Structural Organisation In Animals

Syllabus

Structural Organisation In Animals

Epithelial Tissue, Connective, TissueMuscular Tissue, Neural Tissue, Crockroach

Name : _____ **Contact No.** _____

Epithelial Tissue

Epithelial Tissue

The tissue or epithelium (Epi - upon ; thele nipple) covers both external and internal surfaces of the animal body.

The epithelial tissue has a free surface, which faces either a body fluid or the outside environment and thus, provides a covering or a lining for some part of the body.

Characteristics

The characteristic features of epithelial tissue are as follows

i. The cells are compactly arranged.

ii. Intercellular spaces are narrow, 20-30 nm wide.

iii. Adjacent cells are held together by intercellular junctions.

iv. The epithelial tissue lies on a thin, non-cellular basement membrane.

v. Body vessels are not present in the epithelial tissue.

vi. Materials are exchanged by diffusion between epithelial cells and the blood vessels of the connective tissues across the basement membrane.

vii. Nerve endings may penetrate the epithelial tissues.

Junctions Between Epithelial Cells

The common intercellular junctions may include tight junctions, gap junctions, desmosomes, intercellular bridges and interdigitations.

Tight Junctions

The plasma membrane in the apical region of the adjacent epithelial cells become tightly packed together. These junctions check the flow of materials between the cells and called **occluding junctions.**

Desmosomes

These are thick and strong junctions. They serve, anchoring functions.

Gap Junctions

They are finaly hydrophilic channels between adjacent cells formed with the help of protein cylinders called connexin. They help in chemical exchange between adjacent cells and hence are called communicating junctions.

Types of Epithelial Tissues

The epithelial tissues are broadly classified into two groups, i.e., simple and compound.

1. Simple Epithelial

Simple epithelial is made up of a single layer of compactly arranged cells which rest over a non-cellular basement membrane. It occurs over moist surfaces where a little wear and tear occurs by friction. The simple epitheliam is generally related with absorption, secretion diffusion and movement of materials.

It is further sub-divided into following types

i. Simple Squamous Epithelium

The squamous (*squama*-scale) is formed of a single layer of closely fitted, flattened, polygonal cells, which forms bulges on the cell surface.

The given cells are held together by various types of junctions, mainly tight junctions. The cells of squamous epithelium appear as tiles over a floor. They are also known as pavement epithelium.

The squamous epithelium occurs in the alveoli of the lungs, Bowman's capsule, Henle's loop of uriniferous tubules, pericardial cavity, abdominal cavity, lining of various components of blood vascular system.

Simple Cuboidal Epithelium

It composed of a single layer of **cube-like** cells. The epithelium overlies on the basement membrane. Nucleus is rounded and placed centrally. The free surfaces of the cells may be smooth or bear microvilli. The **microvilli** increases the surface are of free ends of cells by many times.

The simple cuboidal epithelium is commonly found the ducts of glands, tubular parts of nephrous in kindeys, ovaries seminiferous tubules of testes, etc.

Functions

The main function of this epithelium is protection, secretion, absorption, excretion and gamete function.

Simple Columnar Epithelium

It is composed of a single layer of tall and slender cells. The single oval or elongated nucleus is situated near the phase of the cell. Some of its cells produce mucus, called goblet cells.

The simple columnar epithelium occurs in the lining of stomach, small and large intesting, digestive glands of stomach, intesting and pancreas, gall bladder, etc.

The brush border columnar epithelium occurs in the all bladder. The mucus secreting goblet cells are found in the living layer of stomach, intestine, respiratory tract, etc.

Functions

The simple columnar epithelium helps on secretion, absorption and protection to the components of most glandular epithelia.

Simple Ciliated Epithelium

The columnar or cuboidal cells bear cilia on their free surface are called ciliated epithelium. They have particles or musuc in a specific direction over the epithelium. The epithelium lies over a basement. In sensory cells of internal ear, a cilium accompanies number of stereocilia.

This epithelium is of two types, i.e., ciliaetd columnar and ciliated cuboidal.

i. **Simple Ciliated Columnar Epithelium** It possess columnar cells that possess cilia over their free surface. It occurs in respiratory tract, fallopian tubes, parts of uterus and cervix, the different tubules of testes, etc.

ii. **Simple Ciliated Cuboidal Epithelium** It has cuboidal or cubical cells that bear cilia on their free surface. It occurs in many parts of ependyma of nervous system and parts of uriniferous tubules.

Functions The epithelium maintains a flow of mucus, liquid or suspended particles constantly in one direction. In the oviducts, cilia helps in the movement of egg towards the uterus. In respiratory tract, cilia helps to push the mucus towards the pharynx. In nephrous of kidney, cilia keep the urine moving.

In nervous system, cilia of the ventricles of the brain and central canal of the spinal cord helps in the circulation of cerebrospinal fluid.

Pseudostratified Epithelium

The epithelium is one-cell thick, but appears 2-layered because all the cells do not react the free surface. The cells are attached to the basement membrance, hence they are called pseudostratified. The musuc secreting goblet cells also occur in this epithelium.

This epithelium is of two types

i. **Pseudostratified Columnar Epithelium** It has columnar cells without cilia. It lines the large ducts of certain glands, like **paroid salivary glands** and the urethra of human male.

ii. **Pseudostratified Ciliated Columnar Epithelium** It has columnar cells. The tall cells bear cilia at the free surface and the short cells are without cilia. The epithelium lines the trachea and large bronchi.

Functions The pseudostratified epithelium helps in protection, movement of secretions from glands, urine and semen in urethra and musuc loaded with dust particles and bacteria in trachea.

2. Compound Epithelia

The compound epithelium is made up of more than one layer of cells. They cover the surfaces where constant replacement of cells is required due to rapid wear and tear by friction.

The compound epithelia are of two types i.e., stratified and transitional.

a. Stratified Squamous Epithelium The cells in the basal (deepest) layer are columnar or cuboidal with oval nuclei. It is called germinative layer. The cells in this region divide by mitosis to form new cells.

The stratified squamous epithelium is further sub-divided as two main types, i.e., keratinised and non-keratinised.

- **Keratinised Stratified Squamous Epithelium**

The cells of the outer few layers replace their cytoplasm with a hard waterproof protein called keratin or horn. This is called keratinization or cornification. These layer of flat, dead cells are called **stratum corneum** or **horny layer.**

The heavy deposits of keratin in the dead superficial cells makes the epithelium impervious to water and highly resistant to mechanical abrasions. This epithelium forms the epidermis of the skin in land vertebrates.

- **Non-keratinised Stratified Squamous Epithelium**

This epithelium does not have keratin and is unable to check water loss.

b. Stratified Cuboidal Epithelium It has outer layer of cuboidal cells and basal layer of columnar cells forms the epidermis of fishes. It also like the sweat gland ducts and larger salivary a pancreatic ducts.

c. Stratified Columnar Ciliated Epithelium Its outer layer consists of ciliated columnar cells and basal layer of columnar cells. It lies the larynx and upward part of the soft palate.

d. Stratified Columnar Epithelium It consists columnar cells in both superficial and basal layers covers the epiglottis and lines mammary gland and parts of urethra.

Transitional Compound Epithelium

The epithelium consists of more than one layer of cells, but is much thinner and more stretchable than the stratified epithelium. It contains **cuboidal cells** at the base, two or three layers of large polygonal or pear-shaped cells in the middle and a superficial layer of large, broad, rectangular or oval cells.

The transitional epithelium lines the inner surface of urinary bladder, ureter and renal pelvis. They have thick membrance with thin regions that fold when the bladed contracts.

