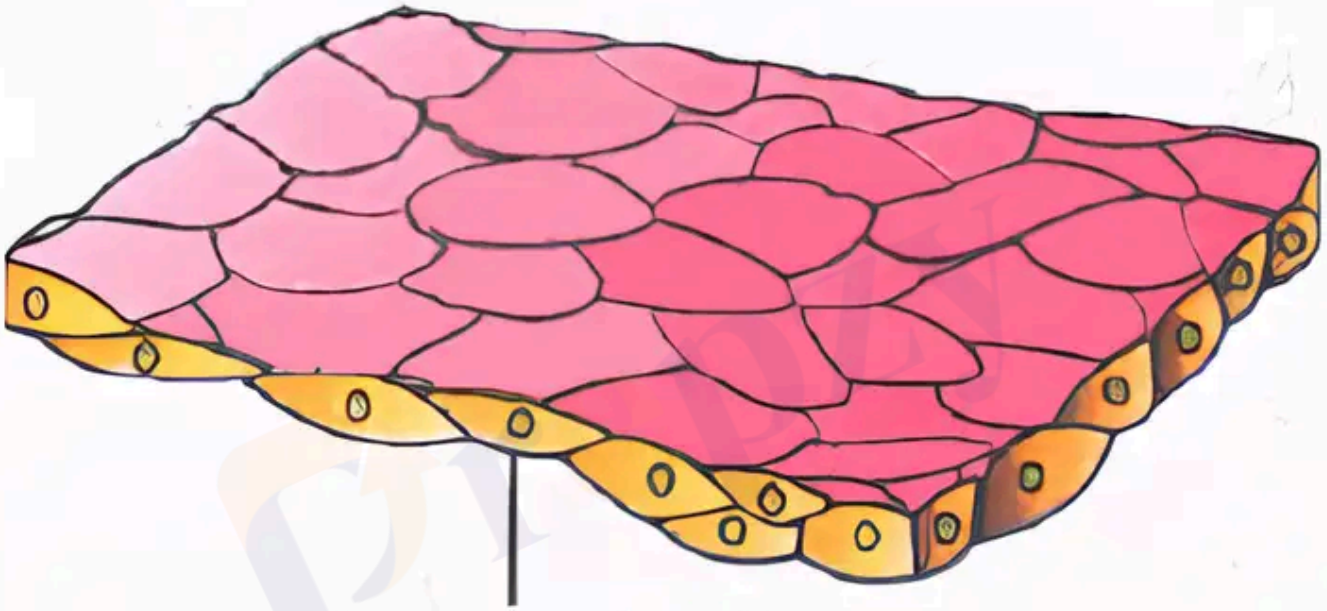


Fig.: Squamous epithelium

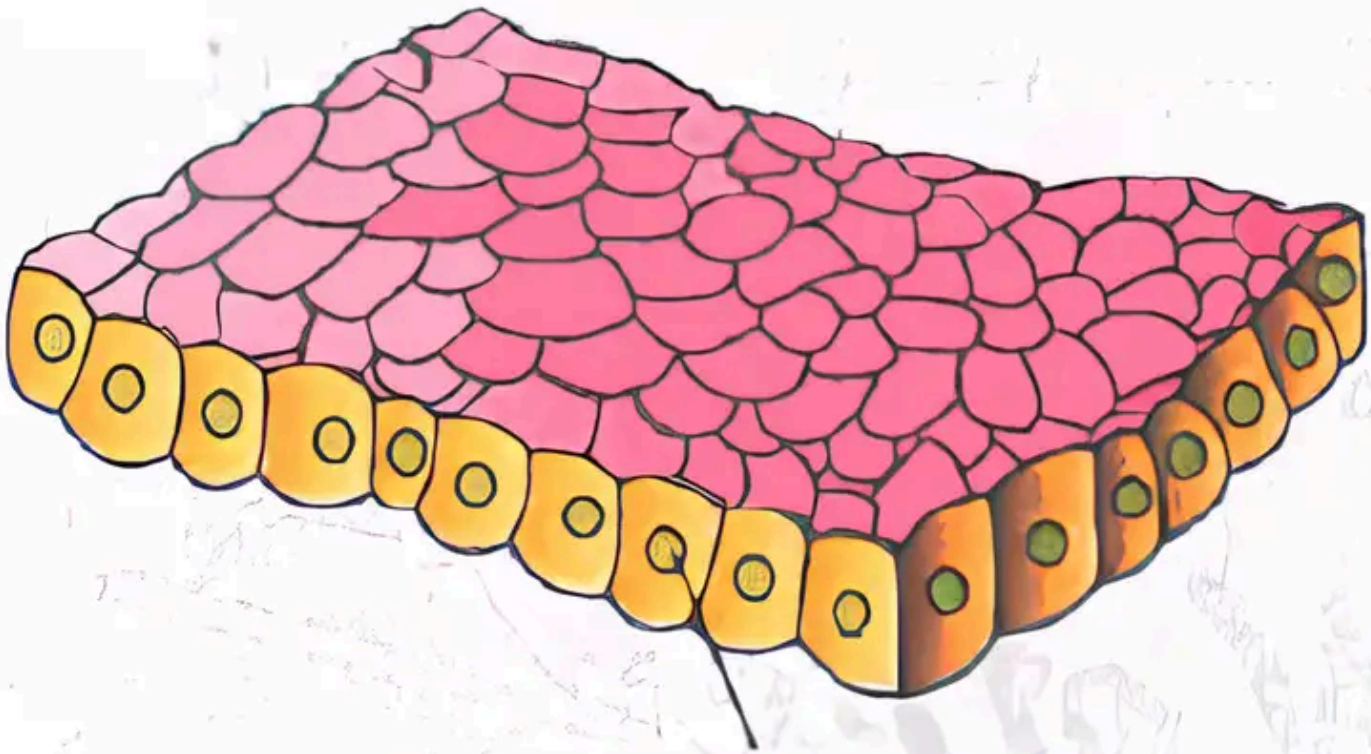


Fig.: Cuboidal epithelium

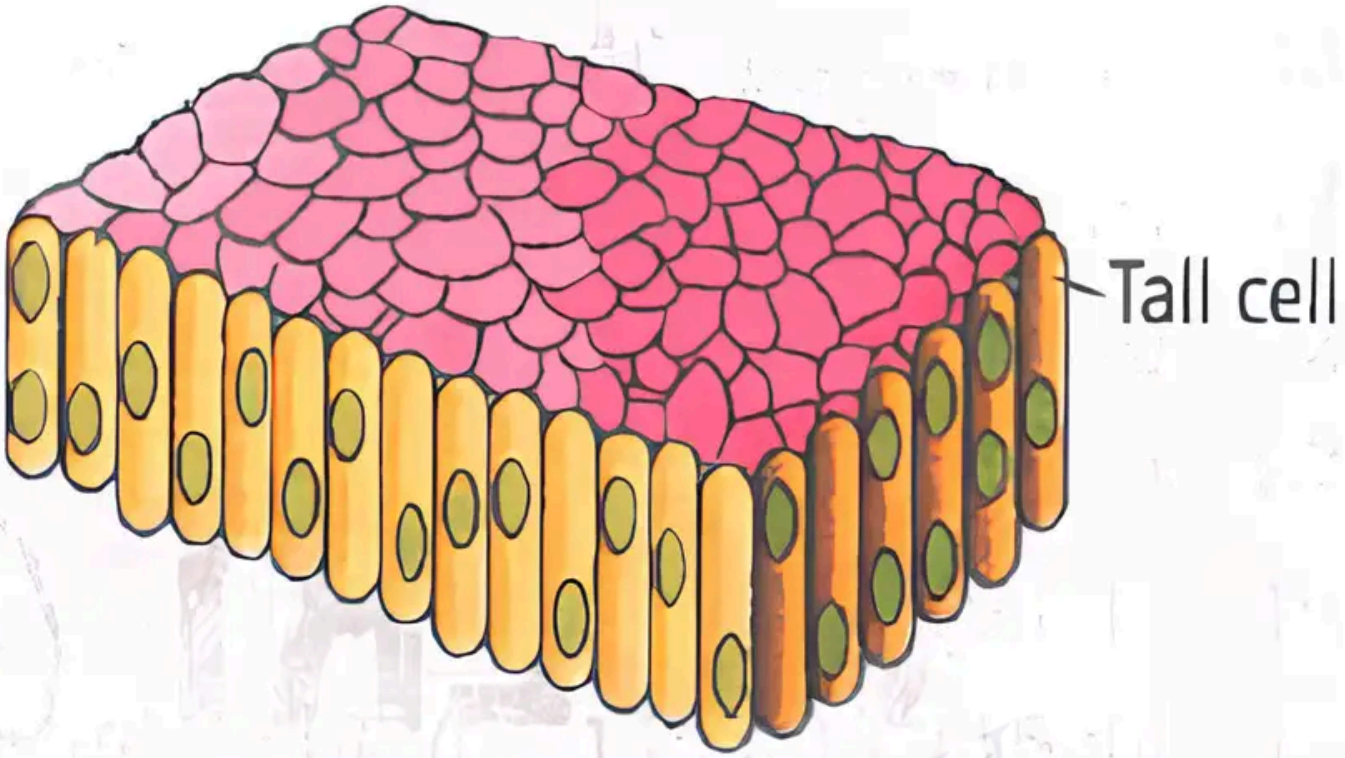


Fig.: Columnar epithelium

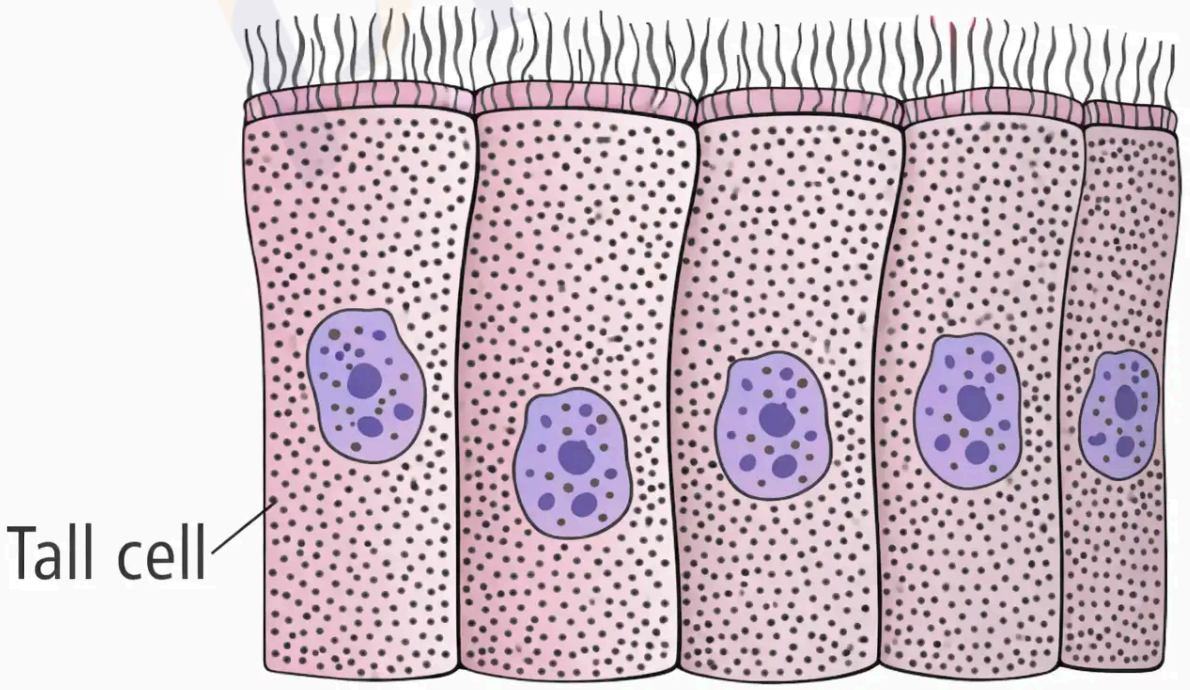


Fig.: Ciliated columnar epithelium

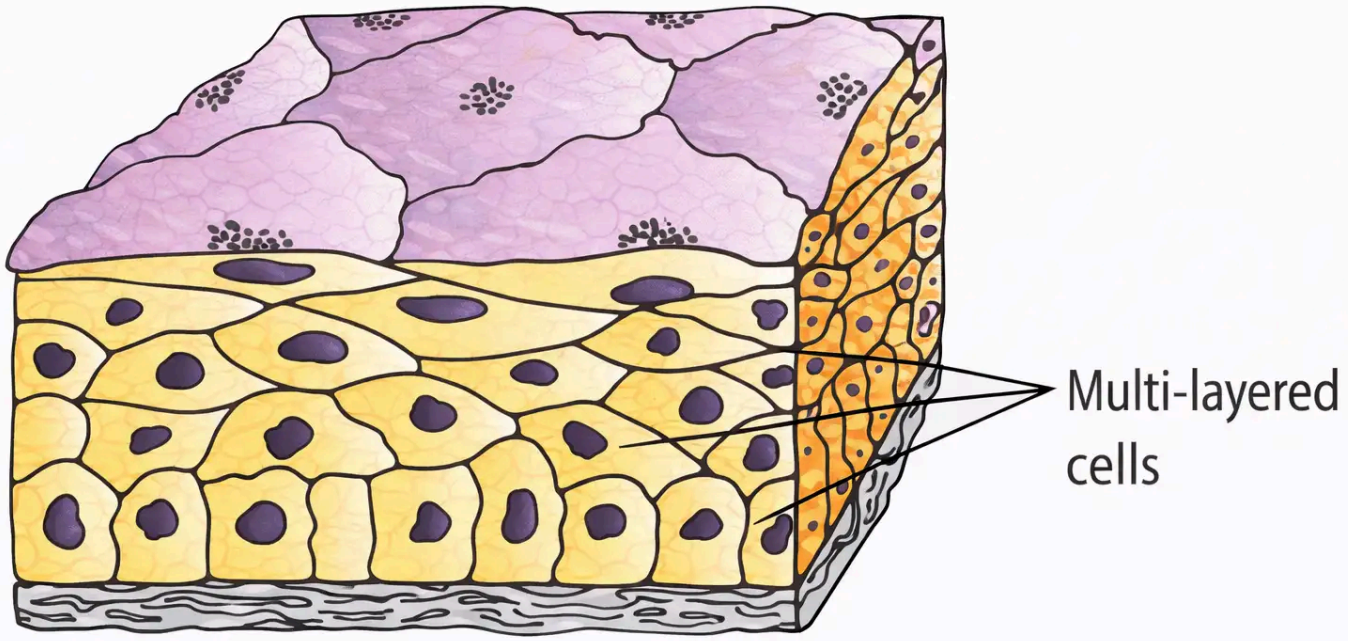


Fig.: Compound epithelium

