HUMAN ANATOMY AND PHYSIOLOGY

Human body operates as a single entity but made up of a number of inter-dependent working systems. Each system is associated with a specific function that is normally essential for well-being of the individual. Survival is ensured by integrated working of the body systems. If any system fails, the consequences can extend to others and reduce the ability of normal body function. The body consists of trillions of atoms in specific arrangements (the chemicals) and thousands of chemical reactions proceeding in a very orderly manner. The human body is therefore complex in the structure and function. This course emphasizes the knowledge of fundamental structure (anatomy) and functioning (physiology) of human body.

ANATOMY

Anatomy is a branch of biology, which means study of the structure of a living body which includes Size, shape, composition, and perhaps even coloration. The term anatomy comes from the Greek words meaning to cut (tomy) apart (ana). It is sub divided into macroscopic anatomy (Gross anatomy) and microscopic anatomy.

1. Gross anatomy (macroscopic anatomy) – the study of large, easily observable structures (by naked eye), such as the heart or bone.
2. Microscopic anatomy– the study of very small structures, where a magnifying lens or microscope is needed. It includes cytology (study of cells) and histology (study of tissues).

PHYSIOLOGY

The study of physiology refers to the overlap of many functions of the various systems of the human body. It is attained by communication of systems with each other by both electrical and chemical ways. Functions of the systems to maintain internal body environment Integrated can be termed as Physiology.

STRUCTURAL ORGANISATION

The human body has the most complex structural organization where cell is the basic unit for its functioning. The structural complexity of human body is exhibited by 6 levels:

1. **Chemical level-** It is the simplest level of structural ladder. At this level atoms combine to form molecules such as water, sugar, & proteins. Inorganic and organic chemicals make up the human body. Inorganic chemicals are usually simple molecules made of one or two elements other than carbon (with a few exceptions).Examples of inorganic chemicals are water (H2O), oxygen (O2) and minerals such as iron (Fe) in hemoglobin, sodium (Na) in the salt sodium chloride that makes tears salty, and calcium (Ca) in the calcium salts that make bones hard. Organic chemicals are often very complex and always contain the elements carbon and hydrogen. In the category of organic chemicals are carbohydrates, fats, proteins, and nucleic acids.
2. **Cellular level** – Organelles are the structural and functional components of a cells which are formed by the combination of different molecules. Cell is the smallest and independent unit of the human body.
3. **Tissue level -** Group of similar cells that have a common structure and function form a tissue. Epithelial tissue, connective tissue, muscle tissue and nerve tissue are the four basic types of tissues in human body.
4. **Organ level -** An organ is a structure composed of two or more tissue types that performs a specific function. Ex: The kidneys contain several kinds of epithelial or surface tissues, for their work of absorption.
5. **Organ System level-** Organ Systems a group of organs that work together to accomplish a common purpose (each organ has its own job to do). Ex: The urinary system, which consists

of the kidneys, ureters, urinary bladder, and urethra. These organs all contribute to the formation and elimination of urine.

6. **Organismal level-** It represents the highest level of structural organization (total of 11 organ systems). All of the organ systems make up an individual person, and all of them function together; that is, they are interdependent. Ex: The respiratory system obtains oxygen from the atmosphere, and the circulatory system distributes the oxygen.

OVER VIEW OF ORGAN SYSTEMS

Human anatomy is studied regionally, systemically and scientifically.

1. Regionally: Studying anatomy by bodily regions.

The human body is divided into several major regions, viz., head, trunk, upper limbs and lower limbs. The head consists of skull (contains the brain) and face (includes eyes, nose, ears, mouth, fore head cheeks and

chin).The neck supports the head and is attached to the trunk. The trunk consists of the chest and abdomen and pelvis. Upper limbs consists of shoulders, armpits, arms, fore arms, wrist and hand. The lower limbs consists of buttocks, thigh, legs and feet. The groin is the area on front surface of the body marked by a crease on each side where the trunk joins the legs.

1. **Systemically: Studying anatomy by specific systems.**

1. Integumentary System 2. Muscular System 3. Skeletal System 4.Nervous System
5. Endocrine System 6. Circulatory System 7. Lymphatic System 8. Respiratory System
9. Digestive System 10. Urinary System 11.Reproductive System

2. **Scientifically: Studying anatomy by specific sciences**

Scientific study includes different anatomical sciences such as Osteology (Bones system and Skeleton), Myology (Muscles, Fascic) and Neurology (Nervous system) etc.

3. **Body Planes:**

An imaginary flat surface which is used define a particular area of anatomy is termed as body plane.

a) **Sagittal Plane (Vertical or antero-posterior plane)**: It divides the body into right and left halves.
   i. Mid -sagittal plane: Passes through the mid line and divides the body into equal right and left halves.
   ii. Para-sagittal plane: is off to one side and divides the body into unequal right and left halves.
b) **Coronal Plane or Frontal Plane:** divides body into anterior and posterior parts
c) **Axial Plane or Transverse Plane**: is the horizontal section which divides the body into upper (superior) and lower parts (inferior).

Body Cavities: The cavities or spaces of the body contain the internal organs or viscera. The two main cavities are the dorsal and ventral cavities. Dorsal cavities include cranium (skull bones brain and its covering) and vertebral regions (spinal cord and beginning of spinal nerves).Ventral cavity includes thoracic (chest), abdominal and pelvic region.

CELL and Cell Organelles:

There are only two main **types** of cells: **prokaryotic and eukaryotic**. **Prokaryotic** cells lack a nucleus and other membrane-bound organelles. **Eukaryotic** cells have a nucleus and other membrane-bound organelles. The components of a cell and the arrangements of these individual parts within the cell form the **cellular organization**. Cells, the basic unit of life, are of 2 types: **prokaryotic cells** (bacteria) and **eukaryotic cells** (fungi, algae, protozoa, plants, and animals). A eukaryotic cell has a true membrane-bound nucleus and has other membranous organelles that allow for compartmentalization of functions. The cells are larger than Prokaryotic cells and have 'True Nucleus', membrane bound organelles and road shaped chromosomes.

A cell is the structural and functional unit of the living body. Each cell is formed by a cell body which has the nucleus and the cytoplasm as the parts and Cell membrane which covers the cell body. The cell contains various structural components to allow it to maintain life which are known as **organelles**. All the organelles are suspended within a gelatinous matrix, the **cytoplasm,** which is contained within the cell membrane. Red blood cells are an exception because they have no nuclei when mature.

CYTOPLASM

It is the simplest structure of the cell. Organelle free sap is called cytosol. Cytoplasm contains two zones:

1. Endoplasm: fluid like and interposed between the nucleus and ectoplasm.
2. Ectoplasm: lies just beneath the cell membrane and consists of a network of microfilaments. Organelles of different structure and function are present in the cytoplasm.

CELL ORGANELLES

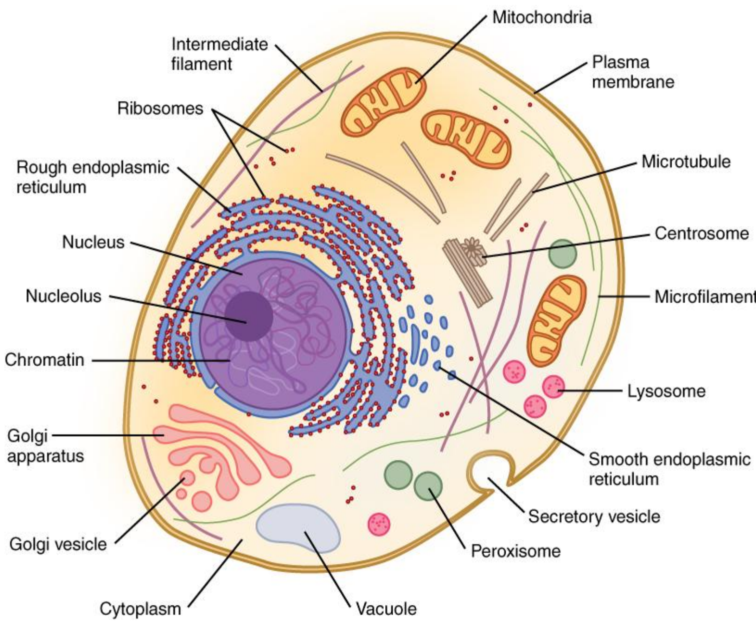
The main organelles are as follows:

- nucleus
- endoplasmic reticulum
- Golgi apparatus
- lysosomes
- mitochondria
- peroxisomes
- Centrosome and centrioles
- microfilaments and microtubules

NUCLEUS

The cell nucleus is an important organelle found in eukaryotic cells. Its roles include regulating all activity such as cellular metabolism and growth in addition to storing and maintaining the cell's DNA for transcription and replication. The cell nucleus comprises numerous components that help it to fulfil its functions. These include the following:

1. Nuclear Membrane (nuclear envelope) - The nucleus is characterized by having a nuclear membrane around it to separate the nuclear contents from the cytoplasm. The membrane comprises two phospholipid bilayers, the space between which is called the perinuclear space. The outer membrane is continuous with that of the rough endoplasmic reticulum and is similarly studded with ribosomes. The outer and inner membrane of the nucleus is also joined at nuclear pores which regulate the passage of materials between the nucleus and cytoplasm.
2. Nucleoplasm – It is gel like ground substance of the nucleus and contains the genetic material.
3. Nucleolus – It synthesizes Ribo nucleic acid (RNA) from five different pairs of chromosomes. RNA condenses to form ribosomes. Ribosomes are sites for protein synthesis and they may me free floating in cytoplasm or attached to endoplasmic reticulam.



4. Genetic material- it is built from thin fibers of Deoxy ribo Nucleic Acid (DNA) and proteins called histones, which are coiled together forming a fine network of thread called chromatin. During cell division chromatin replicates, coils and condenses forming chromosomes which have functional sub units called genes.

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Functions of nucleus:

1. Nucleus controls all activities of the cell.
2. Cell division is controlled by genes.
3. The genetic information provided by DNA is responsible for the functioning of enzymes.
4. Hereditary information is stored in genes and transformed from one generation to another.

RIBOSOMES: Small non-membrane bound organelles and contain two sub units.They are sites of protein synthesis hence termed as protein factory of the cell. They are generated in the nucleolus and either free floating or attached to the Endoplasmic Reticulum**.**

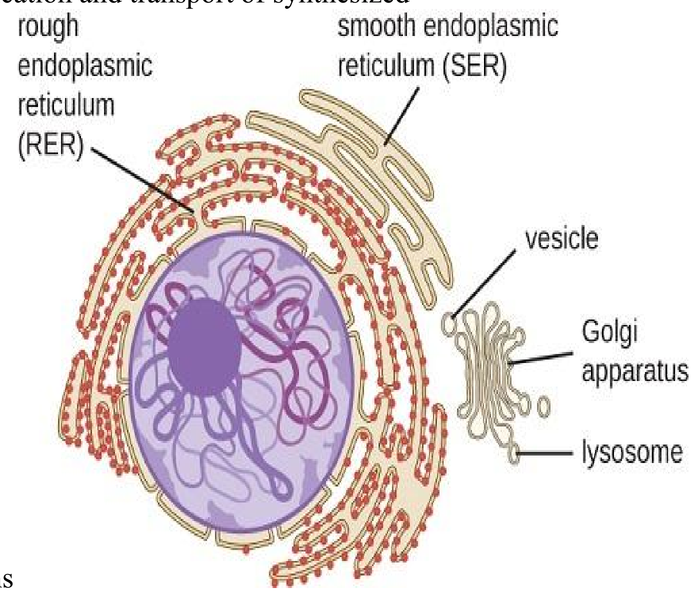
ENDOPLASMIC RETICULUM:

The endoplasmic reticulum (ER) is an important organelle in eukaryotic cells. It plays a major role in the production, processing, and transport of proteins and lipids. The ER produces transmembrane proteins and lipids for its membrane and for many other cell components including lysosomes, secretory vesicles, the Golgi apparatus and the cell membrane. The endoplasmic reticulum is a network of tubules and flattened sacs. The space inside of the ER is called the lumen. There are two regions of the ER that differ in both structure and function. They are

a. **Rough endoplasmic reticulum -** The rough endoplasmic reticulum manufactures membranes and
secretory proteins. The ribosomes attached to the rough ER synthesize proteins by the process of translation. In certain leukocytes (white blood cells), the rough ER produces antibodies. In pancreatic cells, the rough ER produces insulin.

b. **Smooth endoplasmic reticulum -** smooth ER lacks attached ribosomes. The smooth ER has a wide range of functions including carbohydrate and lipid synthesis. In liver cells the smooth ER produces enzymes that help to detoxify certain compounds. In muscles the smooth ER assists in the contraction of muscle cells, and
in brain cells it synthesizes male and female hormones.

