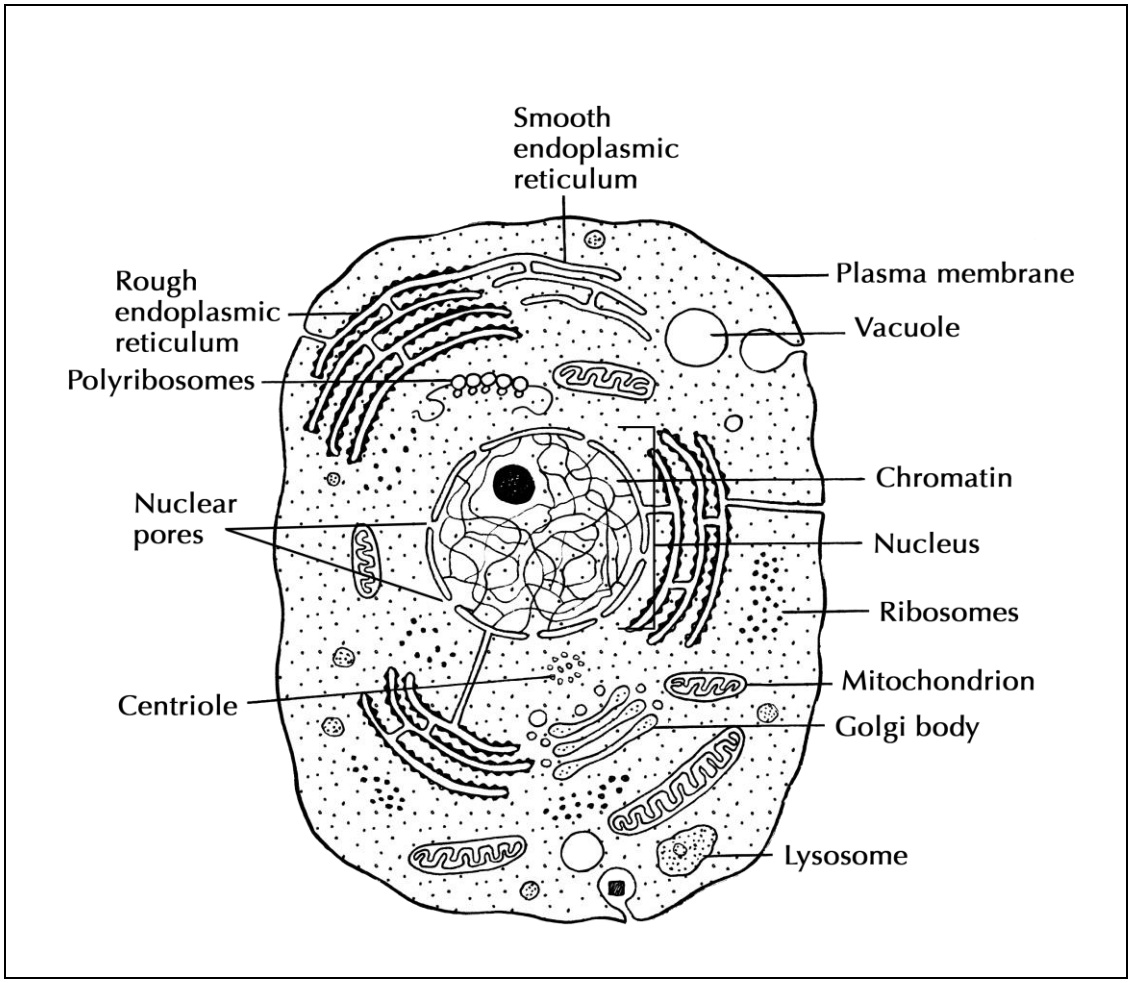
CHAPTER-I

CELL

Cell is the structural and functional unit of body. It is the smallest unit of living tissues. A single cell performs all functions of the body in a unicellular organism But in multicellular organisms cells specialized to form different tissues, each tissue doing a specific function. Cells vary in size and shape from tissue to tissue but most of them have similar intracellular components. Every cell consist of the followings.

1) Cell membrane
2) Cytoplasm
3) Nucleus



(Structure of cell)

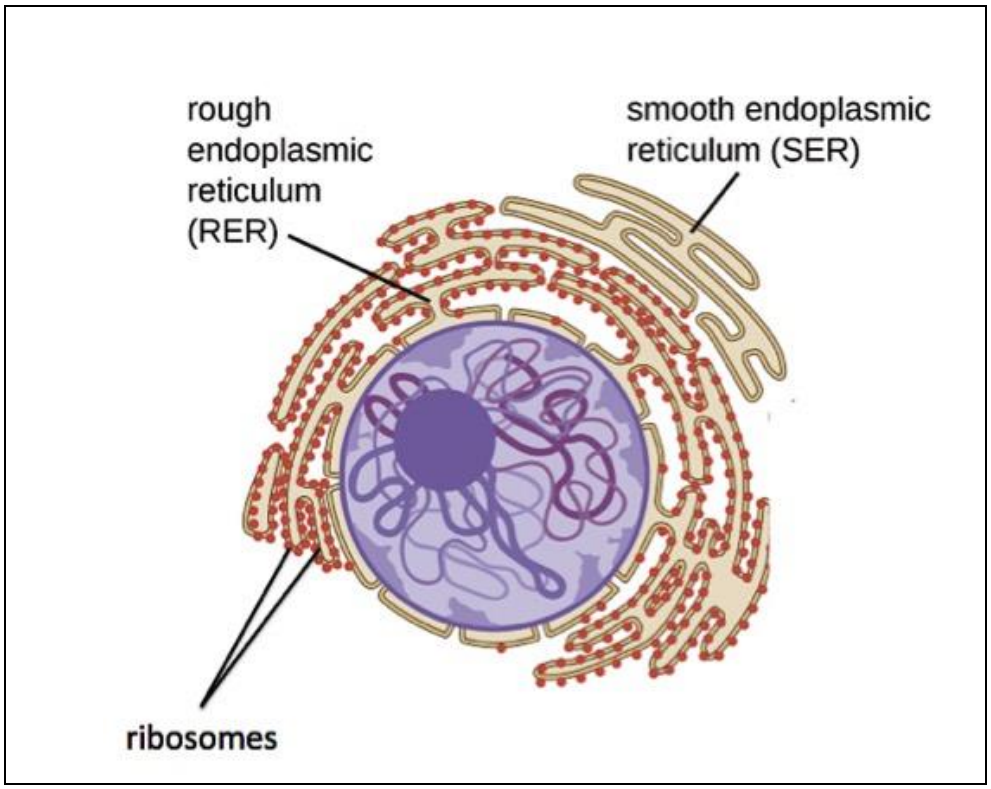
1) Cell membrane: It is the external boundary of the living cell. It is a three layered structure having protein layer embeded in lipid bilayer. It measures approximately 70 A^{o} thick. The cell wall allowed the diffusion of substances into and out of the cell. The outer surface of cell membrane contains number of pinocytatic vesicles and microvilli.

   The function of cell membrane are:

   a) Protection
   b) Ingestion of food
   c) Excretion of waste
   d) Selective permeability
   e) Reception of external stimuli

2) Cytoplasma: it is the region lying between the cell membrane and nucleus. It is the mass of living material which consist of protein, fat, carbohydrates, pigments, minerals, vitamins, and various organelles like EPR (endoplasmic reticulum), Golgi apparatus, mitochondria, lypososmes and centrosomes. All metabolism and synthetic activity of the cell take place in the cytoplasm under the direction received from the nucleus.

   a) Endoplasmic Reticulum: it is the complicated system of membrane which provides continuous channel of communication between cell environment and its nucleus and divided the cell into its numerous components. This consist of a system of membranes which from flattend tubules or vesicles. This membranous reticulum is present in the cytoplasm.



(Structure of Endoplasmic Reticulum)

EPR is of two types.

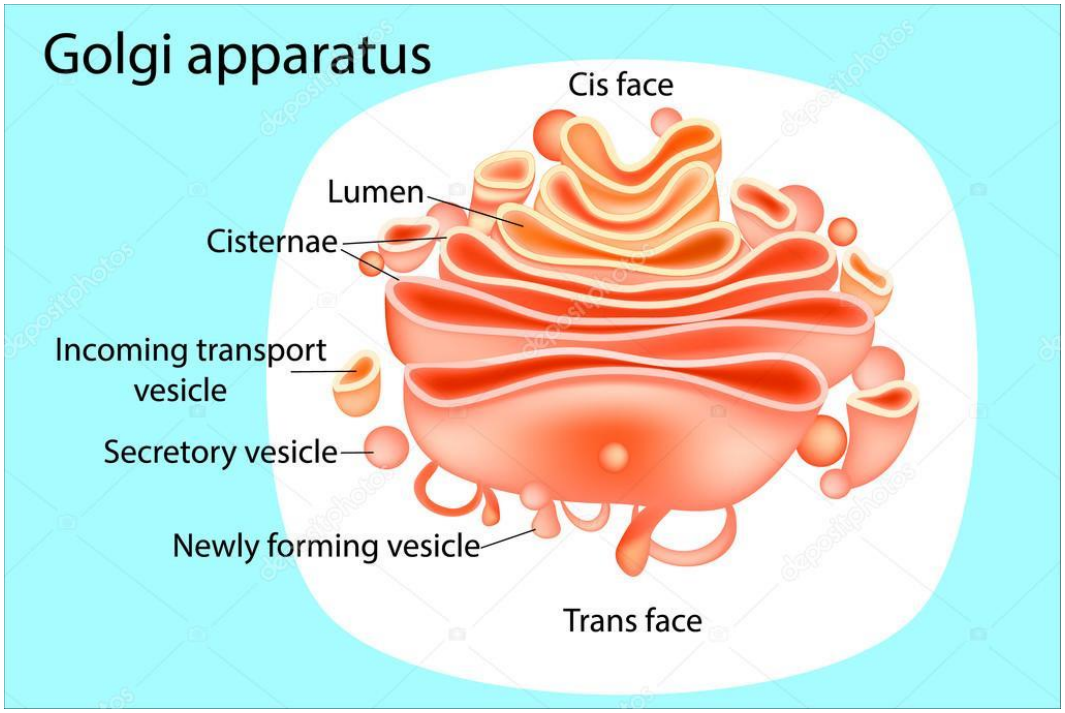
i) Granular or Rough Surface EPR: consist of granular ribosomes is concerned with protein synthesis.

ii) Agranular or Smooth Surface EPR: This does not contain ribosomes. This type of ER is a network of smooth surface tubules concerned with the metabolism and synthesis of fatty acids and steroids. They store and release calcium. It is prominent in the organs such as adrenal cortex, liver and striated muscles. Liver contains both types of ER.

Ribosomes (protein synthesis site) are the translation centers where the language of nucleic acid is translated into the protein of life.

b) Golgi apparatus: It is cup shaped structure and contain vesicles. It contains a large amount of lipoprotein. It is situated between the nucleus and the apex of the cell. Enzymes, ascorbic acid and some other substance are strored. It is involved the formation of secretory products rich in carbohydrates. It is concerned with conc. Of protein

prior to their secretion Golgi appatatus is first to be affected by drugs and poisons. It provides membranous covering for secretion granules and replenishes cell membrane.



c) Secretory granules: they store secretory products of the cell. They are formed in endoplasmic reticulum and Golgi apparatus and some are seen in the cytoplasm.
d) Centrosomes: the cell has a pair of tiny, cylindrical structure called centrioles which can be seen only when the cell is dividing. The 2 centrioles together form the centrosome. Centriole of the centrosome is situated near the nucleus and paly very important role in cell division. Before cell division, centrioles and centrosome division take place. Two radiating line grow centriole and form achromatic spindles. The nucleus divided and chromosomes are equally shaped in the achromatic spindle. These dividing cell are known as daughter cells.
e) Plasmosin: It is cytoplasm and it consist of long protein molecules, especially deoxy-ribo-nucleoprotein.

f) Vacuoles: These are found in cytoplasm of cell. They are covered by fatty material.

g) Lysosomes: These are the membrane bound bodies containing hydrolytic enzymes like phosphase, protease, glycosidase, lipases and carbohydrates. These enzymes are synthesized in EPR and the covering membrane is formed by Golgi appatatus. These are suicide bags of the cell. At death, the lyposomes membrane reptured their enzymes, spill out and autolysis of body cell ensures. The damaged intracellular organelles are broken down and digested lyposomes with the help of enzymes within, digest foreign bodies like bacteria entering the cell. They also help in breakdown of an injured cell. Lyposemes are the cell digestive events are called 1^{o} lyposomes and other which digest foreign bodies including bacteria are called 2^{o} lyposomes.

h) Peroxisomes: These contain enzymes involved in lipid metabolism. It also protect cell from the harmful effects of hydrogenperoxide. Smaller variety of them are called micro peroxisomes.

i) Microtubules and microfilaments: microfilaments are straight, hollow cylinders with a diameter of $200A^{o}$. They are concerned with the maintenance of cell shape. They are also associate with movements of cilia, flagella and mitotic spindles. They are made up of proteins like tubules or actin. They are rod or tube structures and have the following functions.

- ♦ Act as cytoskeleton.
- ♦ Form the component of cilia, flagella and centrioles.
- ♦ Help in intracellular support.

J) Mitochondia: These occur in the cytoplasm at variable numbers. E.g few hundreds to few thousands. The mithochondia are larger, granular rod shaped organelles about 0.5micro in diameter and 4micron in length. They are readily visible even under light microscope, particular when strained with vital dye in Janus green. The shape, size, number and distribution of mitochondira vary depending on the kind of cell and its activity. The average cell contains a few hundred mitochondria, while a liver cell may contain a thousand or more. Mature erythrocytes

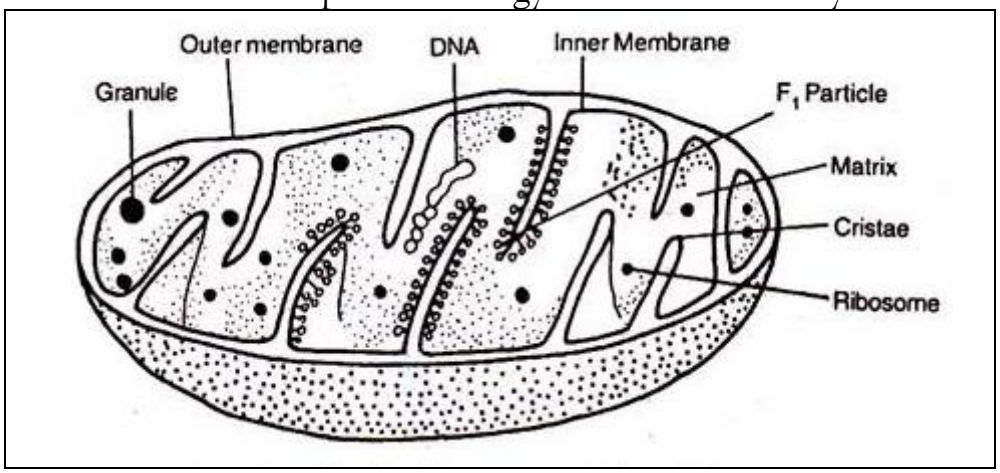
on the other hand, have no mitochondria at all. Within the cell, mitochondria tends to collect in area of greatest cell activity.

Mitochondria is composed of two layer membrane.

1) An outer smooth layer
2) Inner layer

The layer folded inwards to form incomplete partition called cristae. Projecting like shelves into the interior of mitochondria and vastly increasing the surface area of the membrane. Within the inner membrane is the matrix which contain many enzymes, some amount of DNA and RNA. DNA and RNA give them the ability to duplicate themselves during cell division.

The mitochondria is filled with fluid inside. Enzyme present floating in the fluid and other enzyme like flavoprotein and cytochromes associated with the inner membrane activate the various reaction of cell respiration cycle. The energy released in these reaction is stored in the form of ATP. Dehydogenase enzymes are present in the matrix and are involved in kreb's citric acid cycle and lipid and protein synthesis. ATP and GTP are formed in mitochondia and provide energy for various activity of cell.



(Structure of Mitochondia)

K) Microsomes: They are minute particles. They occupy $1/4^{th}$ of the weight of the cell. It consist of membraneous vesicles with or without ribosomes on them. This is not a separate cell organelle but only fraction of rough and smooth Endoplasmic reticulum. These are obtained as a fraction after centrifugation of homogenized cell preparation at a very high speed is 1000rpm.

Microsomes contains:

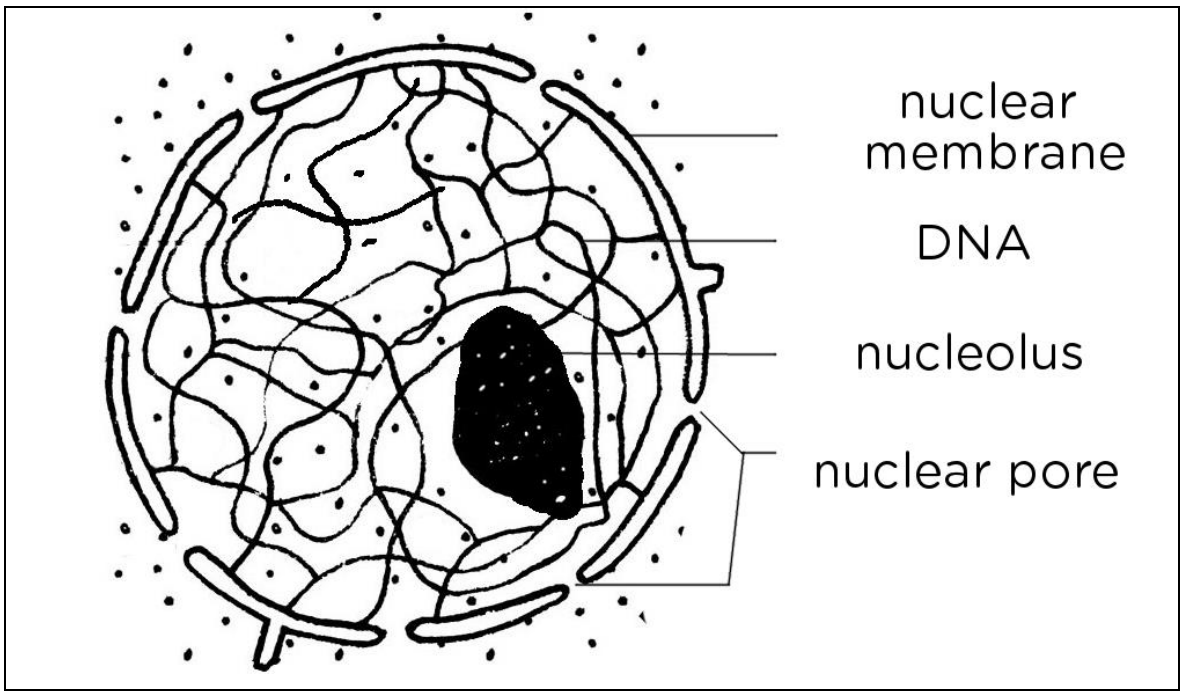
1) Ribosomes
2) Granular matrix

Ribosomes are concerned with protein synthesis while granular matrix contains.

a) Oxidases which generate hydrogen peroxide.
b) Catalase which converts hydrogen peroxide into water.

3) Nucleus: it is the largest structure present almost in the centre of cell. It is the key structure of living cell like brain of man. It consist of dense chromosomal network (chromatin) and nucleolus. The whole nucleus is surrounded by a nucleus membrane which is identical to cell membrane. It is perforated by numerous pores and apperar to be continuous with endoplasmic reticulum.

Nucleus is bonded by two layer nucleus membrane having pores on it. Outer layer of membrane is continuous with EPR. Nucleus pores allow passage of substance between nucleoplasm and cytoplasm. Nucleoplasm is semisolid and consist of mainly chromatin.



(Structure of Nucleus)

Nucleus contains:

I) Nucleolus

II) Cromatin

I) Nucleolus: it is tiny, spherical, dark staining body consisting of 95% protein and 5% RNA. It is a highly coiled filamentous structure present in the nucleus. It is not surrounded by a membrane but I contains numerous granules. A nucleus may contain one or more nucleoli. Nucleolus has a high RNA content. Ribosomal RNA is synthesized in nucleoli. This then goes to cytoplasm through nuclear pores and takepart in protein synthesis. Nucleoli generally disappears temporarily during cell division.

II) Chromatin: these are fibrous treads present me the nucleus. They are compsed of DNA and proteins. The chromatin threads carry genetic information consisting of DNA in the form of genes. When the cell divided, the chromatin becomes compact, dense and rod like particles called chromosomes each human body cell is made up of 46 chromosomes is constant for a particular species of organism. In addition to DNA nucleus, it also consist of RNA.
Most of body cell contains single nucleus which is rounded or oval in shape. However, there are exceptions. Example- skeletal muscle fibres are multinucleatr and he floating RBCs lack the nucleus.

Function of nucleus are:

- Cell divison
- Transfer of hereditary characteristics
- Synthesis of protein and enzymes

Function of cell:

1) Ingestion and assimilation: the cell ingests chemical substances like amino-acids from intracellular fluid. These substances are used to build up complicated substance like proteins.