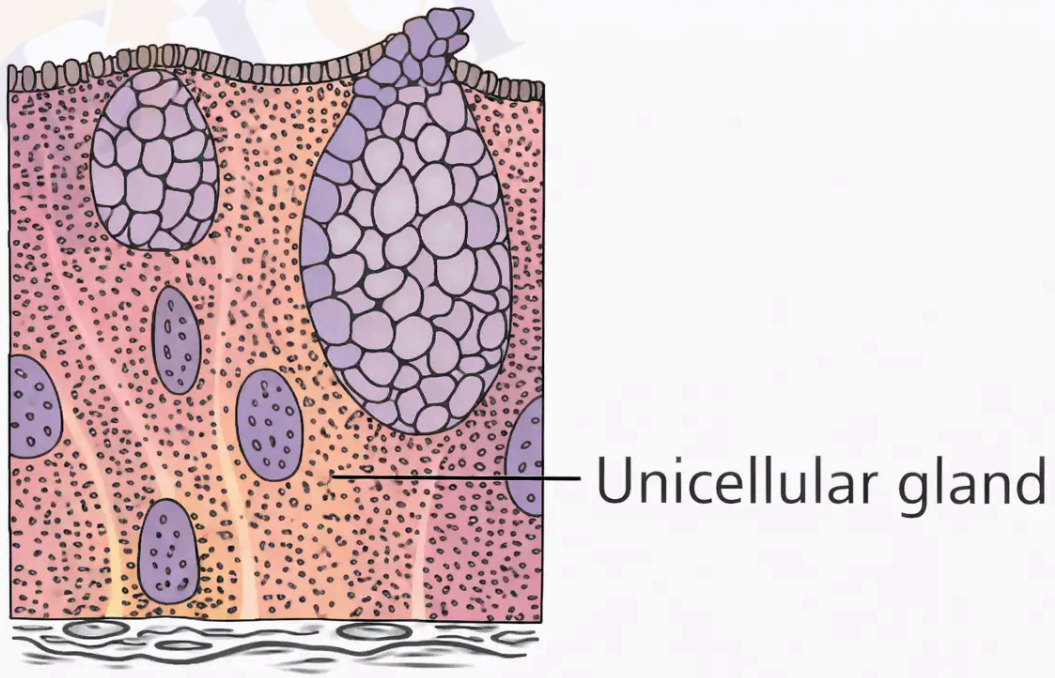


Fig.: Unicellular glandular epithelium

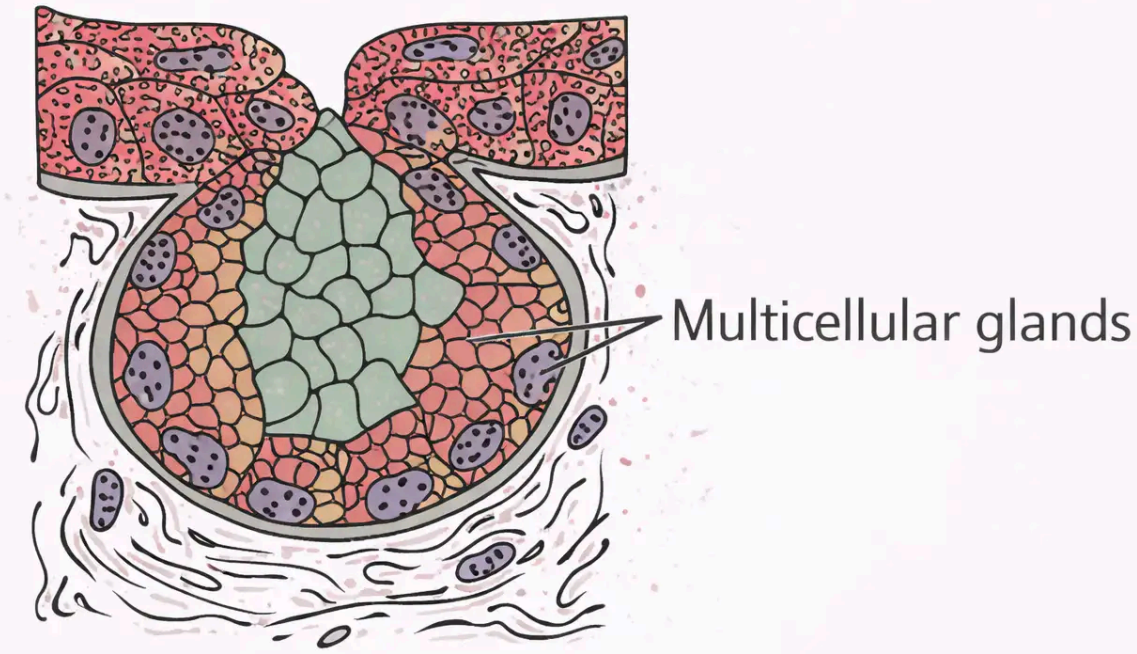


Fig.: Multicellular glandular epithelium

Memory Aids

- Simple epithelium = 1 layer; Compound = multiple layers.
- Squamous = flat; Cuboidal = cube; Columnar = tall.
- Ciliated epithelium moves substances; glandular epithelium secretes.