3. Glandular Epithelium

Some of the columnar or cuboidal cells get specialized for secretion and forms the glandular epithelium.

It is of two types

a. Unicellualr Glandular Epithelium It consist isolated glandular epithelium.

b. Multicellular Glandular Epithelium It consists of cluster of epithelial cells called extra epithelial cells. These cells unite to make up one gland, e.g., Salivary gland.

Gland

A cells, tissue or organ, which secretes some substance is called a **gland.** The secretions of glands may be protein (pancreas), lipids (adrenals), mixture of carbohydrates and proteins (salivary gland) or mixture of all the three materials (mammary glands).

The glands can be classified in different types based on site of secretion, mode of secretion and involvement of single or many cells.

i. Based on Site of Secretion

The glands can be exocrine, endocrine or heterocrine based on the site where the secretion is released.

a. **Exocrine Glands** These glands where have ducts to pour their secretions to their site of action. They often secrete enzymes and its examples include salivary glands, intestinal glands, gastric glands, lacrimal or tear glands.

b. **Endocrine Glands** These glands do not have ducts and pour their secretions directly into the blood or lymph. These glands are also called ductless glands and their secretions are known as **hormones.** Some examples of endocrine glands are pituitary, thyroid, parathyroid, adrenal, etc.

c. **Heterocrine Glands/Myxocrine Glands** These glands are partly exocrine and partly.

ii. Based on Number of Cells

According to the number of cells forming the glands, they are unicellular and multicellular.

a. **Unicellular Glands** The mucus secreting goblet cells of the alimentary canal are called unicellular glands.

b. **Multicellular Glands** These are composed of many cells and are formed by sinking of the gland into the underlying connective tissue. The multicellular glands may be simple or compound glands.

- **Simple Glands** These may be simple tubular glands, e.g., Crypts of Lieberkuhn, simple coiled tubular glands (sweat glands) and simple alveolar glands having flask-shaped secretory units (musuc secreting glands in the skin of frog.)
- **Compound Glands** These have branch system of ducts. These may be compound tubular glands (e.g, Gastric glands of stomach, Brunner's glands of intestine), compound alveolar glands (e.g., Some sebaceous glands and salivary glands) and compound tubuloalveolar glands having both tubular and alveolar secretory units (e.g., Pancreas, functional mammary glands).

Functions of Epithelial Tissue

The main functions of epithelial tissue are listed below

i. The epithelial tissue protects the underlying tissues from mechanical injury, entry of germs, harmful chemicals and drying up.

ii. It check the absorption of harmful or unnecessary materials.

iii. The epithelium of uriniferous tubules is specialised for urine excretion.

iv. The sensory epithelial of sense organs help to receive various stimuli from the atmosphere and convey them to the brain.

v. The epithelium of alveoli of the lungs brings about the exchange of gases between the blood and air.

vi. The pigmented epithelium of the retina darkens the cavity of eyeball.

vii. Epithelium also forms glands that secrete secretions such as mucus, gastric juice and intestinal juice.

viii. Epithelium produces exoskeletal structures like scales, feathers, hair, claws, horns and hoofs.

ix. Ciliated epithelia (e.g., of respiratory and genital tracts) serves to conducts the mucus and other fluids in the ducts they line.

Connective Tissue

The connective tissues are most abundant and widely distributed in the body of complex animals. They are named as connective tissues because of their special function of linking and supporting other tissues/organs of the body.

Generally, connective tissue is made up of three compounds

1. Matrix

It is a clear and viscous substance. its consistency may vary from liquid (e.g., blood) so semi-solid (e.g., cartilage) and solid (e.g., bone) form.

2. Cells Embedded in the Matrix

These are responsible for secreting the matrix and other substances.

The cells of connective tissue are of different types

i. **Fibroblasts** produce fibres and matrix.

ii. **Adipose** cells store fat.

iii. **Plasma** cells synthesize antibodies. These are also called 'cart wheel cells' because thin chromatin in their nucleus forms four or five clumps giving the nucleus a resemblance of a cart wheel.

iv. **Mast cells** produce histamine, heparin and serotonin. These are related to basophils of the blood.

a. Histamine dilates the walls of blood vessels in inflammatory and allergic reactions.

b. Heparin checks clotting of blood inside the blood vessels.

c. Serotonin acts as a vasoconstrictor to checks bleeding and to increase the blood pressure.

v. **Mesenchyma cells** produce various type of connective tissue cells.

vi. **Macrophages** ingest cell debris, bacteria and foreign matter.

vii. **Chromatophores** (pigment cells) are found in the dermis of the skin which impart colour to the animals.

viii. **Reticular cells** form reticular tissue and phagocytic in nature.

3. Fibres

These are non-living products of the cells.

These are of three types

i. **Collagen or Collagenous fibres** (white fibres) a made up of collagen protein. When bolied in the water, collagen changes into gelatin.

ii. **Elastic fibres** (yellow fibres) are formed of a protein called elastin. These fibres are branched and elastic.

iii. **Reticular fibres** are delicate, branched are inelastic. They are made up of reticulin protein. They always form a network.

Types of Connective Tissues

The connective tissues are mainly of following three types

1. Loose Connective Tissue

Loose connective tissue has cells and fibres loosely arranged in a semi-fluid ground substance.

These tissues are of two types, i.e., areolar tissues are adipose tissue.

i. Areolar Tissue

It is found under the epithelial tissue of the skin, visceral organs like stomach, trachea and the walls of the blood vessels, etc. Its matrix is made up of glycoproteins. It contains two types of fibres, i.e., the **white collagen fibres** made up of collagen and the **yellow elastic fibres** made up of elastin.

The different cells of areolar tissue are fibrocytes, macrophages and mast cells.

Functions The tensile strength of collagen fibres and the elasticity of the yellow fibres protect the various organs from mechanical injuries.

This tissue also provies rapid diffusion of the materials and migration of wandering cells towards the areas of infection and repair.

ii. Adipose Tissue

It is a modified type of areolar tissue. Its matrix contains large number of adipose cells along with fibrocytes and macrophages. White and yellow fibres are present in the matrix. The cells of this tissue are specialised to store fats.

The excess of nutrients which are not used immediately are converted into fats and are stored in this tissue. The adipose tissue are found into fats and stored in this tissue. The adipose tissues are found in the subcutaneous region, around the heart, kidneys, eyeballs. etc.

e.g., It is also found in the blubber of whales and elephants, hump of camel, fat bodies of frog and yellow bone marrow.

Functions The adipose tissue is mainly a food reserve or fat depot for storage. It forms a shock-absorbing cushion around the eyeballs and kidneys. The tissue also helps in the production of blood corpuscles.

2. Dense Connective Tissue

Fibres and **fibroblasts** are found compactly packed in the dense connective tissues. This tissue is of two types i.e., dense regular and dense irregular connective tissue.

i. Dense Regular Connective Tissue

In this tissue, the collagen fibres are present in rows between many parallel bundles of fibres.

It is further of two types

a. White Fibrous Connective Tissue

It mainly consists of white fibres arranged in bundles. The fibroblasts are present in rows between the bundles.

It is of two types

- **Tendons** The white fibrous connective tissue forms the cords called tendons. These join the skeletal muscles with the bones.
- Sheets the white fibrous connective tissue also forms flat plats or sheets. It occurs in the dermis of the skin periosteum of the bone, perichondrium of cartilage, pericardium of heart etc. The white fibrous connective tissue has great strength however its flexibility is limited.

b. Yellow Elastic Connective Tissue

It mainly consists of yellow elastic fibres. The fibres are thicker. The fibroblasts and a few white fibres are found in between the yellow fibres.

