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7. Structural Organisation in Animals

POINTS TO REMEMBER :

Tissue : A group of similar cells along with intercellular substances which perform a specific function.

ANIMAL TISSUES :
Animal tissues are classified into four types:

- **Epithelial tissues.**
- **Connective tissues.**
- **Muscular tissues.**
- **Neural tissues.**

Epithelial tissues :

- These tissues commonly called epithelium.
- Has free surface, which faces either a body fluid or the outside environment.
- Cells are compactly packed with little intercellular matrix.
- There are two types of epithelial tissues:
    - **Simple epithelium.**
    - **Compound or stratified epithelium.**

- Simple epithelium is composed of a single layer of cells and functions as a lining for body cavities, ducts and tubes.
- The compound epithelium consists of two or more cell layers and has protective function as it does in our skin.

Simple epithelium, on the basis of modification, divided into three types:

- **Squamous**
- **Cuboidal**
- **Columnar**.

Squamous epithelium :

- Made of single thin layer of flattened cells with irregular boundaries.
- Found in the wall of blood vessels and air sacs of lungs.
- Functions as diffusion boundary.

Cuboidal epithelium :

- Composed of a single layer cube – like cells.
- Found in ducts of glands and tubular part of nephrons in kidneys.
- Main function is secretion and absorption.

Columnar epithelium :

- Composed of a single layer of tall and slender cells.
- Their nuclei located at the base.

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- Free surface may have microvilli.
- Found in the lining of stomach and intestine
- Helps in absorption and secretion.

Ciliated epithelium :

- It is a modified Cuboidal or columnar epithelium.
- Cell bears cilia on their free surfaces.
- Found in the inner surface of hollow organs like bronchioles and fallopian tubes.
- Their function is to move particles or mucus in a specific direction over the epithelium.

Glandular epithelium :

- It is a modified Cuboidal or columnar epithelium.
- Get specialized for secretion.
- **Simple glands** having unicellular and isolated cells of alimentary canal.
- **Multicellular glands**: consisting of cluster of cells, as in salivary gland.
- **Exocrine gland**: the secretory product transported to a point by means of a duct. These glands secrete mucus, saliva, ear wax, milk, digestive enzymes etc
- **Endocrine gland**: commonly called as ductless gland, because the secretory products directly poured into blood. The glands secretes hormone.

Compound epithelium :

- Made of more than one layer of cells.
- Limited role in absorption and secretion.
- Main function is to provide protection against chemical and mechanical stresses.
- They cover the dry surface of skin, moist surface of buccal cavity, pharynx, inner lining of duct of salivary gland and pancreatic duct.

Cell junction :

- Cells of the epithelium are held together with little intercellular matrix.
- Cell junction provide structural and functional link between the cells
- **Tight junction**: help to stop substances from leaking across a tissue.
- **Adhering junctions**: perform cementing to keep neighboring cells together.
- **Gap junctions**: facilitate the cells to communicating the cytoplasm of adjoining cells, for rapid transfer of ions, small molecules.

Connective tissues :

- Most abundant and widely distributed tissues.
- Special function of linking and supporting other tissues/organs of the body.
- Connective tissues include cartilage, bone, adipose, and blood.
- In all connective tissue except blood, the cells secrete fibres of proteins called collagen and elastin.
- The fibre provides strength, elasticity and flexibility to the tissue.
- Presence of **ground substance** or **matrix** in between the cells, modified **polysaccharides.**

Loose connective tissue :

- Has cells and fibres loosely arranged in a semisolid ground substance.

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Areolar tissue :

- **Areolar tissue** is one example of loose connective tissue.
- Present beneath the skin.
- It supports the framework for epithelium.
- It contains cell like **fibroblasts** (secretes fibres), **macrophages** and **mast cells.**

Adipose tissue:

- Another type of loose connective tissues.
- Located mostly beneath the skin.
- Cells of this tissue specialized to store fats called **adipocytes.**

Dense connective tissue :

- Fibres and fibroblasts are compactly packed.

Dense regular tissues :

- Orientation of fibres shows a regular pattern.
- The collagen fibres are present in rows between many parallel bundles of fibres.
- Tendons: joints muscles to bone.
- Ligaments: joins bone to bone are the examples.

Dense irregular tissues:

- Fibroblasts and many fibres are oriented differently.
- This tissue present in skin.