- Exocrine glands use ducts; endocrine glands are ductless.

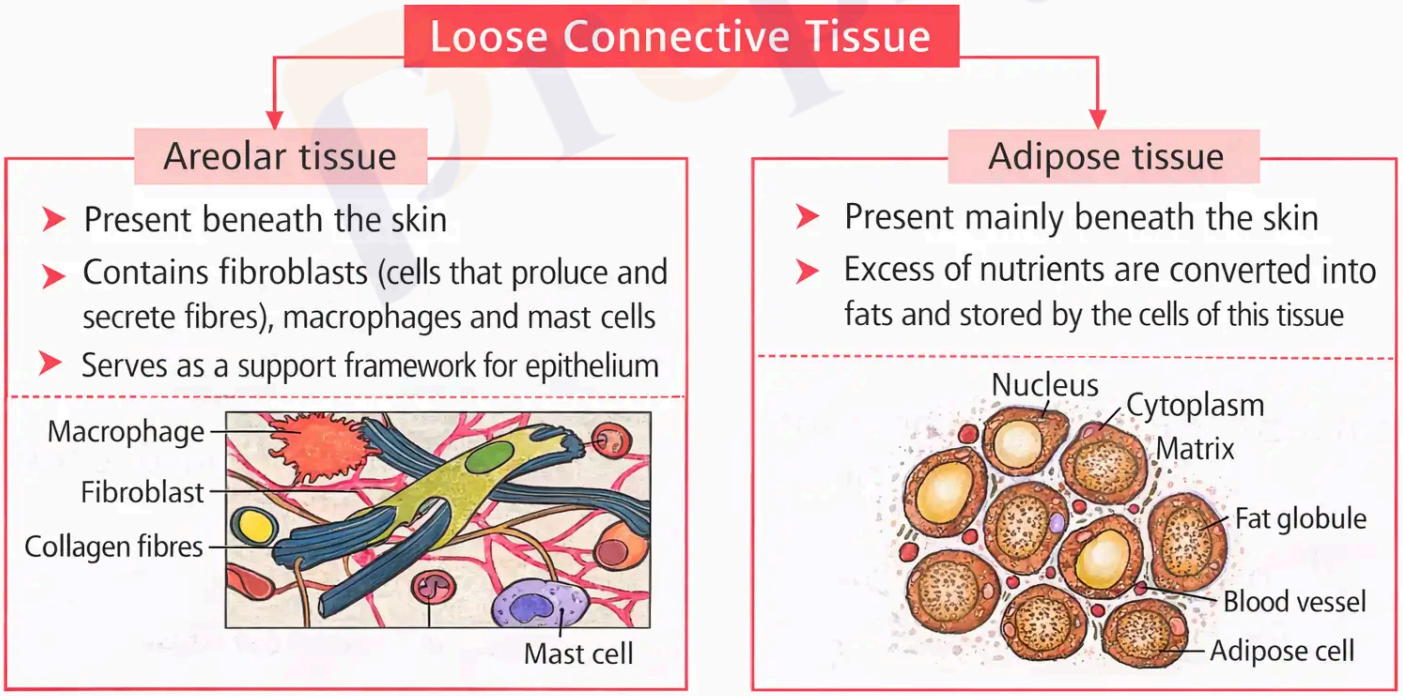
Quick Checkpoints

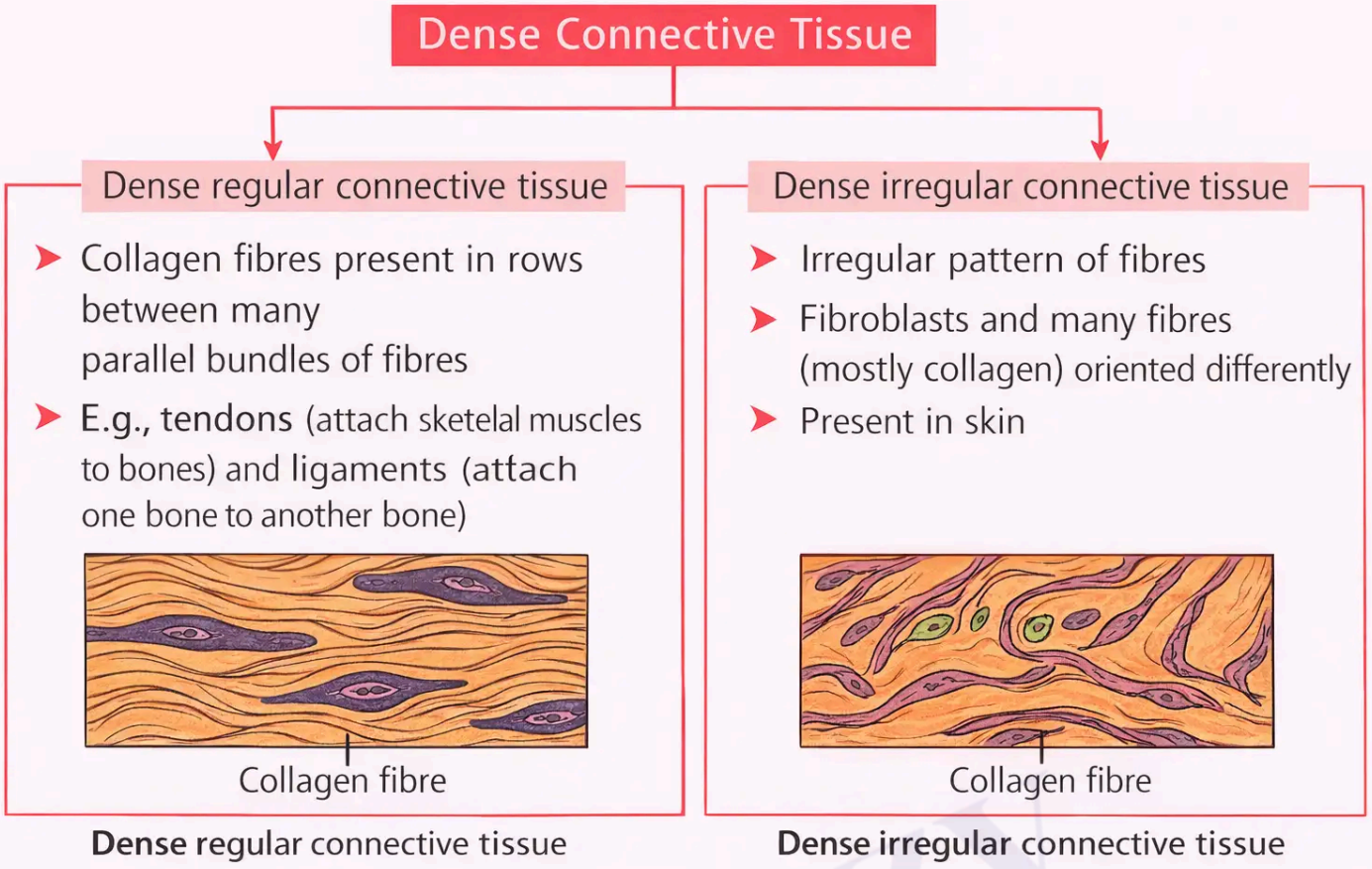
- What are the types of simple epithelium?
- Where is ciliated epithelium found and what is its function?
- Differentiate exocrine and endocrine glands.
- What are the three types of cell junctions in epithelium?