It is also of two types

- **Ligaments** The yellow elastic connective tissue forms the cords called ligaments. These joint bones to bones.
- **Sheets** They yellow fibrous sheets formed by this tissue occur in the walls of blood vessels, lungs and bronchioles, true vocal cords, cartilage of larynx, trachea etc.

The yellow elastic connective tissue has considerable strength and remarkable elasticity. Thus, it allows the stretching of various organs.

ii. Dense Irregular Connective Tissue

It has fibroblasts and many fibres (mostly collagen) that are oriented in different pattern. This tissue is present in the skin.

3. Specialised Connective Tissues

The specialised connective tissues are of following types

i. Skeletal Tissues

These tissues form the endoskeleton of the vertebrates. They form a rigid framwork which supports the body, protects the vital organs and helps in locomotion.

The two types of skeletal tissues, i.e., cartilage and bone.

a. It is a tough, semitransparent, elastic and flexible tissue. The cartilage cells in group of 2-3 in fluid spaces called **lacunae.** The cartilage is bounded externally by a stiff sheath called **perichondrium** containing white fibrous tissue.

The cartilages are of three types, i.e., hyaline, fibrous and calcified.

- **Hyaline Cartilage** It has a clear, translucent, bluish green matrix. It is flexible and forms articular surface at the joints of long bones, where it is called articular cartilage.
- **Fibrous Cartilage** It has well-developed fibres in the matrix. It is of two types i.e., white fibrous cartilage and yellow elastic cartilage.
- **Calcified Cartilage** When matrix of cartilage contains granules of calcium carbonate, the cartilage s called classified cartilage.

b. Bone

It is a hard rigid connective tissue. These are non-pliable ground substance rice in calcium slats and collagen fibres providing strength to the bone. The cells of bone are found in a calcified matrix made up of ossein. The bone cells known as osteocytes lodged in the spaces called **lacunae.**

They also interact with skeletal muscles attached to them to bring about movements.

The bone consists of four parts, i.e.,

- **Periosteum** It is a thick and tough sheath that forms an envelope around the bone. It is composed of collagen fibrous tissue. The periosteum contains blood vessels. It also contains bone-forming cells, the osteoblasts, which produce new bone material.
- **Matrix** It is composed of a protein called ossein. The Haversian canals, a characteristic feature of mammalian bones are present in the matrix. Each Haversian canal contains an artery, a vein a lymph vessel, a nerve and some bone cells.
- **Endosteum** It is present outer to the bone marrow cavity. It comprises white fibrous tissue and the bone forming cells called osteoblast. The latter produces new bone material.
- **Bone marrow** It is the vascular, soft pulpy connective tissue found in the bone marrow cavity of long bones like humorous, femur, etc.

Bone marrow is of two types :

- **Yellow marrow** (rich in fat cells called adipocytes). and
- **Red marrow** (Blood cells are formed in this marrow).

In foetus, red marrow occurs in all bones. After birth, it restricts to limited places.

The bones can be spongy or compact on the basis of density and texture.

a. Spongy (cancellate) **Bone** It contains a network of thin and irregularly longitudinal and transverse bony bars called trabeculae covered by the endosteum. It is found at the ends of long bones (epiphyses).

b. Compact (Dense) **Bone** It is hard and compact and found in the shaft of long bones. It contains yellow bone marrow and has Haversian systems.

Note : In a decalcified bone, the inorganic part of the matrix is removed. For decalcification, the bone is kept in dilute hydrochloric acid for long hours. This is to study living structures of the bone as it dissolves all the inorganic salts leaving behind only the organic matter.

ii. Vascular Tissue

These are motile connective tissues consisting of **fluid matrix** and **free cells.** The matrix is without fibres. The vascular tissue helps in the transport of materials from one place to another.

a. Blood It is a mobile, watery fluid with a slightly salty taste. It is composed of **plasma** (a fluid matrix) and the cells called **blood corpuscles.** It is bright red in colour when oxygenated and purple when deoxygenated. The volume of blood in an adult is about 5L.

It circulates within the blood vessels in higher animals. It is slightly alkaline (pH 7.4) in nature.

Plasma is a yellowish, straw-collared liquid which is composed mainly of water (92%). About 55% of the total blood volume is plasma. The solid materials in plasma include plasma proteins, nutrients (glucose, amino, fatty acids and vitamins), hormones, antibodies, enzymes, lactic acid, cholesterol, dissolved gases (oxygen, carbon dioxide), mineral salts and waste products (urea, uric acid and creatinine).

Functions It helps in transport of substances, provide body immunity, prevent the blood loses, retain fluid in blood, maintain blood pH and conduct heat to skin for dissipation.

Blood Cells

The blood cells or blood corpuscles forms about 45% of the blood volume. These cells are formed in the bone marrow of the long bones and the **lymph nodes.** The process of blood cells formation is called **haemopoiesis** and the tissue where these are formed are called haemopoietic tissue.

The blood cells are of following types

- **Erythrocytes or Red Blood Corpuscles** (RBCs) are the most abundant elements in blood. These carry red-colored oxygen carrying pigment called haemoglobin. They are 7-8μm in diameter.
- The human RBCs are smaller than the white blood corpuscles. In mammals, they are non-nucleated, biconcave and circular. The formation of erythrocytes is called erythropoiesis.
- **Leucocytes** or **White Blood Cells** (WBCs) lack haemoglobin and are colorless. They are nucleated with rounded or irregular shape. They can change their shape and are capable of amoeboid movement.
- **Thrombocytes** (Blood Platelets) These are small, colorless, plate like discs having size of about 2-3μm . Their number ranges between 0.15-0.4 million/mm^3 of blood. Their normal life span is about a week. No nucleus is visible in these cells.

Functions of Blood

The blood performs following functions in the animal body.

- Blood transports oxygen from the respiratory organs to the tissues and carbon dioxide from the tissues to the respiratory organs.
- It transport nutrients to all parts of the body.
- Blood maintains the constant body temperature by distributing the heat throughout the body.

  Lymphocytes and eosinophils produce antitoxins to neutralize the toxins, released by the microbes.
- Blood helps to maintain water balance to a constant level by bringing about constant exchange of water between circulating blood and tissue fluid.
- It helps to regulate the pH of the body fluids as it contains buffer materials such as proteins and mineral salts.
- Blood helps in healing of injuries by maintaining necessary supplies for the repair of damaged tissues.

b. Lymph

It is a mobile connective tissue comprising **lymph plasma** (fluid) and **lymph corpuscles** (cells). It is pale yellow in colour and its composition is similar to plasma without the plasma proteins. It is present in the vessels called **lymph vessels.**

Lymph is formed of liquid components and formed elements or cells. It contains about 94% water and 6% of organic and inorganic substances. The organic part includes protein, fat droplets, carbohydrates, nitrogenous wastes and hormones.

Lymph performs the following functions in animal body

i. It plays an important role in the defence of the body especially against invading organisms.

ii. The digested products of fat digestion enter the lymph vessels present in the villus of the small intestine.

iii. Lymph helps to maintain the blood volume by returing the interstitial fluid back to the blood during circulation.

iv. The lymph nodes produce lymphocytes.

v. It keeps the tissue cells moist.

4. Reticular Connective Tissues

Tissues consist of star-shaped reticular cells whose protoplasmic processes joins to form a cellular network. The reticular fibres are present on the reticular cells (composed of a protein **reticulin**).