2) Growth and Repair: The ingest and assimilated materials are used to synthesis new protoplasm. This leads to increase in size and growth of cell. Also worn out part of the cell are replaced by this process.
3) Metabolism: this involves two process: i) Anabolism: In which the ingested and assimilated food material is used for growth and repair.
   Catabolism: In which food material is broken down to release energy for various functions of the cell.
4) Respiration: It involves the transport of oxygen from lungs through blood to the tissues and removed of waste products like carbondioxide. This is essential for the survival and function of a cell.
5) Excretion: the cell elimination waste products resulting from catabolism into the intrastitial fluid. These products are carried by blood for elimination through lungs and kidney.
6) Irritability and contractility: the cell is active by means of these function. The cell responds to any stimulus (like physical, chemical, thermal, electrical and mechanical) by contraction or the impulse is conducted as that occur in nerve cell.
7) Reproduction: After growing to an optimum size, the cell divides into daughter cells. Reproduction of cells occurs by meiosis and mitosis.

CHAPTER-2

Elementary tissues

Tissue: A group of cells having the same origin, similar shape and different function is known as a tissue.

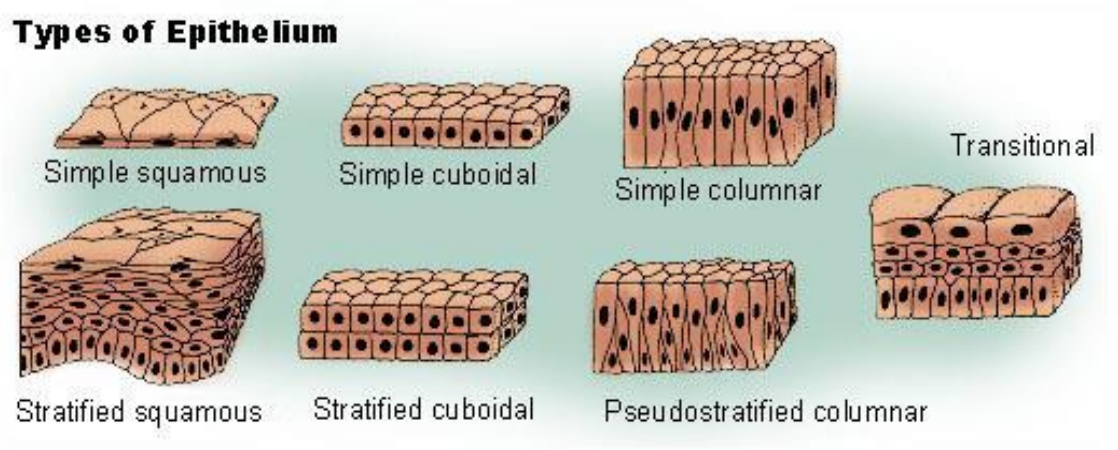
Classification of tissues: Tissues are classified into four types:

1. Epithelial tissue
2. Connective tissue
3. Muscular tissue
4. Nervous tissue

(I) **Epithelial Tissue:** Epithelial tissue consist of cell arranged in continuous sheets in single or multiple layers. It is lining, covering and glandular tissue of body. Epithelial tissue play different roles in body like protection, filtration, absorption and excretion. There are the following three types of epithelial tissues.

1. **Simple Epithelium:** It contains single layer of cells and is of four types:
   a) Simple squamous epithelium: This tissue consists of a single layer of fat cells that resembles a tiled floor when viewed from the apical surface. Simple squamous epithelium is present at sites where the processes of filtration or diffusion occur.
   b) Simple cuboidal epithelium: It consists of single layer of cube shaped cells having round and centrally located nucleus. This epithelium is found in organs such as the thyroid gland and kidneys. It performs the functions of secretion and absorption.
   c) Simple columnar epithelium: The cells of simple columnar epithelium appears like columns, with oval nuclei near the base. These play a role in absorption and secretion. Simple columnar epithelium cells can be ciliated (containing hair on surface).
   d) Pseudo-stratified columnar epithelium: Pseudo-stratified columnar epithelium appears to have several layers because the nuclei of the

cells are at various depths. Even though all the cells are attached to the basement membrane in a Single layer, some cells do not extend to the upper surface. In pseudo stratified ciliated columnar epithelium, the cells secrete mucous or bear cilia. Pseudo-stratified non-ciliated columnar epithelium contains cells without cilia and lacks mucous cells.



2. **Stratified Epithelium:** It contains multiple layers of cells. It is more durable and can better protect underlying tissues. It is four type.

a) Stratified squamous epithelium: Upper layers of this epithelium are squamous, deep are cuboidal and deeper may be columnar. This type of epithelium is found at sites which receive good deal of abrasion, wear and tear. It major functions are protection, prevention of water loss and foreign invasion. This type of epithelium is generally present in skin, wet lining of mouth, esophagus and tongue.

b) Stratified cuboidal epithelium: This is a fairly rare type of epithelium in which cells in the upper layer are cuboidal. Stratified cuboidal epithelium serves a role in protection, secretion and absorption.

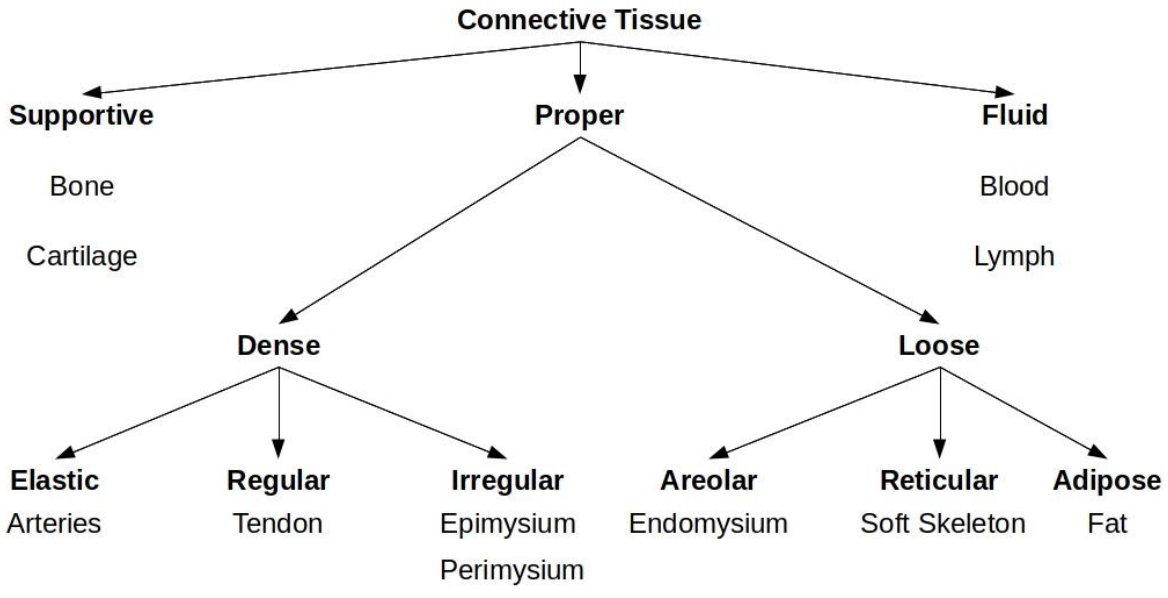
c) Stratified columnar epithelial: The basal layers consists of shortened, irregularly shaped cells; only the upper layer has cells are columnar in shape. This type of epithelium functions in protection and secretion. Present in ducts of glands and conjunctiva of eye.

d) Transitional epithelium: Transitional epithelium is present only in the urinary system. In its relaxed or up-stretched state, transitional epithelium looks like stratified cuboidal epithelium. As the tissue is stretched, its cells become flatter, giving the appearance of stratified squamous epithelium. It allows the urinary bladder to stretch to hold a variable amount of fluid without rupturing.

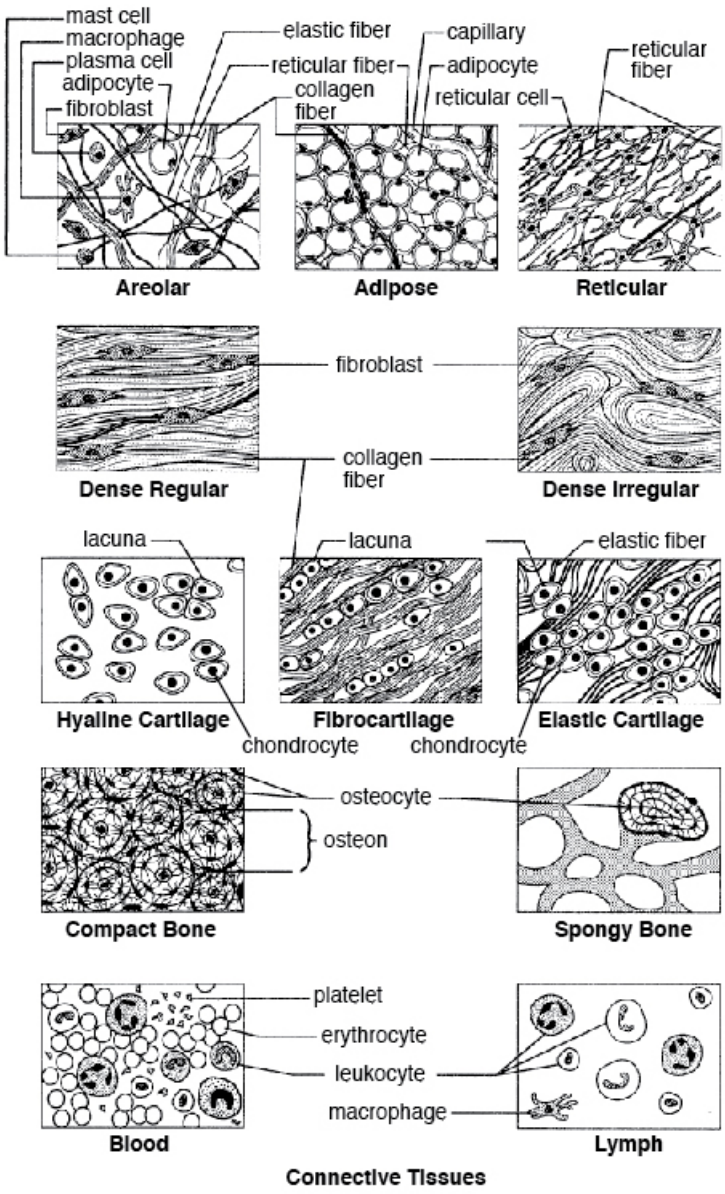
Glandular epithelium: The function of glandular epithelium is secretion. Glandular cells often lie in clusters deep to the covering and lining epithelium. A gland consists of a single cell or a group of cells that secrete substances into ducts (tubes), onto a surface, or into the blood. All glands of the body are classified as either endocrine or exocrine.

(2) **Connective tissue:** Connective tissue is one of the most abundant and widely distributed tissues and physiology of connective tissues in the body. It binds together, supports and strengthens other body tissues and protects internal organs. It is the primary location of stored energy reserves (adipose or fat tissue) and is the main source of immune responses.

Classification of connective tissue: Connective tissue can be divided as:



1. **Loose connective tissue:** In loose connective tissue, fibers present between cells are loosely arranged. Loose connective tissue contains more cells and fewer fibres.
   a) Areolar connective tissue: This is one of the most widely distributed connective tissues in body. Contains several types of cells and all the three types of fibres embedded in ground substance. Due to areolar nature, it acts as reservoir for water, salts and nutrient. It is also called packing material as it is present in almost every body structure e.g. skin, mucous membrane. Its function is to provide strength, elasticity and support.
   b) Adipose connective tissue: This tissue is made up of specific cells called Adipocytes. These adipocytes are specialized to store fat and triglycerides. Adipose tissue forms layer beneath skin which insulates the body from heat and cold, protects the kidney by capsule of fat and Cushion's eye ball socket. It also serves as energy reserve, supports and protects several organs.
   c) Reticular connective tissue: It is delicate network of reticular fibres and reticular cells which forms internal frame work of certain soft organs like liver and spleen. It functions to filter and remove worn out blood cells and microbes in lymph nodes.



2. **Dense connective tissue**: Dense connective tissue contains more numerous, thicker and denser fibres which are packed more closely and fewer cells than loose Connective tissue. There are three types: dense regular connective tissue, dense irregular connective tissue and elastic connective tissue.

   (a) Dense regular connective tissue: It contains mainly collagen fibres regularly arranged in bundles and few fibroblasts are present which are arranged in rows in between the bundles of fibres. It

forms tendons (attaches bone to muscle) and ligaments (attaches bone to bone). It also provides strong attachments between Connective tissue.

(b) Dense irregular connective tissue: It contains collagen fibers which are irregular arranged with few fibroblast present between them. It is present in Sheet beneath skin and around muscles, joint capsules etc. It provide pulling strength in many direction.

(c) Elastic connective tissue: It is made up of branched elastic fibers and fibroblasts. It is present in lungs, elastic arteries, trachea etc. Due to its elastic fibers, it allows strength in many directions.

3. **Cartilage:** It consist of dense network of collagen and elastic fibres. It contains few cells (chondrocytes) and lack amount of external material. It lacks blood supply. It is of three types. Hyaline cartilage, elastic cartilage, fibrocartilage.

   a) Hyaline cartilage: Hyaline cartilage is the most abundant cartilage in the body. It consists of chondrocytes embedded in fine collagen fibers. Extracellular matrix appears glassy, bluish white and shiny substance. It provides flexibility and support and at joints, reduces friction and absorbs shock. Hyaline cartilage is the weakest of the three types of cartilage.

   b) Fibro-cartilage: Chondrocytes are scattered among clearly visible, thick bundles of collagen fibres within the extracellular matrix of fibro-cartilage. With a combination of strength and rigidity, this tissue is the strongest of the three types of cartilage. One location of fibro-cartilage is the intervertebral discs, the discs between the vertebrae (backbones). Its main function is to support and join.

   c) Elastic cartilage: It consists of the chondrocytes located within a thread-like network of elastic fibres within the extracellular matrix. Elastic cartilage provides strength and elasticity and maintains the shape of certain structures, such as the external ear.

4. **Bone Tissue:** The bones supports soft tissues, protects delicate structures and works with skeletal muscles to generate movement.

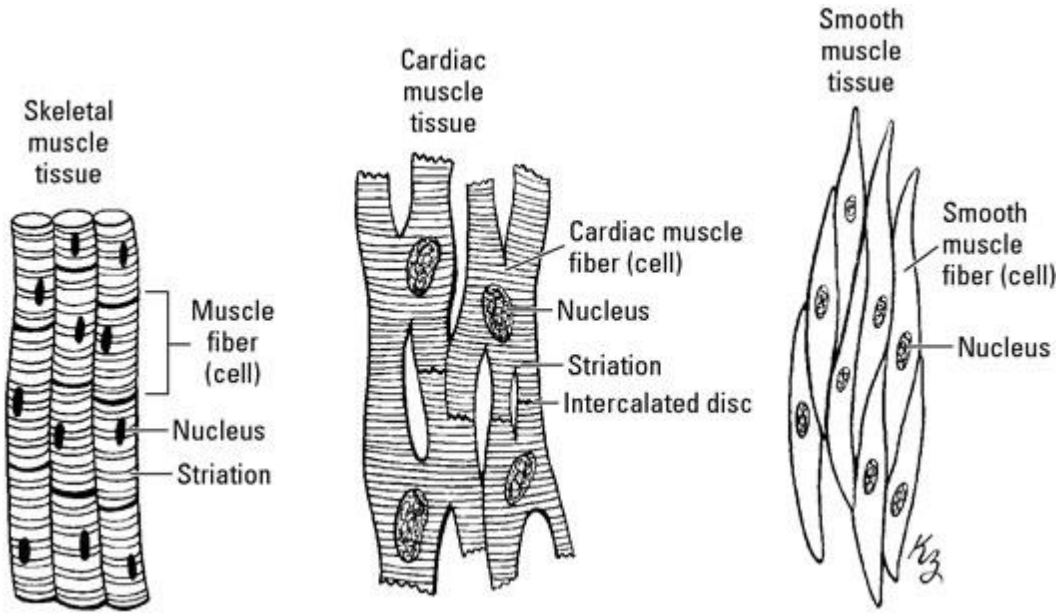
Bones store calcium and phosphorus, house red bone marrow, a storage site for triglycerides.

5. **Liquid connective tissue**: Liquid connective tissue is of two types:
   (a) Blood tissue: It is a connective tissue with a liquid extracellular matrix. The liquid extracellular matrix is called blood plasma which is a pale yellow fluid that consists mostly or water with a wide variety of dissolved substances like nutrients, wastes, enzymes, plasma proteins, hormones, respiratory gases and ions. Cells are suspended in the blood plasma which includes red blood cells (erythrocytes), white blood cells (leukocytes) and platelets.
   (b) Lymph: It is the extracellular fluid that flow in lymphatic vessels. It is a Connective tissue that consists of several types of cells in a clear liquid extracellular matrix that is similar to blood plasma but with much less protein.

(3) **Muscular tissue:** Muscular tissue consists of elongated cells called muscle fibres or myocytes that can use ATP to generate force. Muscular tissue produces body movements maintains posture and generates heat. It also provides protection. Muscular tissue is classified into three types: skeletal, cardiac and smooth.

a) **Skeletal muscle tissue:** It is named for its location as it is usually attached to the bones of the skeleton. It contains striations, alternating light and dark bands within the fibres that are visible under a light microscope. Skeletal muscle is considered voluntary because it can be made to contract or relax by conscious control. A muscle fibre is roughly cylindrical in shape and has many nuclei located at the periphery.
b) **Smooth muscle tissue**: It is located in the walls of hollow internal structures such as blood vessels, airways to the lungs, the stomach, intestines, gall bladder and urinary bladder. Its contraction helps in constriction of blood vessels, physically break down and movement of food along the gastrointestinal tract, movement of fluids through the body and eliminate wastes. Smooth muscle fibres are usually

involuntary and they are non-striated (lack striations), hence named smooth. A smooth muscle fibre is small, thickest in the middle and tapering at each end. It contains a single, centrally located nucleus.



c) **Cardiac muscle tissue**: It forms most of the wall of the heart. It is also striated. It is involuntary to control as its contraction is not consciously controlled. Cardiac muscle fibres are branched and usually have only one centrally located nucleus an occasional cell has two nuclei. They are attached at end to end by intercalated discs. Intercalated discs hold the fibres together during their vigorous contractions and provide a route for quick conduction of muscle action potentials throughout the heart.

(4) **Nervous tissue:** Nervous tissue detects changes in conditions inside and outside the body and responds by generating action potentials (nerve impulses) that activate muscular contractions and glandular secretions. Nervous tissue consists of only two types of cells: Neurons and Neuroglia.

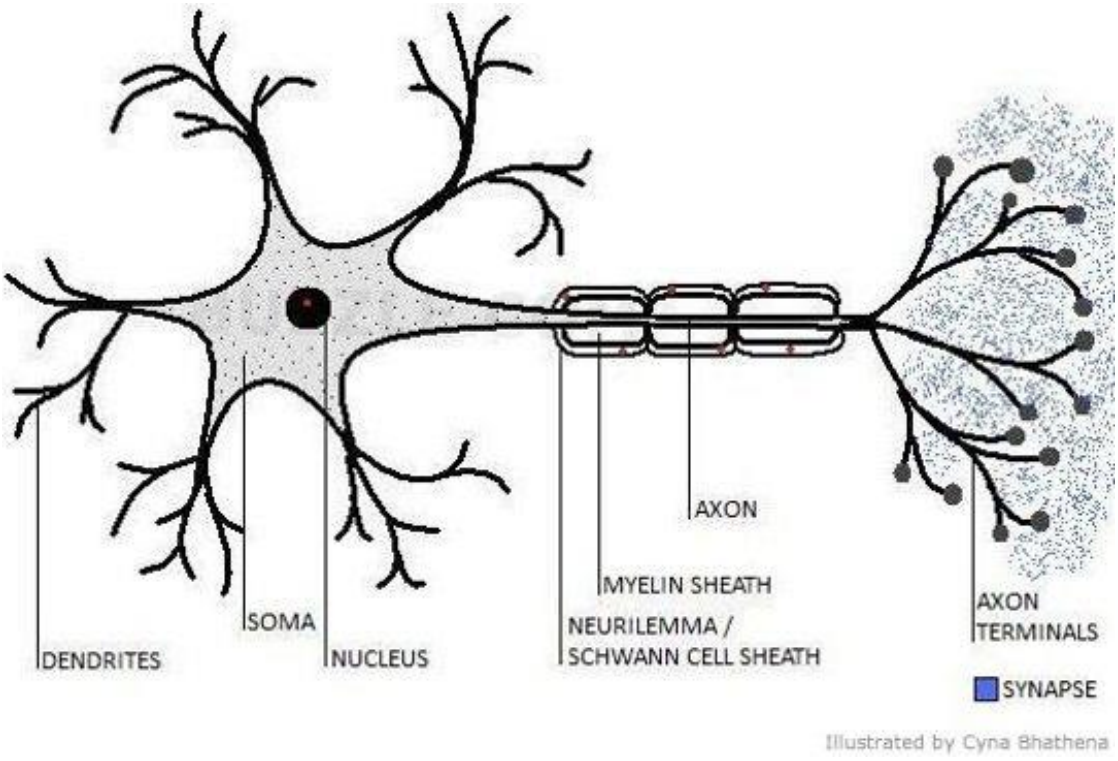
I. **Neurons**: Neurons are the cells which are sensitive to various stimuli. These convert various stimuli into electrical signals, called action

potentials and conduct these action potentials to other neurons, muscle tissue or glands. Neurons consist of three parts:

(a) **Cell body**: It contains the nucleus and other organelles.