Specialized connective tissues :

- **Cartilage bone and blood are the special connective tissues.**

Cartilage:

- Intercellular material of cartilage is solid.
- **Chondrocytes** are the cells of cartilage.
- Pliable and resists compression.
- Cells are enclosed in small cavities within the matrix.
- Most of the cartilage of the embryo replaced by bones in adult.
- Cartilage present in nose tips, ear pinna, between adjacent vertebrae.

Bones:

- Have hard and non pliable matrix or ground substance.
- The matrix is rich in calcium salts and collagen fibers which give the bone its strength.
- Provides the structural frame of human body.
- Support and protect the soft tissues and organs.
- The bone cells called Osteocytes are present in fluid filled cavity called lacunae.
- Sustain body weight.

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- Attached with skeletal muscles meant for locomotion.
- Bone marrow is the site of production of Red blood cells.

Muscular tissues:

- Each muscle is made of many long, cylindrical fibres arranged in parallel arrays.
- Each fibre composed of numerous fine fibrils, called myofibrils.
- Muscle fibres contracts in response to stimulus.
- Muscle plays a great role in movement and locomotion.

Skeletal muscle:

- Closed attached to the skeleton or bone and cartilage.
- Muscle cells are unbranched and multinucleated.
- A number of muscle fibres are bundled together in parallel fashion.
- A sheath of tough connective tissues encloses several bundles of muscle fibres.

Smooth muscle :

- The smooth muscle fibres tapers or pointed at both ends
- Do not show cross striation.
- Cell junctions hold them together.
- They are bundled together in a connective tissue sheath.
- Present in wall of blood vessels, stomach and intestine.
- They are involuntary in nature.

Cardiac muscles:

- Contractile muscular tissue present in heart.
- Cell junctions fuse the plasma membranes of cardiac muscles cells and make them stick together.
- Communication junction or intercalated discs at some fusion points allow the cells to contract as a unit.
- Muscle cells are branched and Uninucleated.

Neural tissues:

- Neural tissues exert greatest control over body's response to changing condition.
- Neurons are the units of nervous tissues.
- Neuroglial cells non-conducting and protects and support neurons.
- Neuroglia makes up more than one-half the volume of neural tissue.
- Electrical impulse is conducted through the plasma membrane of neuron.

EARTHWORM :

Morphology :

- Earthworm has long cylindrical body.
- The body divided into more than 100 equal segments called **metamere.**
- Mid-dorsal dark line indicates the dorsal blood vessel.
- The ventral surface is distinguished by **genital openings**.
- Anterior end consists of the mouth and prostomium.

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- The first segment is called **peristomium**, which contain the **mouth.**
- In matured worm, segments 14-16 are covered by dark band of glandular tissue called **clitellum.**
- Body divisible into:
    - **Preclitellar.**
    - **Clitellar.**
    - **Postclitellar**

- **External apertures:**
    - Four pairs of spermathecal aperture 5th – 9th segments.
    - A female genital aperture- 14th segment.
    - A pair of male genital apertures in 18th segment.
    - Numerous nephridial pores on the skin of each segment.

- There are row of S- shaped **Setae** in each segment except 1st and last segment.
- Setae have principal role in locomotion.

ANATOMY :

Body wall :

- Body wall externally covered by thin non-cellular cuticle.
- Body wall contains epidermis below cuticle.
- Epidermis is made of single layer of columnar epithelium with secretory glands.
- Two layers of muscles (circular and longitudinal).

Digestive system:

- Alimentary canal is a straight tube between 1st and last segment.
- **Mouth** present in the 1st segment.
- Mouth opens into **buccal cavity** 1-3 segments.
- Buccal cavity leads into **muscular pharynx** in 4th segment.
- Narrow **oesophagus** at 5-7 segments.
- Muscular gizzard in 8-9 segments helps in grinding of ingested food.
- **Stomach** extended from 9-14 segments.
- **Calciferous gland** present in the stomach, neutralize the acidic nature of **humic acid** present in the humus.
- Intestine starts from 15th segment and continues till last segment.
- A pair of Intestinal caecae present in the 26th segment.
- Presence of internal median fold of dorsal wall of intestine called **typhlosole** between 26-35 segments.
- Typhlosole increases the surface area for absorption.
- Intestine opens to outside by means of anus.

Blood vascular system :

- Blood vascular system is closed type.
- Blood vascular system consists of:
    - Blood vessels

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- Capillaries
- Heart.

- **Blood glands** present on 4th, 5th and 6th segments.
- Blood glands produce blood cells and haemoglobin.
- Haemoglobin dissolved in plasma instead of embedded in corpuscles.
- Blood cells are **Phagocytic** in nature.