The reticular connective tissue is present in the liver, spleen, lymph nodes, thymus, tonsils, bone marrow and lamina propria of the gut wall

Function This tissue provides strength and support as it forms the supporting framwork of many organs. It also helps to bind together the cells of smooth muscles. The reticular cells are phagocytic and forms the defence mechanism of the body.

5. Pigmented Connective Tissue

The cells of pigmented connective tissue are in irregular and are called pigments cells (Chromatophaea) melanophores). These cells containt yellowish black or blue melanin pigment granules. Melanin produced by other cells called **melanocytes.**

This tissue is present in the choroid ciliary bodies iris of the eye and dermis of the human skin.

Functions It gives colour to the structures.

6. Mucoid Connective Tissue

This tissue occurs as a foetal or embryonic connects tissue as it is present in the umbilical cord.

The mucoid tissue contains a jelly like subject called **Whartson's jelly** and some delicate fibres and primitive type of tibroblasts. It occurs in embryonic connective tissue in the foetus and humour of the eye.

Functions of Connectiv Tissue

The connective tissue performs following main functions

i. The connective tissue mainly joints one tissue another in the organs.

ii. The adipose tissue stores fat.

iii. The cartilage and bones form a support framwork for the body.

iv. Blood and lymph carry materials from one to another in the body.

v. The cells of connective tissues marcophages, monocytes, neutrophils bacteria, cell debris. Thus they protect and clean the body.

vi. The adipose tissue acts as shock absent around some organs, such as eye balls kidneys. It also acts as packing material various organs.

vii. Bone marrow is the source of blood corpus.

viii. The collagen fibres help in the repair of intimal tissues.

Muscular Tissue

The muscle tissue consists of elongated and contractile cells called muscle cells or myocytes.

Due to their elongated nature, the muscle cells are also called muscle fibres. It develops from mesoderm. The muscle cells are surrounded by connective tissue. Each muscle cell is covered by a membranous sheath called **sarcolemma.**

It consists of plasma membrane and basement membrane. The cytoplasm of a myocyte is called **sacroplasm.** The endoplasmic reticulum is called **sacroplasmic reticulum** and the mitochondria are called sacrosomes.

The myoglobin keepts the reserve oxygen for immediate supply during muscle activity.

It also provides light pinkish colour to the muscles. The muscles cells may be uninucleate or multinucleate. The contractile structures of muscle cells are called **myofibrils.** The myofibrils are made of myofilaments. The myofilaments are of two types, i.e., thicker myosin and thinner actin. The contraction of muscles occurs due to sliding of actin filaments passing over the myosin filaments.

Types of Muscles

The muscles can be grouped into three types based on their structure, location and function.

i. Striated or striped or skeletal or voluntary muscles.

ii. Non-striated or unstriped or visceral or smooth or involuntary muscles.

iii. Cardiac muscles.

i. Striated Muscles

The striated or skeletal muscles form about 40% of total body weight. These muscles are attached and bring about the movement of the various bones of the skeleton, so are called **skeletal muscles.** The striated muscles give shape to the body and also release heat during contraction. These muscles have huge supply of nerves and blood vessels. Each striated muscle is a long, narrow, cylindrical, unbranched cell.

The striated muscle fibres are multinucleated or syncytial in nature. The cytoplasm (sacroplasm) of each fibre has a large number of myofibrils (actin and myosin myofibrils) which are tightly packed.

Each myofibril shows **dark** and **light** bands of stripes alternating with each other. Hence, they are called as striped muscle fibres.

ii. Non-Striated (smooth) Muscle

The non-striated muscles are found in the posterios part of oesophagus, stomach, intestine, lungs, urinogenital tract, urinary bladder, blood vessels, iris, ciliary body of eye, drmis of skin, etc.

The non-striated muscle consists of long, narrow, spindle-shaped fibres that are generally shorter than the striated muscle fibres. Their size may range from 20μm (Small blood vessels) -500μm (in pregnant uterus).

Each non-striated muscle fibre contains a single oval nucleus in its thick middle part. In the cytoplasm, the myofibrils are arranged longitudinally. They are composed of myosin. There is no sarcolemma, however, the fibre is enclosed by the plasma membrane.

The smooth muscles help in the **peristalsis** which occurs in the tubular viscera. The autonomic nervous system controls these muscles. Hence, they are not under the control of animal's wall.

iii. Cardiac Muscles

The cardiac muscles are contractile tissues present only in their heart and in the wall of, large veins which enter the heart. The cardiac muscle fibres show the characters of both unstriped and striped muscle fibres. Each fibre is a long and cylindrical structure which has a definite sarcolemma. The fibres are uninucleate and the nuclei lie near the centre.

The myofibrils have transverse faint dark and light bands which alternate which each other.

The cardiac muscle fibres have some special features

i. These muscle fibres are supplied with both central and autonomic nervous system and are not under the will of the animal.

ii. These fibres nerve get fatigue.

iii. Blood capillaries penetrate the cardiac muscle fibres, hence they have rich blood supply.

iv. These fibres have the property of contraction, even when they are isolated from the body temporarily.

Functions of Muscular Tissues

The muscle tissue perform following important functions

i. These are involved in the movement of body parts and locomotion of the organism.

ii. Muscles are responsible for heart beat, production of sound and peristalsis in tubular viscera.

iii. The muscles support the bones and other structures.

iv. Muscles are essential during parturition.

Neural Tissue

The neural tissue is ectodermal in origin. It is specialised to receive stimuli and conducts impulses for controlling and coordinating body functions. It exerts the greatest control over the body's responsiveness to changing conditions. The neural tissue consists of nerve cells and packing cells. The packing cells are called **Schwann cells** in the peripheral nervous system and **neuroglia cells** in the central nervous system.

Neurons

Neurons are the functional unit of neural system. The excitable cells. A neuron consists of a cell body. (cyton) some and fine protoplasmic process called neurites a from the cell body.

Cyton

It contain neuroplasm (cytoplasm), a spherical endoplasmic reticulum, mitocondria, Golgi ribosomes, lysosomes, fat globules, Nissl's granules etc. Nissl's granules are probably involved in the synthesis proteins.

Neurites

The process arising from the neurons are called neuron. These are **dendrites** and an **axon**. Axon is single dendrites may vary from one to several. The dendrite usually shorter and tapering processes. The axon is usually long process of uniform thickness.

Nerve Fibres

The nerve fibres are elongated and slender processes neurons, which are formed by ensheathing of axons. A space of 15-20 nm occurs between axolemma and the covere sheath. It is called **periaxonal space.**

Depending upon the covering sheath.

i. Myelinated Nerve Fibre

An axon covered by myelin sheath is called myelinate **medullated nerve fibre.** The myelin contains lie proteins and water. The medullary sheath serves a insulating layer, preventing loss of energy of the impulse during its passage along the fibre.

ii. Non-Myelinated Nerve Fibres

A non-medullated or non-myelinated fibre consists of an axis cylinder enclosed by neurilemma and connective tissue. It lacks medullary sheath and appears grey in the fresh state.

On the basis of function also, the nerve fibres are of two types

a. **Afferent** (Sensory) Nerve Fibres The afferent nerve fibres carry the nerve impulses from the sense organs to the central nervous system (brain and spinal cord).

b. **Efferent** (Motor) Nerve Fibres They carry nerve impulses from the central nervous system to the effector organs (muscles and glands).

Nerves

A nerve is a complex bundle of nerve fibres enclosed together by a common sheath of connective tissue along with the blood vessels. Each nerve fibre is covered by a thin sheath of connective tissue called **endoneurium.**

A number of nerve fibres, each covered by its own endoneurium are joined to form a bundle called **fasiculus** or **fascicle**.