(b) **Dendrites:** These are tapering, branched and short processes and are the receiving portion of a neuron.

(c) **Axon**: Single, thin, cylindrical and long process. It is the output portion of a neuron which conducts nerve impulses toward another neuron or to some other tissues.



Neuroglia: These cells do not generate or conduct nerve impulses but provide protection and support to neurons. Neuroglia cells are of six types: astrocytes, oligodendrocytes, microglia, ependymal cells, Schwann cells and satellite cells.

CHAPTER-3

Skeletal System

Skeletal system: Bones and joints form the skeletal system of the body.

Functions:

1. Support and protection
2. Gives attachment to muscles
3. Formations of RBCs
4. Storage of minerals

The entire framework of bones and their cartilages, along with ligaments and tendons, constitutes the skeletal system. Supports soft tissues and provides attachment for skeletal muscles. Skeletal system protects internal organs, movement along with skeletal muscles, stores and releases minerals, contains red bone marrow which produces blood cells, contains yellow bone marrow.
The human skeletal is divided into two divisions: axial skeleton and appendicular skeleton.

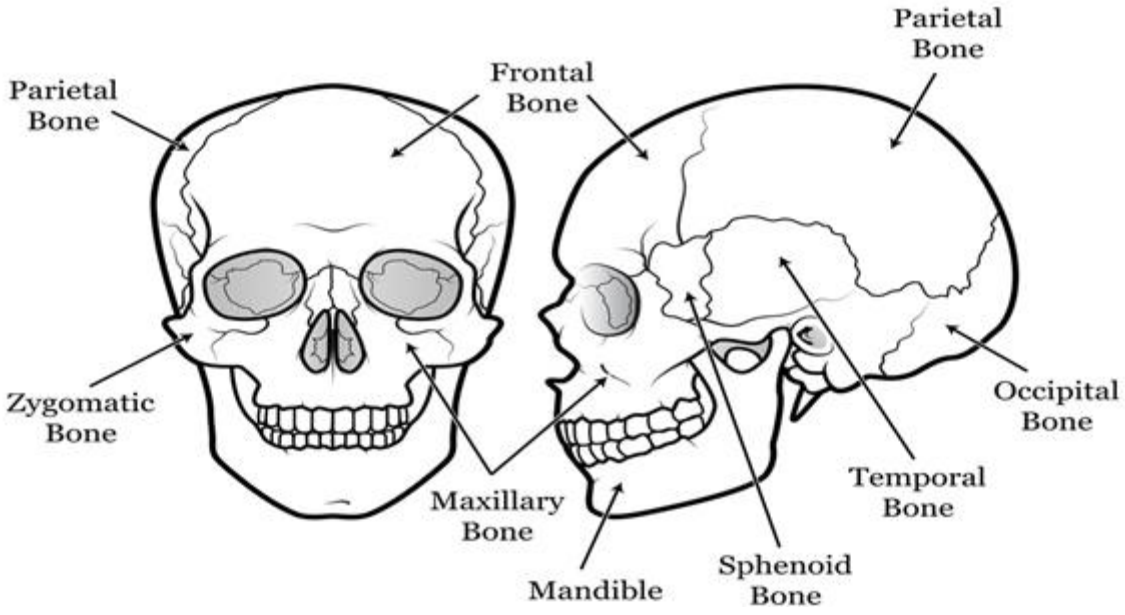
Axial Skeleton: Axial skeleton is the framework of bones which lies along a vertical axis. It consists of the following bones:

a. **Skull**: Bony framework of the head is called Skull.
   The skull, with its 22 bones, rests on the superior end of the vertebral column (backbone).

The bones of the skull are grouped into two categories:

CRANIAL BONES (8 bones)
1 frontal bone
2 parietal bones
2 temporal bones

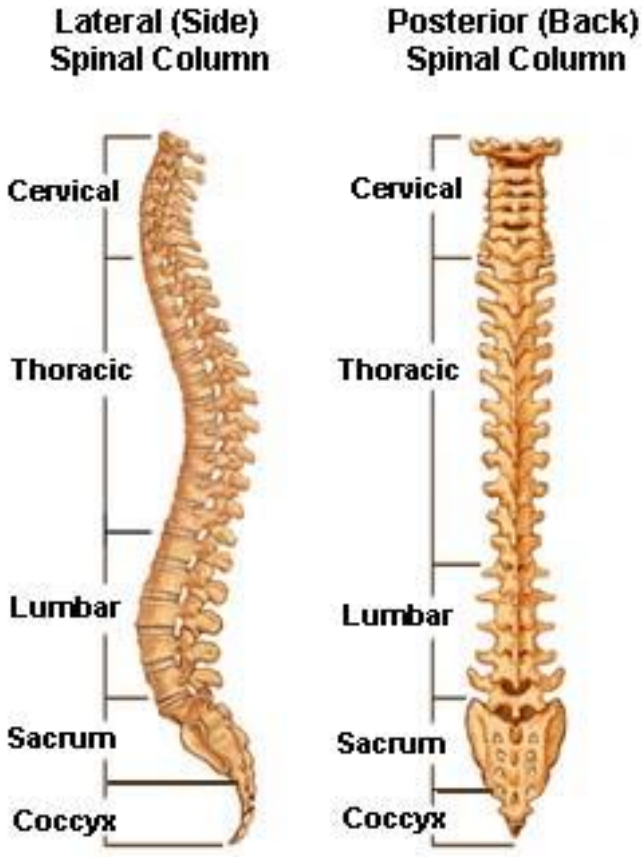
I occipital bone
I sphenoid bone
I ethmoid bone



FACIAL BONES (14 bones)
2 nasal bones
2 maxillae
2 zygomatic bones
2 lacrimal bones
2 palatine bones
2 inferior nasal conchae
I mandible
I vomer

(b) **Vertebral Column**: Vertebral column is also called spinal column, spine or back bone. Composed of a series of 33 bones called vertebrae. Extends from skull to pelvic bones.
Functions as strong flexible rod which can move forward, backward, sideways and rotate. It encloses and protects spinal cord, supports the

head, and serves as a point of attachment for the ribs, pelvic girdle and muscles of the back and upper limbs.
These 33 bones are categorized as first 7 are called cervical vertebrae, next 12 is called thoracic vertebrae, next 5 are called lumber, next 5 are called sacral vertebrae which gets fused to form one sacrum, and last 4 are called coccygeal vertebrae which fused to form coccyx.

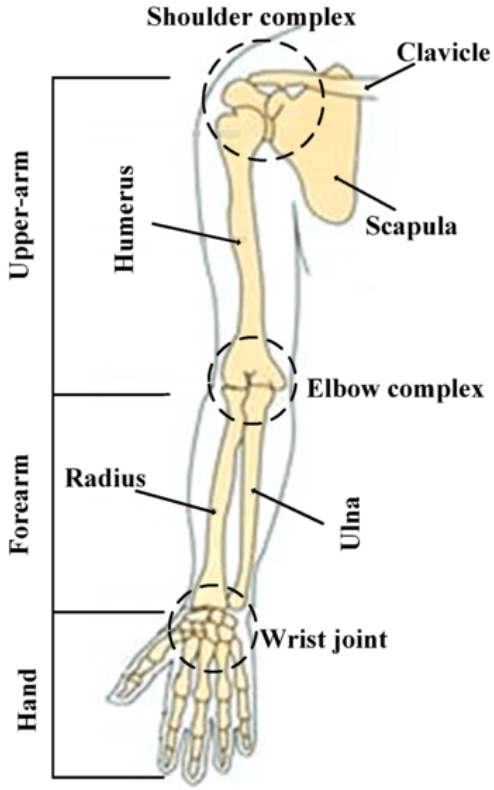


(c) **Thorax:** The term thorax refers to the entire chest. The thoracic cage is a bony enclosure formed by the sternum, ribs and the bodies of the thoracic vertebrae. Also have costal cartilages which attach the ribs to the sternum. It encloses and protects the organs (heart, lungs and blood vessels) in the thoracic cavity and provides
support to the bones of the upper limbs. Divided mainly into two parts i.e. Sternum and Ribs.

Appendicular Skeleton: The appendicular skeleton includes the bones that make up the upper and lower limbs as well as the bones of the two girdles that attach the limbs to the axial skeleton. It consists of the following bones:

(a) **Pectoral griddle**: The human body has two pectoral or shoulder girdles that attach the bones of the upper limbs to the axial skeleton. It consists of the following bones.

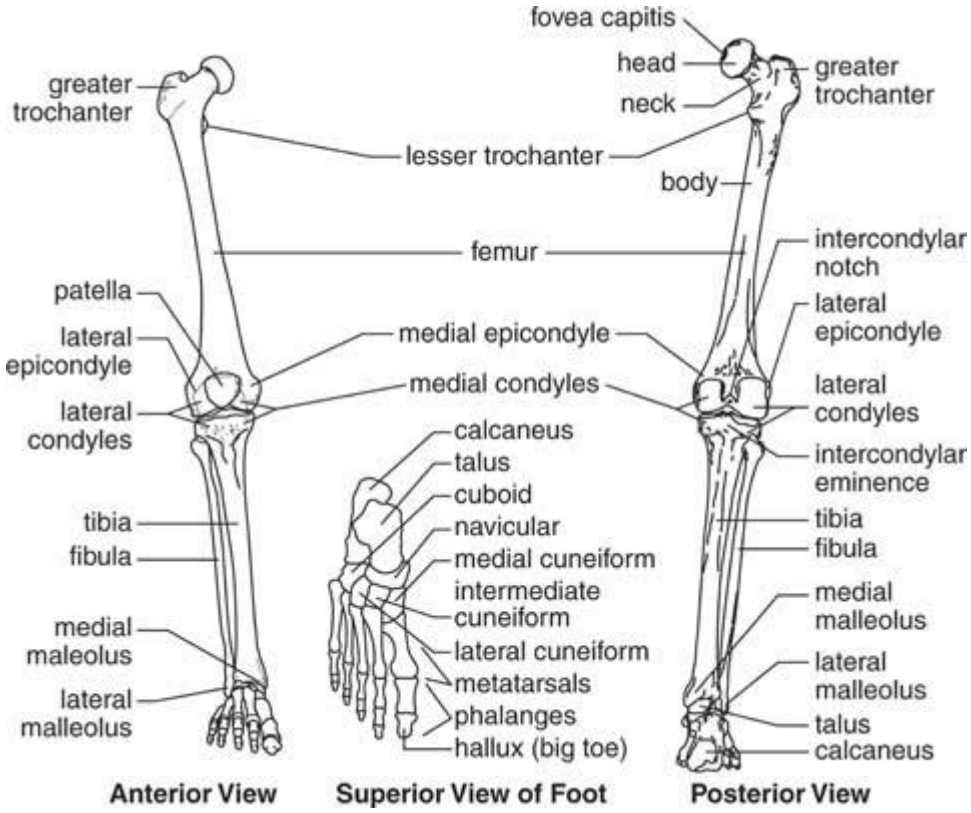
(b) **Upper limbs**: Each upper limb has 30 bones in three locations: Humerus in the arm, Ulna and radius in the forearm, 8 carpals in the carpus (wrist), 5 metacarpals in the metacarpus (palm), 14 phalanges (bones of the digits) in the hand.



(c) **Pelvic or Hip griddle**: Consist of two bones called coxal bones or hip bones. The hip bones unite anteriorly at a joint called the pubic symphysis. They unite posteriorly with the sacrum at the sacroiliac

joints. Complete ring composed of hip bones, pubic symphysis and sacrum forms a deep, basin like structure called the bony pelvis.

(d) **Lower limbs**: Each lower limb has 30 bones in four locations. Femur in the thigh. The Patella (knee cap), The Tibia and Fibula in the leg, 7 Tarsals in the tarsus (ankle), 5 Metatarsals in the metatarsus, 14 Phalanges (bones of the digits) in the foot.



CHAPTER-4
Cardiovascular System

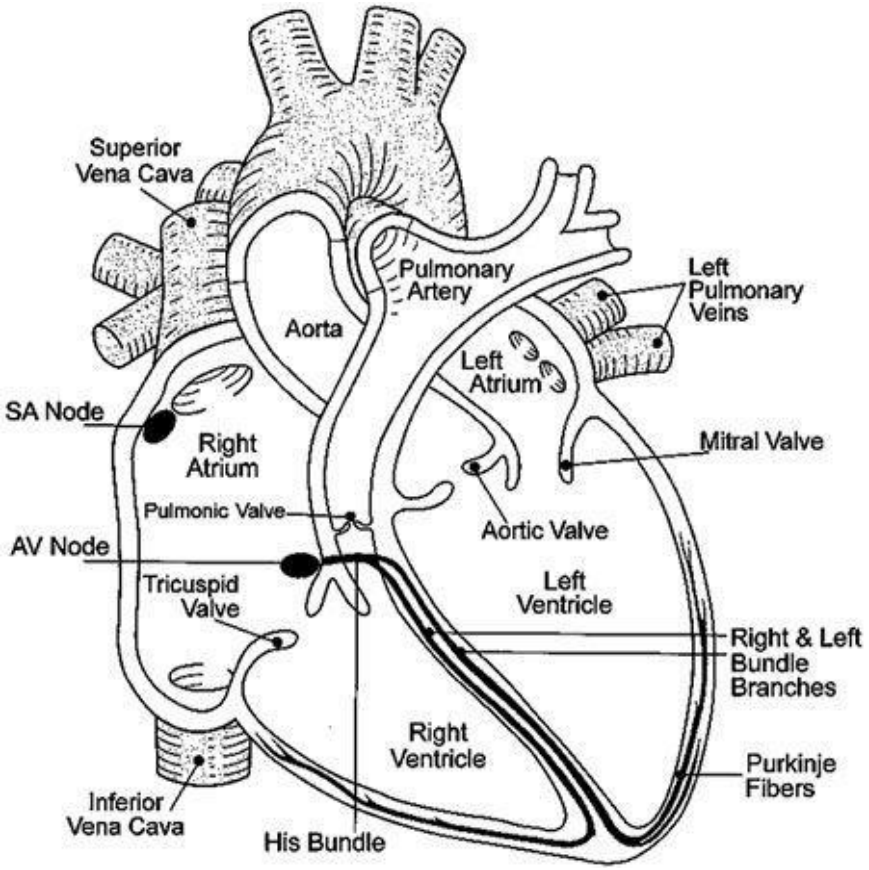
Heart: The heart rests on the diaphragm, near the midline of the thoracic cavity in the mediastinum. It is about 12 cm long, 9 cm wide at its broadest point, and 6 cm thick, with an average mass of 250 gm in adult females and 300 gm in adult males. About two-thirds of the mass of the heart lies to the left of the body's midline. The pointed apex is formed by the tip of the left ventricle (lower chamber of the heart) and rests on the diaphragm. The base of the heart is formed by the atria (upper chambers) of the heart, mostly the left atrium.

Layers of Heart Wall: The wall of the heart consists of three layers:

(a) Epicardium: It is thin, transparent outer layer of the heart wall, also called the visceral layer of the serous pericardium. It is composed of delicate connective tissue that imparts a smooth, slippery texture to the outermost surface of the heart.

(b) Myocardium: It is the middle layer made up of cardiac muscle tissue. It makes up about 95% of the heart and is responsible for its pumping action. It is striated and involuntary in nature.

(c)Endocardium: It is the innermost thin layer of endothelium. It provides a smooth lining for the chambers of the heart and covers the valves of the heart. It minimizes surface friction as blood passes through the heart and blood vessels.



Chambers of the Heart:

(a) Right Atrium: It forms the right border of the heart. It receives blood from three veins. The superior vena cava, inferior vena cava, and coronary sinus, and delivers to right ventricle through a valve called tricuspid valve or right atrioventricular valve. Interatrial septum (septum a dividing wall) divides both atria into right atrium and left atrium.

(b) Right Ventricle: It forms most of the anterior surface of the heart. The inside of the right ventricle contains a series of ridges formed by cardiac muscle fibres called trabecular carneae. The cusps of the tricuspid valve are connected to tendon like cords, the chordae tendineae, which in turn are connected to cone shaped trabeculae carneae called papillary muscles. Internally, the right ventricle is separated from the left ventricle by interventricular septum. Right ventricle received blood from the right atrium and passes it into a large artery called pulmonary trunk through

pulmonary valve (pulmonary semilunar valve). Pulmonary trunk divides into right and left pulmonary arteries which deliver blood to right and left lung respectively for removal of CO, Arteries always takes blood away from the heart.

(C) Left Atrium: The left atrium is about the same thickness as the right atrium. It forms most of the base of the heart. It receives purified blood from the lungs through four pulmonary veins. Blood passes from the left atrium into the left ventricle through the bicuspid (mitral) valve also called the left atrioventricular valve.

(d) Left Ventricle: The left ventricle is the thickest chamber of the heart and forms the apex of the heart. Like the right ventricle, the left ventricle also contains trabeculae carneae and has chordae tendinae that anchor the cusps of the bicuspid valve to papillary muscles. Left ventricle receives blood from the left aorta and bicuspid valve and passes it to ascending aorta through the aortic valve (aortic semilunar valve). From ascending aorta some of the blood flows into the coronary arteries, which carry blood to the heart wall. The remainder of the blood passes into the arch of the aorta and descending aorta (thoracic aorta and abdominal aorta). Branches of the arch of the aorta and descending aorta carry blood throughout the body.

Blood Group: The surfaces of erythrocytes contain a genetically determine dassortment of antigens composed of glycoproteins and glycolipids. These antigens, called agglutinogens, occur in characteristic combinations. Based on the presence or absence of various antigens, blood is categorized into different blood groups. Within a given blood group, there may be two or more different blood types. There are at least 24 blood groups and more than 100 antigens that can be detected on the surface of red blood cells. Two major blood groups are ABO and Rh. ABO Blood.

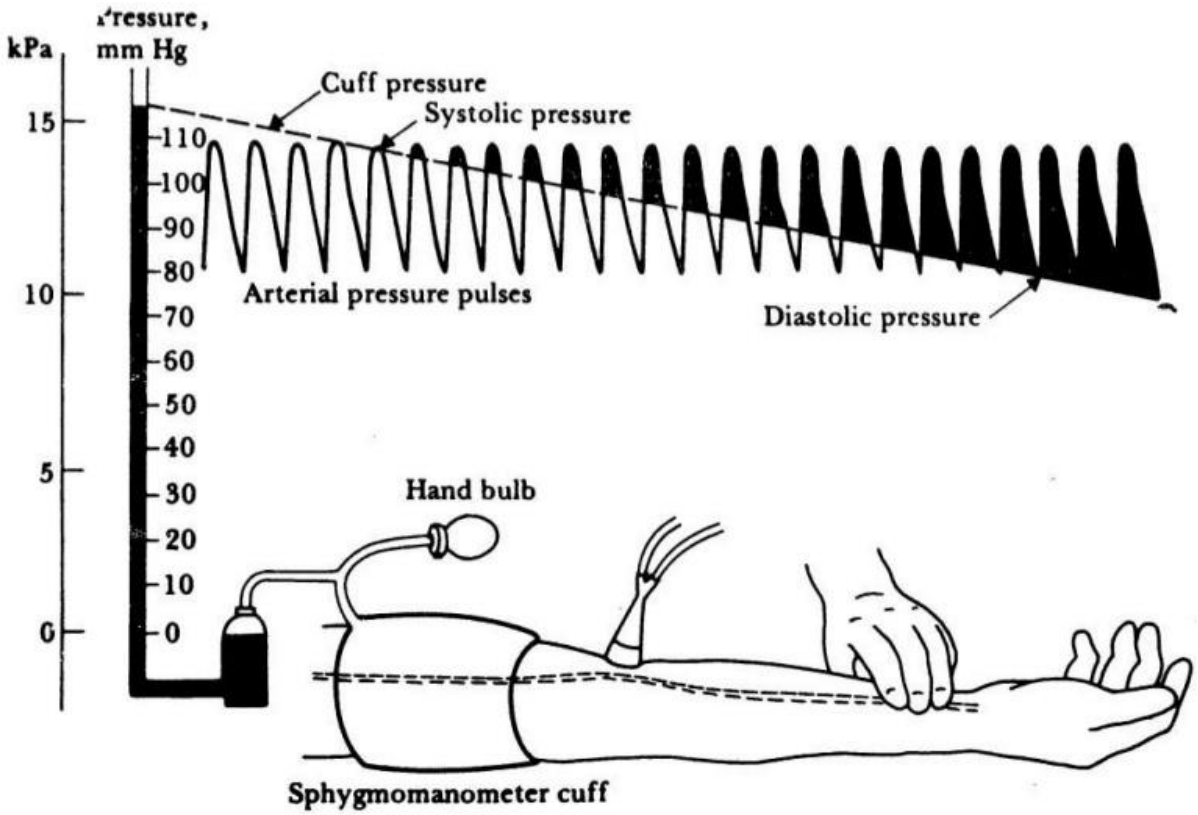
Group: The ABO blood group is based on two glycolipid antigens called A and B. A person who's RBCs display only antigen A has type A blood. Those who have only antigen B are type B. Individuals who have both A

and B antigens are type AB; those who have neither antigen A nor B are type O. Blood plasma usually contains antibodies called agglutinins that react with the A or B antigens if the two are mixed. These are the anti-A antibody, which reacts with antigen A, and the anti-B antibody, which reacts with antigen B.