Connective Tissue

Overview and Types

- Most abundant tissue; links and supports other tissues/organs.
- Cells secrete collagen or elastin fibers for strength and flexibility.
- Matrix contains modified polysaccharides.
- Types: Loose (areolar, adipose), Dense (regular, irregular), Specialized (cartilage, bone, blood).
- Loose connective tissue: cells and fibers loosely arranged in semi-fluid ground substance.
- Dense connective tissue: fibers and fibroblasts densely packed.
- Dense regular: collagen fibers in parallel; found in tendons and ligaments.
- Dense irregular: collagen fibers in multiple directions; found in skin.
- White fibrous connective tissue: collagen bundles, strong but less flexible.
- Yellow elastic connective tissue: elastic fibers, flexible; forms ligaments and vessel walls.





Dense regular connective tissue

Dense irregular connective tissue

Memory Aids

- Loose = loose fibers; Dense = tightly packed fibers.
- White fibrous = strength; Yellow elastic = elasticity.

Quick Checkpoints

- What are the main functions of connective tissue?
- Differentiate loose and dense connective tissue.
- Where is white fibrous connective tissue found?

Specialised Connective Tissue

Cartilage

- Soft skeletal tissue with chondrocytes in lacunae.

- Matrix is solid, pliable, resists compression.
- Most embryonic cartilage replaced by bone in adults.
- Types: Hyaline (common, joints, trachea), White fibrous (strongest, intervertebral discs), Yellow elastic (ear, epiglottis).

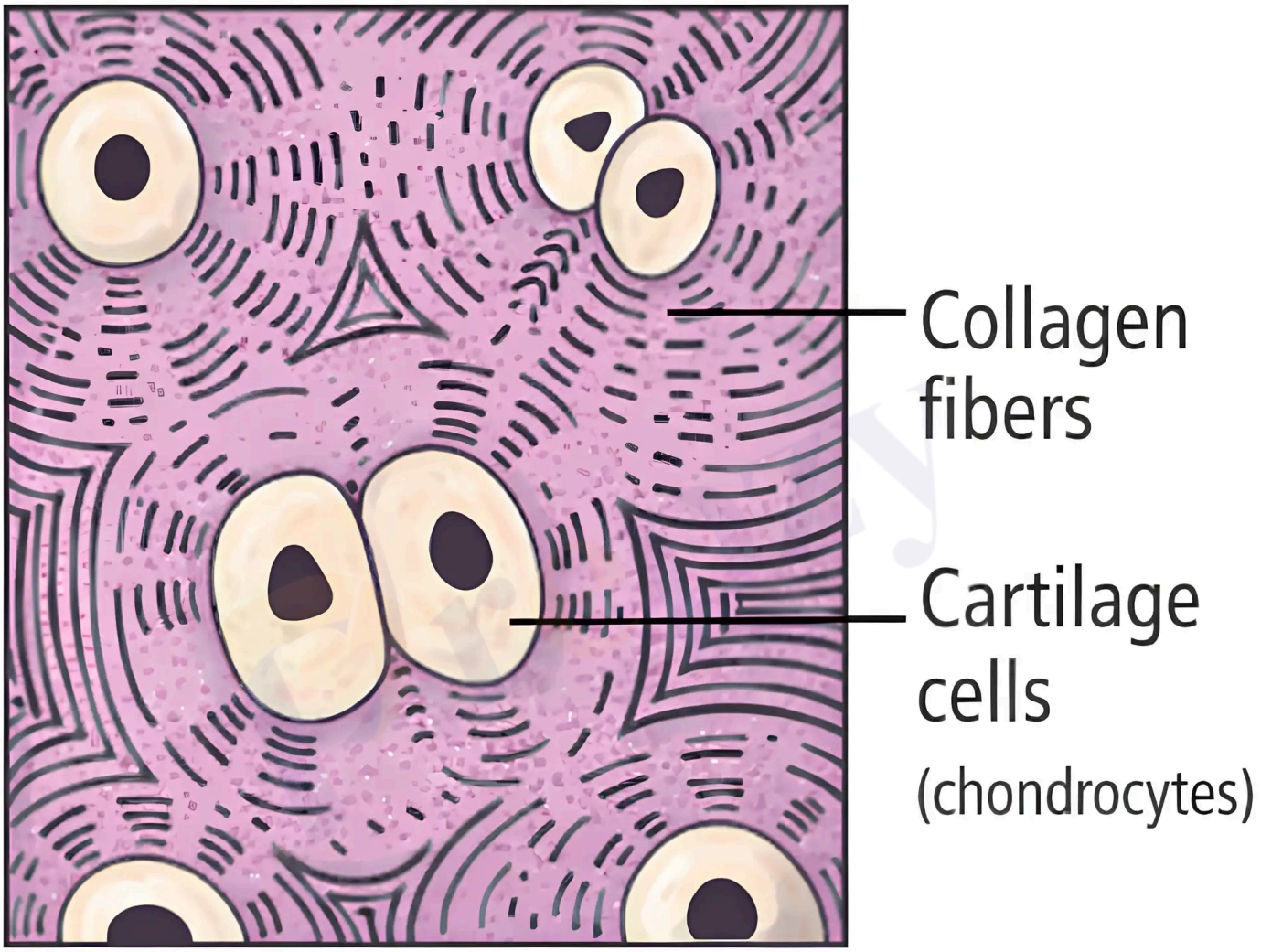


Fig.: Cartilage

Bone

- Osteocytes in lacunae; matrix rich in calcium salts and collagen.
- Provides body frame, support, protection.
- Limb bones aid movement; red marrow produces blood cells.

- Osteon (Haversian system) = lamellae + lacunae + Haversian canal; absent in spongy bone.