1. Lipid synthesis
2. Synthesis of steroids hormones and cholesterol.
3. Catabolism of toxic substances
4. Modification and transport of synthesized



proteins

GOLGI APPARATUS:

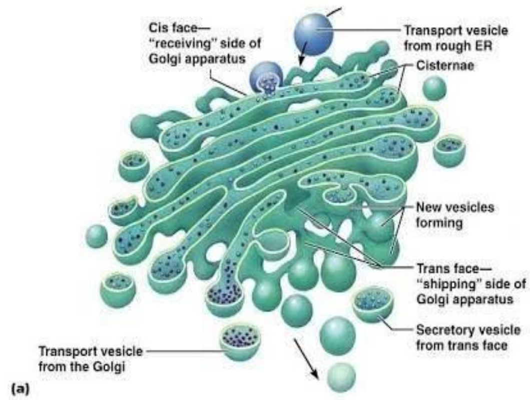
The Golgi apparatus is a major organelle in most of the eukaryotic cells. They are membrane bound organelles, which are sac-like. The Golgi complex is composed of stacks of membrane-bound structures; these structures are known as the cisternae. An individual stack of the cisternae is sometimes referred as dictyosome. In a typical animal cell, there are about 40 to 100 stacks. In a stack there are about four to eight cisternae which contain special enzymes meant for package and transportation of proteins. The Golgi apparatus is a series of flattened sacs that sort and package cellular materials. The receiving side of the Golgi apparatus is called the cis face. The opposite side is called the trans face. The transport vesicles that formed from the ER travel to the cis face, fuse with it, and empty their contents into the lumen of the Golgi apparatus. As the proteins and lipids travel through the Golgi, they undergo further modifications that allow them to be sorted.

Functions of Golgi apparatus:

The main function of the Golgi apparatus is to modify, sort and package the macromolecules that are synthesized by the cells for secretion purposes or for use within the cell.

1. It mainly modifies the proteins that are prepared by the rough endoplasmic reticulum.
2. They are also involved in the transport of lipid molecules around the cell.
3. They also create lysosomes.

4. The Golgi complex is thus referred as post office where the molecules are packaged, labelled and sent to different parts of the cell.



LYSOSOMES:

Membrane bound organelle containing a variety of enzymes. They have thickest covering membrane. Lysosomes are common in animal cells contain hydrolytic enzymes called lysozymes necessary for intracellular digestion of carbohydrates, proteins, lipids and nucleic acids. Lysozymes are synthesized in Rough endoplasmic reticulum and processed and packed into lysosomal vesicles in the Golgi apparatus. "The Police Force of the Cell" or "suicide bags".

Functions of lysosomes:

In general, the functions of lysosomes involve breaking-down i.e. processing to 'make safe' or make use of, or removing from the cell e.g. by exocytosis, useless and potentially harmful materials such as old worn-out parts of the cell or potential threats such bacteria. Lysosomes can therefore be thought of as the **rubbish disposal units** within cells.

MITOCHONDRIA:

They are small rod-shaped or spherical structures present in the cytoplasm in the cell which show aerobic respiration. The shape depends upon the physiological condition of the cell. The size of the mitochondria may vary from cell to cell. Usually, it is 0.2 to 1.0 micron meter in diameter and 2 to 8 micron meter in length. The size and shape of mitochondria varies.

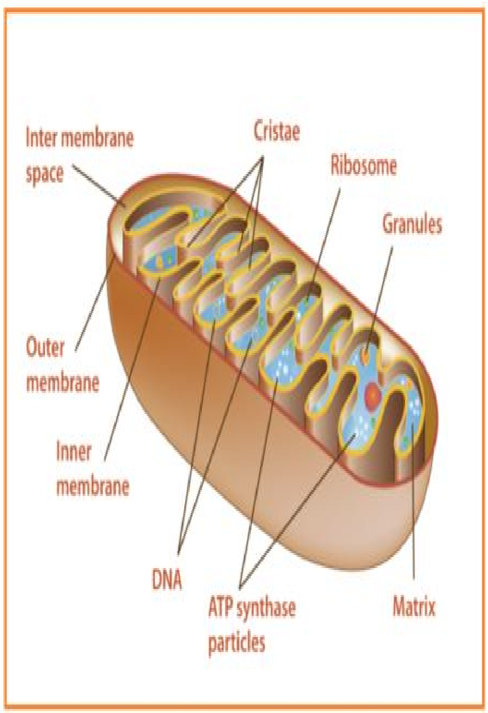
Mitochondrion contains outer and inner membranes composed of phospholipid bilayers and proteins. The two membranes have different properties. Because of this double membrane organization, there are five distinct parts to mitochondria. They are:

1. The outer mitochondrial membrane – contain large number of integral proteins called porins.
2. The intermembrane space: The space between outer and inner membrane.
3. The inner mitochondrial membrane contain unusual phospholipid called cardiolipin. Both outer and inner membranes are covered with thousands of enzymes.
4. The matrix: Space within the inner membrane. Contains enzymes, mitochondrial ribosomes, tRNA and mitochondrial DNA , It is important for the production of ATP as it contains ATPsynthase in the inner membrane
5. The cristae: Formed by in-folding of inner membrane. Have F_1 particles or oxysomes which enhance the ATP production. Depending on the energy needed for the cell, the cristae may increase or decrease.

Mitochondria is the Power of house of the cell. The food we eat must first be converted to basic chemicals that the cell can use. Some of the best energy supplying foods contain sugar or carbohydrates. The sugars are broken down by enzymes that split them into simplest form sugar which called glucose. Then glucose enters the cell by special molecules in the membrane called "Glucose transporter". Once inside the cell, glucose is broken down to make ATP and is termed as cellular respiration. The food we eat is oxidized to produce high energy electrons that converted to store energy. This energy is stored in the form of Adenosine Tri phosphate (ATP).ATP is converted from Adenosine Diphosphate by adding the phosphate group with high energy bond. Various reaction in the cells can be either use energy where by the ATP is converted back to ADP(releasing the high energy bond).

Functions of mitochondria:

1. The most important function of mitochondria is to produce energy. The simpler molecules of nutrition are sent to the mitochondria to be processed and to produce charge molecules. These charged molecules combined with oxygen and produce ATP molecules. This process is known as oxidative phosphorylation.
2. Mitochondrion helps the cell to maintain the proper concentration of calcium ions within the compartments of cell.
3. The mitochondria also help in building certain part of blood and hormones like testosterone and estrogen.
4. The liver cell mitochondria have enzymes that detoxify ammonia.
5. Regulate cellular metabolism.



They are small organelles called micro bodies. Peroxisomes are derived from endoplasmic reticulum and contain
oxidative enzymes.
Functions of peroxisomes:

1. They carry out oxidative reactions in which toxic hydrogen peroxide is produced and is destroyed by the enzyme catalase.
2. They are also concerned with glycogenesis from fats.

PLASMA MENBRANE

The cell membrane (plasma membrane) is a thin semi-permeable membrane that surrounds the cytoplasm of a cell. The cell membrane is a fluid mosaic of lipids, proteins and carbohydrates. It is an extremely pliable structure composed primarily of back-to-back phospholipids (a "bilayer"). Cholesterol is also present, which contributes to the fluidity of the membrane, and there are various proteins embedded within the membrane that have a variety of functions.

STRUCTURE OF THE CELL MEMBRANE:

The cell membrane is a three layered membrane:

- Central electro lucent layer called the lipid layer, formed by lipid substances.
- Two electro-dense layers, one on either side of the central layer, formed by proteins and some carbohydrate molecules.

Lipid layer

Entire body of the cell is covered by two lipid layers made up of lipid molecules. A single phospholipid molecule has a phosphate group on one end, called the "head," and two side-by-side chains of fatty acids that make up the lipid tails. The phosphate group is negatively charged, making the head polar and hydrophilic—or "water loving."

A **hydrophilic** molecule (or region of a molecule) is one that is attracted to water. The phosphate heads are thus attracted to the water molecules of both the extracellular and intracellular environments. The lipid tails, on the other hand, are uncharged, or nonpolar, and are hydrophobic—or "water fearing." A **hydrophobic** molecule (or region of a molecule) repels and is repelled by water. Some lipid tails consist of saturated fatty acids and some contain unsaturated fatty acids. This combination adds to the fluidity of the tails that are constantly in motion. Phospholipids are thus amphipathic molecules. The cholesterol part forms only 25% of the lipid layer. If cholesterol level increases then the permeability of the cell membrane decreases.

Protein layer

Protein layers are electron dense layers which cover the two surfaces of the central layer. They are coiled polypeptides and
have charged hydrophilic or uncharged hydrophobic groups.

Two types of protein molecules are present.

1. Integral proteins
2. Peripheral proteins

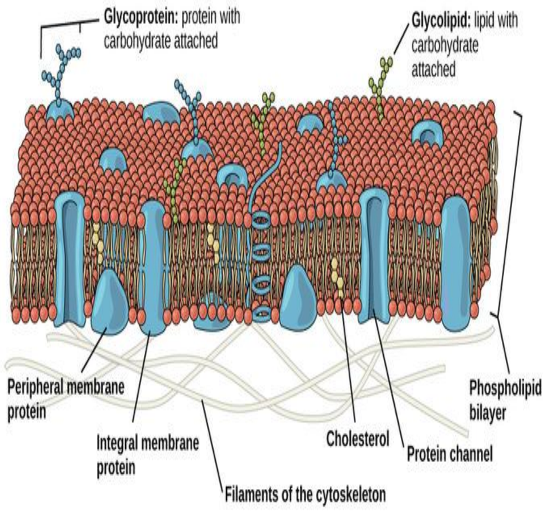
Integral proteins can pass through the cell membrane. The pores get entirely lined by integral protein molecules because the protein molecules invaginate into the pores of lipid layer from either side. The pores are called hypothetical pores which form protein channels through which diffuse water, electrolytes and also the substances which pass through lipid layer. Depending on the relationship with bilayer Integral proteins are classified into trans membrane proteins which spread through the entire length of the membrane and integral monotopic proteins which are permanently attached to the membrane from one side.

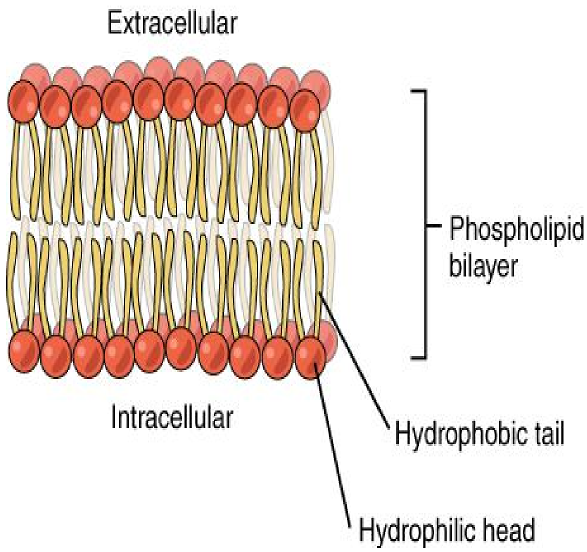
Peripheral proteins are temporarily attached to the lipid bilayer or to integral proteins and are only bound to the surface. **Carbohydrate layer**

Some carbohydrates are attached to the proteins or lipids forming glycoproteins and glycolipids throughout the cell membrane. They are temporarily attached to the lipid bilayer or integral proteins.