Blood pressure (B.P): It is defined as the lateral pressure exerted on the walls of the vessels by the contained blood. This is due to the muscularity and elasticity of the walls of blood vessels. The blood pressure also depends upon the force exerted by the heart when it pumps the blood. The maximum pressure during systole is defined as systolic blood pressure whereas the minimum pressure during diastole is defined as the diastolic blood pressure. The difference between the systolic and diastolic blood pressure is described as pulse pressure. The average systolic blood pressure in
healthy adult is 100-140 mm Hg, the average diastolic blood pressure is 80-100 mm Hg. The average pulse pressure is about 30-50 mm Hg.
There are two methods which are used to measure blood pressure using sphygmomanometer, which are:

A. Palpatory method (feeling pulse).
B. Auscultatory method (hearing pulse).

Indirect Blood Pressure Measurement - Sphygmomanometer



Procedure:

1. Ask the subject to sit down or lie down at ease on the couch in the supine position. Remove the garments round the arm, place the arm on a table and adjust position such that it is level of the heart.

2. Tie the cuff of sphygmomanometer around the arm. It should be neither too tight to cause any discomfort to the subject, nor too loose to allow its movement round the arm.

3 Feel the artery and mark its course in the cubital fossa. Also feel and mark the radial pulse at the place where it is feel well.

4 Place the manometer by the side of the subject, between his arm and the body. Tight the screw of the rubber pump and press the pump to inflate

the bag. It inflate to raise the mercury to 200 mm level or 20-25 mm Hg higher after the disappearance of pulse.

5. Keep the eyes fixed at mercury level and the finger at the pulse (which is disappeared) slowly release pressure by unscrewing the valve of the rubber Pump. The reading of the level of the mercury when the pulse reappears gives the systolic pressure. This is palpatory method. This method does not give any idea about diastolic pressure.
6. In auscultatory method, after inflation as usual, the chest piece of stethoscope is place over the bronchial artery in the cubital fossa and deflation is started by slowly releasing the pressure. The pressure at which sudden tap heard is the systolic pressure. The sound gets muffled and disappears. The level at which the sound gets muffled is the diastolic pressure. The sound heard is called Korokorr's sound.

Sphygmomanometer: An instrument for measuring blood pressure, particularly in arteries. The two type of sphygmomanometer are a mercury column and a guage with a dial face. The sphygmomanometer is most frequent use today consist of a guage attached to rubber cuff which is wrapped around the upper arm and is inflated to constrict the arteries.
A blood pressure reading consist of two number systolic and diastolic. Systolic refer that phase when the heart pump blood but into the aorta. Diastolic refer to diastole, the resting period when the heart refiles with blood. At each heartbeat, blood pressure is raised to the systolic level and up beats it drops to the diastolic.

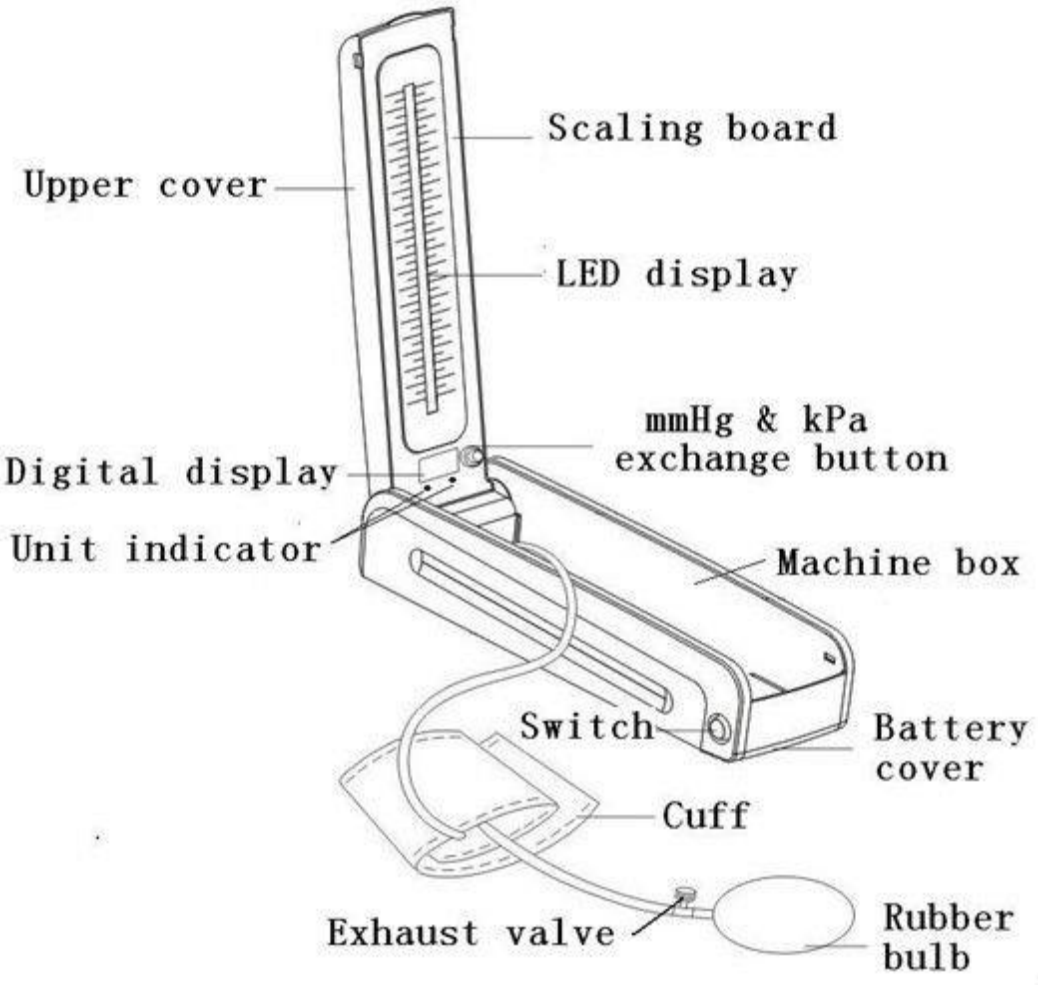
Various parts of sphygmomanometer:

(i) Bladder: The bladder is the inflatable bag that when filled compressed the arm to osculate the artery bladder should flow very specific sizing parameter to ensure full arteries compression.
(ii) Cuff: The cuff designed to hold the bladder around the limb during measurement. A properly designed cuff ensure proper placement and positioning essentially for accurate measurement.

(iii) Manometer: Manometer is the portion of sphygmomanometer that measure the air pressure in mm Hg. The aneroid contains a watch like movement that measure the air pressure applied to cuff.

(iv) Valve: The deflection valve allows for controlled deflection of cuff critical for accurate measurement. Valve is made from solid and plated in nickel. Filter screen protection and micro thread design ensure precious and long life.

(v) Bulb; the bulb pump air into the cuff. An end valve prevents air from escaping. Bulbs are made from either spin cost PVC or dip molded neophere. Available in large size for use with bigger cuffs. Filter screen and valves provide are additional dust barrier.



CHAPTER-5
Respiratory system

"Respiration is defined as the exchange of gases between body tissues and the external environment. Supply oxygen to the tissues and excretion of carbon dioxide occur through respiration."
The respiratory system plays a role in exchange of oxygen and carbon dioxide between the atmospheric air, blood and tissue cells. Metabolic reactions in human body use oxygen to produce energy from nutrients in form of ATP. At the same time, these reactions release carbon dioxide ($CO_,$) which must be eliminated quickly to prevent acidity due to CO_2. The respiratory and cardiovascular systems cooperate to supply and eliminate CO_2. The respiratory system provides for gas exchange i.e. intake of O_2 and elimination of CO_2. The cardiovascular system transports these gases through blood between the lungs and body cells.

Functions of respiration are:

1. Transport of oxygen to tissues and exchange of carbon dioxide.
2. Exchange of volatile substance like ammonia.
3. Regulation of body temperature through loss of heat in expired air.
4. Maintenance of pH of blood.
5. Regulation of body balance through excretion of water vapour.

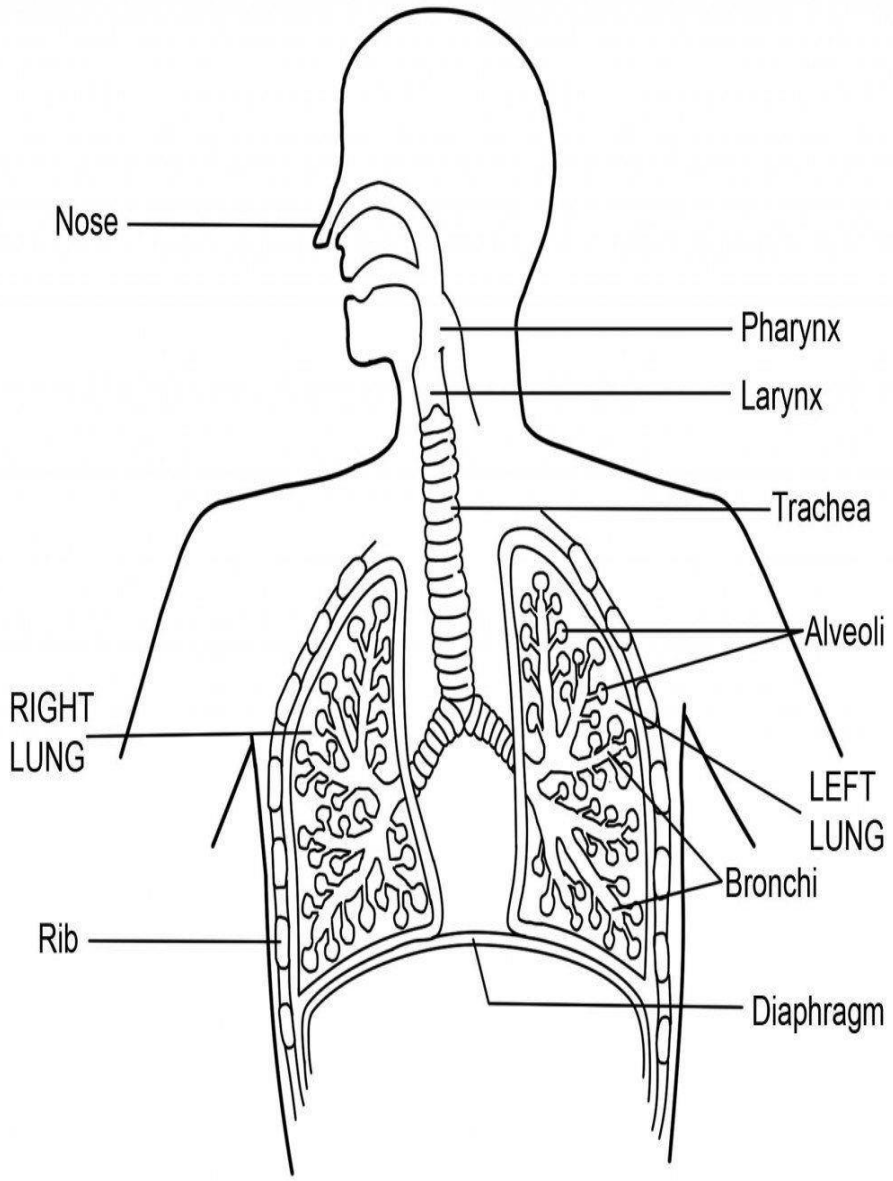
Respiratory system: The respiratory system consist of the following structure.
I. Nose: It is only externally visible organ of respiratory system. Nose can be divided into two parts:

(a) External nose: The external nose consists of a framework of bones and hyaline cartilage covered with muscle and skin and lined by a mucous membrane. On the under surface of the external nose are two openings called the external nares or nostrils.

(b) Internal nose: Internal nose is larger cavity and is present inferior to nasal bone and superior to mouth. Anteriorly, it merges with external nose

and posteriorly joins with pharynx through two openings called internal nares. Space within internal nose is called nasal cavity. A vertical partition called the nasal septum divides the nasal cavity into right and left sides.

2. Pharynx: It is the junction between the oral and nasal cavity and inferiorly, it is attached to larynx and oesophagus. The larynx gets it connected with wind pipe and oesophagus provides its attachment with digestive system. The major functions of pharynx are to transport air to respiratory system and food to the digestive system.



(Respiratory System)

(3) **Larynx:** The larynx or voice box is a short passageway that connects the laryngopharynx with the trachea. It lies in the midline of the neck anterior to the oesophagus. It is made up of nine cartilages. One of the cartilages, called epiglottis extends superiorly and forms a lid over trachea during swallowing so that liquid and food do not enter into wind pipe. Larynx acts as a

passageway and produces sound by modifying air vibrations.

4. Trachea: The trachea or wind pipe is a tubular passageway for air that is about 12 cm (5 in.) long and 2.5 cm (1 in.) in diameter. It is located anterior to the oesophagus and extends from the larynx to the superior border of the fifth thoracic vertebra (T5), where it divides into right and left primary bronchi.

6. **Bronchi:** At the superior border of the fifth thoracic vertebra, the trachea divides into a right primary bronchus which goes into the right lung and a left primary bronchus which goes into the left lung. On entering the lungs, the primary bronchi divides to form smaller bronchi, the secondary (lobar) bronchi, one for each lobe of the lung (The right lung has three lobes; the left lung has two.). The secondary bronchi continue to branch, forming still smaller bronchi, called tertiary bronchi, that divide into bronchioles. Bronchioles in turn branch repeat and the smallest ones branch into even smaller tubes called terminal bronchioles. This extensive branching from the trachea resembles and inverted tree and is commonly referred to as the bronchial tree. Terminal bronchioles subdivided into microscopic branches called respiratory bronchioles. Respiratory bronchioles in turn subdivided into several alveolar ducts. Around the alveolar ducts are numerous alveoli and alveolar sacs. On the outer surface of the alveoli, there is a network of blood capillaries called pulmonary capillaries. The exchange of O and CO between the air spaces in the lungs and the blood takes place by diffusion across the alveolar and capillary walls.

6. Lungs: The lungs are paired cone-shaped organs in the thoracic cavity. They are separated from each other by the heart and other structures in the mediastinum. Each lung is enclosed and protected by a double-layered membrane called the pleural membrane. Between the both layers of pleural membrane, a small space is present which is called the pleural cavity. The broad inferior portion of the lung is called the base and is present over the

diaphragm. The narrow superior portion of the lung is called apex. The medial surface of each lung contains a region called the hilum through which bronchi pulmonary blood vessels, lymphatic vessels, and nerves enter and exit. Medially the left lung also contains a concavity called the cardiac notch in which the heart lies. Each lung is divided further into lobes by the fissures. Right lung is divided into three lobes (Superior lobe, Middle lobe and Inferior lobe) by horizontal and oblique fissure. The left lung is divided into two lobes (Superior lobe and Inferior lobe) by oblique fissure. Each lobe is further divided into number of small lobules.

Mechanism of respiration: Respiration involves two stages:

1. **Inspiration:** It is an active process contraction of diaphragm which enlarge the chest cavity vertically. Intracoastal muscles contract produce elevation. This enlargement the chest cavity in all the other four sides.

2. **Expiration:** It is passive process. It is produced by the relaxation of diaphragm and intercoastal muscles. This process reduce in the size of chest cavity. So the pressure in the lungs increases which forces the air out.

CHAPTER-6

Urinary System

The urinary system is the main excretory system of the body. The urinary system consists of two kidneys, two ureters, one urinary bladder and one urethra. Kidneys filter blood plasma to remove waste materials, solutes and water. They return most of the water and solutes to the blood stream. The remaining water constitutes urine, which passes through the ureters and is stored in the urinary bladder until it is excreted from the body through the urethra.

Kidney: The kidneys are two reddish, bean-shaped, retroperitoneal organs located just above the waist. The kidneys are located between the levels of the last thoracic and third lumbar vertebrae. A typical adult kidney is 10-12 cm long, 5-7 cm wide and 3 cm. near the centre of the concave border, an indentation is present called the renal hilum. Through renal hilum, the ureter, blood vessels, lymphatic vessels and nerves enter and exit the kidney.

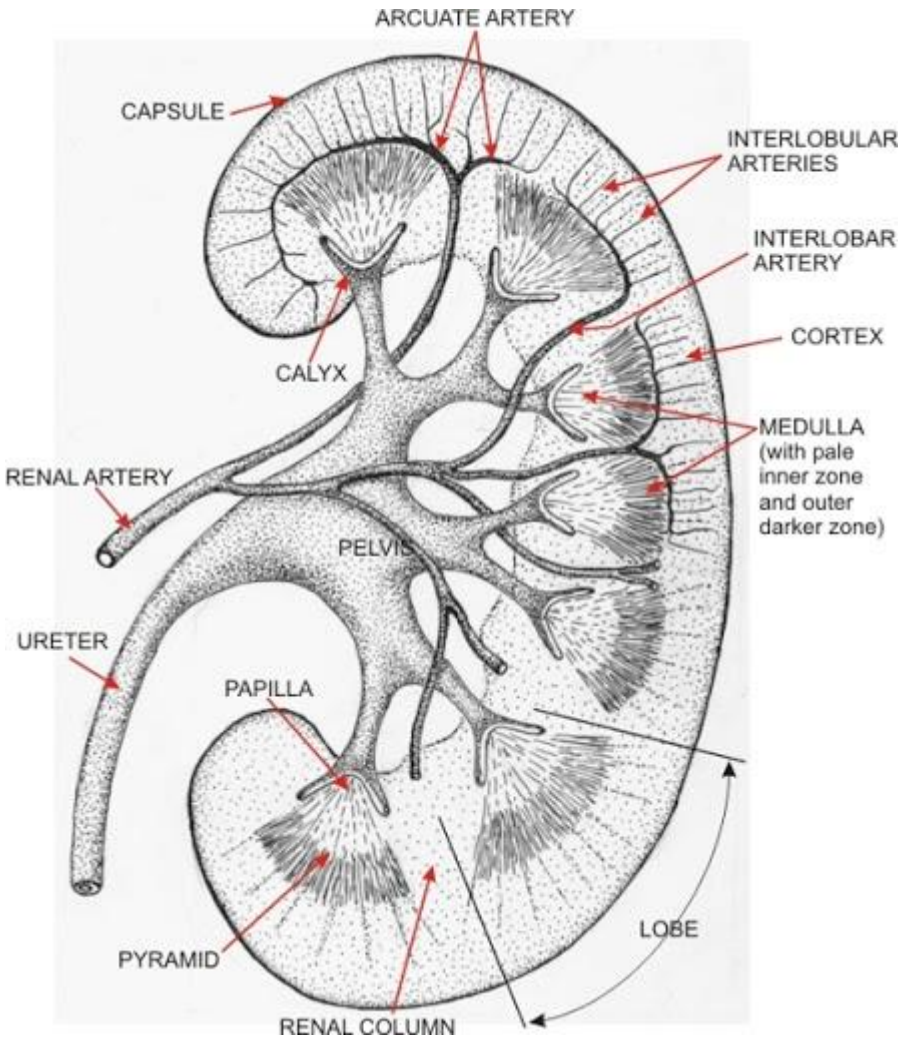
Three layers of tissue surround each kidney:
1. Renal capsule
2. Adipose capsule
3. Renal fascia

A kidney is divided into two distinct regions:

(a) Renal medulla: It is inner region of kidney which appears dark reddish-brown in colour. It consists of several cone-shaped regions called renal pyramids. The broad side of each pyramid (called base) faces the renal cortex and its apex (called renal papilla) points toward the renal hilum.