Respiration:

- Earthworm lack specialized breathing devices.
- Gaseous exchange takes place through moist surface of skin.
- Transport of respiratory gases takes place in haemoglobin.

Excretory system:

- Excretory organs are segmentally arranged coiled tubules called **nephridia.**
- There are three types of nephridia:

- **Septal nephridia:**
  - Present on both side of intersegmental septa of segment 15 to last segment.
  - They opened into the intestine.

- **Integumentary nephridia.**
  - Attached to the lining of the body wall from 3th to last segment.
  - Opened into the body surface.

- **Pharyngeal nephridia:**
  - Present in three pairs in 4th, 5th and 6th segment.

- Nephridia regulate the volume and composition of body fluids.
- A nephridium starts with a ciliated funnel like structure called nephrostome, connected with a tubular part.

Nervous system :

- Represented by ganglia arranged segmentally on the ventral paired nerve cord.
- Nerve cord in the anterior region (3rd and 4th segments) bifurcates, laterally encircling the pharynx and joins the cerebral ganglia dorsally to form nerve ring.
- Segmental ganglia give rise to nerve fibres to the body organs.

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Sensory organs :

- Possesses light and touch sensitive organs (receptor cells)
- Have specialized chemoreceptor, which reacts to chemical stimuli.
- Sense organs located in the anterior part of the body.

Reproductive system :

- Earthworm is hermaphrodite
- Two pairs of testes present in the 10th and 11th segments.
- Their vasa deferentia run upto 18th segment and joins with prostatic duct.
- Two pairs of accessory glands present one pair each in the 17th and 19th segment.
- The prostrate and spermatic duct (vasa dererentia) opens to exterior by a pair of male genital pore on the ventro-lateral side of the 18th segment.
- Four pairs of spermathecae are located in 6th – 9th segments.
- They receive and store spermatozoa during copulation.
- One pair of ovaries is attached at the inter-segmental septum of 12th and 13th segment.
- Ovarian funnel continued as oviduct, join together and open by a single female genital aperture on the 14th segment.
- Mutual exchange of sperm occurs between two worms during mating.
- Mature sperms and egg cells and nutritive fluid are deposited in the cocoons produced by gland cells of clitellum.
- Fertilization takes place inside the cocoon which deposited in soil,
- After three weeks each cocoon produces two to twenty baby worms.
- Development is direct without larval stage.

COCKROACH :

Morphology :

- Adults cockroach *Periplaneta americana* are about 34-53 cm long with wings that extended beyond the tip of the abdomen.
- Segmented body distinguished into head, thorax and abdomen.
- Entire body is covered by external chitinous exoskeleton.
- Each segment has hardened plates called sclerites (dorsal**tergites**, ventral **sternites**).
- Successive sclerites are joined by flexible articular membrane (arthrodial membrane)

Head :

- Head is formed by fusion of six segments, with flexible neck.
- The head bears a pair of compound eye, a pair of antennae.
- Antennae have sensory receptors.
- Head bears appendages meant for biting and chewing types of mouth parts.
- The mouth parts consists of:
    - A labrum (upper lip)
    - A pair of mandibles.
    - A pair of maxillae
    - A labium (lower lip)
    - A median flexible lobe acting as tongue (hypopharynx).

Thorax :

- Thorax consists of three parts – **prothorax, mesothorax and metathorax.**

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- Each thoracic segment bears a pair of walking legs.
- First pair of wings arises from mesothorax and second pair from metathorax.
- The hind wings are transparent, membranous meant for flying.

Abdomen :

- The abdomen consists of 10 segments.
- In female the 7th segment is boat shaped and along with 9th and 10th segment it forms the broad or genital pouch.
- Genital pouch contains female gonopore, spermathecal pores and collateral glands.
- In male the genital pouch bounded dorsally by 9th and 10th terga and ventrally by the 9th sternum.
- Male bears a pair of anal style, absent in female.
- Anal cerci present in both sexes in 10th segment.