According to the nature of fibres, nerves can be of following three types

i. **Sensory** (Afferent) **nerves** These nerves bring sensory impulses or excitation from different parts of the body and sence organs.

ii. **Motor** (Efferent) nerves These nerves carry message from central nervous system to parts of the body and effector organs to perform their function.

iii. **Mixed nerves** The nerves contain both sensory and motor fibres.

Neurogila

The neuroglia or glia cells are supporting cells which form a packing around the neurons in the in the brain, spinal cord and ganglia. These cells have different shapes and many processes. The neuroglia cells have various roles like myelin formation, transport of materials to neurons, maintenance of ionic balance and phagocytosis.

Neurosecretory Cells

These are specialised neurons or neuron-like cells, which secrete biologically active substance that are effective in other structures, often at a different size. The neurosecretory cells occur in hypothalamus. They produce hormones called neurohormones.

Functions of Neural tissue

Neural tissue perform the following functions

i. The neural tissue coordinates and controls the functioning of different parts of the body.

ii. The sensation of smell, vision, taste, hearing, pain, pleasure, etc., are performed through the nervous tissue.

iii. The neural tissue helps in meditating conscious activities.

iv. The information about the changes in various internal structures is provided by nerves.

v. It makes us aware about the environment around us.

vi. The nervous tissue brings about an appropriate response to each and every stimulus.

vii. The tissue is also a seat of experiences, memories, etc.

Crockroach

Classification

Phylum :- Arthropoda

a Jointed appendages

b. Blood containing cavity called **"Haemocoel"**

c. Exoskeleton made up of chitin

Largest Phylum - 90% animal out of total animals belong to this phylum.

Cass :- Insecta : Largest class.

a. 75% animals included in class insecta

b. body divided into head, Thorax, Abdomen

c. Three pair of legs (Hexapoda).

Sub class :- Pterigota

a. Two pairs of wings

Order :- Orthropetra

Wings disimillar type.

Genus :- Periplenata americana

↓

"Common Cockroach"

Blatta germanica - smallest cockroach

Male Blatta have wings - female wingless.

Blatta name - Linnaeus

Periplaneta - "Burmeister"

a. "Nocturnal Animal"

b. Cursorial animals - fast runner and less capacity of flight.

c. Body divided in to three parts called "Tegmeta".

3 - Tegmata Ebryo stage { 6 segment } → Heat ↓ 6 segment, Thorax ↓ 3, Adbomen ↓ 11 Total = 20

some segment fuses in adult stage.

Head 1 (6 segments fussed)

Throax 3

Abdomen 10

} Total 14 segment

d. Exo skeleton of chitinplates occured in each segment. Chitin plate called "Sclerites".

e. Scleritics joined each other by "Membrance" called "Articular a Arthroidal Membrane".

Sclerites of dorsal side - tergum or tergite

Sclerites of Ventral side - Sternum of sternite

Sclerites of Lateral side - Pleurons or pleurites.

Head:-

a. **"Hypognathus Condition"** :- Bent downwards at an angle of 90^0 from the long axis of body.

b. Sclerites of the head joined fully and form **Head capsule.**

c. Top part of Head is called "Vertex" and on the vertex a chitin plate present called **"Occiput".** An inverted Y-shaped **epicranial** or medical structure divided the occiput in to right and left and called **"Epicranial plates".**

d. On the lateral side of Head apex 1 pair of compound eye.

e. Each compound eye made up of 2000 units called **"Omatidia"**

f. A small light colored spot called **Fenestra or Ocellar** spot is located upon dorsal surface close to each eye. In insect it function as a photoreceptor organ.

In Crockroach - Inactive and called **"Vestigial simple eye".**

g. lateral side of Head apex bear of 1 pair of **Antennae.** Main receptor of touch, temp, vibration in cockroach. **Antennae :-** long filliform, unbranched.

h. A big chitin plate situated below the vertex. called **frons** or **Forehead.**

i. Two long Flattened chitin plates situated on lateral side called **"geena"** or "**Cheeck"**

j. A bing chitin plate present in Anterior part of frons called "Clypeus". a movable chitin plate joined with Anterior part of clypeus known as **"Labrum"** or **"Upper lip"**.

k. A big pore situated in the ventral part of head called **"Occipetal Foramen".**

l. Neck joined with head on the **"Occipetal Foramen".**

m. Occipetal foramen - surrounded by two pair of chitin plate.

Internal :- Post Occiput

External :- Post Gena

n. A mouth situated in the anterior side of head which is surrounded by many chitinous structure called **"Mouth parts".**

o. **Mouth Part :-** According to food habits.

"Mouth Parts of Cockroach" :-

Bitting and chewing type

1. **Labrum or Upper lip :-** Broad and flattened terminal sclerite of the dorsal side of head capsule moving articulated to the clypeus. It dorsally overhangs the mouth and hence referred to as **"Upper lip".** Several gustatory sensory setae are located on both sides of the Indenation.

2. **Mandibles :- Jew**

1-pair of mandibles.

They form the lateral wall of preoral cavity. Their margins towards the mouth are serrated in to three large and a few small, strong and pointed teeth like processes called Denticles. Horizontal movement occurs in mandibles. Abductor and adductor muscle associated with mandibles.

A soft structure present base of mandibles called **"Prostheca":-** Prostheca have sensory setae.

Pronotum is Largest notum covers Neck

3. **First Maxillae :-**

One-pair and form lateral wall of preoral cavity.

i. **Endopodite :-** surrounds preoral cavity laterally.

(**lacinia - Inner** → spine attached on free end. and help in chewing food **outer - galea**

ii. **Exopodite :-** Maxillary palp

a. Made up of five segment

b. First segment joined on stripe called **"Palpifer".**

c. Setae present on maxillary palp sensory for touch, olfactory and Gustatory.

d. With the help of maxillary palp cockroach pickup its food and put it in preoral cavity for chewing.

Maxillary palps also used as brush to clean antenna and wing.

4. IInd Maxillae or "Labium" or lower lip :

i. Form floor preoral cavity

ii. Cover ventral side.

iii. Made up of three flats chitin plate. ie., Submentum, Mentum, Prementum.

There pair of appendages joined from prementum

1-pair-Labial palps - which joined to Prementum with the help of chitin piece called **"Palpiger".** These represent **"Exopodite".** These are 3 segmented structures and have touch, Gustatory, olfactory setae.

1 – pair Glossae
1 – pair pare Glossa } Two segmented

Glossa + Para glossa – "Ligula"

These are "Endopodite". These prevent outwarding of food from pre oral cavity. Labium are one pair in embryo stage. both Labium fusses in adult stage.

Hypopharynx :- or "Lingua"

This is a small, cylindrical mouth part sandwiched between first maxillae on the side and covered by Labrum and respectively on dorsal and Ventral sides. It bears several sensory setae at its free end, and the opening of common salivary duct upon its basal part.

Salivarium - Posterior part of ciberium

II segment of Head	-	Antennae
III segment of Head	-	Labrum
IV segment of Head	-	Mandibles
V segment of Head	-	I Maxillae
VI segment of Head	-	II Maxillae (Labium)

Obviously seen.

I segment do not form appendages.