(b) Renal cortex: It is outer region which is light red in colour. The renal cortex is the smooth textured area extending from the renal capsule to the

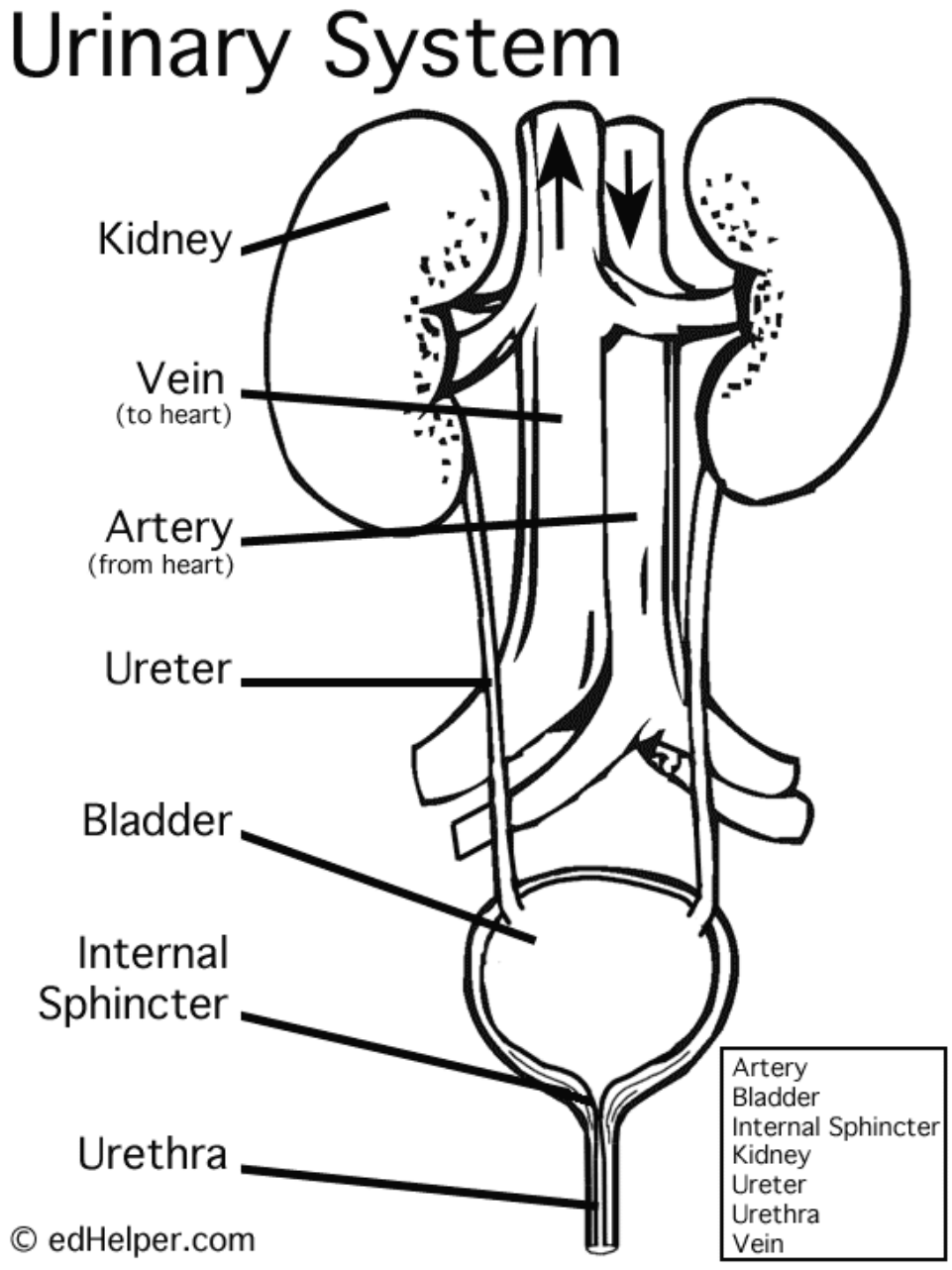
bases of the renal pyramids and into the spaces between them. It is further divided into an outer cortical zone and an inner Juxta medullary zone. The portions of the renal cortex present between renal pyramids are called renal columns.



Major **functions** performed by kidney are:
Regulation of ionic concentration, pH, pressure, osmolality and volume of blood. It also produce some hormones like renin, calcitriol, erythropoietin etc. and it also excrete waste of body and foreign particles.

Nephrons: Nephrons are the functional units of the kidneys. Each kidney contains approximately 1 million nephrons. Each nephron consists of two parts:

Renal corpuscle: This is the part where blood plasma is filtered. It is further divided into two components: The glomerulus which is a network of blood capillaries and the glomerular (Bowman's) capsule which is a double-walled epithelial cup that surrounds the glomerular capillaries.



Renal tubule: This is the part into which the filtered fluid passes. It has three main sections:

a. Proximal convoluted tubule
b. Loop of Henle (nephron loop)
c. Distal convoluted tubule.

Ureters: The ureters are two 25-30 cm long, thick walled, retroperitoneal narrow tubes that vary in diameter from 1 mm to 10 mm. They extend from kidney to urinary bladder. The ureters transport urine from the kidneys to the urinary bladder.

Urinary Bladder: The urinary bladder is a hollow, distensible muscular organ situated in the pelvic cavity posterior to the pubic symphysis. In males, it is directly anterior to the rectum and in females, it is anterior to the vagina and inferior to the uterus. Its shape depends upon quantity of urine present. It is collapsed when empty and pear shaped when filled. Urinary bladder capacity averages 700-800 ml. In the floor of the urinary bladder, a small triangular area is present called the trigone. The two posterior corners of the trigone contains the two ureteral openings and the opening into the urethra forms anterior corner.

Urethra: The urethra is a small tube leading from the internal urethral orifice in the floor of the urinary bladder to the exterior of the body. In both males and females, the urethra is the terminal portion of the urinary system. In females, the urethra lies directly posterior to the pubic symphysis and has length of 4 cm. The opening of the urethra to the exterior is called the external urethral orifice and is located above vaginal opening. In males, the urethra is 15-20 cm long. It extends from the internal urethral orifice to the exterior. The male urethra is subdivided into three anatomical regions:

(1) The prostatic urethra passes through the prostate.
(2) The membranous (intermediate) urethra passes through the deep muscles of the perineum.
(3) The spongy urethra, the longest portion, passes through the penis.

Formation of urine: The formation of urine by kidney involves three process.

1. Glomerular filtration
2. Tubular secretion
3. Tubular reabsorption

1. **Glomerular filtration:** Filtration of water, salts and other substances occurs in the glomerular. Glomerular filtration is the fluid that is formed after filtration.
2. **Tubular secretion:** It is an active process which occurs in the convoluted tubules.
3. **Tubular reabsorption:** nearly 99 percent of glomerular filtration is reabsorbed. Reabsorption of water occurs in the convoluted tubules and collecting tubule.

CHAPTER-7

MUSCULAR SYSTEM

The muscular system consists of a large number of muscles (more than 300). They bring about various movements in the body. Muscles are attached to bones, cartilages, ligaments, skin or other muscles by fibrous structure called tendons. Tendons is cord like structure. Tendons is a strong fibrous sheet. Muscles are richly by blood vessels and nerves. Each muscle has an origin and an insertion. Origin is the end which remains stationary when the muscle contracts. The end which moves is called insertion.

Functions of skeletal muscles:

- They give shape, form and appearance to the body.
- They protect the vital organs of the body.
- They keep the joints in proper position.
- They produce movements of the body.
- They help in venous return and lymphatic drainage.

❖ MUSCLES OF HEAD, FACE AND NECK:

They are classified into the following main groups:

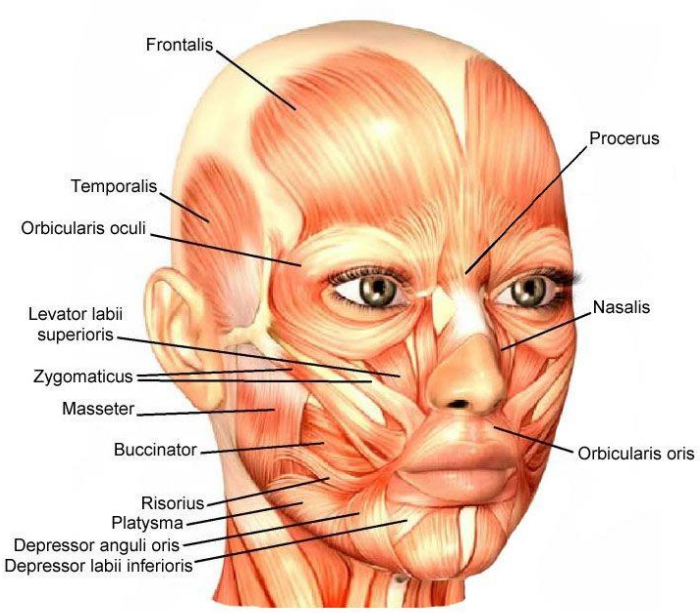
1. Muscles of scalp: Occipital frontalis is the muscle of the scalp. It consists of two parts:
   (i) Occipital belley which is situated under the skin of occipital bone.
   (ii) Frontal belley which is situated under the skin of frontal bone. Contraction of this muscle produces wrinkles in forehead and raising of eye brows.

2. Muscles of facial expression:

(i) Orbicularis oculi which are circular muscles around the eye. It produce closing of the eyes.
(ii) Orbicularis oris which is present in the lips.
(iii) Buccinator the muscle of cheek. It is used in chewing and sucking.

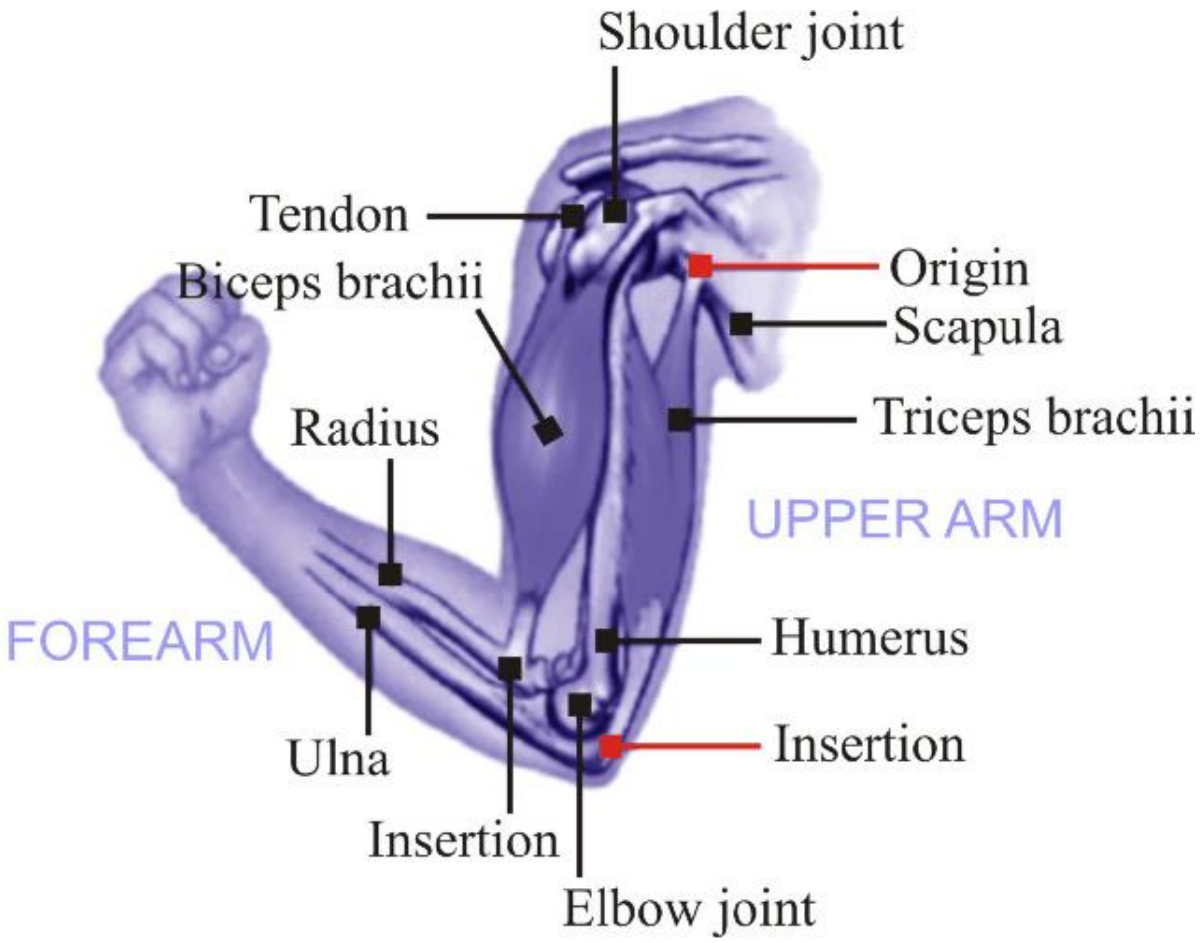
3. Muscles of mastication:
   (i) Temporal muscles arising from temporal fossa of skull.
   (ii) Masseter muscle arising from zygomatic arch of temporal bone.
   (iii) These muscles control the movements of lower Jaw. They are involved in chewing.

4. Muscles of neck: They attach the head to trunk: They are:
   (i) Platisma which extends from lower Jaw to deep fascia of chest. It depresses the jaw.
   (ii) Sterno-mastoid which extends from sternum and clavicle below to mastoid process of skull.
   (iii) Trapezius which arises from occipital bone and spine of all thoracic and cervical vertebrae. It is inserted into calvicle and also spine and acromion process of scapula.
   (iv) Scalene muscles which extend from cervical vertebrae to the first two ribs.



❖ MUSCLES OF SHOULDER GIRDLE:

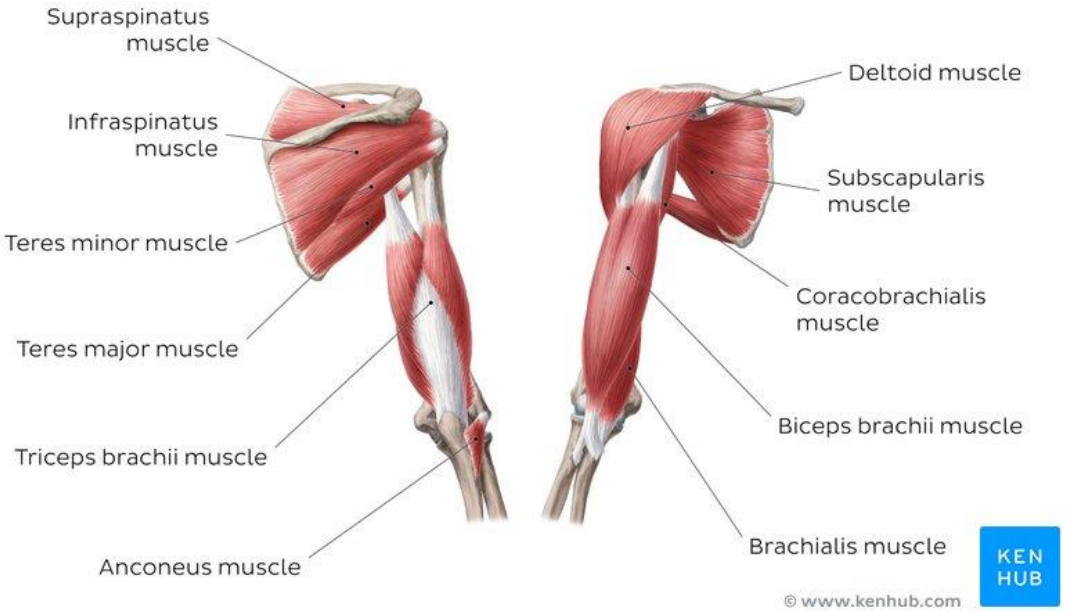
1. Deltoid muscle which is commonly used for intra muscular injections. It extends from scapula and clavicle to deltoid tuberosity of humerus.
2. Supraspinatus which extends from supraspinous fossa of scapula to the greater tuberosity of humerus.
3. Infraspinatus which extends from infraspinous fossa of scapula to the greater tuberosity of humerus.
4. Subscapularis muscle which lies in the subscapular fossa. It produces medial rotation of humerus.



❖ MUSCLES OF UPPER LIMB:

Muscles of arm:

1. Biceps containing two heads. The long head arises from the upper part of glenoid cavity. The short head arises from corcoid process. It is inserted into bicipital tubercle of radius. Its movements are:
   (i) Supination of forearm
   (ii) Flexion of elbow joint.
   (iii) Forward movement of shoulder joint.
2. Brachialis which lies deep to biceps. It runs from humerus to ulna. It assists biceps in flexing the elbow.
3. Triceps which contains three heads. It passes from scapula to olecrenon fossa of ulna. It extends the elbow joint.



Muscles of forearm:

They can be grouped into anterior muscles and posterior muscles.

Anterior muscles are:

1. Flexor digitorum sublimus: which is a superficial muscle. Its actions are flexion of i) fingers ii) wrist joint ii) elbow joint.
2. Flexor digitonum profundus: (deep muscle): Its actions are flexion of wrist and fingers.
3. Flexor carpi radialis and flexor carpi ulnaris: Which extend from humerus to the wrist bones. These muscles flex the elbow and wrist.
4. Prontor teres, pronator quadratus and brachio radialis: Which produce pronation and supination.

Posterior muscles are:

1. Extensor digitorum communis which extends from lateral epicondyle of humerus to elbow joint.
2. Extensor muscles of fingers which are attached to the back of the bases of terminal phalanges.
3. The eminence is a prominence Situated at the base of the thumb.

4. Hypothenar eminence is a prominence present at the base of little finger and ulnar side of hand.

❖ MUSCLES OF ABDOMEN

Anterior abdominal wall: It is composed of

1. Rectus abdominis which are two muscles lying one on each side. They are separated in the middle by linea alba which is a thin fibrous tissue. It arises from xiphoid process and adjacent costal cartilages. It is inserted into the upper border of pubis.
2. Extermal oblique which arises from the lower eight ribs. Its fibres run downwards and forwards.
3. Internal oblique which arises from iliac crest. Its fibres pass upwards and medially. It is inserted
   into a) rectus sheath b) lower ribs.
4. Transversus abdominis which runs horizontally across the anterior abdominal wall.

Posterior abdominal wall:

Iliacus which arises from iliac fossa. It is inserted into the lesser trochanter of femur.

1. Psoas which arises from lumbar vertebrae. It is inserted with iliacus into the lesser trochanter of femur.
2. Quadratus lumborum which extends from iliac crest to the 12th rib.

❖ MUSCLES OF LOWER LIMB

MUSCLES OF BUTTOCK:

They arise from the outer surface of ilium and inserted into greater trochanter of femur.

MUSCLES OF THE FOOT:

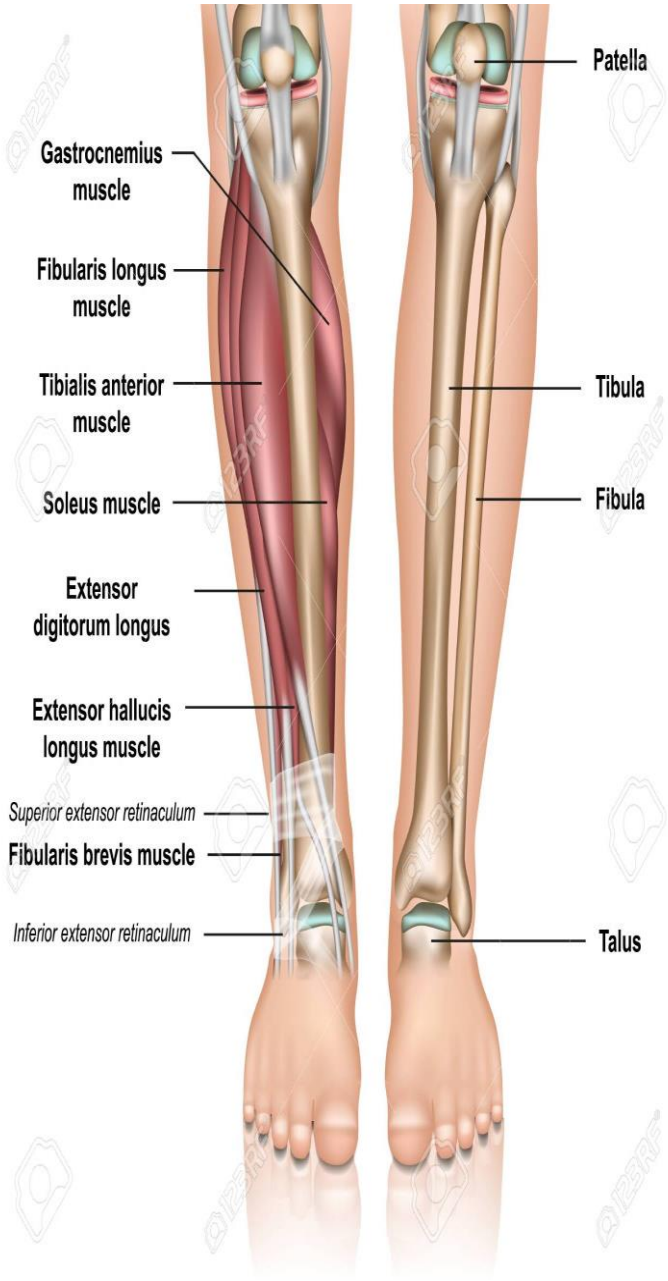
Some leg muscles concerned with the movements of toes are helped by foot muscles. Flexor digitorum brevis is the flexor of big toe. Flexor hallucis brevis is the flexor of other toes. There are a few short muscles of the sole which are attached to big toe. Interosseus and lumbrical muscles also exist for the toes.

➢ DISEASES OF MUSCLES

1. Myopathy: It is a term used to describe any disease or disorder of skeletal muscle.it occurs due to some inherent error of muscle metabolism. The main symptom is an increasing muscle weakness.

2. Myositis: It is the term used to indicate inflammation or disease of skeletal muscle. It may be acute or chronic. Myositis ossificans is a chronic type. The muscle fibres are first replaced by fibrous tissue and later by bone.

3. Cramp: It is an involuntary, painful, localised contraction of muscle. It occurs in normal people after vigorous exercise or at night.



➢ THE PHYSIOLOGY OF MUSCLE

Muscular tissues can be classified into:

1. Smooth, non-striated or involuntary muscles- Smooth muscles are present in the walls of digestive organs (e.g. oesophagus, stomach), urinary bladder, ureter etc. Their movements cannot be controlled by will.
2. Cardiac muscle or myocardium - Cardiac muscle occurs in the heart.

3. Skeletal, striated or voluntary muscles – skeletal muscles is attached to the skeleton. The movement of skeletal muscles can be controlled by will.

PHYSIOLOGY OF MUSCLE CONTRACTION

1. During normal resting state of a muscle, the muscle membrane is in a polarised state.
   (a)The interior of the muscle cell is negatively charged. It contains a large concentration of K^+.
   (b) The exterior of the muscle cell is positively charged. It contains a large concentration of Na+ ions.