ANATOMY :

Digestive system :

- Alimentary canal divided into three regions; **foregut, midgut and hindgut.**
- The mouth opens into short **pharynx** leading to **oesophagus.**
- Oesophagus opens into a sac like **crop,** which store food.
- Crop is followed by **gizzard** or **proventriculus.**
- Gizzard contains chitinous teeth for grinding the food.
- The entire fore gut is lined by **cuticle.**
- A ring of 6-8 blind tubules called **hepatic or gastric caecae** present at the junction of foregut and midgut, which secretes **digestive juices**.
- Midgut is long tube like structure.
- At the junction of midgut and hindgut, another ring of 100-150 yellow coloured thin filamentous **Malpighian tubules**are present.
- Malpighian tubules are meant for excretion from haemolymph.
- The hindgut is broader and differentiated into **ileum, colon** and **rectum.**

Blood vascular system:

- Blood vascular system is open type.
- Blood vessels are poorly developed and open into space called **haemocoel.**
- Visceral organs located in the haemocoel and bathed in blood called **haemolymph.**
- The haemolymph composed of colourless plasma and haemocytes.
- Heart is elongated multichambered, funnel shaped with ostia.
- Blood enter into the heart through ostia and is pumped anteriorly into the sinuses.
- The haemocoel differentiated into three sinuses;
    - **Pericardial sinus.**
    - **Perivisceral sinus.**
    - **Perineural sinus.**

Respiratory system :

- The respiratory system consists of a network of trachea.
- Trachea opens to outside by 10 pairs of small holes called spiracles on lateral side of the body.
- Trachea gives rise to branching tubes called tracheal tubes which subdivided into tracheoles.
- Opening of spiracles regulated by valves.
- Movement of air takes place by diffusion and directly to the body cell.

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Excretion:

- Excretion is performed by malpighian tubules.
- Each tubule is lined by glandular and ciliated cells.
- They absorb nitrogenous wastes from the haemocoel and converted into uric acid and poured into the hindgut.
- Hence cockroach is **uricotelic** in nature.
- Nephrocytes and uricose glands also assist in excretion.

Nervous system:

- Consists of a series of segmentally arranged ganglia joined by paired longitudinal double ventral nerve cord.
- Three ganglia lie in thorax and six in the abdomen.
- Head contain a bit of nervous system.
- The brain is represented by supra-oesophageal ganglion which innervates the compound eye and antennae.
- The sense organs are antennae, eyes maxillary palps, labial palps, anal cerci etc.
- Each compound eye consists of about 2000 hexagonal ommatidia.
- Each ommatidium forms a part of the image, called mosaic vision.

Reproductive system :

- Cockroaches are dioecious and sex organs are well developed.
- Male reproductive system consists of a pair of testes lying one on each in 4th and 6th segments.
- Vas deferens arises from each testis, opens into ejaculatory duct through seminal vesicle.
- Ejaculatory duct opens into the male gonopore situated ventral to anus.
- Accessory reproductive gland called mushroom gland present on 6th-7th segment.
- External genitalia represented by male **gonopophysis** or **phallomere.**
- Sperms are sorted in the seminal vesicles and are glued together in the form of bundles called **spermatophores**which are discharged during copulation.
- **The female reproductive system consists of two large ovaries present in 2nd – 6th abdominal segments.**
- Each ovary is formed a group of eight ovarian tubules or ovarioles, containing chain of developing ova.
- Oviduct of each ovary fused to form single median oviduct or vagina, which opens into genital chamber.
- A pair of spermatheca is present in the 6th segment which opens into genital chamber.
- Sperms are transferred through spermatophores.
- The fertilized eggs are encased in capsules called oothecae.
- Ootheca is dark reddish to blackish brown capsule about 3/8” long.
- On average, female produce 9-10 oothecae, each containing 14-16 eggs.
- Development is pourometabolous i.e development through nymphal stages.
- The nymph grows by molting about 13 times to reach the adult form.

FROG :

- Frog belongs to class Amphibia.
- Most common species in India is *Rana tigrina.*
- They are cold blooded animal; the body temperature varies according to environmental temperature.
- They have ability to change the body colour according to the environment.
- They undergo **hibernation (summer sleep)** and **aestivation (winter sleep).**

Morphology :

- The skin is smooth and moist, slippery due to **mucus.**

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- Dorsal body is olive green with dark irregular spots.
- Ventral side of the body is uniformly pale yellow coloured.
- The frog never drinks water and absorb it through skin **(hygroscopic).**
- Body divisible into **head** and **trunk.** Neck is absent.
- On either side of the eyes a membranous tympanum (represents the external ear), to receive the sound waves.
- Forelimbs and hind limbs helps in swimming, leaping and burrowing.
- Fore limb have four digit and hind limb stronger and has five digits.
- Frog exhibit sexual dimorphism.
- Male frog distinguished from female frog:
    - Having sound producing vocal sac.
    - Copulatory pad or amplexury pad on the first digit of the fore limb.