Functions of cell membrane:

1. The cell membrane forms a barrier between the inside of the cell and the environment outside the cell - enclosing cytoplasm and any organelles within the cell, and enabling different chemical environments to exist on each side of the cell membrane.
2. In many cases the cell membrane also helps to hold the cytoskeleton (which is within the cell) in place. This is achieved by some proteins in the cell membrane attaching to some cytoskeletal fibers and helps to define and maintain the shape of the cell.
3. In many cases (but not all, e.g. not in the case of single celled-organisms) the cell membrane interacts with the cell membrane of adjacent cells e.g. to form plant and animal tissues.
4. The cell membrane protects the cell from some harmful chemicals in its external environment. It also protects the cell from loss of useful biological macromolecules held within the cell by its plasma membrane.
5. The cell membranes that enclose cells (inside the cell wall in the cases of plant cells and prokaryotic cells)
   are selectively permeable. That is, the structure of these membranes is such that they allow certain particles, incl. e.g. molecules, - but not others - to pass through the membrane, hence into or out of the cell.
6. Cell membranes, also known as "plasma membranes", can allow active transport of specific molecules across the cell membrane in either direction, i.e. either into or out of the cell.
7. Exocytosis is the process by which a cell moves the contents of secretory vesicles out of the cell via the cell membrane. Endocytosis is the opposite process by which the contents of secretory vesicles are moved into the cell via the cell membrane.
8. neurotransmitters and immune proteins. In this way the cell can recognize and process some signals received from the extracellular environment.
9. Plasma membranes include as part of their structures certain proteins and enzymes that are involved in some of the metabolic processes of the cell.
10. Proteins called surface protein markers embedded in the cell membrane identify the cell, enabling nearby cells to communicate with each other.
11. Cell membranes often include receptor sites for interaction with specific bio chemicals such as certain hormones.





Tissue systems

A tissue is a group of cells that have similar structure and functions together as a unit

The interaction matrix fills the spaces between the cells. This may be abundant in some tissues and minimal in others. The intercellular matrix

may contain special substances such as salts and fibers.

There are four main types of tissues in the body. They are

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

EPITHELIAL TISSUE

Epithelium tissue lies on the surface of the interior of the body known as endothelium. The cells are closely packed together with small amount of intracellular material called matrix. Epithelial tissue is separated from the underlying tissue by thin sheet of connective tissue called basement membrane. Based on the number of cell layers, epithelia can either be simple or stratified.

- **Simple epithelia**– consist of a single cell layer (found where absorption, secretion, and filtration occur).
- **Stratified epithelia**– are composed of two or more cell layers stacked on top of each other (typically found in high abrasion areas where protection is needed).

All epithelial cells have six sides but they vary in height. For this reason, there are three ways to describe the shape and height of epithelial cells.

1. **Squamous cells**– are flat and scale-like.
2. **Cuboidal cells**– are box-like (same height and width).
3. **Columnar cells**– are tall (column shaped).

FUNCTIONS OF
EPITHELIAL TISSUE

primary functions of epithelial tissues are:

(1) To protect the tissues that lie beneath it from radiation, desiccation, toxins, invasion by pathogens, and physical trauma

(2) The regulation and exchange of chemicals between the underlying tissues and a body cavity

(3) The secretion of hormones into the blood vascular system, and/or the secretion of sweat, mucus, enzymes, and other products that are delivered by ducts

(4) To provide sensation.

(5) Certain epithelial cells in the lining of small intestine absorb nutrients from the digested food.

CONNECTIVE TISSUE

As the name implies, connective tissue serves a "connecting" function. It supports and binds other tissues in the body. Unlike epithelial tissue which has cells that are closely packed together, connective tissue typically has cells scattered throughout an extracellular matrix of fibrous proteins and glycoproteins attached to a basement membrane. Connective tissue surrounds many organs. Cartilage and bone are specialized forms of connective tissue. All connective tissue is derived from mesoderm, the middle germ cell layer in the embryo.

TYPES OF CONNECTIVE TISSUE

1. Loose connective tissue
2. Dense connective tissue
3. Elastic connective tissue
4. Reticular connective tissue
5. Adipose connective tissue
6. Specialized connective tissue
    - Bone
    - Blood
    - Cartilage

BLOOD

Approximately 8% of an adult's body weight is made up of blood. Females have around 4-5 lit, while males have around 5-6 lit. This difference is mainly due to the differences in body size between men and women. Its mean temperature is 38 OC. It has a pH of 7.35-7.45, making it slightly basic .Whole blood is about 4.5-5.5 times as viscous as water, indicating that it is more resistant to flow than water. This viscosity is vital to the function of blood because if blood flows too easily or with too much resistance, it can strain the heart and lead to severe cardiovascular problems. Blood in the arteries is a brighter red than blood in the veins because of the higher levels of oxygen found in the arteries.

FUNCTIONS OF THE BLOOD

Blood has three main functions: transport, protection and regulation.

Transport

Blood transports the following substances:

- Gases, namely oxygen (O_2) and carbon dioxide (CO_2), between the lungs and rest of the body

- Nutrients from the digestive tract and storage sites to the rest of the body
- Waste products to be detoxified or removed by the liver and kidneys
- Hormones from the glands in which they are produced to their target cells
- Heat to the skin so as to help regulate body temperature

Protection

- Leukocytes, or white blood cells, destroy invading microorganisms and cancer cells
- Antibodies and other proteins destroy pathogenic substances
- Platelet factors initiate blood clotting and help minimize blood loss

Regulation

- pH by interacting with acids and bases
- Water balance by transferring water to and from tissues

COMPOSITION OF BLOOD

Blood is classified as a connective tissue and consists of two main components:

1. Plasma, which is a clear extracellular fluid
2. Formed elements, which are made up of the blood cells and platelets.

1. BLOOD PLASMA

Blood plasma is a mixture of proteins, enzymes, nutrients, wastes, hormones and gases. The specific composition and function of its components are as follows:

Proteins

These are the most abundant substance in plasma by weight and play a part in a variety of roles including clotting, defense and transport. There are three major categories of plasma proteins, and each individual type of proteins has its own specific properties and functions in addition to their overall collective role:

Albumins, which are the smallest and most abundant plasma proteins. Reductions in plasma albumin content can result in a loss of fluid from the blood and a gain of fluid in the interstitial space (space within the tissue), which may occur in nutritional, liver and kidney disease. Albumin playing an important role in plasma transport of substances such as drugs, hormones and fatty acids.

Globulins, which can be subdivided into three classes from smallest to largest in molecular weight into alpha, beta and gamma globulins. The globulins include high density lipoproteins (HDL), an alpha-1 globulin, and low density lipoproteins (LDL), a beta-1 globulin. HDL functions in lipid transport carrying fats to cells for use in energy metabolism, membrane reconstruction and hormone function..

Fibrinogen, which is a soluble precursor of a sticky protein called fibrin, which forms the framework of blood clot. Fibrin plays a key role in coagulation of blood.

Amino acids: These are formed from the breakdown of tissue proteins or from the digestion of digested proteins. **Nitrogenous waste**: Being toxic end products of the breakdown of substances in the body, these are usually cleared from the bloodstream and are excreted by the kidneys at a rate that balances their production.

Nutrients: Those absorbed by the digestive tract are transported in the blood plasma. These include glucose, amino acids, fats, cholesterol, phospholipids, vitamins and minerals.

Gases: Some oxygen and carbon dioxide are transported by plasma. Plasma also contains a substantial amount of dissolved nitrogen.

Electrolytes: The most abundant of these are sodium ions, which account for more of the blood's osmolarity than any other solute.

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FORMED ELEMENTS

The formed elements are so named because they are enclosed in a plasma membrane and have a definite structure and shape. All formed elements are cells except for the platelets, which are tiny fragments of bone marrow cells. Formed elements are:

- Erythrocytes, also known as Red blood cells (RBCs)
- Leukocytes, also known as White blood cells (WBCs)
- Platelets

RED BLOOD CELLS

1. To pick up oxygen from the lungs and deliver it to tissues elsewhere
2. To pick up carbon dioxide from other tissues and unload it in the lungs

An erythrocyte is a disc-shaped cell with a thick rim and a thin sunken centre. The plasma membrane of a mature RBC has glycoproteins and glycolipids that determine a person's blood type. On its inner surface are two proteins called spectrin and actin that give the membrane resilience and durability. This allows the RBCs to stretch, bend and fold as they squeeze through small blood vessels, and to spring back to their original shape as they pass through larger vessels.

RBCs are incapable of aerobic respiration, preventing them from consuming the oxygen they transport because they lose nearly all their inner cellular components during maturation. The lack of a nucleus means that RBCs are unable to repair themselves. However, the resulting biconcave shape is that the cell has a greater ratio of surface area to volume, enabling O_2 and CO_2 to diffuse quickly to and from Hb. The cytoplasm of a RBC consists mainly of a 33% solution of hemoglobin (Hb), which gives RBCs their red color. Hemoglobin carries most of the oxygen and some of the carbon dioxide transported by the blood. Circulating erythrocytes live for about 120 days. As a RBC ages, its membrane grows increasingly fragile. Many RBCs die in the spleen, where they become trapped in narrow channels, broken up and destroyed. Haemolysis refers to the rupture of RBCs, where hemoglobin is released leaving empty plasma membranes which are easily digested by cells known as macrophages in the liver and spleen. The Hb is then further broken down into its different components and either recycled in the body for further use or disposed of.

WHITE BLOOD CELLS

White blood cells (WBCs) are also known as leukocytes. They can be divided into granulocytes and a granulocytes. The former have cytoplasm's that contain organelles that appear as colored granules through light microscopy, hence their name. Granulocytes consist of neutrophils, eosinophils and basophils. In contrast, a granulocytes do not contain granules.
They consist of lymphocytes and monocytes.

Granulocytes

1. **Neutrophils:** These contain very fine cytoplasmic granules that can be seen under a light microscope. Neutrophils are also called polymorphonuclear (PMN) because they have a variety of nuclear shapes. They play roles in the destruction of bacteria and the release of chemicals that kill or inhibit the growth of bacteria.
2. **Eosinophils:** These have large granules and a prominent nucleus that is divided into two lobes. They function in the destruction of allergens and inflammatory chemicals, and release enzymes that disable parasites.

3. **Basophils:** They have a pale nucleus that is usually hidden by granules. They secrete histamine which increases tissue blood flow via dilating the blood vessels, and also secrete heparin which is an anticoagulant that promotes mobility of other WBCs by preventing clotting.

Agranulocytes

Lymphocytes: These are usually classified as small, medium or large. Medium and large lymphocytes are generally seen mainly in fibrous connective tissue and only occasionally in the circulation bloodstream. Lymphocytes function in destroying cancer cells, cells infected by viruses, and foreign invading cells. In addition, they present antigens to activate other cells of the immune system.

Monocytes: They are the largest of the formed elements. Their cytoplasm tends to be abundant and relatively clear. They function in differentiating into macrophages, which are large phagocytic cells, and digest pathogens, dead neutrophils, and the debris of dead cells. Like lymphocytes, they also present antigens to activate other immune cells.

PLATELETS

Platelets are small fragments of bone marrow cells and are therefore not really classified as cells themselves.

Platelets have the following functions:

1. Secrete vasoconstrictors which constrict blood vessels, causing vascular spasms in broken blood vessels
2. Form temporary platelet plugs to stop bleeding
3. Secrete pro-coagulants (clotting factors) to promote blood clotting
4. Dissolve blood clots when they are no longer needed
5. Digest and destroy bacteria

UNIT-II

CARDIOVASCULAR SYSTEM

ANATOMY OF THE HEART

STRUCTURE OF THE HEART WALL

The heart wall is made of 3 layers: epicardium, myocardium and endocardium.

1.Pericardium

The heart sits within a fluid-filled cavity called the pericardial cavity. The walls and lining of the pericardial cavity are a special membrane known as the pericardium. Pericardium is a type of serous membrane that produces serous fluid to lubricate the heart and prevent friction between the ever-beating heart and its surrounding organs. Besides lubrication, the pericardium serves to hold the heart in position and maintain a hollow space for the heart to expand into when it is full. The pericardium has 2 layers fibrous pericardium and serous pericardium.