2. Nerve is stimulated, acetylcholine is liberated at the neuromuscalar junction.

3. Acetylcholine increases the permeability of the muscle membrane. So Na^+ ions enter into the cell and K^+ ions come out of the cell. Change in electrical charge. Both the interior and exterior of the muscle cell become positively charged. Now the membrane becomes depolarnsed. This depolarisation produces a muscle contraction.

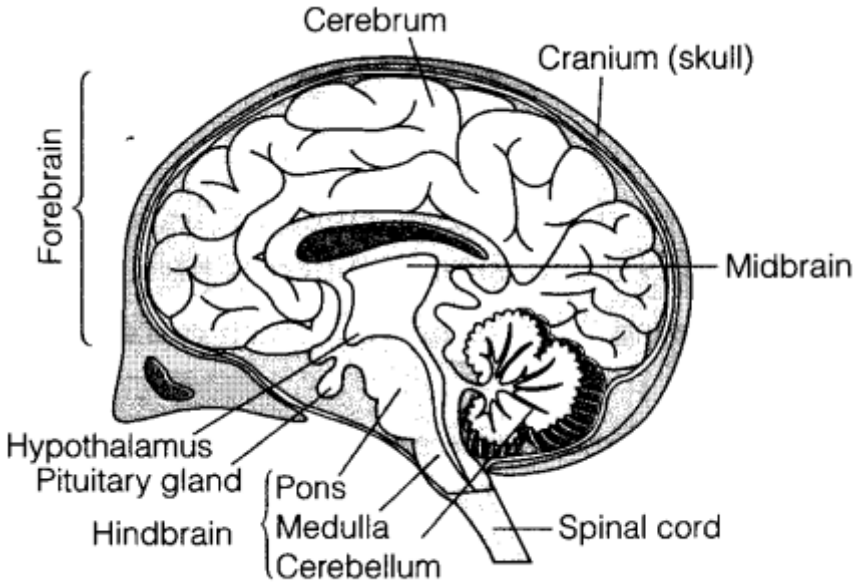
4. When the muscle contraction is over, acetvlcholine is destroyed by the enzyme acetyl cholinesterase.

5. Now, K^+ ions move into the cell and Na+ ion ions out of the cell. This produces repolarization of the muscle membrane.

CHAPTER-8
Central Nervous System

The Central Nervous System (CNS) consists of the brain and spinal cord. The CNS processes many different kinds of incoming sensory information. It is also the source of thoughts, emotions, memories and other numerous activities.

Brain: Brain is that portion of the central nervous system which is present within the cranium. The brain is the control center for receiving sensations, correlating them, storing information, making decisions and taking actions. It also is the center for the intellect, emotions, memory and behavior. Different parts of the brain also work together to accomplish certain shared functions.



Human brain

Cranium and Meninges: The cranium (skull bones) and the cranial meninges surround and protect the brain. The meninges consists of three layers of connective tissue that cover the spinal cord and brain. The spinal meninges surround the spinal cord and are continuous with the cranial meninges, which encircle the brain. The three layers are: Dura matter, Arachnoid matter and Pia matter.

Cerebrospinal fluid (CSF): It is a clear, colorless liquid that protects the brain and spinal cord from chemical and physical injuries. It also carries oxygen, glucose, and other needed chemicals from the blood to neurons and neuroglia. CSF continuously circulates through cavities (called ventricles) in the brain and spinal cord, and around the brain and spinal cord in the subarachnoid space (between the arachnoid matter and pia matter). CSF contains glucose, proteins, lactic acid, urea, cations (Na, K^{+}, Ca^{2++}, and $Mg2^{++}$), anions (Cl^{-} and HCO^{3-}) and some white blood cells.

Parts of Brain:

1. **Brain stem**: The brain stem is present between the spinal cord and the diencephalon. It consists of three structures: (a) medulla oblongata, (b) pons and midbrain. Extending through the brain stem is the reticular formation, a net like region of interspersed grey and white matter.

2. **Cerebellum**: The cerebellum is present posterior to the medulla and pons and inferior to the posterior portion of the cerebrum. A deep groove known as the transverse fissure, separate the cerebellum from the cerebrum. In superior or inferior views, the shape of the cerebellum resembles a butterfly. Each hemisphere is further divided into anterior, posterior lobes. The anterior lobe and posterior lobe controls subconscious aspects of skeletal muscle movements. It is made up of grey matter. Deep to the grey matter, region of white matter is present which is called arbor vitae (tree of life). Even deeper within the white matter cerebellar nuclei are present that contains axons carrying impulses from the cerebellum to other brain centers.

3. **The diencephalon**: It is middle part of brain and extends from the brain stem to the cerebrum. It includes the thalamus, hypothalamus and epithalamiums.

4. **Thalamus**: The thalamus consists of paired oval masses of grey matter organized into nuclei with interspersed tracts of white matter. A bridge of

grey matter called the intermediate mass joins the right and left halves of the thalamus.

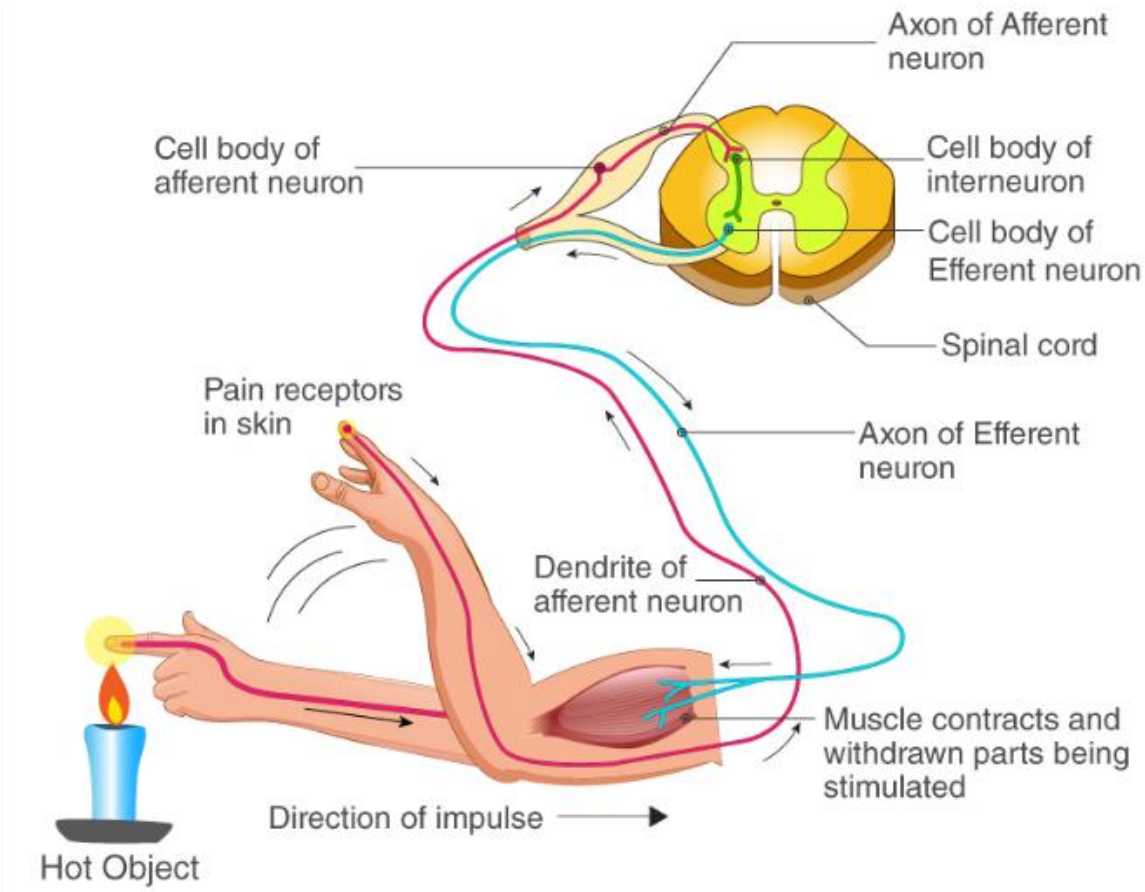
5. **Hypothalamus**: The epithalamus is a small region superior and posterior to the thalamus. It consists of the pineal gland and nuclei and pineal gland secretes the hormone melatonin. Melatonin contributes to the setting of the body's biological clock, which is controlled by the hypothalamus.

Reflex Action: Reflex is an involuntary and sudden response to stimuli. It happens to be an integral component of the famed survival instinct. Most of the common reflexes are a response to all the well trained, accumulated knowledge of caution that internalized. It could be anything and ranges from the reflex action of abruptly withdrawing the hand as it comes in contact with an extremely cold or hot object. This action is termed as the reflex action. It has a subtle relation to instinct.

The Action of Neuron: Two neurons dominate the pathway, afferent nerves (receptor) and the efferent nerves (effector).

- Firstly, it begins with receptor detecting the stimulus or a sudden change in the environment, where the instinct again has a role to play. The stimulus is received from a sensory organ.
- Then, the sensory neuron sends a signal to the relay neuron.
- This is followed with the relay neuron sending the signal to the motor neuron.
- Further, the motor neuron sends a signal to the effector.
- The effector produces an instantaneous response, for example, pulling away of the hand or a knee-jerk reaction.

From the above explanations, it can be clearly summarized that the moment the afferent neuron receives a signal from the sensory organ; it transmits the impulse via a dorsal nerve root into the **Central Nervous System.** The efferent neuron then carries the signal from the CNS to the effector. The stimulus thus forms a reflex arc.


Axon of Afferent neuron
Cell body of afferent neuron
Cell body of interneuron
Cell body of Efferent neuron
Spinal cord
Pain receptors in skin
Axon of Efferent neuron
Dendrite of afferent neuron
Muscle contracts and withdrawn parts being stimulated
Direction of impulse
Hot Object

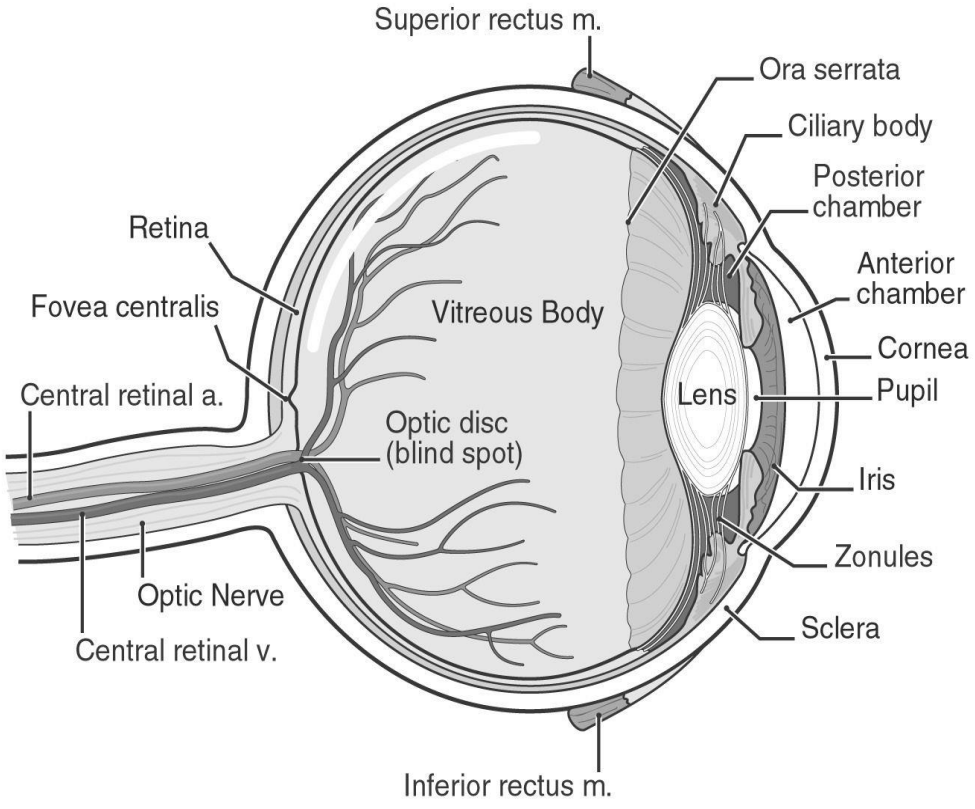
(Reflex Arc)

CHAPTER-9
Sensory Organs

The eye and sense of sight

Sight or vision is extremely important to human survival. More than half of the sensory receptors in the human body are located in the eyes, and a large part of the cerebral cortex is devoted to process visual information. In this section, can examine electromagnetic radiation, the accessory structures of the eye, the eyeball itself, the formation of visual images, the physiology of vision, and the visual pathway from the eye to the brain.

Eye: The adult eyeball measures about 2.5 cm (1 in.) in diameter. Of its total surface area, only the anterior one-sixth is exposed; the remainder is recessed and protected by the orbit, into which it fits. Anatomically, the wall of the eyeball consists of three layers: (1) fibrous tunic, (2) vascular tunic, and (3) retina.



1) **Fibrous tunic:** The fibrous tunic is the superficial layer of the eyeball and consists of the anterior cornea and posterior sclera. The cornea is a transparent coat that covers the coloured iris. Because it is curved, the cornea helps to focus light onto the retina. The sclera is the "white" part of the eye. The sclera covers the entire eyeball except the cornea, it gives shape to the eyeball, makes it more rigid and protects its inner parts.

2) **Vascular tunic:** The vascular tunic or uvea is the middle layer of the eyeball. It is composed of three parts: choroid, ciliary body and iris.

(a) The highly vascularized choroid, which is the posterior portion of the vascular tunic, lines most of the internal surface of the sclera. The choroid also contains melanocytes that produce the pigment melanin, which causes this layer to appear dark brown in colour. Melanin in the choroid absorb stray light rays, which prevents reflection and scattering of light within the eyeball. As a result, the image cast on the retina by the cornea and lens remains sharp and clear.

(b) In the anterior portion of the vascular tunic, the choroid becomes the ciliary body. It extends from the oraserrata, the jagged anterior margin of the retina, to a point just posterior to the junction of the sclera and cornea. Like the choroid, the ciliary body appears dark brown in colour because it contains melanin producing melanocytes. In addition, the ciliary body consists of ciliary processes and ciliary muscle.

(c) The iris, the coloured portion of the eyeball, is shaped like a flattened donut. It is suspended between the cornea and the lens and is attached at its outer margin to the ciliary processes. It consists of melanocytes and circular and radial smooth muscle fibres. The amount of melanin in the iris determines the eye colour. A principal function of the iris is to regulate the amount of light entering the eyeball through the pupil, the hole in the center of the iris.

3) The third and inner layer of the eyeball, the retina, lines the posterior three- quarters of the eyeball and is the beginning of the visual pathway. The pigmented layer is a sheet of melanin-containing epithelial cells located between the choroid and the neural part of the retina. The melanin in the pigmented layer of the retina, like in the choroid, also helps to absorb stray light rays. The neural (sensory) layer of the retina is a multi-layered. Three distinct layers of retinal neurons the photoreceptor layer, the bipolar cell layer and the ganglion cell layer. Photoreceptors are specialized cells that begin the process by which light rays are ultimately converted to nerve impulses. There are two types of photoreceptors: rods and cones. Each retina has about 6 million cones and 120 million rods. Rods allow us to see in dim light, such as moonlight. Brighter lights stimulate cones, which produce colour vision. Three types of cones are present in the retina:
(1) Blue cones, which are sensitive to blue light
(2) Green cones, which are sensitive to green light.
(3) Red cones, which are sensitive to red light.
From photoreceptors, information flows through the outer synaptic layer to bipolar cells and then from bipolar cells through the inner synaptic layer to ganglion cells. The axons of ganglion cells extend posteriorly to the optic disc and exit the eyeball as the optic nerve.

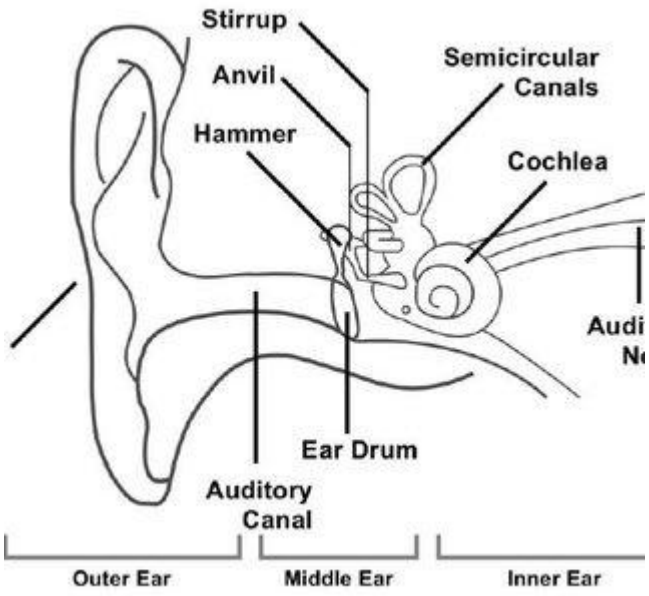
Lens: Behind the pupil and iris, within the cavity of the eyeball, is the lens. Within the cells of the lens, proteins called crystalline, arranged like the layers of an onion, naked-up the refractive media of the lens, which normally is perfectly transparent and blood vessels. It is enclosed by a clear connective tissue capsule and held in position by encircling zonular fibres, which attach to the ciliary processes. The lens to focus images on the retina to facilitate clear vision.

Ear and Sense of Hearing

The ear is an engineering marvel because its sensory receptors can transduce sound vibrations with amplitudes as small as the diameter of an atom of gold (0.3 nm) into electrical signals 1000 times faster than

photoreceptors can respond to light. Besides receptors for sound waves, the ear also contains receptors for equilibrium.

Ear: The ear is divided into three main regions: (1) the external ear, which collects sound waves and channels them inward; (2) the middle ear, which conveys sound vibrations to the oval window; and (3) the internal ear, which houses the receptors for hearing and equilibrium.



(1) **The external (outer) ear** consists of the auricle, external auditory canal and ear drum. The auricle (pinna) is a flap of elastic cartilage shaped like the flared end of a trumpet and covered by skin. The rim of the auricle is the helix; the inferior portion is the lobule. The external auditory canal is a curved tube about 2.5 cm long that lies in the temporal bone and leads to the ear drum. The tympanic membrane or ear drum is a thin, semi-transparent partition between the external auditory canal and middle ear. Near the exterior opening, the external auditory canal contains a few hairs and specialized sweat glands called ceruminous glands that secrete ear wax or cerumen.

(2) The middle ear is a small, air-filled cavity in the petrous portion of the temporal bone that is lined by epithelium. It is separated from the

external ear by the tympanic membrane and from the internal ear by a thin bony partition that contains two small membrane covered openings: the oval window and the round window. Extending across the middle ear and attached to it by ligaments are the three smallest bones in the body. The incus is the middle bone in the series, articulates with the head of the stapes. The base or foot plate of the stapes fits into the oval window. Directly below the oval window is another opening, the round window, which is enclosed by a membrane, called the secondary tympanic membrane. The anterior wall of the middle ear contains an opening that leads directly into the auditory (pharyngotympanic) tube is commonly known as the Eustachian tube.

(3) The internal (inner) ear is also called the labyrinth because of its complicate series of canals. Structurally, it consists of two main divisions: an outer bony labyrinth that encloses an inner membranous labyrinth. The bony labyrinth is a series of cavities in the petrous portion of the temporal bone divided into three areas:

(i) The vestibule, both of which contains receptors for equilibrium.
(ii) The cochlea, which contains receptors for hearing. The semicircular canals.
(iii)The bony labyrinth is lined with periosteum and contains perilymph. This fluid, which is chemically similar to cerebro spinal fluid, surrounds the membranous labyrinth. Membranous lahyrinth is a series of epithelial sacs and tubes inside the bony labyrinth that have the same general form as the bony labyrinth. The epithelial membranous labyrinth contains endolymph.

CHAPTER-10

Digestive system

The digestive system is a system of body which breakdown food into forms that can be absorbed and used by body cells. It also absorbs water vitamins and minerals, and eliminates wastes from the body. It breakdowns the larger molecules present in food into molecules that are small enough to enter body cells by a process known as Digestion. The organs which are involved in the breakdown of food are collectively called the Digestive system. The digestive system is a tubular system which extends from the mouth to the anus.

Mouth and Oral Cavity:

(a) **Lips:** They are partly surrounded by skin and consists of striated muscles and mucous glands. The main function of lips is to provide a gateway to the digestive system.

(b) **Teeth:** There are total 32 teeth in a normal adult. They are further classified as: incisors (2), canine (1), premolar (2) and molars (3) on the each side of jaw, and same number of teeth are there in lower jaw. Major functions of teeth are cutting, gripping and tearing, crushing and grinding.

(c) **Salivary glands**: Salivary glands are present in our mouth which secretes saliva to moisten, lubricate and digest the food, we engulf. They are of three types: parotid, sublingual, and submandibular gland.