Anatomy :

Digestive system :

- Digestive system consists of alimentary canal and digestive glands.
- Alimentary canal is short because frogs are carnivorous.
- Mouth opens into buccal cavity that leads into oesophagus through pharynx.
- Oesophagus is a short tube that opens into the stomach, which inturn continues as the intestine, rectum and finally opens outside by the cloaca.
- Liver secrete bile that stored in the gall bladder.
- Pancreas a digestive gland produces pancreatic juice containing digestive enzymes.
- Food is captured by bilobed tongue.
- Digestion of food takes place by the action of HCl and gastric juice secreted from the walls of the stomach.
- Partially digested food in the stomach is called **chyme.**
- Chyme passed from stomach to intestine, the duodenum.
- The duodenum receives the bile from gall bladder and pancreatic juice from pancreas through a common bile duct.
- Bile emulsifies fat and pancreatic juices digest carbohydrates and proteins.
- Final digestion takes place in intestine.
- Digested food is absorbed by intestinal villi and microvilli.
- The undigested food removed to outside through cloaca.

Respiratory system :

- In water frog respire through skin (cutaneous respiration)
- Exchange of respiratory gases takes place through diffusion.
- In land it respires through buccal cavity, skin and lungs.
- Respiration by lungs is called pulmonary respiration.
- During aestivation and hibernation it respires through skin.

Circulatory system :

- The blood vascular system includes heart, blood vessel and blood.
- The lymphatic system includes lymph, lymph nodes and lymphatic vessels.
- Heart is three chambered with two atria and one ventricle.
- Heart is covered by a membrane called **pericardium.**
- A triangular **sinus venosus** opens into right atrium. It receives the deoxygenated blood through vena cava.
- The ventricle opens into **conus atreriosus** on the ventral side of the heart.
- Form the conus atreriosus the blood circulated to different part of the body by arterial system.
- Blood collected from the body to the heart by venous system.

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- Special venous connection between liver and intestine is called **hepatic portal system.**
- Venous connection between lower part of the body and kidney is called **renal portal system.**
- The blood is composed of plasma and cells.
- The blood cells are; erythrocytes (RBC), leucocytes (WBC) and Thrombocytes (Platelets).
- RBC is nucleated and contains hemoglobin.
- The lymph differs from in, it lack proteins and RBC.

Excretory system :

- The excretory system consists of a pair of kidneys, ureters, cloaca and urinary bladder.
- Each kidney composed of several **uriniferous tubules** or **nephrons.**
- The ureter arises from the kidney act as urinogenital duct which opens into cloaca in male.
- In female the ureters and oviduct open separately into the cloaca.
- Thin walled urinary bladder located ventral to rectum, opens to the cloaca.
- The frog excretes nitrogenous waste in the form of urea, hence **ureotelic.**

Control and coordination system :

- It includes both nervous and endocrine system.
- Chemical coordination is carried out by hormones secreted by endocrine glands.
- Endocrine glands found in frog are pituitary, thyroid, parathyroid, thymus, pineal body, pancreas, adrenal and gonads.
- The nervous system organized 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 arises from the brain.
- Brain is enclosed in side the cranium.
- The brain differentiated into; fore brain, mid brain and hind brain.
- Fore brain includes;
    - Paired olfactory lobe.
    - Paired cerebral hemisphere
    - Unpaired diencephalon.

- The mid brain is characterized by a pair of optic lobes.
- Hind brain consists of cerebellum and medulla oblongata.
- Medulla oblongata passes through foramen of magnum and continues as spinal cord which runs inside the vertebral column.

Sense organs:

- Frog has different types of sense organs;
    - Organs of touch (sensory papillae)
    - Taste (taste buds)
    - Smell (nasal epithelium)
    - Vision (eye)
    - Hearing (tympanum with internal ear)

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- Eye is well organized inside the orbit of the skull.
- Ear is an organ for hearing and equilibrium (balancing).

Male reproductive system:

- Consists of a pair of yellowish ovoid testes, attached to the upper part of kidneys, by **mesorchium.**
- Vasa efferentia are 10-12 in number arises from the testes.
- They enter into the kidney and opens into **Bidder's canal.**
- Bidder's canal communicates with the urinogenital duct that comes out of the kidneys and opens into the cloaca.
- The cloaca is a small median chamber that is used to pass faecal matter, urine and sperms to the exterior.

Female reproductive system:

- Includes a pair of ovaries present near the kidneys.
- A pair of oviduct arising from ovaries opens into the cloaca separately.
- A mature female lays 2500 to 3000 ova at a time.
- Fertilization is external i.e. in water
- Development is indirect involved a larval stage called **tadpole larva.**
- Tadpole larva metamorphoses into adult frog.

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