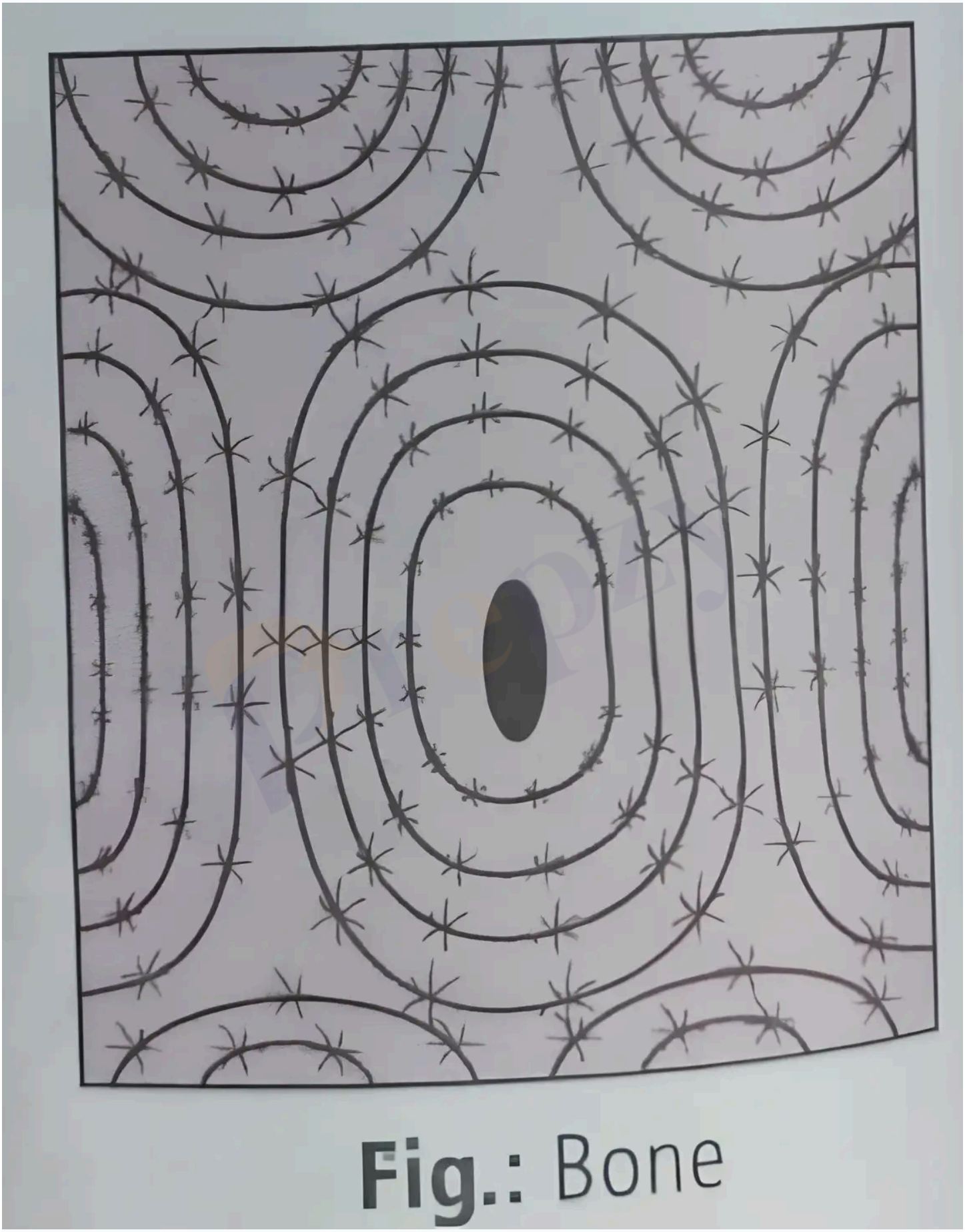


Fig.: Bone

Blood

- Fluid connective tissue with plasma, RBCs, WBCs, platelets.
- Transports substances throughout the body.
- RBCs carry oxygen; platelets aid clotting; WBCs fight infection.

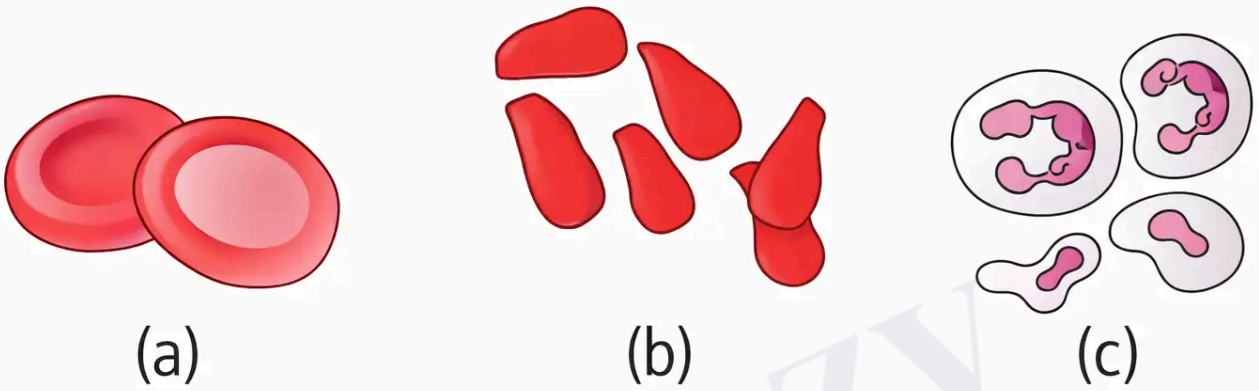


Fig.: Blood: (a) RBC, (b) Platelets, (c) WBC

Memory Aids

- Cartilage = flexible support; Bone = hard support; Blood = transport.
- Osteon is the functional unit of compact bone.

Quick Checkpoints

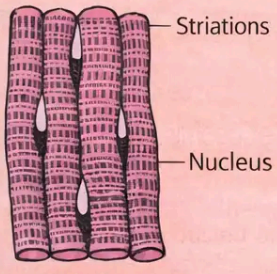
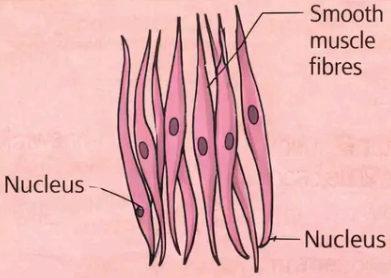
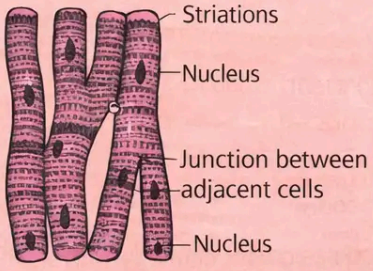
- What are the types of cartilage and their locations?
- Describe the structure of an osteon.
- What are the components of blood and their functions?

Muscular Tissue

Structure and Function

- Made of long cylindrical fibers with myofibrils in sarcoplasm.
- Fibers contract and relax to produce movement or maintain posture.
- Three types: Skeletal (voluntary, striated), Smooth (involuntary, non-striated), Cardiac (involuntary, striated with intercalated discs).
- Skeletal muscles attach to bones; smooth muscles in internal organs; cardiac muscle in heart.

Table : Types of Muscle

Skeletal Muscle	Smooth Muscle	Cardiac Muscle
The fibres are cylindrical and unbranched. They are also called striped or striated muscle fibres.	The muscle fibres are non-striated and spindle shaped.	The muscle fibres are striped but have dark intercalated disc (communication junction) which allows the cells to contract as a unit.
These muscle fibres are bundled together in a parallel fashion. A sheath of tough connective tissue encloses several bundles of muscles fibres.	Cell junctions hold them together and they are bundled together in a connective tissue sheath.	Cell junctions fuse the plasma membrane of cardiac muscle cells which stick them together.
They are attached to skeletal bones (*e.g.*, limbs). These muscles are found in body walls, tongue and beginning of oesophagus.	These are found in wall of internal organs such as blood vessels, stomach and intestine.	These are present in the wall of heart and in the wall of large veins (e.g., pulmonary veins and superior vena cava) where these veins enter the heart.
These muscles are voluntary in nature, *i.e.*, their functioning can be controlled directly and they soon get fatigued.	These muscles do not get fatigued and are involuntary, *i.e.*, their functioning cannot be directly controlled.	These muscles never get fatigued and are involuntary in nature.
 Striations	 Smooth muscle fibres	 Cardiac Muscle

Memory Aids

- Skeletal = voluntary, striated; Smooth = involuntary, no striations; Cardiac = involuntary, striated with discs.

Quick Checkpoints

- What are the three types of muscle tissue?
- Where is smooth muscle found?
- What special features does cardiac muscle have?

Neural Tissue

Structure and Function

- Controls body's response to stimuli.
- Neurons are the main units; consist of cyton (cell body), dendrites, and axon.
- Axon ends in terminal arborisations; axon/dendrite with sheath called nerve fiber.
- Neuroglial cells support and protect neurons; >50% of neural tissue volume.
- Nerve fibers: medullated (with myelin sheath, nodes of Ranvier) and non-medullated (without sheath).
- Electrical impulses travel along neuron membrane when stimulated.

Memory Aids

- Neuron = cyton + dendrites + axon; neuroglia support neurons.
- Myelin sheath speeds impulse; nodes of Ranvier are gaps.

Quick Checkpoints

- What are the parts of a neuron?
- Difference between medullated and non-medullated nerve fibers?
- Role of neuroglial cells?

Organ and Organ System

Overview

- Basic tissues form organs (e.g., heart has epithelial, connective, muscular, neural tissues).
- Organs combine to form organ systems; organ systems form an organism.
- Organisation ensures efficient, coordinated cell activities.
- **Morphology**: Study of external features of animals.
- **Anatomy**: Study of internal organ morphology.

Memory Aids

- Organ = Tissues combined; Organ system = Organs combined.
- Morphology = External form; Anatomy = Internal structure.

Quick Checkpoints

- What tissues form an organ?
- Difference between morphology and anatomy?
- Why is organ organisation important?