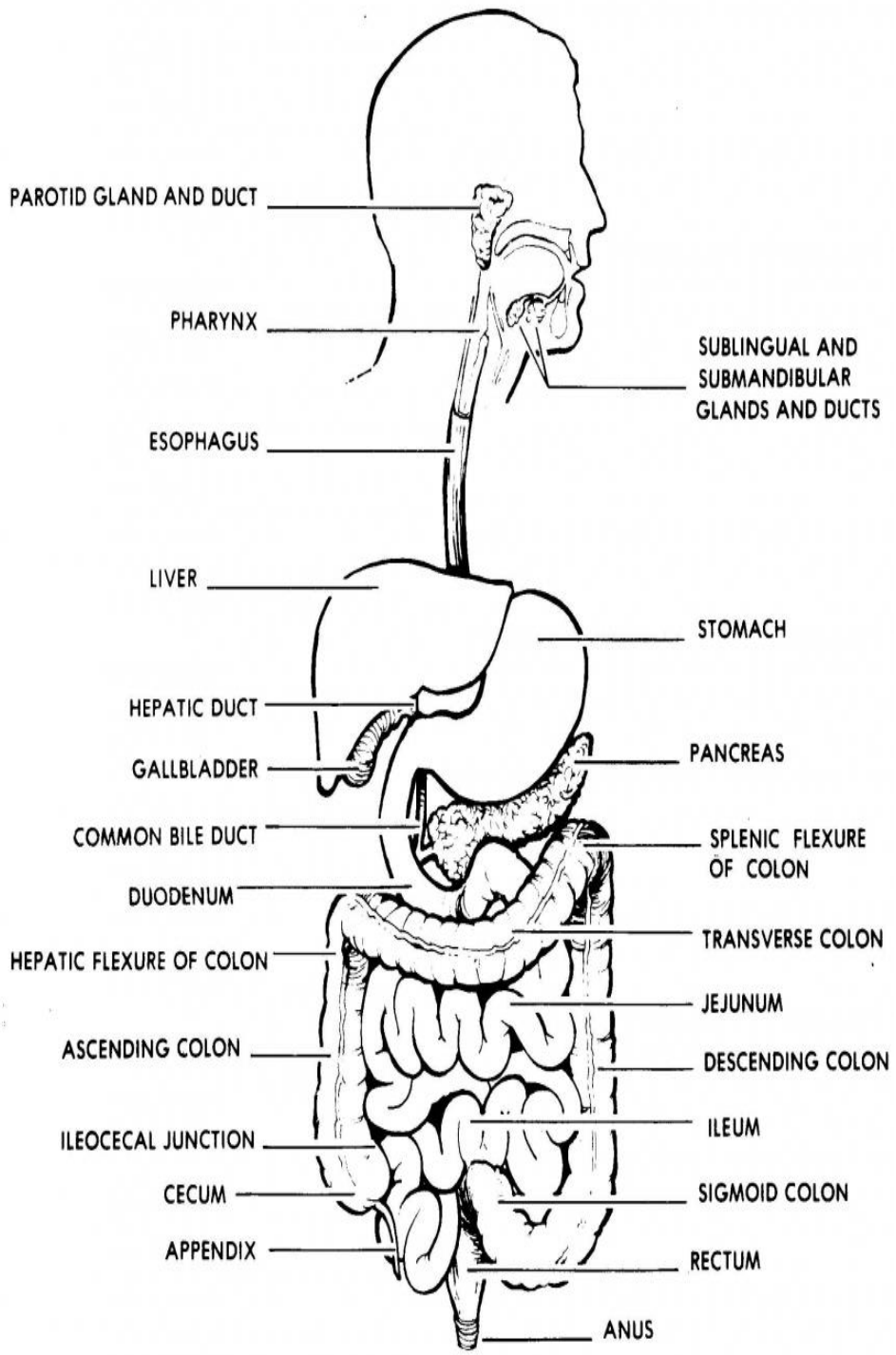


Figure 1-1. The digestive system.

(d) **Tongue**: Tongue is an accessory digestive organ composed of skeletal

muscle covered with mucous membrane. It helps to taste the food, swallow food and to speak. Tongue and its associated muscles form floor of mouth.

(e) **Pharynx:** It is the junction between the oral and nasal cavity and inferiorly, it is attached to larynx and esophagus. The larynx gets it connected with wind pipe and oesophagus provides its attachment with digestive system. The major functions of pharynx are to transport air to the respiratory system and food to the digestive system.

(f) **Oesophagus:** It is about 25 cm long tube, which extend from the pharynx to the stomach and lies in the thoracic cavity. The major function performed by oesophagus is transport of food from pharynx to stomach with the help of a process called peristalsis.

(g) **Stomach:** Stomach is a shaped enlargement of GI Tract which lies directly inferior to diaphragm. It connects oesophagus to duodenum (first part of small intestine). Stomach serves as mixing chamber and holding reservoir for food. When food is ingested, stomach pushes a small quantity of food into duodenum periodically. As the size of stomach can vary, it can store large amount of food. It is divided into four parts: Cardiac, Fundus, Body and Pylorus. The pylorus communicates with the duodenum of the small intestine via smooth muscle sphincter called the pyloric sphincter. In stomach, semi-solid bolus is converted into liquid, digestion of starch continues, digestion of triglycerides and protein starts, and absorption of several substances takes place.

(h) **Small Intestine**: Small intestine starts from pyloric sphincter of stomach, coils through central and inferior part of abdominal cavity and ends at large intestine. It has major role in digestion and absorption of nutrients.

Anatomy: It has three major parts:

1. **Duodenum**: This is first part of small intestine. It starts from pyloric

sphincter, extends up to 25 cm and merges into jejunum. It secretes proteolytic enzymes (trypsinogen, chymotrypsin, procarboxy peptidase, nuclease, and collagenas to digest proteins. It also secretes amylase which digest carbohydrates and lipase for digestion of lipids.

(n) Jejunum: It is middle part and extends up to ileum. It secretes intestinal juice which is consists of various proteolytic enzymes like pepsin, arginase, nuclease etc., carbohydrate splitting enzymes like amylase, maltase, lactase etc., and lipid digesting enzymes like lipase.

(i) Ileum: It is last part of small intestine and ends at ileocecal junction of large intestine. It involves in absorption of digested food material.

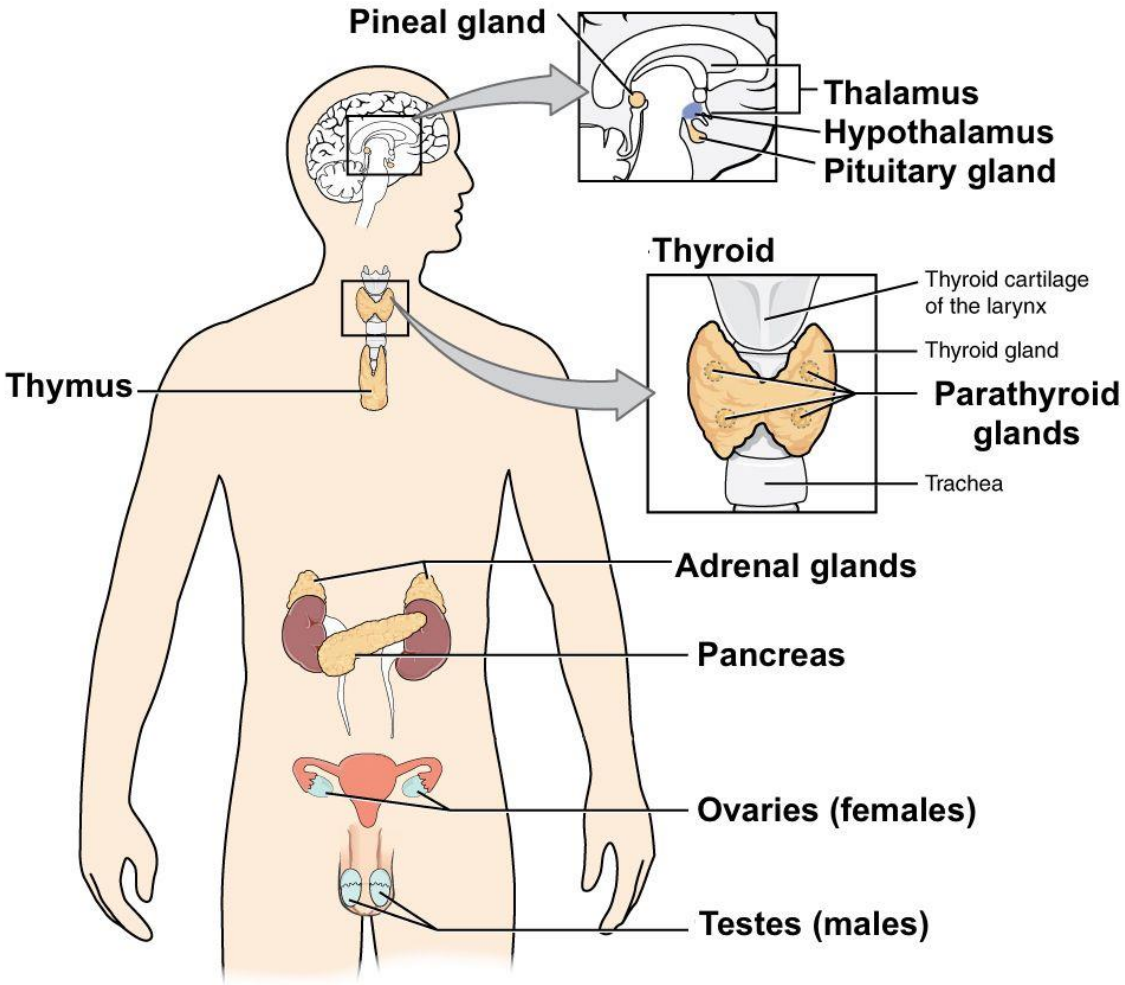
(j) Large intestine: The large intestine is the terminal portion of the GI tract. The overall functions of the large intestine are the completion of absorption, the production of certain vitamins, the formation of feces and the expulsion of feces from the body.
Large intestine is about 1.5 m long and extends from ileum to anus. The joining of small and large intestine occurs at ileocecal sphincter which controls movement of material from small intestine to large intestine. Large intestine consists of four major regions cecum, colon, rectum and anal canal.

Metabolism: It is defined as biochemistry changes which occur in the body in order to maintain its vital functions.
Metabolism is classified into two types.

1) Anabolism: it is a constructive process. It leads to building up of fresh tissues from nutritive of food.
2) Catabolism: It is a destructive process. It leads to break down of worn out tissue and their removal.

CHAPTER-11
Endocrine system

The endocrine system consist of ductless glands which secrets hormones. The hormones are directly poured into circulation without help of duct.



Endocrine glands are ductless glands of the endocrine system that secrete their products, hormones, directly into the blood. The major glands of the endocrine system include the pineal gland, pituitary gland, pancreas,

ovaries, testes, thyroid gland, parathyroid gland, hypothalamus and adrenal glands.

Endocrine System Functions

- Makes hormones that control your moods, growth and development, metabolism, organs, and reproduction.
- Controls the release of hormones.
- Sends those hormones in bloodstream that can travel to other body parts.

Parts of the Endocrine System

Many glands make up the endocrine system. The hypothalamus, pituitary gland, and pineal gland are in your brain. The thyroid and parathyroid glands are in neck. The thymus is between your lungs, the adrenals are on top of your kidneys, and the pancreas is behind stomach. Ovaries (woman) or testes (man) are in pelvic region.

- **Hypothalamus.** This organ connects your endocrine system with your nervous system. Its main function is that pituitary gland to start or stop making hormones.
- **Pituitary gland.** It is also known as master gland. It uses information it gets from brain to other glands in human body. It makes many important hormones, including growth hormone; prolactin, which helps breastfeeding moms make milk and luteinizing hormone, which manages estrogen in women and testosterone in men.
- **Pineal gland.** It makes a chemical called melatonin that helps body get ready to go to sleep.
- **Thyroid gland.** This gland makes thyroid hormone, which controls your metabolism. If this gland doesn't make enough called hypothyroidism and gain weight. If it makes too much (hyperthyroidism), everything speeds up and lose weight without trying.

- **Parathyroid.** This is a set of four small glands behind thyroid. They play a role in bone health. The glands control levels of calcium and phosphorus.
- **Thymus.** This gland makes white blood cells called T-lymphocytes that fight infection and are crucial as a child's immune system develops. The thymus starts to shrink after puberty.
- **Adrenals.** Best known for making the "fight or flight" hormone adrenaline (also called epinephrine), these two glands also make hormones called corticosteroids. They affect your metabolism and sexual function, among other things.
- **Pancreas.** This organ is part of both digestive and endocrine systems. It makes digestive enzymes that break down food. It also makes the hormones insulin and glucagon. These ensure you have the right amount of sugar in your bloodstream and your cells.
- Type 1 diabetes, blood sugar levels can get dangerously high. In type 2 diabetes, the pancreas usually makes some insulin but not enough.
- **Ovaries.** In women, these organs make estrogen and progesterone. These hormones help develop breasts at puberty, regulate the menstrual cycle, and support a pregnancy.
- **Testes.** In men, the testes make testosterone. It helps them grow facial and body hair at puberty. It also tells the penis to grow larger and plays a role in making sperm.

Endocrine System Disorders

- **Acromegaly.** Sometimes the pituitary gland makes too much growth hormone and your bones get bigger. It usually affects your hands, feet, and face. It usually starts in middle age.
- **Adrenal insufficiency.** When you have this, your adrenal glands don't make enough of certain hormones, like cortisol, which controls stress.
- **Cushing's disease.** In this, your body makes too much cortisol. You could gain weight, get stretch marks, bruise easily at first, then get weakened muscles and bones and possibly develop a hump on your upper back.

- **Hyperthyroidism.** This is when your thyroid gland makes more hormones than your body needs. You might hear it called overactive thyroid. It makes your system run fast and you might feel nervous, lose weight, and have a rapid heartbeat or trouble sleeping.
- **Hypothyroidism.** When your body doesn't make enough thyroid hormone, your system slows down. You might feel tired, gain weight, have a slow heartbeat, and get joint and muscle pains.
- **Hypopituitarism.** Sometimes your pituitary gland doesn't make enough of certain hormones and your adrenal and thyroid glands can't work right.
- **Multiple endocrine neoplasia.** This is a group of disorders that affect your endocrine system. It causes tumors on at least two endocrine glands or in other organs and tissues.
- **Polycystic ovary syndrome.** An imbalance of reproductive hormones can cause your ovaries to either not make an egg or not release it during ovulation. This can throw off your periods, cause acne, and make hair to grow on your face or chin.
- **Precocious puberty** . When glands that control reproduction don't work properly, some kids start puberty abnormally early around 8 in girls and 9 in boys.

CHAPTER-12
Reproductive System

Male reproductive system: The organs of the male reproductive system is to perform the following functions:

- To produce, maintain, and transport sperm and protective fluid (semen).
- To discharge sperm within the female reproductive tract during intercourse.
- To produce and secrete male sex hormones responsible for maintaining the male reproductive system

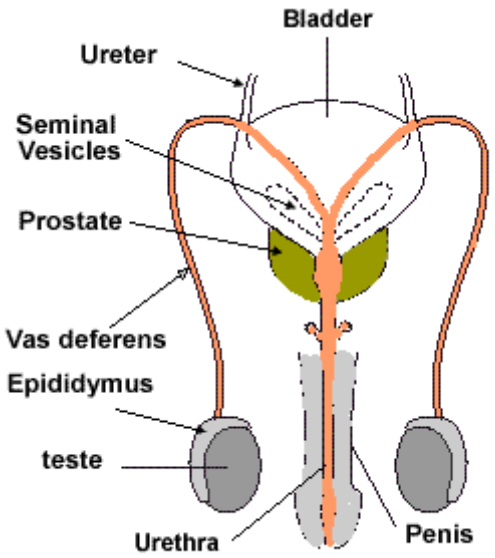
Male reproductive system is located outside of the body. These external structures include the penis, scrotum, and testicles.

- **Penis:** This is the male organ used in sexual intercourse. It has three parts: the root, which attaches to the wall of the abdomen; the body, or shaft; and the glans, which is the cone-shaped part at the end of the penis. The glans, also called the head of the penis, is covered with a loose layer of skin called foreskin. This skin is sometimes removed in a procedure called circumcision. The opening of the urethra, the tube that transports semen and urine, is at the tip of the penis. The glans of the penis also contains a number of sensitive nerve endings.

  The body of the penis is cylindrical in shape and consists of three circular shaped chambers. These chambers are made up of special, sponge-like tissue. This tissue contains thousands of large spaces that fill with blood when the man is sexually aroused. As the penis fills with blood, it becomes rigid and erect, which allows for penetration

during sexual intercourse. The skin of the penis is loose and elastic to accommodate changes in penis size during an erection.

Semen, which contains sperm (reproductive cells), is expelled (ejaculated) through the end of the penis when the man reaches sexual climax (orgasm). When the penis is erect, the flow of urine is blocked from the urethra, allowing only semen to be ejaculated at orgasm.

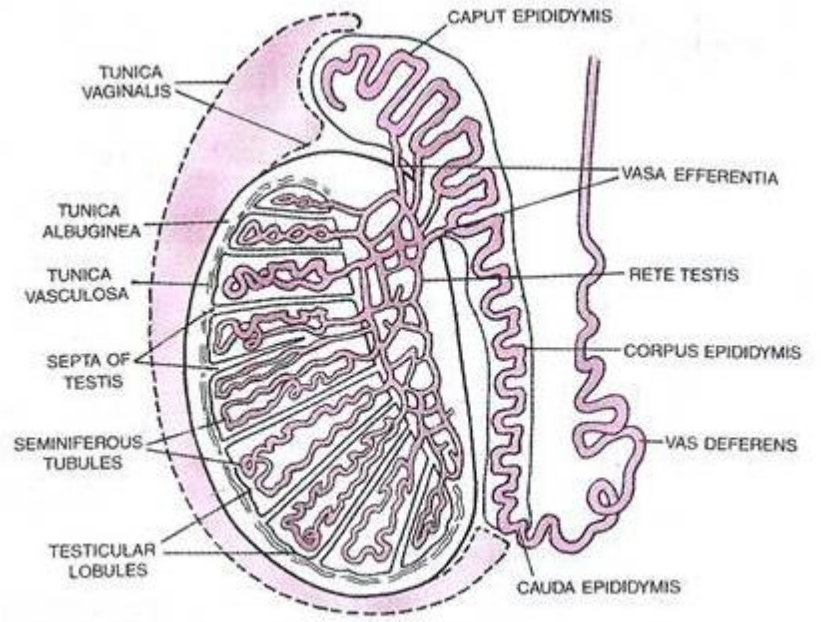


(Male Reproductive System)

- **Scrotum:** This is the loose pouch-like sac of skin that hangs behind and below the penis. It contains the testicles (also called testes), as well as many nerves and blood vessels. The scrotum acts as a "climate control system" for the testes. For normal sperm development, the testes must be at a temperature slightly cooler than body temperature. Special muscles in the wall of the scrotum allow it to contract and relax, moving the testicles closer to the body for warmth or farther away from the body to cool the temperature.

- **Testicles (testes):** These are oval organs about the size of large olives that lie in the scrotum, secured at either end by a structure called the spermatic cord. Most men have two testes. The testes are responsible for making testosterone, the primary male sex hormone, and for generating sperm. Within the testes are coiled masses of tubes called

seminiferous tubules. These tubes are responsible for producing sperm cells.



L.S. of mammalian testis and different ducts.

The internal organs of the male reproductive system, also called accessory organs, include the following:

- **Epididymis:** The epididymis is a long, coiled tube that rests on the backside of each testicle. It transports and stores sperm cells that are produced in the testes. It also is the job of the epididymis to bring the sperm to maturity, since the sperm that emerge from the testes are immature and incapable of fertilization. During sexual arousal, contractions force the sperm into the vas deferens.
- **Vas deferens:** The vas deferens is a long, muscular tube that travels from the epididymis into the pelvic cavity, to just behind the bladder. The vas deferens transports mature sperm to the urethra, the tube that carries urine or sperm to outside of the body, in preparation for ejaculation.

- **Ejaculatory ducts:** These are formed by the fusion of the vas deferens and the seminal vesicles (see below). The ejaculatory ducts empty into the urethra.
- **Urethra:** The urethra is the tube that carries urine from the bladder to outside of the body. In males, it has the additional function of ejaculating semen when the man reaches orgasm. When the penis is erect during sex, the flow of urine is blocked from the urethra, allowing only semen to be ejaculated at orgasm.
- **Seminal vesicles:** The seminal vesicles are sac-like pouches that attach to the vas deferens near the base of the bladder. The seminal vesicles produce a sugar-rich fluid (fructose) that provides sperm with a source of energy to help them move. The fluid of the seminal vesicles makes up most of the volume of a man's ejaculatory fluid, or ejaculate.
- **Prostate gland:** The prostate gland is a walnut-sized structure that is located below the urinary bladder in front of the rectum. The prostate gland contributes additional fluid to the ejaculate. Prostate fluids also help to nourish the sperm. The urethra, which carries the ejaculate to be expelled during orgasm, runs through the center of the prostate gland.
- **Bulbourethral glands:** Also called Cowper's glands, these are pea-sized structures located on the sides of the urethra just below the prostate gland. These glands produce a clear, slippery fluid that empties directly into the urethra. This fluid serves to lubricate the urethra and to neutralize any acidity that may be present due to residual drops of urine in the urethra.

The entire male reproductive system is dependent on hormones, which are chemicals that regulate the activity of many different types of cells or organs. The primary hormones involved in the male reproductive system are follicle-stimulating hormone, luteinizing hormone, and testosterone.