Throx

Prothorax

Mesothorax Each segment of Abdomen

Metathorax

Exoskeleton of each segment made up of

4-chitin plate-1-tergum, 1-sternum and one pair pleurone tergum of thorax - "Notum"

Prothroax	-	Pronotum	}
Mesothroax	-	Mesonotum	}
Metathroax	-	Metanotum	}

One-pair of present in each segment of Thorax. 3-pairs of legs (6 legs)

1. Segment - **"Coxa"** - Broadest segment
2. Segment - Trochanter :- Small segment
3. Long segment - femur
4. Tibia - longest segment
5. Tarsus - tarsus made up of live subsegments piece of chitin on end segment called "Pretarsus"

two structure -

i. Arolium or Pulvilus - These are adhesive pads

ii. **One pair claws** - Move on the smooth surface by the help of "Arolium" and on rough surface with the help of claws.

In Blatta :- Arolium is absent.

Small pads present in between of tarsus segment called **"Plantuli"**

Cockroach clium on the wall by the help of plantuli and Arolium.

Tactile setae present on each segment of legs.

"Wings" 2 - pair wing

(1) Fore wings	**(2) Hind wing**
↓	↓
On mesothorax	On Metathorax
↓	↓
long, narrow, leathery strong	Small, broad, thin, soft
↓	↓
Fore wings are so long so cover full abdomen. In male projecting out ward form abdomen.	These wings help in flight

These called Elytra or Tegmina.

tubular communicating with haemocoel Hence, Haemocoelmic fluid circulates in these.

These tubules provide Nutrition to wings After ageing these tubules dry and provide strongest to wings.

Two-pair Muscles connected to each wing.

1-pair to tergum

These are flight muscle. these are not more active in cockroach.

Abdome

1. 10 segment
2. 9 segment in male
3. 7 segment in female

Remaining Segment :- modified and reduced.

- 1-tergum
- 1-sternum
- 2-pleurons

7th tergum largest in male and female and covers 8th and 9th terga 10th tergum - bowl shaped and Bifurcated. 10th tergam 1 pair - **"Anal Cerci".**

Each **"Anal Cerci"** - 15 segmented - These are main sound receptor.

Sternum - In male 9 sternum, in female 7 sternum

Projected one-pair of spine like structure from 9th sternum of male called **"Analstyles".** these are nonsegmented and help in copulation.

7th sternum of female - special type of Boat shaped.

Free end - divided in to two plates.

Plates :-

"Gynavalvular plates" or "Apical lobs".

These plate surround a pore called **"Ootheca pore".**

All characters of sexual dimorphism in cockroach present in abdomen. Stink gland present in between 5th and 6th tergum. smell - repell the enemies.

Endoskeleton

1. made up of chitin plates called **"Apodemes".**
2. Apodemes formed form invegination of Sclerites.

3. **Apodemes :-** provide attachment surface to muscles of cockroach.
4. 1-Apodem in head - Tentorium (**Tentorium - tent like**)
   3-pair or arms attached to tentorium. Plate like apodems occurs in each segment of thorax.
   Apodemes absent in Abdomen.

Outermost - thick cuticle. It differentiated in to two parts.
Outer - Epicuticle, Inner - Procuticle
Epicuticle - chitin - absent
Made up of Brown scleroprotein. A waxy layer occurs or epicuticle.
Procuticle - made up of alternate layer of protein and chitin.
Procuticle - **Two parts**

a. Outer - Thin (1) exocuticle
b. Inner - Thick (2) endocuticle

Exocuticle - Attached with protein, and granules of Ouinones and Melaninm Dark in colour.
Endocuticle - Melanin ond Ouinone - absent, light colored.
"Epicuticle and Exocuticle" - Discontinuous, absent in joints of sclerites.
Endocuticle - Continuous, endocutile become thin in joints and form Articular Membrane".

2. Hypodermis - (Epidermis)

a. Made up of columnar epithelium.
b. It contains some special cells.

i. **Dermal gland** - Secretion of chitinase and proteinase enzyme at the time of moulting. They separate old cuticle from body and secrete new cuticle.
ii. **Trichogen cell** - elongated cell and reach up to the epicuticle.
   These recrete **"sensory setae"** on Epicuticle.
iii. **Tormogen cell** - long, cup like cell.
   These cell secrete flexible membrance on the base of setae.
iv. **Neuro - Sensory cell** -
   a. These situated in the invagination of tormogen cell. One end of Neurosensory cells join setae and other end joined with nerves.
   b. Trichogen + Tormogen + Neurosensory cell - All three form sensory unit called "Sensilla".
v. **"Oenocytes"** - Function - uncertain perhaps these secrete wax on epicuticle.

3. "Inner Most Layer" - Basement Layer -

a. **"Simple squamouse epithelium"**

Body Cavity

a. Called Heamocoel
b. Blood filled cavity.
c. Blood of cockroach - "Heamolymph"
d. Blood almost colorless.
e. Blood not related with respiration
f. Trehalose sugar in blood - Disaccharide.

a. Not true coelom.
b. It is a **"large blood sinus".**
c. In embryo stage sevral small blood sinuses fuse and form **"Large Blood sinus".**
d. All arthropods - "True coelomate" - But highly reduced and found only in the form of cavity of **"Gonads".**
   Cavity of Gonads :- "True Coelom"

e. large fat body present in Haemocoel of cockroach.

f. analogous to liver of higher animals.

Four types of cells present in fat body

i. **Trophocytes** - These store food in the form of glycogen + Protein + Fats.

ii. **Mycetocytes** -

a. Presence of **"Symbiotic Bacteria".**

b. These symbiotic bacteria synthesize amino acid and vitamin.

c. These change glucose in the glycogen (glycogenesis).

d. Possibly **"Uric Acid"** is converted in protein. this reaction called **"reserve asimilation".**

iii. **Oenocytes** - These cells related with metabolism of moulting.

iv. **Urate cell** - Absorption of extretory material from Heamocoel and storage in the form of "Uric Acid" so called "Storage excretion".

Digestive System

1. **Fore gut** - **Ectodermal** - Formed by the invagination of Body wall.

Mouth to - Gizzard is foregut mouth open in the small Buccal cavity

Buccal Cavity - opensin tubular pharynx.

Pharynx - open near occipetal Foramen in **"Oesophagus".**

In thorax oesophagus expand and called "Crop"

Crop opens into thick walled gizzard.

a. **Wall of Gizzard** - circular muscle "layer" well developed.

b. cavity of gizzard called - "Armarium"

c. six cuticular teeth occur in cavity. these made up of longitudinal muscle layer and sharp cuticle.

d. fine grinding of food.

e. cuticular hairs present in the posterior part of gizzard these form **"sieve".**

2. Cardia

a. Anterior part - cardia

b. Gizzard open in cardia by **"stomodial valve".**

c. eight small and tubular, finger like blind process called **Hepatic caeca,** project freely into the heamocoel form the front end of cardia.

These secrete "Digestive juice".

d. Muscular wall of mesenteron

e. Inner - circular muscle

Outer - longitudinal muscle, cavity lined by endodermal epithelium.

3. "Hind gut or Proctodaeum" -

a. Thin tubules attached at the junction of hind gut and mid gut called **"Malphighi tubules".** these are excretory organ.

b. Hind gut - first part Ileum its wall is thin and internally folded. Its cuticle bears minute spines which serve to break the peritrophic membrane.

c. **Colon** - longest and broader part

d. **Rectum** - last part, oval shaped and internally folded wall.

Its wall 6 folds called rectal papillae.

These absorb water

e. **Anus** - At the end of 10th and abdominal segment.

Salivary gland -

a. 1-pair and attached to with oesophagus and occured in thorax.

b. Two parts of each salivary gland.

i. Reservoir part - cylindrical and storage of saliva.

ii. Glandular part - leaf like and Bifurcated.