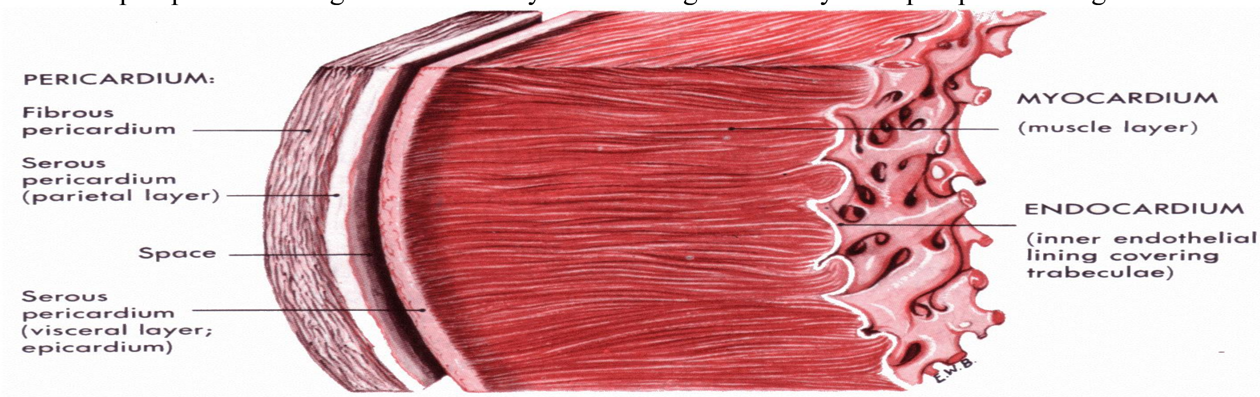
Fibrous pericardium

The **fibrous pericardium** is the most superficial layer of the pericardium. It is made up of dense and loose connective tissue, which acts to protect the heart, anchoring it to the surrounding walls, and preventing it from overfilling with blood. It is continuous with the outer adventitial layer of the neighboring great blood vessels. It is inside the great blood vessels.

Serous pericardium

The **serous pericardium**, in turn, is divided into two layers, the *parietal pericardium*, which is fused to and inseparable from the fibrous pericardium, and the *visceral pericardium*, which is part of the epicardium. Both of these layers function in lubricating the heart to prevent friction during heart activity.
2. Myocardium. The myocardium is the muscular middle layer of the heart wall that contains the **cardiac muscle tissue**. Myocardium makes up most the thickness and mass of the heart wall and is the part of the heart responsible for pumping blood. Below the myocardium is the thin endocardium layer.
3.Endocardium. Endocardium is the simple squamous endothelium layer that lines the inside of the heart. The endocardium is very smooth and is responsible for keeping blood from sticking to the inside of the heart and forming potentially deadly blood clots.

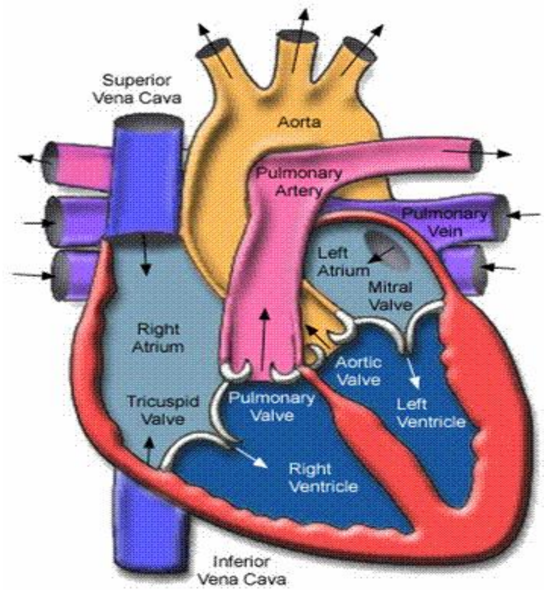
The thickness of the heart wall varies in different parts of the heart. The atria of the heart have a very thin myocardium because they do not need to pump blood very far—only to the nearby ventricles. The ventricles, on the other hand, have a very thick myocardium to pump blood to the **lungs** or throughout the entire body. The right side of the heart has less myocardium in its walls than the left side because the left side must pump blood through the entire body while the right side only must pump to the lungs.



Section of the heart wall showing the components of the outer pericardium (heart sac), muscle layer (myocardium), and inner lining (endocardium).

CHAMBERS OF THE HEART

The heart contains 4 chambers: the **right atrium**, **left atrium**, **right ventricle**, and **left ventricle**. The atria are smaller than the ventricles and have thinner, less muscular walls than the ventricles. The atria act as receiving chambers for blood, so they are connected to the veins that carry blood to the heart. The ventricles are the larger, stronger pumping chambers that send blood out of the heart. The ventricles are connected to the arteries that carry blood away from the heart.
The chambers on the right side of the heart are smaller and have less myocardium in their heart wall when compared to the left side of the heart. This difference in size between the sides of the heart is related to their functions and the size of the 2 circulatory loops. The right side of the heart maintains pulmonary circulation to the nearby lungs while the left side of the heart pumps blood all the way to the extremities of the body in the systemic circulatory loop.



VALVES OF THE HEART

The heart functions by pumping blood both to the lungs and to the systems of the body. To prevent blood from flowing backwards or "regurgitating" back into the heart, a system of one-way valves is present in the heart. The heart valves can be broken down into two types: atrioventricular and semilunar valves.

- ***Atrioventricular valves*-** The atrioventricular (AV) valves are in the middle of the heart between the atria and ventricles and only allow blood to flow from the atria into the ventricles. The AV valve on the right side of the heart is called the **tricuspid valve** because it is made of three cusps (flaps) that separate to allow blood to pass through and connect to block regurgitation of blood. The AV valve on the left side of the heart is called the **mitral valve** or the bicuspid valve because it has two cusps. The AV valves are attached on the ventricular side to tough strings called **chordae tendineae**. The chordae tendineae pull on the AV valves to keep them from folding backwards and allowing blood to regurgitate past them. During the contraction of the ventricles, the AV valves look like domed parachutes with the chordae tendineae acting as the ropes holding the parachutes taut.

- ***Semilunar valves*-** The semilunar valves, so named for the crescent moon shape of their cusps, are located between the ventricles and the arteries that carry blood away from the heart. The semilunar valve on the right side of the heart is the **pulmonary valve**, so named because it prevents the backflow of blood from the pulmonary trunk into the right ventricle. The semilunar valve on the left side of the heart is the **aortic valve**, named for the fact that it prevents the **aorta** from regurgitating blood back into the left ventricle. The semilunar valves are smaller than the AV valves and do not have chordae tendineae to hold them in place. Instead, the cusps of the semilunar valves are cup shaped to catch regurgitating blood and use the blood's pressure to snap shut.

BLOOD FLOW THROUGH THE HEART

- Deoxygenated blood returning from the body first enters the heart from the superior and inferior vena cava. The blood enters the right atrium and is pumped through the tricuspid valve into the right ventricle.
- From the right ventricle, the blood is pumped through the pulmonary semilunar valve into the pulmonary artery.
- The pulmonary artery carries blood to the lungs where it releases carbon dioxide and absorbs oxygen.
- The blood in the lungs returns to the heart through the pulmonary veins. From the pulmonary veins, blood enters the heart again in the left atrium.
- The left atrium contracts to pump blood through the bicuspid (mitral) valve into the left ventricle.

- The left ventricle pumps blood through the aortic semilunar valve into the aorta. From the aorta, blood enters systemic circulation throughout the body tissues until it returns to the heart via the vena cava and the cycle repeats.

Pathway of Blood Through the Heart and Lungs

- Right atrium → tricuspid valve → right ventricle
- Right ventricle → pulmonary semilunar valve → pulmonary arteries → lungs
- Lungs → pulmonary veins → left atrium
- Left atrium → bicuspid valve → left ventricle
- Left ventricle → aortic semilunar valve → aorta
- Aorta → systemic circulation

CIRCULATION TYPES

In a human body, there are three types of circulation of blood:

1.Systemic (greater) circulation:

The blood flows from the left ventricle, through various parts of the body, to the right atrium, i.e. from the left to the right side of the heart through the arteries and veins which traverse the whole body. This circulation is responsible for keeping the body tissues alive by supplying a continuous stream of blood to them.

2. Pulmonary (lesser) circulation:

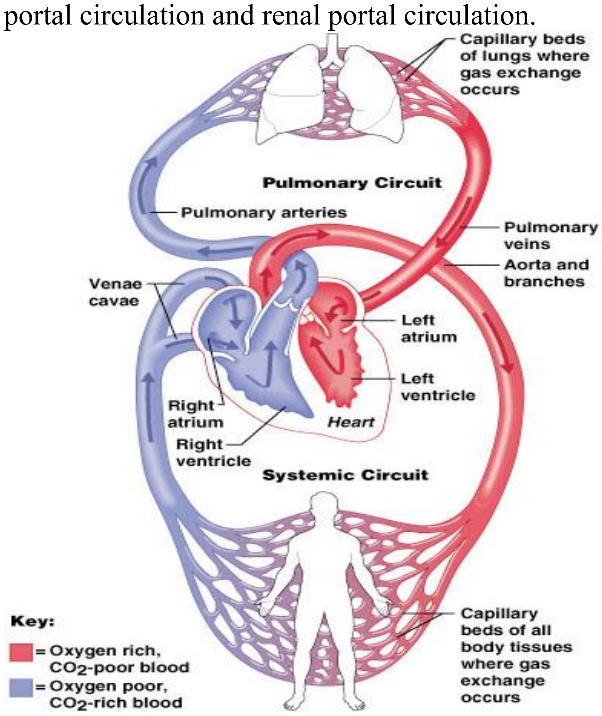
The blood flows from the right ventricle, through the lungs, to the left atrium, i.e. from the right to the left side of the heart. This circulation is responsible for oxygenation of blood. In pulmonary circulation, the blood passes through the lungs where Carbon dioxide is eliminated and Oxygen is added to blood. In this way, the pulmonary circulation makes sure that systemic circulation remains effective.

3. Portal circulation:

It is a part of systemic circulation, which has the following characteristics.

The blood passes through two sets of capillaries before draining into a systemic vein.

The vein draining the first capillary network is known as *portal vein* which branches like an artery to form the second set of capillaries or sinusoids. Examples: hepatic portal circulation, hypothalamo hypophyseal portal circulation and renal portal circulation.



PHYSIOLOGY OF THE HEART

Coronary Systole and Diastole

At any given time the chambers of the heart may found in one of two states:

1.Systole. During systole, cardiac muscle tissue is contracting to push blood out of the chamber.

2.Diastole. During diastole, the cardiac muscle cells relax to allow the chamber to fill with blood. Blood pressure increases in the major arteries during ventricular systole and decreases during ventricular diastole. This leads to the 2 numbers associated with blood pressure—systolic blood pressure is the higher number and diastolic blood pressure is the lower number. For example, a blood pressure of 120/80 describes the systolic pressure (120) and the diastolic pressure (80).

THE CARDIAC CYCLE

The cardiac cycle includes all the events that take place during one heartbeat. There are 3 phases to the cardiac cycle: atrial systole, ventricular systole, and relaxation.

- ***Atrial systole*:** During the atrial systole phase of the cardiac cycle, the atria contract and push blood into the ventricles. To facilitate this filling, the AV valves stay open and the semilunar valves stay closed to keep arterial blood from re-entering the heart. The atria are much smaller than the ventricles, so they only fill about 25% of the ventricles during this phase. The ventricles remain in diastole during this phase.

- ***Ventricular systole*:** During ventricular systole, the ventricles contract to push blood into the aorta and pulmonary trunk. The pressure of the ventricles forces the semilunar valves to open and the AV valves to close. This arrangement of valves allows for blood flow from the ventricles into the arteries. The cardiac muscles of the atria repolarize and enter the state of diastole during this phase.