Cockroach

General Characteristics

- Scientific name: *Periplaneta americana*.
- Class: Insecta; Phylum: Arthropoda.
- Brown or black, nocturnal, omnivorous.
- Body divided into head, thorax, abdomen; covered by chitinous exoskeleton.
- Exoskeleton plates called sclerites (tergites dorsal, sternites ventral) joined by flexible membranes.
- Head triangular, fused from 6 segments, flexible neck, with compound eyes and antennae.
- Mouthparts chewing type: labrum (upper lip), labium (lower lip), maxillae, mandibles, hypopharynx (tongue-like).

- Thorax has prothorax, mesothorax, metathorax; each with a pair of legs.
- Two pairs of wings: forewings (opaque, leathery), hindwings (transparent, membranous for flight).

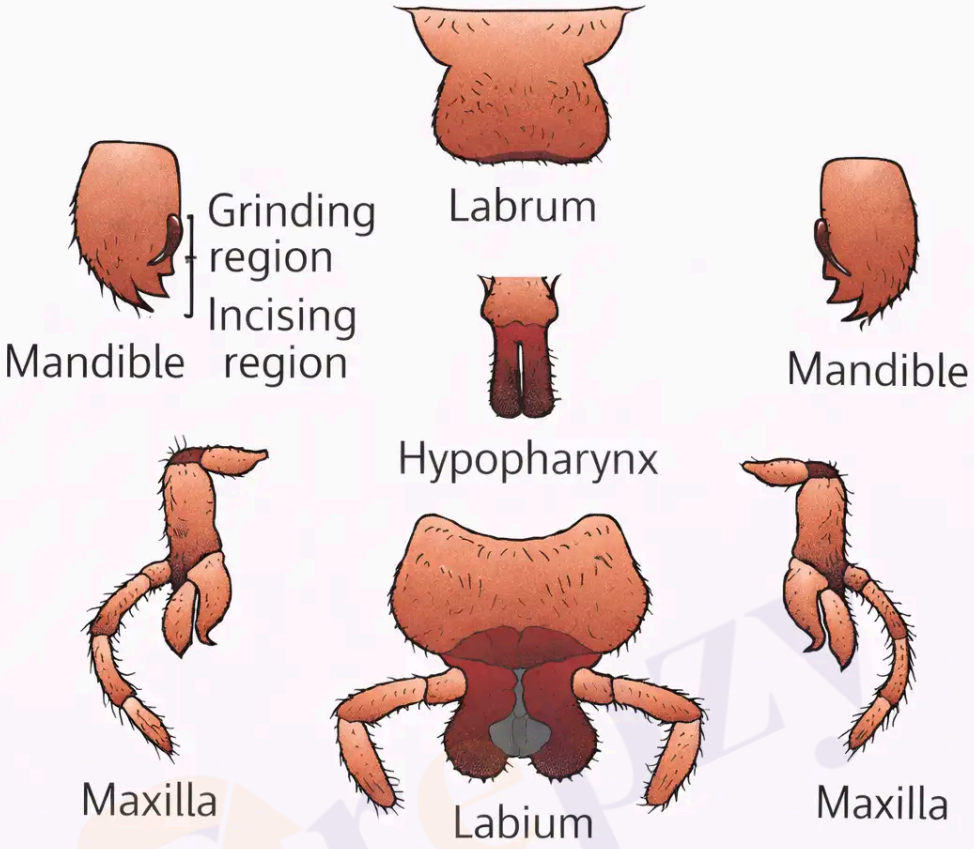


Fig.: Mouth parts of cockroach

Mouthparts Function

- Mandibles: strong jaws for cutting and crushing food; grinding and incising regions.
- Maxillae: hold and manipulate food.
- Labrum: upper lip, holds food in place.
- Hypopharynx: inside mouth, mixes food with saliva.
- Labium: lower lip, holds food during eating.

Memory Aids

- Mandibles = jaws; Maxillae = food holders; Labrum = upper lip; Labium = lower lip; Hypopharynx = tongue.

Quick Checkpoints

- What are the main mouthparts of cockroach?
- Function of mandibles and maxillae?
- Role of hypopharynx?

Morphology

Body Structure

- Body segmented into head, thorax, abdomen.
- Covered by hard chitinous exoskeleton with sclerites (tergites dorsal, sternites ventral) joined by flexible membranes.
- Head triangular, fused from 6 segments, flexible neck, with compound eyes and antennae.
- Mouthparts: labrum (upper lip), labium (lower lip), maxillae, mandibles, hypopharynx (tongue-like).
- Thorax: prothorax, mesothorax, metathorax; each segment has a pair of walking legs with segmented podomeres.
- Wings: two pairs from meso- and metathorax; forewings opaque and leathery, hindwings transparent and membranous for flight.

Memory Aids

- Head = 6 fused segments; Thorax = 3 parts with legs; Abdomen = 10 segments.
- Forewings cover hindwings at rest.

Quick Checkpoints

- How is cockroach body segmented?
- What are sclerites?
- Describe the wings and their function.

Anatomy

Body Segments and Sexual Differences

- Abdomen has 10 segments in both sexes.
- Female 7th sternum boat-shaped; 7th-9th sterna form brood pouch with female gonopore, spermathecal pores, collaterial glands.
- Male genital pouch at hind abdomen, bounded by 9th-10th terga and 9th sternum; contains anus, male genital pore, gonapophysis.
- Males have short anal styles; both sexes have anal cerci on 10th segment.

Memory Aids

- Female brood pouch = 7th-9th sterna; Male genital pouch = 9th-10th terga + 9th sternum.
- Anal cerci present in both sexes; anal styles only in males.

Quick Checkpoints

- How many abdominal segments in cockroach?
- Differences in male and female genital structures?
- What are anal cerci and anal styles?

Digestive system

Structure and Function

- Alimentary canal divided into foregut, midgut, hindgut.
- **Foregut**: Mouth → pharynx → oesophagus → crop (stores food) → gizzard (proventriculus) with 6 chitinous teeth for grinding.
- **Midgut**: Short, narrow, coiled; junction with foregut has 6-8 hepatic caecae secreting digestive juice.
- Midgut-hindgut junction has 100-150 Malpighian tubules removing excretory products.
- **Hindgut**: Ileum, colon, rectum with 6 rectal glands; opens via anus; more permeable to water than foregut.

- Foregut and hindgut ectodermal, lined by cuticle; midgut endodermal, no cuticle.

Memory Aids

- Crop stores food; Gizzard grinds food.
- Hepatic caecae = digestive juice; Malpighian tubules = excretion.
- Foregut/hindgut lined with cuticle; midgut not.

Quick Checkpoints

- What are the three regions of alimentary canal?
- Function of crop and gizzard?
- Role of hepatic caecae and Malpighian tubules?

Blood vascular system

Features

- Open type system; vessels open into haemocoel.
- Haemolymph bathes visceral organs; consists of colourless plasma and haemocytes.
- No respiratory pigment; does not aid respiration.
- Heart is elongated muscular tube with funnel-shaped chambers and ostia; pumps blood anteriorly.
- Heart is neurogenic.

Memory Aids

- Open system with haemocoel.
- Haemolymph lacks respiratory pigment.
- Heart has ostia and is neurogenic.

Quick Checkpoints

- Type of blood vascular system?
- Composition and function of haemolymph?
- What is neurogenic heart?

Respiratory system

Structure and Function

- Network of tracheae opening through 10 pairs of spiracles on body sides.
- Spiracles guarded by bristles to prevent dirt entry.
- Tracheal tubes carry oxygen to tissues; subdivide into tracheoles for gas exchange by diffusion.
- Most CO_2 exits through body cuticle, little through spiracles.

Memory Aids

- 10 pairs of spiracles with bristles.
- Tracheoles = site of gas exchange.
- CO_2 mostly leaves via cuticle.

Quick Checkpoints

- How does cockroach breathe?
- Function of spiracles and tracheae?
- Pathway of CO_2 exit?

Excretory system

Components and Function

- Excretion by Malpighian tubules lined with glandular and ciliated cells.
- Malpighian tubules absorb nitrogenous wastes, convert to uric acid; cockroach is uricotelic.
- Also reabsorb salts and water.
- Fat body, nephrocytes, uricose glands assist excretion.

Memory Aids

- Malpighian tubules = uric acid excretion.
- Insects are uricotelic.
- Fat body and nephrocytes aid excretion.

Quick Checkpoints

- What excretes nitrogenous wastes?
- Why are insects uricotelic?
- Other excretory aids?

Nervous system

Structure and Features

- Comprises central, peripheral, sympathetic systems.
- Fused, segmental ganglia joined by paired longitudinal connectives ventrally.
- 9 ganglia: 3 thoracic, 6 abdominal.
- Brain = bilobed supra-oesophageal ganglion; supplies antennae and compound eyes.
- Compound eyes have ~2000 hexagonal ommatidia; provide mosaic nocturnal vision (high sensitivity, low resolution).
- Other sense organs: antennae, maxillary palps, labial palps, anal cerci.