Synthesis of saliva occurs in this part each part have separate tubules.

Reservoir duct	**and**	**Glandular duct**
Reservoir duct of both side fused to form "common reservoir duct"		glandular duct of both side fused to form "common glandular duct".

c. Both common ducts fuse to forms **efferent salivary duct.**

d. This duct open in preoral cavity at base of hypopharynx.

e. rings of cuticle occur in wall of duct of salivary gland.

which prevents these tubules from collapsing.

Saliva - "Carbohydrate-digestive enzymes".

Ex. Amylase, chitinase cellulase

Digestion -

a. Start from preoral cavity

b. **saliva** - Enzymes of saliva act upon the food till it reaches the corp. Digestion of carbohydrate takes place.

c. **In crop** - Heaptic caeca - Complete digestive juice reaches in crop through the gizzard.

d. **Gizzard** - Food throughly grinded in to a paste by the thick and sharp edged cuticle of internal folds and grooves.

e. Grinded food enter in to the midgut through stomodial value.

f. **Wall of Cardia** - A membrane secreted around the food called **peritrophic membrane.**

It is made up of Glycogen + Protein. It serves to protect the wall of midgut from friction with food particles.

This membrane is permeable to digestive enzyme and digestive food.

g. Digestion completed in the Anterior part of **midgut.**

h. Absorption of digested food in the posterior part of mid gut.

Distribution of Digested food - by "Heamocoelomic fluid"

Peritrophic membrane and undigested food enter into the Ileum.

spine - break the peritrophic membrane so undigested substance free in Ilem, Maximum absorption of H_2O occured in rectum by rectal papilla.

Respiration

1. Respiratory organ - **"Respiratory tubules"**
2. Network of respiratory tubules in body.
3. This network open out side the body by the **"spiracles"**
4. 10-pair spiracles

2-pair on thorax	8-pair on Abdomen
1 pair between prothorax and	on first 8 abdominal segment mesothorax.
1 pair between mesothorax and metathorax.	

All Spiracles :- on "Pleurone" -

a. First pair of spiracle of abdomen situated on lateral side of "tergum"

b. **Each spiracles** - surrounded by a ring shaped sclerites called "Peritreme". Each spiracle is guarded by a valve and bears cilia like bristles for filtering the incoming air.

c. Valve absent in 1-pair spiracles of thorax and abdomen both.

d. Each spiracles open into chamber called **"Atrium"** or tracheal chamber.

e. Tracheal capillaries - "Intra - cellular"

f. Tracheal capillaris closed in a cell called "tracheal end cell".

g. Long process found in tracheal end cell.

h. These process deeply merge in tissues of boy

i. Each cell of body is directly in contact with processes Blood not related with respiration in Blood respiratory pigment absent.

j. During day time - cockroach is less active so osmotic pressure of tissue fluid - low

k. Tissue fluid rises in to tracheoles

l. Exchange of gases during day time by the tissue fluid.

m. Cockroach is more active in night so O.P. of tissue fluid high so tissue fluid do not enter into tracheoles.

n7. Direct exchange of gases take place.

Histology

Respiratory Tubules ;-

A. Ectodermal cuticle on inner side and ectodermal epidermal epithelium lines outerside of wall.

B. Spiral ring of chitin occure in the wall of respiratory tubules. They prevent collasping. spiral rings also called "Tenidia".

C. Spiral rings absent in tracheal capillaries.

Breathing -

a. **Several tergo - sternal** muscles extend between the tergites and sternites of all abdominal segments.

b. When the abdomen expands, atmospheric air gets filled in the tracheal system through spiracles. This is Inspiration.

c. When the abdomen contracts, the air is forced out. This is Expiration.
Expiration take place through first pairs of spiracles of throx and first pairs spiracles of abdomen.

d. The spiracular values control and regulate the in and out passage of the air and abdomen.

e. The cuticle of corckroach is very permeable to CO_2, but not to O_2

f. Most of CO_2 diffuse out side from body wall some of CO_2 out through spiracles.

Blood Vascular System -

a. Open types or Lacunar types blood filled in blood sinuses.

b. True blood vessel - absent

c. Larget blood sinus - "Haemocoel"

d. Blood of corckroach - "Haemolymph"
Colourless - plasma
Blood corpuscles (Haematocytes)

e. "Haematocytes"
i. Phagocytosis of Bacteria. ii. Related with blood clotting.

Hydrolic Skeleton

A. Not related with respiration because respiratory pigment absent.

B. It works as **"Hydrolic Skeleton".**

C. Exchange of food, hormones and excretory materials.
Two horizontal septa.

i. Dorsal diaphragm

ii. Ventral diaphragm - these have pores called "Fenestrae"

Diaphragms divided the haemocoel in three chambers i.e,.

1. P.C.S. have heart in Dorsal part (Peri cardial sinus)
2. **Middle sinus** - P. Visceral sinus it have alimentary canal and fat body.
3. **Ventral chamber** - Perineural sinus have nerve cord.

Hear of Corckroach -

a. Divided in to 13 chamber.

b. Chamber - inverted funnel like.

c. Each chamber connected with P.C.S by 1-pair of pores, called **"Ostia"**. These pores act as valve.

d. Blood enters from P.C sinus to heart through Ostia.

e. Each posterior chamber of Heart connected related with anterior chamber by a valve like pore.

f. These pore help in flow of blood from posterior to anterior part.

g. Two layer of heart wall.

Outer layer	Inner layer
↓	↓
fibrous connective tissue	muscular

h. Special type of cells attached with heart wall called **"Nephrocytes"**. Functions of nephrocytes.

i. These control Heart beat.

Heart Beat - 49 heartbeat / minutes

ii. **Storage excretion** storage of excretory substance in the form of Uric Acid.

i. First chamber of heart in the form of long tubule called **"Anterior Aorta"** It opens into head sinus.

j. **Based Anterior Aorta** One blood vessel each arise from heart in mesothorax and 3-6 abdominal segments.

a. These are not divided into capillaries

b. Open ends.

k. Tergosternal muscle also help in blood circulation mainly these concerned with respiration.

l. **Pulsatile Ampulla** present at base of each Antennae and base of each wing. **Pulsatile Ampulla** help in blood circulation in Antenna and wings.

Passage of B.Circulation -

a. From P.V.S blood goes to paricardial sinus and then by ostia blood enter into heart (in Diastole)

b. **Systole phase** - when the heart is filled, it contracts from behind to forward and blood enters in head sinus → in neck → "P.N." sinus

oesophagus prevents flow of blood into P.V. sinus two path of blood flow form P.N.S to P.V.S

a. By fenestrae

b. Through legs

A vertical septa present in cavity of legs, these septa divide cavity of legs in two chamber

Dorsal chamber	**Ventral Chamber**
↓	↓
Connected with p. visceral sinus	Connected with P. Neural sinus

Excretory System

a. Main excretory organ - Malpighi tubules

b. These associated with Alimentary canal at the junction of **midgut** and hing gut.

c. 90-tubules (60-120).

d. Arrange in groups of six to eight and each group have 15 tubules. These are **Ectodermal.**

Two part -

i. Proximal Part - absorptive part

ii. Distal part - secretory part

e. **Wall** - cuboidal epithelium with Brush border of microvilli

f. Pulsation due to membrane made up of fibrous connective tissue and muscles.

g. Pulsation due to muscle, 5-15 pulsation/minute.

h. Excretory substance enter in to alimentary canal by pulsation.

i. Distal part of malpighi tubules collects excretory substance from Heamocoel

j. Excretory substance mainly in the form of **potassium urate.**

k Potassium urate converted into **Uric Acid** and potassium Bicarbonate by the cells of cuboidal epithelium. They secrete these substances into cavity of malpighitu bules.

l. Reabsorption process occurs in proximal part. All essential materials absorbed and return into heamocoel.

a. Water absorbed by alimentary canal and excretory materials along with undigested substances excreted outside.

b. Melpighitubules are enteronephric and help in Osmoregulation.