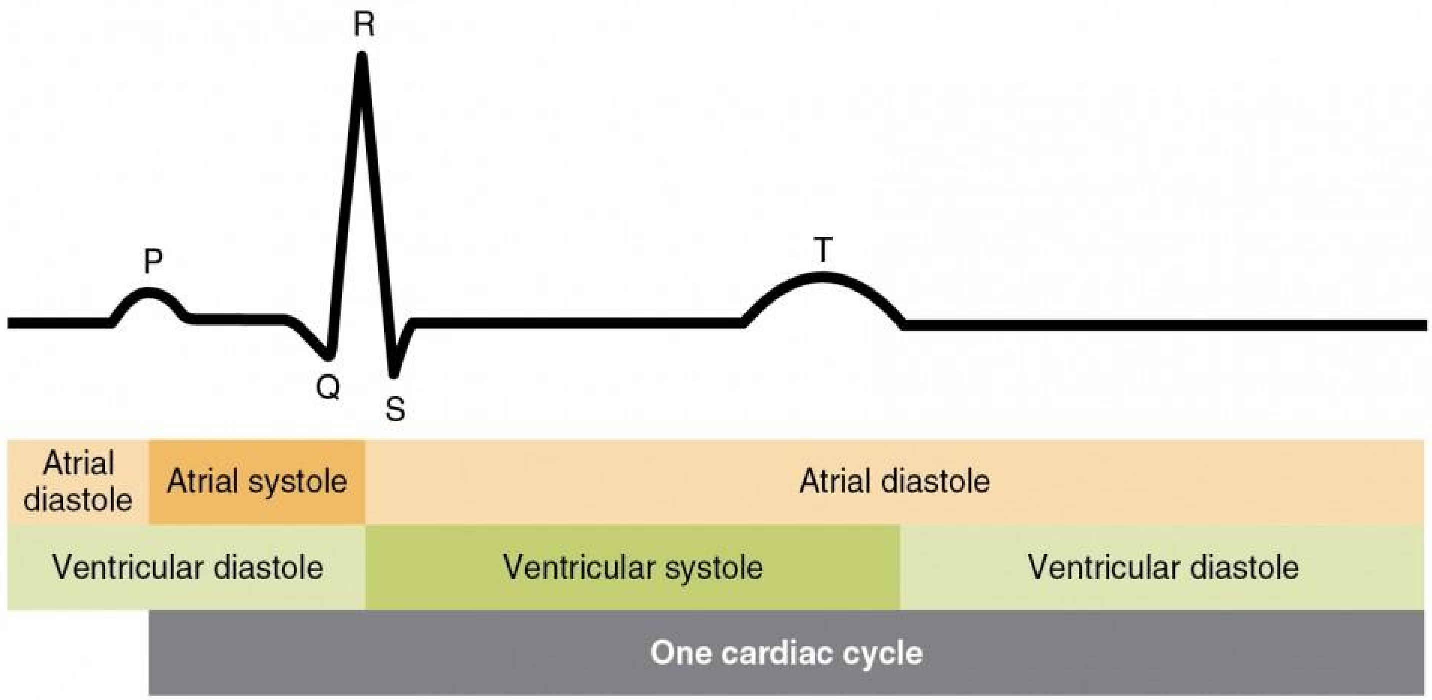
- ***Relaxation phase*:** During the relaxation phase, all 4 chambers of the heart are in diastole as blood pours into the heart from the veins. The ventricles fill to about 75% capacity during this phase and will be filled only after the atria enter systole. The cardiac muscle cells of the ventricles repolarize during this phase to prepare for the next round of depolarization and contraction. During this phase, the AV valves open to allow blood to flow freely into the ventricles while the semilunar valves close to prevent the regurgitation of blood from the great arteries into the ventricles.

THE ELECTROCARDIOGRAM

The electrocardiogram (also known as an EKG or ECG) is a non-invasive device that measures and monitors the electrical activity of the heart through the skin. The EKG produces a distinctive waveform in response to the electrical changes taking place within the heart.

The first part of the wave, called the P wave, is a small increase in voltage of about 0.1 mV that corresponds to the depolarization of the atria during atrial systole. The next part of the EKG wave is the QRS complex which features a small drop in voltage (Q) a large voltage peak (R) and another small drop in voltage (S). The QRS complex corresponds to the depolarization of the ventricles during ventricular systole. The atria also repolarize during the QRS complex, but have almost no effect on the EKG because they are so much smaller than the ventricles.

The final part of the EKG wave is the T wave, a small peak that follows the QRS complex. The T wave represents the ventricular repolarization during the relaxation phase of the cardiac cycle. Variations in the waveform and distance between the waves of the EKG can be used clinically to diagnose the effects of heart attacks, congenital heart problems, and electrolyte imbalances.



HEART SOUNDS

The sounds of a normal heartbeat are known as “lubb” and “dupp” and are caused by blood pushing on the valves of the heart. The “lubb” sound comes first in the heartbeat and is the longer of the two heart sounds. The “lubb” sound is produced by the closing of the AV valves at the beginning of ventricular systole. The shorter, sharper “dupp” sound is similarly caused by the closing of the semilunar valves at the end of ventricular systole. During a normal heartbeat, these sounds repeat in a regular pattern of lubb-dupp-pause. Any additional sounds such as liquid rushing or gurgling indicate a structure problem in the heart. The most likely causes of these extraneous sounds are defects in the atrial or ventricular septum or leakage in the valves.

Cardiac Output

Cardiac output (CO) is the volume of blood being pumped by the heart in one minute.
The equation used to find cardiac output is: CO = Stroke Volume x Heart Rate
Stroke volume is the amount of blood pumped into the aorta during each ventricular systole, usually measured in milliliters. The average heart can push around 5 to 5.5 liters per minute at rest. Heart rate is the number of heart beats per minute.

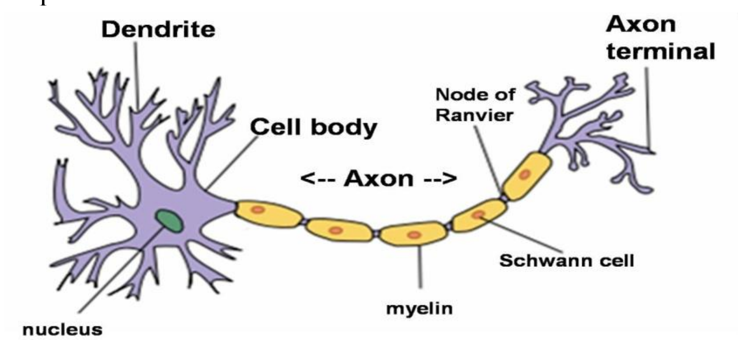
UNIT - III
THE HUMAN NERVOUS SYSTEM

The nervous system has two divisions. The **central nervous system** (**CNS**) consists of the brain and spinal cord. **The peripheral nervous system** (**PNS**) consists of cranial nerves and spinal nerves. The PNS includes nerves to and from skin and skeletal muscles. The peripheral nervous system relays information to and from the central nervous system, and the brain is the center of activity that integrates this information, initiates responses, and makes us the individuals.

It also includes the autonomic nervous system (ANS), with nerves to visceral effectors, and the enteric nervous system, which is located in the wall of the alimentary tube.

The peripheral nervous system relays information to and from the central nervous system, and the brain is the center of activity that integrates this information, initiates responses, and makes us the individuals we are**.**

Structure of Nerve cells: The human body is made up of trillions of cells. Cells of the nervous system, called nerve cells or neurons. There are three distinct parts in all kinds of neurons. The human brain has approximately 100 billion neurons. Nerves act like wires in a telephone .Neurons come in many different shapes and sizes. Some of the smallest neurons have cell bodies that are only 4 microns wide.



Some of the biggest neurons have cell bodies that are 100 microns wide. .Neurons is responsible for sending, receiving, and interpreting information from all parts of the body.

Neuron and Glial cells: Nervous system is made up of two kinds of cells- **Neurons (Nerve cells)** and **Glial cells**. **Neurons** are the functional units, which receive and process information and generate responses.

Glial cells are supportive cells-they help the neuron in carrying out its function by providing nutrients. They also protect the neurons. Insulate neurons, nourish neurons, and remove waste products. Neurons receive information, integrate it, and pass it along. They communicate with one another, with cells in the sensory organs, and with muscles and glands.

Both the cells are equally important for the nervous system to function. No two neurons in the nervous system have the same appearance. In general, we can identify three distinct Parts in all kinds of neurons. They are **cell body, dendrites and axon.** The cytoplasm of the neuron has all the organelles like mitochondria, Golgi, lysosomes etc., Nerves does not have centrosome so it cannot undergo division. Neurons may be Unipolar, Bipolar and Multipolar.

Cell Body: Each neuron has a soma, or cell body, which is the central area of the neuron. Cell body is the centre for all the synthetic activity of the neuron. The cell body has a large nucleus with one or two large nucleoli. The most characteristic feature of the cell body in the presence of large granules in the cytoplasm called Nissl Granules. These are groups of ribosomes and are made up of RNA and proteins and other structures common to all cells in the body.

Dendrites: These are projections or processes arising from the cell body. The number of dendrites ranges one to several thousands. Dendrites are short and branched structures. They arranged in the form of a tree with branches. Dendrites receive information from other neurons and carry this information to the cell body. They do not have Nissl substance.

Axon: Axon is also a projection from the cell body. Each neuron has only one axon. Unlike dendrites, axons are very long and are usually branched structures. The axon is generally called as nerve fiber. The cytoplasm of the axon is covered with a plasma membrane. Nissl granules are absent in axon. At the end, the axon gives out several branches that end in Nerve Terminals. Each of these nerve terminals makes contact with the dendrites or cell body or even axons of another neuron. Some of the axons also make contact with the cells in the effectors organs such as muscles or glands. This site is called a SYNAPSE. At the synapse, the membranes of nerve terminal and the cells of the effectors organ are separated from each other by a space. In neurons, axons are covered by a whitish, fatty substance sheath called MYELIN SHEATH. At regular intervals, the myelin sheath leaves small gaps called nodes of ranvier. Neurons having myelin sheath are called myelinated neurons and those that do not have myelin sheath are called unmyelinated neurons. Myelin sheath prevents the leakage of electrical currents from the axon. Myelinated axons conduct impulses much faster than unmyelinated axons.

Neurons are classified mainly into three different ways. **Sensory neurons, Interneuron's and Motor neurons.**

Afferent which carry messages towards the central nervous system (spinal cord (or) brain) from nerve endings on the muscles of different sense organs that sense the change in surroundings (or) environment are called stimulus detectors? These are also called 'Sensory' nerves.

Motor neurons have many dendrites and a single axon which carry messages from the central nervous system to muscle fibers or glands.

Interneuron's: These are highly-branched dendrites within the central nervous system (CNS),convey messages between parts of the CNS and form complex brain pathways accounting for thinking, memory, language, etc.

THE BRAIN

The **brain** is made of approximately 100 billion neurons and contains trillions of synapses, all of which function as an integrated whole. The major parts of the brain are **the medulla, Pons, and midbrain** collectively called the **brainstem, the cerebellum**, the **hypothalamus, the thalamus, and the cerebrum.**

VENTRICLES

The **ventricles** are four cavities within the brain: two lateral ventricles, the third ventricle, and the fourth ventricle. The ventricles are lined with ciliated ependymal cells and filled with **cerebrospinal fluid** (**CSF**).Each ventricle contains a capillary network called a **choroid plexus**, which forms the cerebrospinal fluid from blood plasma.

BRAINSTEM:

1. **Midbrain**: The **midbrain** extends from the Pons to the hypothalamus and encloses the **cerebral aqueduct**, a tunnel that connects the third and fourth ventricles. Several different kinds of reflexes are integrated in the midbrain, and auditory reflexes. The ability to read depends in part on the coordinated movement of the eyeballs from word to word; this is scanning and is another reflex mediated by the midbrain. Turning your head (ear) to a sound is an example of an auditory reflex, as is the "startle" reflex, a jump or cringe upon hearing a sudden loud sound such as thunder. The midbrain is also concerned with what are called righting reflexes, those that keep the head upright and maintain balance or equilibrium. Human mid brains is not nearly that efficient. The relay station of the brain, it transmits messages to and from the spinal cord, the cerebrum and the cerebellum

2. Pons: Situated in front of the cerebellum, below the midbrain and above the medulla oblongata. It consists of nerve. The Pons bulges anteriorly from the upper part of the medulla. Within the Pons are two respiratory centers that work with those in the medulla to produce a normal breathing rhythm. The many other neurons in the Pons connect the medulla with other parts of the brain fibers, which bridge the gap between the 2 hemispheres of the cerebellum. Like the midbrain, transmits messages to and from the spinal cord and cerebrum.

3. Medulla Oblongata: Lowest part of the brain stem, situated above the spinal cord and below the Pons. Its construction is different from the cerebrum and cerebellum with white matter on the surface and gray

matter in the center. It is known as a vital center because it controls the actions of the heart and lungs (respectively the centers of the vascular and respiratory systems). It has 4 centers.
Cardiac center: controls rate and force of heart beat.
Respiratory center: controls rate and depth of breathing.
Vasomotor center: controls constriction and dilation of blood vessels.
Reflex center: responds to irritants thus controls vomiting, coughing, sneezing and swallowing

CEREBELLUM
The **cerebellum** is separated from the medulla and Pons by the fourth ventricle and is inferior to the occipital lobes of the cerebrum. The functions of the cerebellum are concerned with movement. These include coordination, regulation of muscle tone, the appropriate trajectory and end point of movements, and the maintenance of posture and equilibrium. Notice that these are all involuntary; that is, the cerebellum functions below the level of conscious thought. If you decide to pick up a pencil, for example, the impulses for arm movement come from the cerebrum. The cerebellum then modifies these impulses so that your arm and finger movements are coordinated, and you don't reach past the pencil. The cerebellum seems also to be involved in certain sensory functions. The cerebellum is, in part, responsible for this ability. To regulate equilibrium, the cerebellum (and midbrain) uses information about gravity and movement provided by receptors in the inner ears.