Memory Aids

- 9 ganglia: 3 thorax, 6 abdomen.
- Brain = supra-oesophageal ganglion.
- Compound eyes = mosaic vision with ommatidia.

Quick Checkpoints

- Number and location of ganglia?
- Function of supra-oesophageal ganglion?
- What is mosaic vision?

Reproductive system

Male and Female Structures

- Dioecious: sexes separate.
- Male: testes in 4th-6th abdominal segments, 3-lobed with follicles.
- Vas deferens opens into ejaculatory duct via seminal vesicles; stores sperms as spermatophores.
- Accessory mushroom-shaped gland in 6th-7th segments.
- External genitalia: male gonapophyses (phallomeres).
- Female: ovaries in 2nd-6th segments with ovarioles containing developing ova.
- Oviducts unite into median oviduct opening into genital chamber.
- Spermathecae in 6th segment open into genital chamber.
- Collaterial glands behind ovaries secrete ootheca (egg-case).
- Sperms transferred as spermatophores; fertilized eggs encased in reddish-brown oothecae.
- Females produce 9-10 oothecae, each with 14-16 eggs.
- Development is paurometabolous via nymphal stage; nymph moults ~13 times to adult.
- Some species are pests, contaminating food and spreading bacterial diseases.

Memory Aids

- Dioecious = separate sexes.
- Male: testes → vas deferens → ejaculatory duct → gonopore.
- Female: ovaries → oviduct → genital chamber; ootheca from collaterial glands.
- Development: paurometabolous with moulting.

Quick Checkpoints

- What does dioecious mean?
- Describe male reproductive tract.
- What forms the ootheca?
- Type of development in cockroach?

Frog

Characteristics

- Class Amphibia, Phylum Chordata; live in water and on land (amphibians).
- Common Indian frog: *Rana tigrina*.
- Cold-blooded (poikilotherms): body temperature varies with environment.
- Can change body color for camouflage (mimicry).
- Undergo aestivation (summer sleep) and hibernation (winter sleep) in extreme conditions.

Memory Aids

- Amphibians = live in both water and land.
- Poikilotherms = body temperature varies.
- Mimicry = protective coloration.
- Aestivation = summer sleep; Hibernation = winter sleep.

Quick Checkpoints

- What class and phylum does frog belong to?
- Define poikilotherms.
- What is mimicry in frogs?
- What are aestivation and hibernation?

Morphology

External Features

- Dorsal color: olive green with dark spots; ventral side pale yellow.
- Skin moist, smooth, slippery; absorbs water, does not drink.
- Body parts: head and trunk; no neck or tail.
- Nostrils above mouth; bulged eyes with nictitating membrane.
- Tympanum (ear) on sides of eyes for sound reception.
- Forelimbs: 4 digits; hindlimbs: 5 digits, muscular, webbed for swimming.
- Sexual dimorphism: males have vocal sacs and copulatory pads; males darker and slender.

Memory Aids

- Skin absorbs water, not drinking.
- Hindlimbs larger, webbed for swimming.
- Male vocal sacs and copulatory pads for mating.

Quick Checkpoints

- What are the body divisions of a frog?
- How do frogs absorb water?
- Describe sexual dimorphism in frogs.
- Function of tympanum?

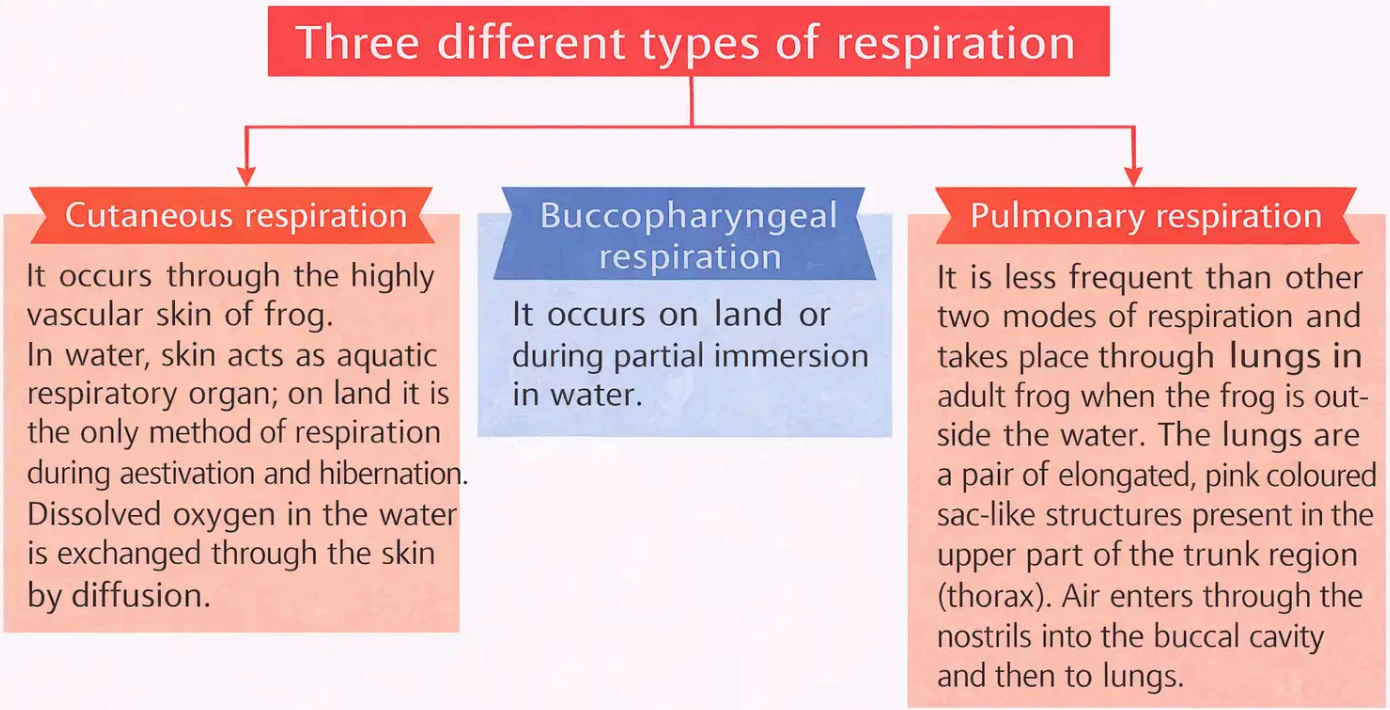
Anatomy

Digestive System

- Short alimentary canal; frogs are carnivores.
- Mouth → buccal cavity → pharynx → oesophagus → stomach (cardiac and pyloric parts).
- Small intestine: duodenum (digestion) and ileum (absorption).
- Rectum opens into cloaca.
- Digestive glands: liver (bile), pancreas (pancreatic juice), gastric and intestinal glands.
- Food captured by bilobed tongue; digestion by HCl and gastric juices.
- Chyme passes to duodenum; bile emulsifies fats; enzymes digest carbs and proteins.
- Absorption by villi and microvilli in intestine.
- Undigested waste expelled via cloaca.

Respiratory System

- Three types of respiration: cutaneous (skin), buccopharyngeal (mouth and throat), pulmonary (lungs).
- Cutaneous respiration mainly in water; pulmonary on land via nostrils to lungs.



Circulatory System

- Closed circulatory system: heart, blood vessels, blood; lymphatic system present.
- Heart: 3 chambers (2 atria, 1 ventricle), covered by pericardium.
- Sinus venosus joins right atrium; ventricle opens into conus arteriosus.
- Arteries carry blood from heart; veins return blood to heart.
- Hepatic portal system (liver-intestine) and renal portal system (kidney-lower body) present.
- Blood: plasma + cells (nucleated RBCs with hemoglobin, WBCs, platelets).
- Blood transports nutrients, gases, water; heart pumps blood.

Excretory System

- Components: paired kidneys, ureters, cloaca, urinary bladder.
- Kidneys: dark red, bean-shaped, contain nephrons (uriniferous tubules).
- Male ureters act as urinogenital ducts; female ureters and oviduct open separately into cloaca.
- Urinary bladder thin-walled, opens into cloaca.

- Frog is ureotelic; excretes urea.
- Excretory wastes filtered from blood by kidneys.

Memory Aids

- Short intestine due to carnivorous diet.
- Three respiration types: skin, mouth/throat, lungs.
- Heart has 3 chambers; closed circulation.
- Ureotelic animal: excretes urea.