Female Reproductive system: The ovary is the organ that produces ova (ovum) or eggs. The two ovaries present in each female are held in place by the following ligaments:

- The broad ligament is a section of the peritoneum that ovaries, uterus, ovarian ligament, and suspensory ligament. It includes both the mesovarium and mesometrium. The mesovarium is a fold of peritoneum that holds the ovary in place.
- The suspensory ligament anchors the upper region of the ovary to the pelvic wall. Attached to this ligament are blood vessels and nerves, which enter the ovary at the hilum.
- The ovarian ligament anchors the lower end of the ovary to the uterus.

The following two tissues cover the outside of the ovary:

- The germinal epithelium is an outer layer of simple epithelium.
- The tunica albuginea is a fibrous layer inside the germinal epithelium. The inside of the ovary or stromal that is divided into two indistinct regions, the outer cortex and the inner medulla. Embedded in the cortex are saclike bodies called ovarian follicles. Each ovarian follicle consists of an immature oocyte (egg) surrounded by one or more layers of cells that nourish the oocyte as it matures. The surrounding cells are called follicular cells, if they make up a single layer or granulosa cells.
  - The uterine tubes (oviducts) transport the secondary oocytes away from the ovary and toward the uterus (the ovaries consist of primary oocytes, which develop into secondary oocytes). The following regions characterize each of the two uterine tubes (one for each ovary):
  - The infundibulum is a funnel-shaped region of the uterine tube that bears fingerlike projections called fimbriae. Pulsating cilia on the fimbriae draw the secondary oocyte into the uterine tube.
  - The ampulla is the widest and longest region of the uterine tube. Fertilization of the oocyte by a sperm usually occurs here.
  - The isthmus is a narrow region of the uterine tube whose terminus enters the uterus.

The wall of the uterine tube consists of the following three layers:

- The serosa, a serous membrane, lines the outside of the uterine tube.
- The middle muscular is consists of two layers of smooth muscle that generate peristaltic contractions that help propel the oocyte forward.
- The inner mucosa consists of ciliated columnar epithelial cells that help propel the oocyte forward, and secretory cells that lubricate the tube and nourish the oocyte.
- The uterus (womb) is a hollow organ within which fetal development occurs. The uterus is characterized by the following regions:
  - The fundus is the upper region where the uterine ducts join the uterus.
  - The body is the major, central portion of the uterus.
  - The isthmus is the lower, narrow portion of the uterus.
  - The cervix is a narrow region at the bottom of the uterus that leads to the vagina. The inside of the cervix, or cervical canal, opens to the uterus above through the internal and the vagina below through the external. Cervical mucus secreted by the mucosa layer of the cervical canal serves to protect against bacteria entering the uterus from the vagina. If an oocyte is available for fertilization, the mucus becomes thin and slightly alkaline. These are attributes that promote the passage of sperm. At other times, the mucus is viscous and impedes the passage of sperm.

The uterus is held in place by the following ligaments:

- Broad ligaments
- Uterosacral ligaments
- Round ligaments
- Cardinal (lateral cervical) ligaments

The wall of the uterus consists of the following three layers:

- The perimetrium is a serous membrane that lines the outside of the uterus.
- The myometrium consists of several layers of smooth muscle and imparts the bulk of the uterine wall. Contractions of these muscles during childbirth help force the fetus out of the uterus.
- The endometrium is the highly vascularized mucosa that lines the inside of the uterus. If an oocyte has been fertilized by a sperm, the zygote implants on this tissue. The endometrium itself consists of two layers. The stratum functionalis (functional layer) is the innermost layer (facing the uterine lumen) and is shed during menstruation. The outermost stratum basal is is permanent and generates each new stratum functionalis.

- The vagina (birth canal) serves both as the passageway for a newborn infant and as a depository for semen during sexual intercourse. The upper region of the vagina surrounds the protruding cervix, creating a recess called the fornix. The lower region of the vagina opens to the outside at the vaginal orifice. A thin membrane called the hymen may cover the orifice. The vaginal wall consists of the following layers:

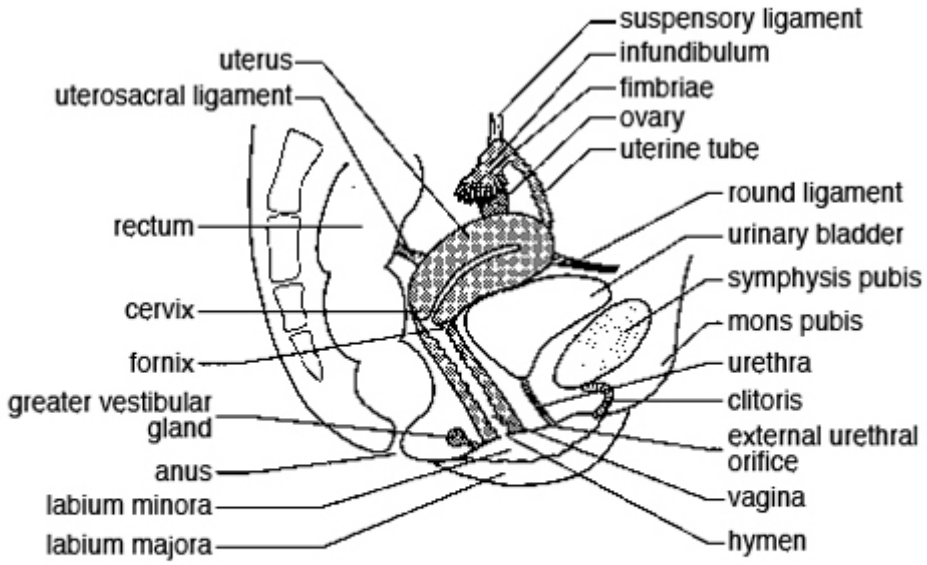
  - The outer adventitia holds the vagina in position.

  - The middle muscular is consists of two layers of smooth muscle that permit expansion of the vagina during childbirth and when the penis is inserted.

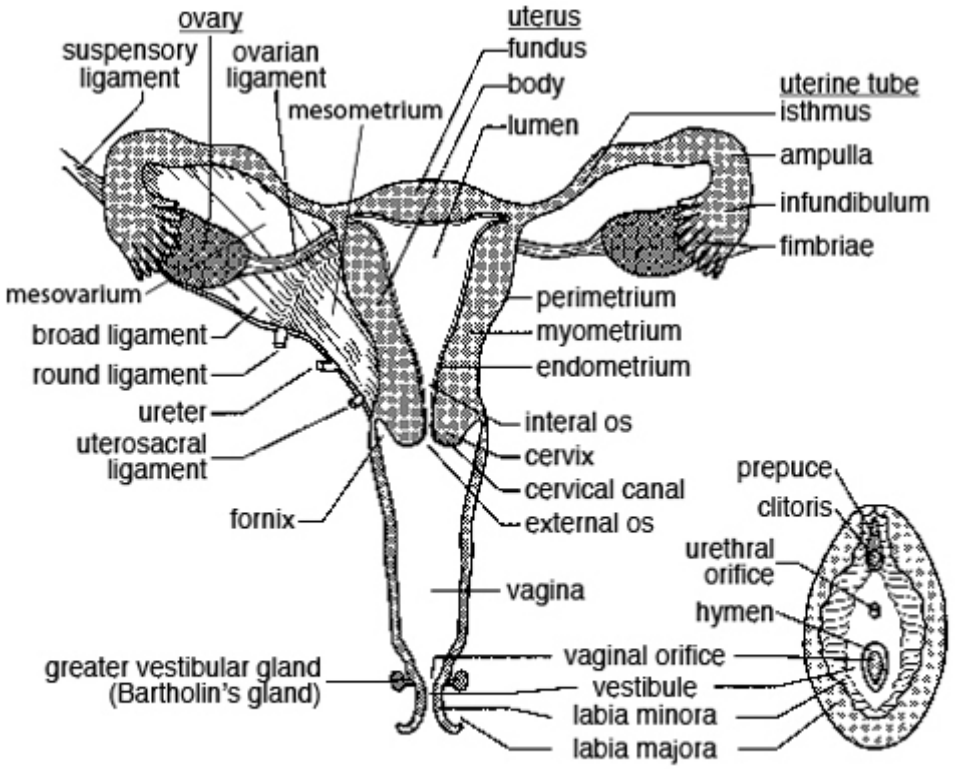
  - The inner mucosa has no glands. But bacterial action on glycogen stored in these cells produces an acid solution that lubricates the vagina and protects it against microbial infection. The acidic environment is also inhospitable to sperm. The mucosa bears transverse ridges called rugae.

- The vulvae (pudendum) make up the external genitalia. The following structures are included:
  - The mons pubis is a region of adipose tissue above the vagina that is covered with hair.

- The labia major are two folds of adipose tissue that border each side of the vagina. Hair and sebaceous and sudoriferous glands are present. Developmentally, the labia major are analogous to the male scrotum.
- The labia minora are smaller folds of skin that lie inside the labia majora.
- The vestibule is the recess formed by the labia minora. It encloses the vaginal orifice, the urethral opening, and ducts from the greater vestibular glands whose mucus secretions lubricate the vestibule.
- The clitoris is a small mass of erectile and nervous tissue located above the vestibule. Extensions of the labia minora join to form the prepuce of the clitoris, a fold of skin covering the clitoris.



Sagittal View of Female Reproductive System



Posterlar View of Female Reproductive System

Inferlor View of Vulva

Mammary glands:

The mammary glands are sudoriferous (sweat) glands specialized for the production of milk. The milk-producing secretory cells form walls of

bulb-shaped chambers called alveoli that join together with ducts, in grapelike fashion, to form clusters called lobules. Numerous lobules assemble to form a lobe. Each breast contains a single mammary gland consisting of 15 to 20 of these lobes. Lactiferous ducts leading away from the lobes widen into lactiferous sinuses that serve as temporary reservoirs for milk. The ducts narrow again as they lead through a protruding nipple. The nipple, whose texture is made coarse by the presence of sebaceous glands, is surrounded by a ring of pigmented skin called the areola. Contraction of myoepithelial cells surrounding the alveoli force milk toward the nipples.

The breasts begin to enlarge in females at the onset of puberty. Proliferating adipose (fat) tissue expands the breast, while suspensory ligaments attached to the underlying fascia provide support. In nonpregnant females (and in males), the glands and ducts are not fully developed.

During pregnancy, estrogen and progesterone stimulate extensive development of the mammary glands and associated ducts. After childbirth, various hormones, especially prolactin from the anterior pituitary, initiate lactation, or milk production. When neurons are stimulated by the sucking of an infant, nerve impulses activate the posterior pituitary to secrete oxytocin, which in turn stimulates contraction of the myoepithelial cells surrounding the alveoli. Milk is then forced toward the nipple (the letdown reflex).

Oogenesis:

Oogenesis consists of the meiotic cell divisions that lead to the production of ova (eggs) in females. The process begins during fetal development with the fetal ovary. Diploid cells called oogonia divide by mitosis and differentiate to produce primary oocytes (still diploid with 46 chromosomes). Each primary oocyte is encircled by one or more layers of cells. The oocyte and encircling cells together are called an ovarian follicle. The primary oocytes (within their follicles) begin meiosis, but division progresses only to prophase I. They remain at this stage until puberty.

The following stages in the development of an ovarian follicle are observed:

1. The primordial follicle, the initial fetal state of the follicle, encircles the oocyte with a single layer of cells, called follicular cells.
2. The primary follicle, the next stage of follicular development, possesses two or more layers of encircling cells, now called granulosa cells.
3. The secondary follicle is distinguished by the presence of the antrum, a fluid-filled, central cavity.
4. In a mature (vesicular, or Graafian) follicle, the primary oocyte has completed meiosis I. It is the stage of follicular development that precedes ejection of the oocyte from the ovary (ovulation). The following features are observed:
5. The zona pellucida, a clear layer of glycoprotein, surrounds the oocyte.
6. The corona radiata, a ring of granulosa cells, encircles the zona pellucida.
7. Several layers of cells (theca cells) surround the granulosa cells.
8. The corpus luteum is the remains of the follicle following ovulation. It remains functional, producing estrogen, progesterone, and inhibin, until it finally degenerates.

During each menstrual cycle, one primary oocyte, enclosed in its follicle, resumes meiosis I to produce two daughter cells (each haploid with 23 chromosomes). One daughter cell, the secondary oocyte, contains most of the cytoplasm, ensuring that adequate amounts of stored food, as well as mitochondria, ribosomes, and other cytoplasmic organelles, will be available for the developing embryo. The other daughter cell, a first polar body, is much smaller and contains little cytoplasm and few if any organelles. The secondary oocyte then begins meiosis II (equatorial division) but again stops at prophase (this time prophase II). The first polar body may also begin meiosis II, but it will eventually degenerate.

Ovulation occurs when a secondary oocyte and its first polar body, surrounded by the zona pellucida and corona radiata, rupture from their

mature follicle and are expelled from the surface of the ovary. The oocyte is then swept up into the uterine (fallopian) tube and advances toward the uterus. If a sperm cell penetrates the corona radiata and zona pellucida and enters the secondary oocytes, meiosis II resumes in the secondary oocytes, producing an ovum and a second polar body. If a first polar body is present, it too, may resume meiosis II, producing daughter polar bodies. Fertilization occurs when the nuclei of the sperm cell and ovum unite, forming a zygote (fertilized egg). Any polar bodies present ultimately degenerate.

Hormonal regulation of oogenesis and the menstrual cycle

The human female reproductive cycle is characterized by events in the ovary (ovarian cycle) and the uterus (menstrual cycle). The purpose of these cycles is to produce an egg and to prepare the uterus for the implantation of the egg, should it become fertilized. The ovarian cycle consists of three phases:

1. The follicular phase describes the development of the follicle, the meiotic stages of division leading to the formation of the secondary oocytes, and the secretion of estrogen from the follicle.
2. Ovulation, occurring at midcycle, is the ejection of the egg from the ovary.
3. The luteal phase describes the secretion of estrogen and progesterone from the corps luteum (previously the follicle) after ovulation.

The menstrual (uterine) cycle consists of three phases:

1. The proliferative phase describes the thickening of the endometrium of the uterus, replacing tissues that were lost during the previous menstrual cycle.
2. The secretory phase follows ovulation and describes further thickening and vascularization of the endometrium in preparation for the implantation of a fertilized egg.

3. The menstrual phase (menstruation, menses) describes the shedding of the endometrium when implantation does not occur.

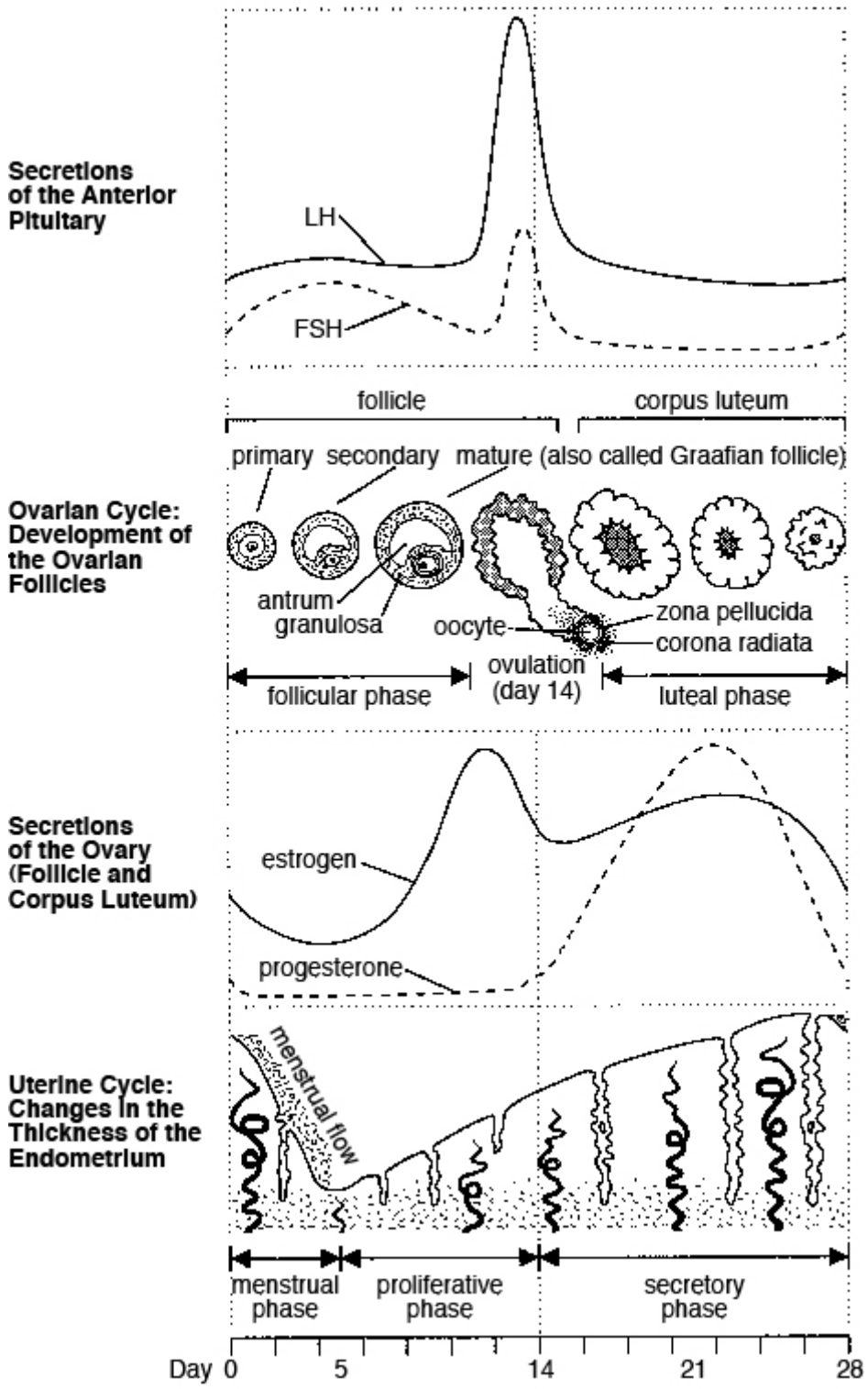
The activities of the ovary and the uterus are coordinated by negative- and positive-feedback responses involving gonadotropin releasing hormone (GnRH) from the hypothalamus, follicle stimulating hormone (FSH) and luteinizing hormone (LH) from the anterior pituitary, and the hormones estrogen and progesterone from the follicle and corpus luteum. A description of the events follows):

1. *The hypothalamus and anterior pituitary initiate the reproductive cycle:* The hypothalamus monitors the levels of estrogen and progesterone in the blood. In a negative-feedback fashion, low levels of these hormones stimulate the hypothalamus to secrete GnRH, which in turn stimulates the anterior pituitary to secrete FSH and LH.
2. *The follicle develops:* FSH stimulates the development of the follicle from primary through mature stages.
3. *The follicle secretes estrogen:* LH stimulates the cells of the theca interna and the granulosa cells of the follicle to secrete estrogen. Inhibin is also secreted by the granulosa cells.
4. *Ovulation occurs:* Positive feedback from rising levels of estrogen stimulate the anterior pituitary (through GnRH from the hypothalamus) to produce a sudden midcycle surge of LH. This high level of LH stimulates meiosis in the primary oocyte to progress toward prophase II and triggers ovulation.
5. *The corpus luteum secretes estrogen and progesterone:* After ovulation, the follicle, now transformed into the corpus luteum, continues to develop under the influence of LH and secretes both estrogen and progesterone.
6. *The endometrium thickens:* Estrogen and progesterone stimulate the development of the endometrium, the inside lining of the uterus. It thickens with nutrient-rich tissue and blood vessels in preparation for the implantation of a fertilized egg.

7. *The hypothalamus and anterior pituitary terminate the reproductive cycle:* Negative feedback from the high levels of estrogen and progesterone cause the anterior pituitary (through the hypothalamus) to abate the production of FSH and LH. Inhibin also suppresses production of FSH and LH.
8. *The endometrium either disintegrates or is maintained, depending on whether implantation of the fertilized egg occurs, as follows:*

    - Implantation does not occur: In the absence of FSH and LH, the corpus luteum deteriorates. As a result, estrogen and progesterone production stops. Without estrogen and progesterone, growth of the endometrium is no longer supported, and it disintegrates, sloughing off during menstruation.
    - Implantation occurs: The implanted embryo secretes human chorionic gonadotropin (hCG) to sustain the corpus luteum. The corpus luteum continues to produce estrogen and progesterone, maintaining the endometrium. (Pregnancy tests check for the presence of hCG in the urine.)

In addition to influencing the reproductive cycle, estrogen stimulates the development of secondary sex characteristics in females. These include the distribution of adipose tissue (to the breasts, hips, and mons pubis), bone development leading to a broadening of the pelvis, changes in voice quality, and growth of various body hair.


Secretions of the Anterior Pituitary
LH
FSH
follicle
corpus luteum
primary
secondary
mature (also called Graafian follicle)
Ovarian Cycle: Development of the Ovarian Follicles
antrum
granulosa
oocyte
zona pellucida
corona radiata
ovulation (day 14)
follicular phase
luteal phase
Secretions of the Ovary (Follicle and Corpus Luteum)
estrogen
progesterone
Uterine Cycle: Changes in the Thickness of the Endometrium
menstrual flow
menstrual phase
proliferative phase
secretory phase
Day 0
5
14
21
28