HYPOTHALAMUS
Located superior to the pituitary gland and inferior to the thalamus, the **hypothalamus** is a small area of the brain with many diverse functions:1. Production of **antidiuretic hormone** (ADH) and **oxytocin**; these hormones then stored in the posterior pituitary gland. ADH enables the kidneys to reabsorb water back into the blood and thus helps maintain blood volume. 2. The hypothalamus produces **growth hormone–releasing hormone** (GHRH), which stimulates the anterior pituitary gland to secrete growth hormone (GH). Regulation of body temperature by promoting responses such as sweating in a warm environment or shivering in a cold environment. 4. Regulation of food intake; the hypothalamus is believed to respond to changes in blood nutrient levels, to chemicals secreted by fat cells, and to hormones secreted by the gastrointestinal tract. 5. Integration of the functioning of the autonomic nervous system, which in turn regulates the activity of organs such as the heart, blood vessels, and intestines.6. Stimulation of visceral responses during emotional situations.7. Regulation of body rhythms such as secretion of hormones sleep cycles, changes in mood, or mental alertness.

THALAMUS:
The **thalamus** is superior to the hypothalamus and inferior to the cerebrum. The third ventricle is a narrow cavity that passes through both the thalamus and hypothalamus. Many of the functions of the thalamus are concerned with sensation. Sensory impulses to the brain follow neuron pathways that first enter the Thalamus. The thalamus integrates the impulses from the cutaneous receptors and from the cerebellum; that is, it puts them together in a sort of electrochemical package and directs them to the sensory area in the parietal lobe of the cerebrum so that the neurons there feel the whole and are able to interpret the sensation quickly.

CEREBRUM
The largest part of the human brain is the **cerebrum**, which consists of two hemispheres separated by the longitudinal fissure. At the base of this deep groove is the **corpus callosum**, a band of 200 million neurons that connects the right and left hemispheres. Within each hemisphere is a lateral ventricle **cerebral cortex**. Gray matter consists of cell bodies of neurons, which carry out the many functions of the cerebrum. Internal to the gray matter is white matter, made of myelinated axons and dendrites that connect the lobes of the cerebrum to one another and to all other parts of the brain .In the human brain the cerebral cortex is folded extensively. The folds are called **convolutions** or **gyri**, and the grooves between them are **fissures** or **sulci** .This folding permits the presence of millions more neurons in the cerebral

cortex. This difference enables us to read, speak, do long division, write poetry and songs, . The cerebral cortex is divided into lobes that have the same names as the cranial bones external to them. Therefore, each hemisphere has a **frontal lobe, parietal lobe, temporal lobe, and occipital lobe. These lobes**, to be associated with specific functions.

Functions

• Controls voluntary movement.• Interprets and perceives conscious sensations like pain, heat and cold. • Controls mental activity, like memory, intelligence and reasoning

1. ***Frontal Lobes***

- Within the **frontal lobes** are the **motor areas that** generate the impulses for voluntary movement. The largest portions are for movement of the hands and face, those areas with many muscles capable of very fine or precise movements. The left motor area controls movement on the right side of the body, and the right motor area controls the left side of the body. The parts of the frontal lobes just behind the eyes are the **prefrontal** or **cortex**.

- This area is concerned with things such as keeping emotional responses appropriate to the situation, realizing that there are standards of behavior and following them, and anticipating and planning for the future. This is the part not always think the way we do. .Also in the frontal lobe, usually only the left lobe for most right-handed people, is **Broca's motor speech** area ,which controls the movements of the mouth involved in speaking

2. ***Parietal Lobes***

The **general sensory areas** in the **parietal lobes** receive impulses from receptors in the skin and feel and interpret the cutaneous sensations. The left area is for the right side of the body and vice versa. These areas also receive impulses from stretch receptors in muscles for consciousness sense. The largest portions of these areas are for sensation in the hands and face, those parts of the body with the most cutaneous receptors and the most muscle receptors. The **taste areas**, which overlap the parietal and temporal lobes, receive impulses from taste buds on the tongue and elsewhere in the oral cavity.

3. ***Temporal Lobes***

- The **olfactory areas** in the **temporal lobes** the meaning of odors such as the smell of sour milk, or fire, or brownies baking in the oven. The **auditory areas**, as their name suggests, receive impels from receptors in the inner ear for hearing. The auditory association area is quite large. Part of it is concerned with the meanings of words we hear, that is, with speech .

4. Occipital Lobes

- Impulses from the retinas of the eyes travel along the optic nerves to the **visual areas** in the **occipital lobes**. These are as "see." The visual association areas interpret what is seen enable the thinking cerebrum to use the information. Other parts of the occipital lobes are concerned with spatial relationships; such as judging distance and seeing in three dimensions or the ability to read a map and relate it to the physical world. The cerebral cortex has the characteristic of **neural plasticity**, the ability to adapt to changing needs, to recruit different neurons for certain functions

Association Areas

- As many parts of the cerebral cortex are not concerned with movement or a particular sensation. These may be called **association areas** and perhaps are what truly make us individuals.

- It is probably these areas that give each of us a personality, a sense of humor, and the ability to reason and use logic. Learning and memory are also functions of these areas.

Basal Ganglia

- The **basal ganglia** are paired masses of gray matter within the white matter of the cerebral hemispheres. Their functions are certain subconscious aspects of voluntary

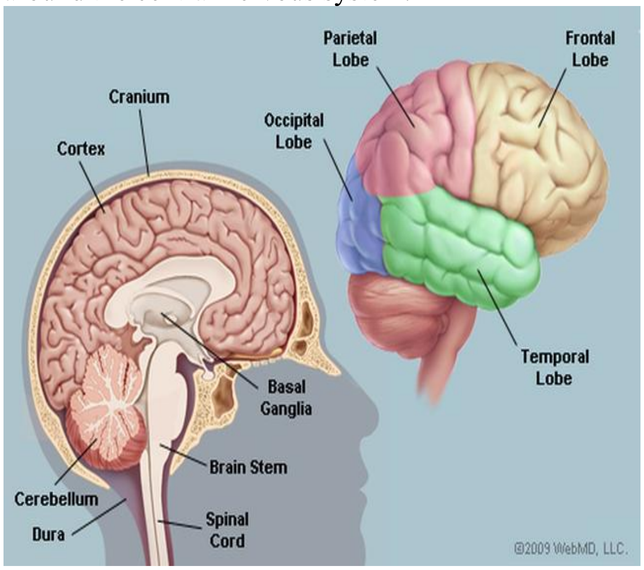
- Movement and they work with the cerebellum. The basal ganglia help regulate muscle tone, and they coordinate accessory movements such as swinging the arms when walking or gesturing while speaking. The most common disorder of the basal ganglia is Parkinson's disease .

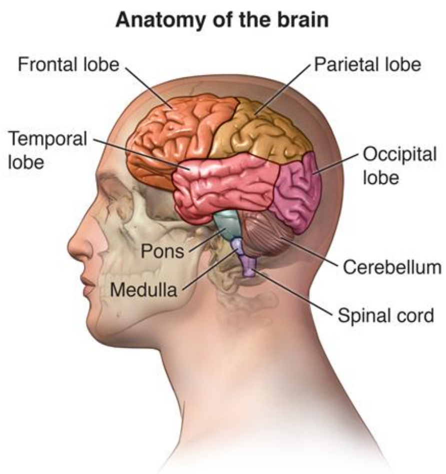
Corpus Callosum

- As , the **corpus callosum** is a band of nerve fibers that connects the left and right cerebral hemispheres. This enables each hemisphere to know what the other is doing. The corpus callosum is important because for most of us the left hemisphere contains speech areas and the right hemisphere does not. The corpus callosum, therefore, lets the left hemisphere know what the right hemisphere is thinking about, and the right hemisphere know what the left hemisphere is thinking and talking about.

MENINGES AND CEREBROSPINAL FLUID

The connective tissue membranes that cover the brain and spinal cord are called **meanings**; The thick outermost layer, made of fibrous connective tissue, is the **Dura mater** (Latin for"tough mother"), which lines the skull and vertebral canal. The middle **arachnoids membrane** (arachnids are spiders) is made of web-like strands of connective tissue. The innermost **pia mater** (Latin for "gentle mother") is a very thin membrane on the surface of the spinal cord and brain. Between the arachnoids and the pia mater is the **subarachnoid space**, which contains cerebrospinal fluid (CSF), the tissue fluid of the central nervous system. Recall the ventricles (cavities) of the brain: two lateral ventricles, the third ventricle, and the fourth ventricle. Each contains a choroid plexus, a capillary network that forms **cerebrospinal fluid** from blood plasma. This is a continuous process, and the **cerebrospinal fluid** then circulates in and around the central nervous system.





Spinal card anatomy:

The spinal cord is the most important structure between the body and the brain. The spinal cord extends from the foramen magnum where it is continuous with the medulla to the level of the first or second lumbar vertebrae. It is a vital link between the brain and the body, and from the body to the brain. The spinal cord has a varying width, ranging from 0.5 inch thick in the cervical and lumbar regions to 0.25 inch thick in the thoracic area. The length of the spinal cord is approximately 45 cm (18 in) in men and about 43 cm (17 in) long in women.

Two consecutive rows of nerve roots emerge on each of its sides. These nerve roots join distally to form 31 pairs of **spinal nerves**. The spinal cord is a cylindrical structure of nervous tissue composed of white and gray matter, is uniformly organized and is divided into four regions: cervical (C), thoracic (T), lumbar (L) and sacral (S), each of which is comprised of several segments. The spinal nerve contains motor and sensory nerve fibers to and from all parts of the body. Each spinal cord segment innervates a dermatome.

Segmental and Longitudinal Organization

The spinal cord is divided into four different regions: the cervical, thoracic, lumbar and sacral regions. The different cord regions can be visually distinguished from one another. Two enlargements of the spinal cord can be visualized: The cervical enlargement, which extends between C3 to T1; and the lumbar enlargements which extends between L1 to S2. The cord is segmentally organized. There are 31 segments, defined by 31 pairs of nerves existing the cord. These nerves are divided into 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal nerve. Dorsal and ventral roots enter and leave the vertebral column respectively through intervertebral foramen at the vertebral segments corresponding to the spinal segment. The cord is sheathed in the same three meninges as is the brain: the pia, arachnoid and dura. The dura is the tough outer sheath, the arachnoid lies beneath it, and the pia closely adheres to the surface of the cord. The spinal cord is attached to the dura by a series of lateral denticulate ligaments emanating from the pial folds. All spinal nerves, except the first, exit below their corresponding vertebrae. In the cervical segments, there are 7 cervical vertebrae and 8 cervical nerves. C1-C7 nerves exit above their vertebrae whereas the C8 nerve exits below the C7 vertebra. It leaves between the C7 vertebra and the first thoracic vertebra. Therefore, each subsequent nerve leaves the cord below the corresponding vertebra. In the thoracic and upper lumbar regions, the difference between the vertebrae and cord level is three segments. Therefore, the root filaments of spinal cord segments have to travel longer distances to reach the corresponding intervertebral foramen from which the spinal nerves emerge. The lumbosacral roots are known as the cauda equina .

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Each spinal nerve is composed of nerve fibers that are related to the region of the muscles and skin that develops from one body segment. A spinal segment is defined by dorsal roots entering and ventral roots exiting the cord.