Nervous System

Three types of Nervous System -

1. Central Nervous system -

a. **Brain ring** - It is located in the head around the pharynx, just in front of tentorium.

Its dorsal part of is a thick and bilobed **supraoesophageal ganglion** or **Cerebral ganglion** formed by fusion of three pairs of cephalic ganglia.

3 pair ganglia -

i. Protocerebrum

ii. deutocerebrum

iii. tritocerebrum

Sub-oesophageal ganglion on ventral side of alimentary canal. Sub oesophageal ganglion formed by the fusion of three pairs of ganglia.

Both ganglia connected to each other by circumoesophageal connective.

2. Ventral Nerve Cord - double solid and ladder like.

Nerve cord have nine segmental ganglia, i.e., There large ganglia in thorax and six in abdomen. Last ganglion is located in 7th abdominal segment.

All ganglia formed in embryo stage by the fussion of 2-ganglia. Last segmental ganglion formed by fusion of many ganglia.

Peripheral Nervous System

i. 3-pair of Nerve - form cerebral ganglion.

1-pair from protocerebrum - supply compound eye.

1-pair deutocerebrum - in antennae.

1-pair tritocrebrum - in labrum.

ii. Six pair of nerve from prothoracic and five from each of the mesothoracic and metathoracic ganglia innervate different parts of their respective segments.

iii. A single pair of nerves arises from each of the first five abdominal ganglia to innervate muscles, spiracles, heart chambers and other parts in their respective segments.

iv. From the last abdominal ganglion three parts of nerve arise.

All nerves - Mixed nerves < Motor nerve / Sensory nerve

Autonomous System

It is divisible into three parts -

1. **Stomogastric Nervous System** - This includes the following five ganglia and the nerves arising from these to innervate the anterior part of gut as follows this system regulates in voluntary activity of foregut.

a. **Frontal ganglion** - This is a small median ganglion located dorsally upon the pharynx just in front of brain to which it is connected by a pair of short and thick frontal connectives.

b. **Hypocerebral ganglion** - This is also a small median ganglion located dorsally upon oesophagus behind the brain. It is connected in fron with the frontal gangliion by means of a thick **recurrent nerve.**

It is also connected, by means of two pairs of fine connectives, with two pairs of adjacent endocrine glands.

Glands named - (i) Corpar allata (ii) Corpora cardiaca

All three form "Retrocerebral Comples"

(Hypocerebral ganglion + corora Cardiaca and Corpora Allata)

c. **Visceral Ganglion** - This is located mid-dorsally upon the crop at about its middle. A thick oesophageal nerve connects it with hypocerebral ganglion. In front several fine branches of the oesophageal nerve innervate the salivary glands.

d. **Proventricular ganglie** - (last ganglia)

These are two small ganglia, one upon gorsal and the other upon Ventral surface of gizzard. Each of these is connected with vesceral ganglion by means of a long and thick visceral nerve.

These regulate the activity of forgut as of "Peristalsis"

2. **Spiracular Nervous System -**

a. These control the activities of spiracles.

b. A nerve plexus found around the each spiracle. These connected with segmental ganglia of Nerve chord.

c. These regulate the activity of spiracle.

Endocrine Glands

I. **Inter cerebxal endocrine cells** - These cells found in cerebral ganglia and secrete to brain Harmone.

It regulates the activity of prothorasic gland.

II. **Corpora Cardiaca** It secrete growth Harmone in childhood to control the growth of nymph. In adult stage these gland regulate heart beat.

III. **Corpora - Allata**

a. These glands secrete juvenile hormone - **"Neotinin"** in childhood stage.

b. Neotining regulates the growth and differentiatio of tissues, preventing untimely moulting and metamorphosis.

c. These glands secrete **"Gonadotropic"** harmone in adult stage - It regulates the activity of reproductive organs.

IV. Prothoracic Gland -

a. Found only in Nymph stage

b. Secretion of **Ecdyson Harmone** in Nymph - Moulting Harmone

This hormone induce moulting.

Compound Eyes

1. Compound eye made up of 2000 units called **"Omatidia".**
2. Outer part of **omatidia** hexagonal lens or **Corneal Leans** which is formed of transparant cuticle.
3. Just beneath the each lens 2 small cells called **Corneagen cells.**
4. These secrete lens
5. At the time of moulting lens also shed from body so cockroach becomes blind for some time.
6. **Corneagen cell** secretion of a new lens.
7. Beneath these cell is a crystalline cone formed by four surrounding concial cell (vitrella or cone cells)
8. **Crystalline cone** serves as an accessory lens
9. Part of omatidia up to cone cell known as **dioptric part of focussing part.**
10. Beneath the crystalline cone there is a circle of seven cells called **retinular cells.**
11. The inner border of each retinular cell bears microvilli.

Reproductive System

Cockroaches are dioecious animals, i.e., both the sexes have well developed reproductive organs.

Male Reproductive System

It consists of a pair of testes lying one on each lateral side in the 4th-6th abdominal segments. From each testis arises a thin as deferens which opens ejaculatory duct through seminal vesicle.

The ejaculatory duct opens into male genopore situated ventral to the anus. A characteristics. From each shaped gland is present in 6th-7th abdominal segments which functions as an accessory reproductive gland.

The external genitalia are represented by **male gonapophysis** or **phallomere** (chitinous asymmetrical structures surrounding the male gonopore). The **sperms** are surrounded in the seminal vesicles and are glued together in the form of bundles called spermatophores, which are discharged during copulation.

Female Reproductive System

It consists of two large ovaries, lying laterally in the 2th-6th abdominal segments. Each ovary is formed of a group of eight ovarian tubules or ovarioles, containing a Chian of developing ova. Oviducts of each ovary unite into a median oviduct (also called vegina) which opens into the genital chamber. A pair of spermatheca is present in the 6th segment which opens into the genital chamber.

Fertilisation

The male and female cockroaches come together by their posterior ends. The spermatophores are transferred to the genital chamber of the female. The sperms are liberated from the spermatophores and reaches the left spermatheca slowly.

The eggs come from both the ovaries alternately into the common oviduct the passes through the female gential pore into the gential chamber where they are fertilised by the sperms coming from the left spermatheca.

The secretion of collateral glands form the egg case of the ootheca (ploothecae). The fertilised egg are encased in oothecae. **Ootheca** is a dark reddish to blackish-brown capsule, about 3/8'' (8 mm) long.

The oothecae are dropped to a suitable surface, usually in a crack or crevice of relatively high humidity near of food source. On an average, female produce 9-10 oothecae, each containing 14-16 eggs.

Economic Important of Cockroaches

Many species of cockroaches are wild and are of no economic importance. A few species thrive in and around human habitat. They damage and destroy household objects such as eatables, clothes, shoes, etc. They also carry harmful germs of diseases like diarrhoea, cholera, typhoid, tuberculosis, etc.

The contaminate food items with their smelly excreta. The animals like frogs, toads, lizards, birds and snakes, etc. eat cockroaches. Thus, they from the part of food chain. They are used in laboratories as experimental animals