Quick Checkpoints

- What are the parts of frog's digestive system?
- Explain the three types of respiration in frogs.
- Describe the structure of frog's heart.
- What is the excretory system composed of?

Control and Co-ordination

Neural and Endocrine Systems

- Control system includes nervous and endocrine systems.
- Endocrine glands: pituitary, thyroid, parathyroid, thymus, pineal, pancreatic islets, adrenals, gonads.
- Nervous system: central (brain, spinal cord), peripheral (cranial, spinal nerves), autonomic (sympathetic, parasympathetic).
- Brain enclosed in cranium; divided into forebrain, midbrain, hindbrain.
- Ten pairs of cranial nerves arise from brain.
- Sense organs: touch, taste, smell, vision (eyes), hearing (tympanum and internal ears).

Memory Aids

- Brain parts: forebrain, midbrain, hindbrain.
- 10 pairs cranial nerves.

- Endocrine glands regulate body functions via hormones.

Quick Checkpoints

- What are the components of frog's nervous system?
- Name major endocrine glands in frogs.
- How many cranial nerve pairs are present?
- List the sense organs of frog.

Reproductive System

Male and Female Systems

- Male: paired yellowish testes, vasa efferentia, urinogenital ducts.
- Testes attached to kidneys by mesorchium.
- Vasa efferentia open into Bidder's canal, which connects to urinogenital duct opening into cloaca.
- Cloaca passes faeces, urine, and sperms.
- Female: paired ovaries, oviducts, cloaca.
- Mature female lays 2500-3000 ova at a time.
- Fertilisation is external in water.
- Development includes larval tadpole stage; metamorphosis forms adult.

Memory Aids

- Mesorchium connects testes to kidneys.
- External fertilisation in water.
- Tadpole undergoes metamorphosis.

Quick Checkpoints

- Describe male reproductive organs in frog.
- How does fertilisation occur?
- What is metamorphosis?

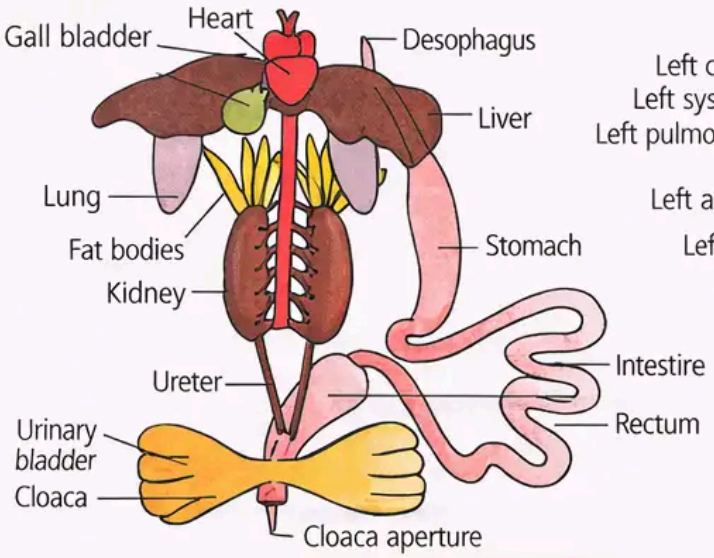
- Number of ova laid by female frog?

Economic Importance

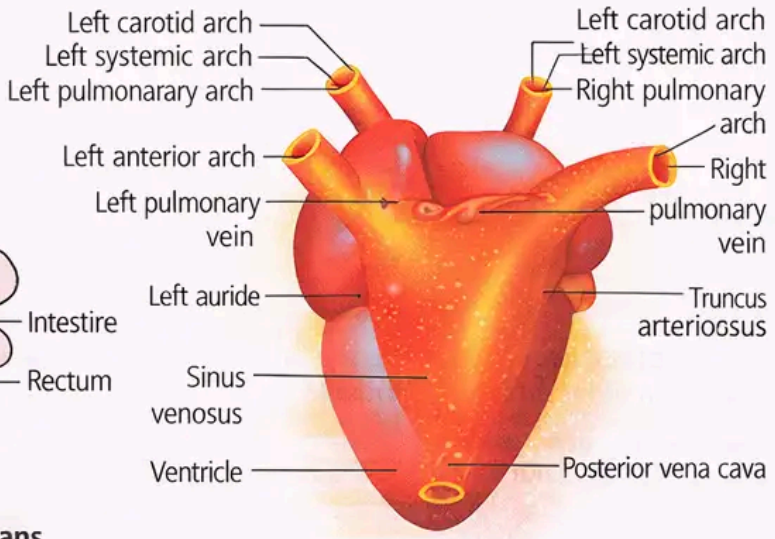
Benefits to Humans and Ecosystem

- Frogs eat insects, protecting crops.
- Maintain ecological balance as part of food chain and web.
- Frog legs consumed as food in some countries.

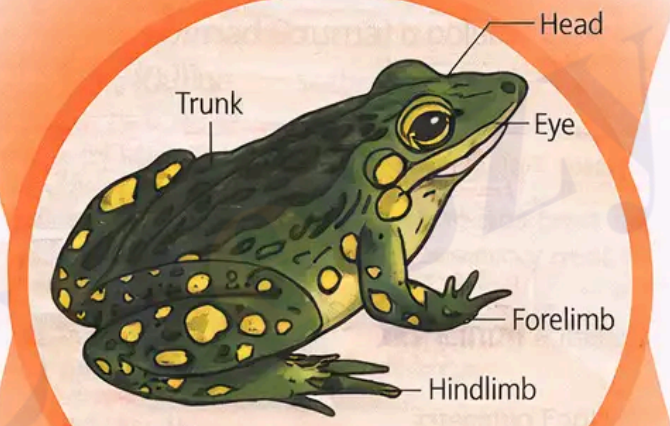
Frog



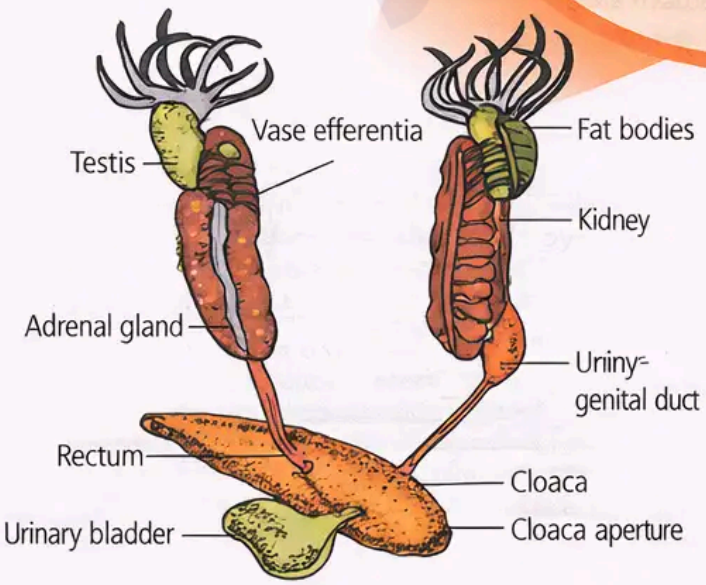
Diagrammatic representation of internal organs of frog showing complete digestive system



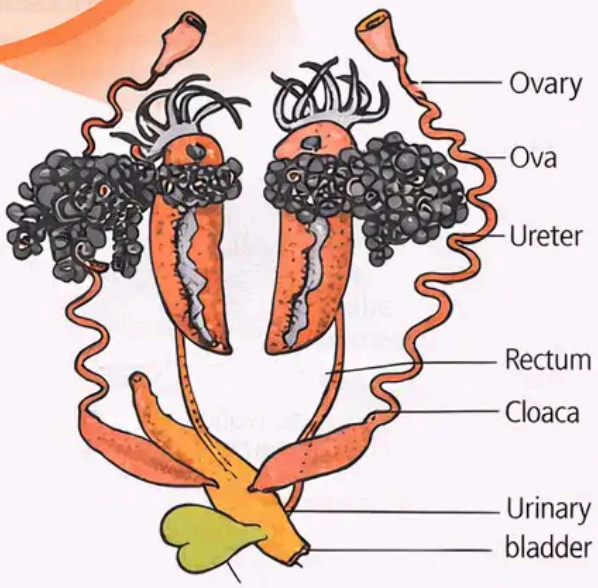
Dorsal view of heart of frog



External features of frog



Male reproductive system



Female reproductive system

Memory Aids

- Frogs control insect population.
- Important link in ecosystem food chains.
- Edible frog legs in some cultures.

Quick Checkpoints

- How do frogs benefit agriculture?
- What role do frogs play in ecosystems?
- Are frogs used as food?