A dermatome is an area of skin supplied by peripheral nerve fibers originating from a single dorsal root ganglion. If a nerve is cut, one loses sensation from that dermatome. Because each segment of the cord innervates a different region of the body, dermatomes can be precisely mapped on the

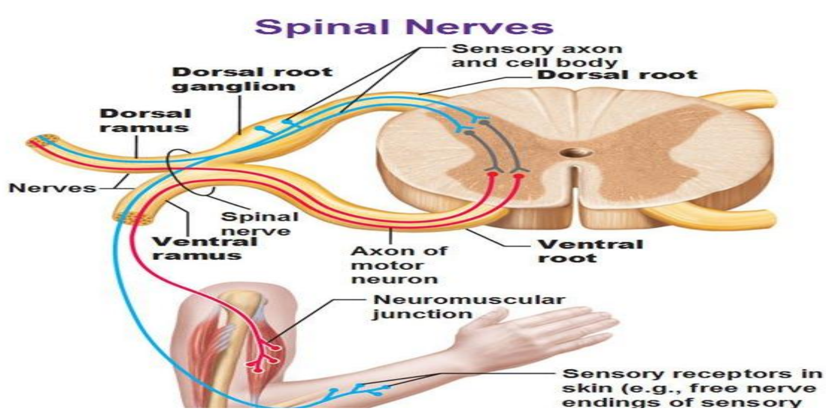
body surface, and loss of sensation in a dermatome can indicate the exact level of spinal cord damage in clinical assessment of injury. Because sensory information from the body is relayed to the CNS through the dorsal roots, the axons originating from dorsal root ganglion cells are classified as primary sensory afferents, and the dorsal root's neurons are the first order (1°) sensory neuron.

Internal Structure of the Spinal Cord

A transverse section of the adult spinal cord shows white matter in the periphery, gray matter inside, and a tiny central canal filled with CSF at its center. Surrounding the canal is a single layer of cells, the ependymal layer. Surrounding the ependymal layer is the gray matter – a region containing cell bodies – shaped like the letter "H" or a "butterfly". The two "wings" of the butterfly are connected across the midline by the dorsal gray commissure and below the white commissure . The shape and size of the gray matter varies according to spinal cord level. At the lower levels, the ratio between gray matter and white matter is greater than in higher levels, mainly because lower levels contain less ascending and descending nerve fiber.

The gray matter mainly contains the cell bodies of neurons and glia and is divided into four main columns: dorsal horn, intermediate column, lateral horn and ventral horn column. The dorsal horn is found at all spinal cord levels and is comprised of sensory nuclei that receive and process incoming somatosensory information. From there, ascending projections emerge to transmit the sensory information to the midbrain and diencephalon. The intermediate column and the lateral horn comprise autonomic neurons innervating visceral and pelvic organs. The ventral horn comprises motor neurons that innervate skeletal muscle.

The root cells are situated in the ventral and lateral gray horns and vary greatly in size. The most prominent features of the root cells are large multipolar elements exceeding 25 μm of their somata. The root cells contribute their axons to the ventral roots of the spinal nerves and are grouped into two major divisions: 1) somatic efferent root neurons, which innervate the skeletal musculature; and 2) the visceral efferent root neurons, also called preganglionic autonomic axons, which send their axons to various autonomic ganglia.



Rexed Laminae
The distribution of cells and fibers within the gray matter of the spinal cord exhibits a pattern of lamination. The cellular pattern of each lamina is composed of various sizes or shapes of neurons (cytoarchitecture) which led Rexed to propose a new classification based on 10 layers (laminae). Laminae I to IV, in general, are concerned with exteroceptive sensation and comprise the dorsal horn, whereas laminae V and VI are concerned primarily with proprioceptive sensations. Lamina VII is

equivalent to the intermediate zone and acts as a relay between muscle spindle to midbrain and cerebellum, and laminae VIII-IX comprise the ventral horn and contain mainly motor neurons. The axons of these neurons innervate mainly skeletal muscle. Lamina X surrounds the central canal and contains neuroglia.

White Matter

Surrounding the gray matter is white matter containing myelinated and unmyelinated nerve fibers. These fibers conduct information up (ascending) or down (descending) the cord. The white matter is divided into the dorsal column , lateral column and ventral (or anterior) column. Three general nerve fiber types can be distinguished in the spinal cord white matter: 1) long ascending nerve fibers originally from the column cells, which make synaptic connections to neurons in various brainstem nuclei, cerebellum and dorsal thalamus, 2) long descending nerve fibers originating from the cerebral cortex and various brainstem nuclei to synapse within the different Rexed layers in the spinal cord gray matter, and 3) shorter nerve fibers interconnecting various spinal cord levels such as the fibers responsible for the coordination of flexor reflexes. Four different terms are often used to describe bundles of axons such as those found in the white matter: funiculus, fasciculus, tract, and pathway.

Spinal Cord Tracts: The spinal cord white matter contains ascending and descending tracts.

Ascending tracts. **The nerve fibers comprise the ascending tract emerge from the first order (1°) neuron located in the dorsal root ganglion (DRG). The ascending tracts transmit sensory information from the sensory receptors to higher levels of the CNS**. The ascending gracile and cuneate fascicule occupying the dorsal column, and sometimes are named the dorsal funiculus. These fibers carry information related to tactile, two point discrimination of simultaneously applied pressure, vibration, position, and movement sense and conscious proprioception.

Descending tracts. **The descending tracts originate from different cortical areas and from brain stem nuclei. The descending pathway carry information associated with maintenance of motor activities such as posture, balance, muscle tone, and visceral and somatic reflex activity.** These include the lateral corticospinal tract and the rubrospinal tracts located in the lateral column (funiculus). These tracts carry information associated with voluntary movement.

Information from the skin, skeletal muscle and joints is relayed to the spinal cord by sensory cells located in the dorsal root ganglia. The dorsal root fibers are the axons originated from the primary sensory dorsal root ganglion cells. Each ascending dorsal root axon, before reaching the spinal cord, bifurcates into ascending and descending branches entering several segments below and above their own segment. The ascending dorsal root fibers and the descending ventral root fibers from and to discrete body areas form a spinal nerve. There are 31 paired spinal nerves.

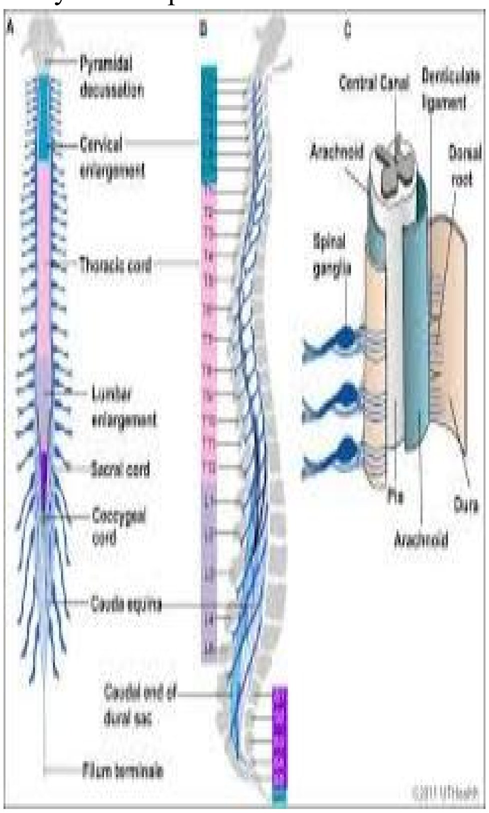
Ventral Root

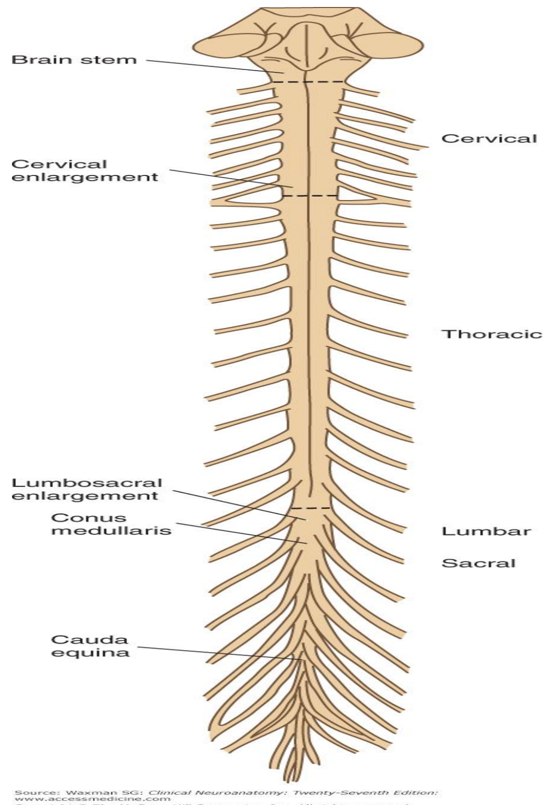
Ventral root fibers are the axons of motor and visceral efferent fibers and emerge from poorly defined ventral lateral sulcus as ventral rootlets. The ventral rootlets from discrete spinal cord section unite and form the ventral root, which contain motor nerve axons from motor and visceral motor neurons.

Functions of spinal card

1. It carries sensory information (sensations) from the body and some from the head to the central nervous system (CNS) via afferent fibers, and it performs the initial processing of this information.

2. Motor neurons in the ventral horn project their axons into the periphery to innervate skeletal and smooth muscles that mediate voluntary and involuntary reflexes.
3. It contains neurons whose descending axons mediate autonomic control for most of the visceral functions.
4. It is of great clinical importance because it is a major site of traumatic injury and the locus for many disease processes





THE SKELETAL SYSTEM

The skeleton system has 206 bones and associated cartilage, tendons and ligaments. The bones are rigid and it gives the body a framework, maintains its shape, and protects vital organs. Bones provide a place for muscles and supporting structures to attach, and with the movable joints it forms a system of levers upon which muscles can act to produce body movements. A joint is a place of union between two or more bones that may be movable or immovable. If the skeleton were without joints, no movement would have taken place and the significance of human body; no more than a stone.

1. **Support**
   The skeleton is the framework of the body; it supports the softer tissues and provides points of attachment for most skeletal muscles.

2. **Protection**
   The skeleton provides mechanical protection for many of the body's internal organs, reducing risk of injury to them.
   For example, cranial bones protect the brain, vertebrae protect the spinal cord, and the ribcage protects the heart and lungs.

3. **Assisting in Movement**
   Skeletal muscles are attached to bones, therefore when the associated muscles contract they cause bones to move.

4. **Storage of Minerals**
   Bone tissues store several minerals, including calcium (Ca) and phosphorus (P). When required, bone releases minerals into the blood - facilitating the balance of minerals in the body.

5. **Production of Blood Cells**
   The red bone marrow inside some larger bones (including, for example, the ....) blood cells are produced.

6. **Storage of Chemical Energy**
   With increasing age some bone marrow changes from 'red bone marrow' to 'yellow bone marrow'. Yellow bone marrow consists mainly of adipose cells, and a few blood cells. It is an important chemical energy reserve.

The **Human Skeleton** can be divided up into to two parts, the *Axial Skeleton* which is the central core of the body and the *appendicular skeleton* which forms the extremities of the arms and legs.

THE AXIAL SKELETON
The Axial skeleton consists of the *skull*, the *hyoid bone*, the *vertebral column* (spine, sacrum and coccyx), the *sternum* and the *ribs*.
Bones of the Axial Skeleton
The Axial Skeleton is the central core of the human body housing and protecting its vital organs. That's about 40% of all the bones in your body. The axial skeleton consists of 80 bones. It includes the skull, vertebral column, ribs and the sternum or chest bone.
29 bones in the head - (8 cranial and 14 facial bones) and then also 7 associated bones (6 auditory ossicles and the Hyoid Bone)
25 bones of the thorax - (the sternum and 24 ribs)
26 bones in the vertebral column (24 vertebrae, the sacrum and the coccyx)

Skull
Skull bones protect the brain and form an entrance to the body. The skull consists of the cranial bones and the facial skeleton.. Its 22 bones feature eight in the cranium, the cranial bones compose the top and back

of the skull and enclose the brain. The facial skeleton, as its name suggests, makes up the face of the skull, fourteen facial bones, including a movable mandible (lower jaw) and a maxilla (upper jaw), with sockets for teeth.

BONE CLASSIFICATION:

The 206 bones that compose the adult skeleton are divided into five categories based on their shapes. Their shapes and their functions are related such that each categorical shape of bone has a distinct function.

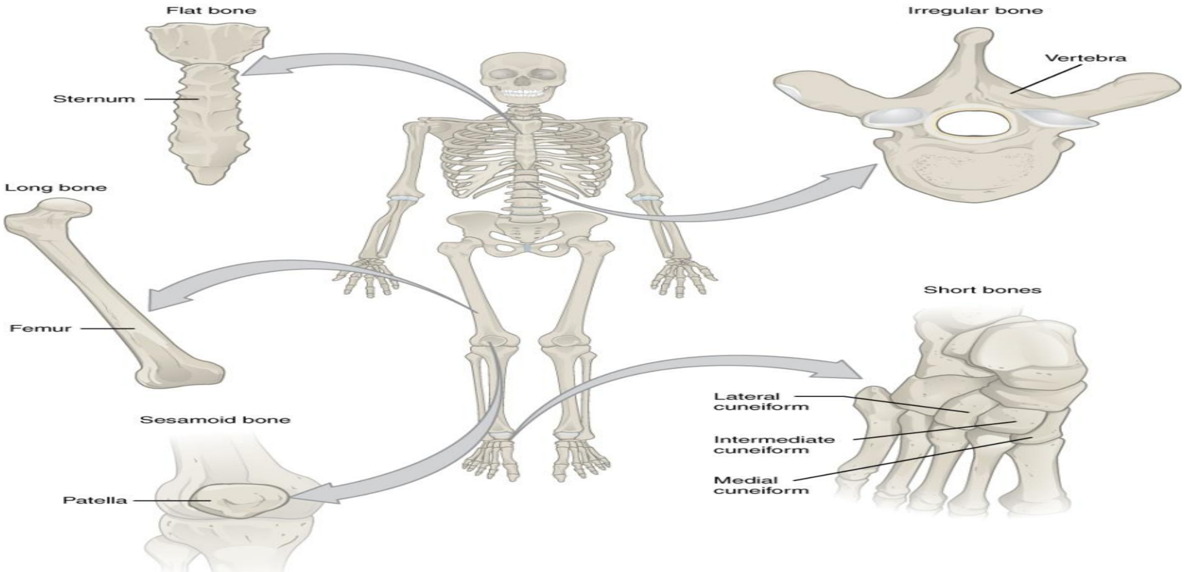


Fig: Bones are classified according to their shape.

Long Bones

A long bone is one that is cylindrical in shape, being longer than it is wide. The term describes the shape of a bone, not its size. Long bones are found in the arms (humerus, ulna, radius) and legs (femur, tibia, fibula), as well as in the fingers (metacarpals, phalanges) and toes (metatarsals, phalanges). Long bones function as levers; they move when contract muscles.

Short Bones

A short bone is one that is cube-like in shape, being approximately equal in length, width, and thickness. The only short bones in the human skeleton are in the carpals of the wrists and the tarsal's of the ankles. Short bones provide stability and support as well as some limited motion.

Flat Bones

Flat bone is typically thin, it is also often curved. Examples include the cranial (skull) bones, the scapulae (shoulder blades), the sternum (breastbone), and the ribs. Flat bones serve as points of attachment for muscles and often protect internal organs.

Irregular Bones

An irregular bone is one that does not have any easily characterized shape and therefore does not fit any other classification. These bones tend to have more complex shapes, like the vertebrae that support the spinal cord and protect it from compressive forces. Many facial bones, particularly the ones containing sinuses, are classified as irregular bones.

Sesamoid Bones

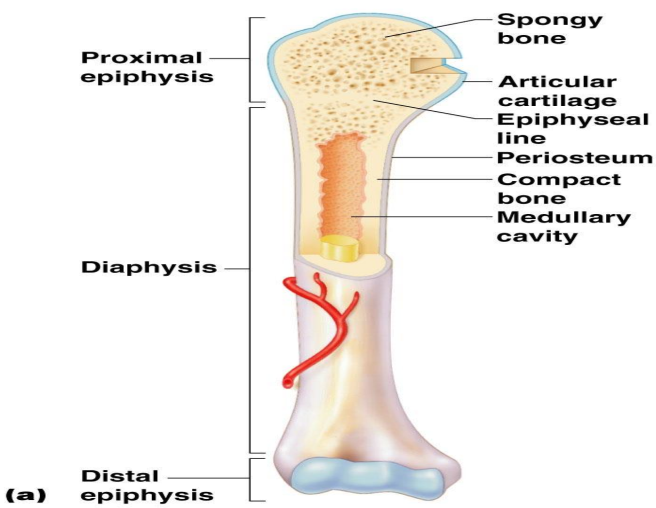
A sesamoid bone is a small, round bone that, as the name suggests, is shaped like a sesame seed. These bones form in tendons (the sheaths of tissue that connect bones to muscles) where a great deal of pressure is generated in a joint. The sesamoid bones protect tendons by helping them overcome compressive forces. Sesamoid bones vary in number and placement from person to person but are typically found in tendons associated with the feet, hands, and knees. The patellae (singular = patella) are the only sesamoid bones found in common with every person.

Structure of long bone:

Elongated bone consisting of a body (diaphysis) and two terminal parts (epiphyses), such as the leg and arm bones (femur, radius, phalanges and others). A typical long bone has a shaft or diaphysis composed of compact bone tissue. Within the shaft is a medullary cavity containing the yellow form of bone marrow, which is high in fat? The irregular epiphysis at either end is made of a less dense, spongy bone tissue containing the blood-forming red bone marrow. A thin layer of cartilage covers the epiphysis and protects the bone surface. Between the diaphysis and the epiphysis at each end of the bone, in a region called the metaphysis, is the growth region or epiphyseal plate. When the bone stops growing in length, this area becomes fully calcified but remains visible as the epiphyseal line. The thin layer of fibrous tissue that covers the outside of the bone, the periosteum, nourishes and protects the bone and also generates new bone cells for growth and repair.

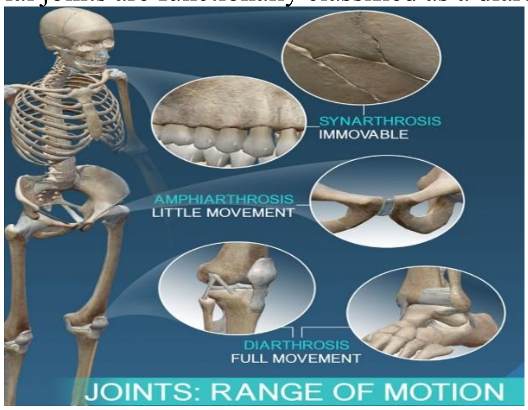
Bone tissue is classified into two types based on structure: compact bone and spongy bone. The parallel arrays of lamellae are organized into different arrangements depending on the bone structure. The lamellae in compact bone form tubular structures, called osteons. The osteons of compact bone are oriented in the direction of the load-bearing axis. The osteons also create a central canal for the passage of blood vessels. Osteocytes in the osteons are embedded in small cavities called lacunae (singular is lacuna), and are oriented around the central canal parallel with the lamellae on the load-bearing axis. The diaphyses of long bones are stronger on their long axis than in any other direction, because of the parallel array of osteons and osteocytes.

The lamellae in spongy bone form a random mesh-like structure of interconnecting plates called trabeculae . Likewise, osteocytes within spongy bone are randomly arranged. The strongest trabeculae in spongy bone are arranged on the bone axis that undergoes the most stress. Flat bones of the skull are primarily made of spongy bone and are good at resisting forces from many directions because of the trabecular arrangement. In types of bone tissue, the mineral components, calcium and phosphate, combine with collagen to provide the compressive and tensile strength of bone. Spongy and compact bone tissues are combined to create bones, which store and release calcium and phosphate into the blood through constant resumption and deposition. Many bones then articulate with each other to form the skeletal system.



FUNCTIONAL CLASSIFICATION OF JOINTS

The functional classification of joints is determined by the amount of mobility found between the adjacent bones. Joints are thus functionally classified as a synarthrosis or immobile joint, an amphiarthrosis or slightly moveable joint, or as a diarthrosis, which is a freely moveable joint. Depending on their location, fibrous joints may be functionally classified as a synarthrosis (immobile joint) or an amphiarthrosis (slightly mobile joint). Cartilaginous joints are also functionally classified as either a synarthrosis or an amphiarthrosis joint. All synovial joints are functionally classified as a diarthrosis joint.



SYNARTHROSIS

Fibrous Joints

Between the articulations of **fibrous joints** is thick connective tissue, which is why most (but not all) fibrous joints are immovable (synarthroses). There are three types of fibrous joints:

(1) **Sutures** are nonmoving joints that connect bones of the skull. These joints have serrated edges that lock together with fibers of connective tissue.

(2) The fibrous articulations between the teeth and the mandible or maxilla are called **gomphoses** and are also immovable.

(3) A **syndesmosis** is a joint in which a ligament connects two bones, allowing for a little movement (amphiarthroses). The distal joint between the tibia and fibula is an example of a syndesmosis.

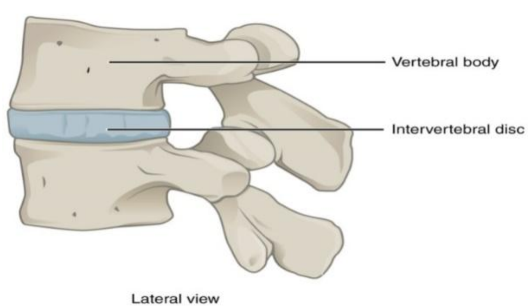
AMPHIARTHROSIS

An amphiarthrosis is a joint that has limited mobility (Partly movable joints). This type of joint is characterized by bones that are connected by hyaline cartilage(fibro cartilage).The ribs that connect to the sternum are an example of an amphiarthrosis joint.

Another example of an amphiarthrosis is the pubic symphysis of the pelvis. This is a cartilaginous joint in which the pubic regions of the right and left hip bones are strongly anchored to each other by fibro cartilage. This joint normally has very little mobility. The strength of the pubic symphysis is important in conferring weight-bearing stability to the pelvis.

Intervertebral Disc

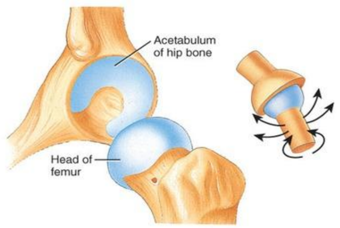
An intervertebral disc unites the bodies of adjacent vertebrae within the vertebral column. Each disc allows for limited movement between the vertebrae and thus functionally forms an amphiarthrosis type of joint. Intervertebral discs are made of fibro cartilage and thereby structurally form a symphysis type of cartilaginous joint.



DIARTHROSIS

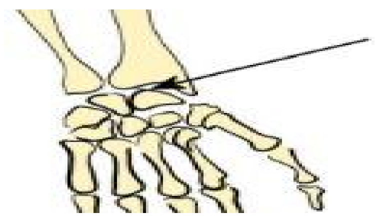
A freely mobile joint is classified as a diarthrosis. These types of joints include all synovial joints of the body, which provide the majority of body movements. Most diarthrotic joints are found in the appendicular skeleton and thus give the limbs a wide range of motion. There are six types of diarthroses joints .These are:

(i)Ball and socket joint: The ball-shaped end of one bone fits into a cup shaped socket on the other bone allowing the widest range of motion including rotation. Examples include the shoulder and hip.



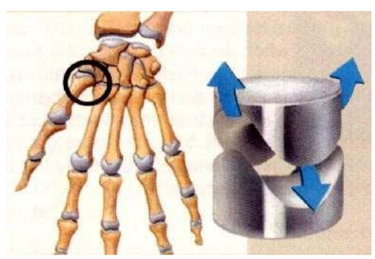
Ball and socket joint

***(ii)Condyloid*:** Oval shaped condoyle fits into elliptical cavity of another allowing angular motion but not rotation. This occurs between the metacarpals (bones in the palm of the hand) and phalanges (fingers) and between the metatarsals (foot bones excluding heel) and phalanges (toes).



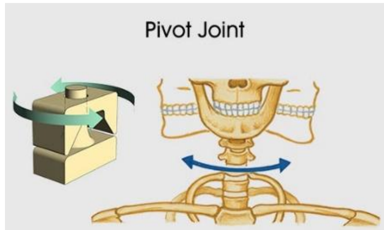
Hinge joint

***(iii)Saddle*:** This type of joint occurs when the touching surfaces of two bones have both concave and convex regions with the shapes of the two bones complementing one other and allowing a wide range of movement. The only saddle joint in the body is in the thumb.

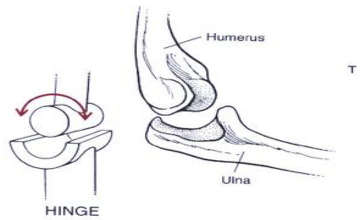


Saddle joint

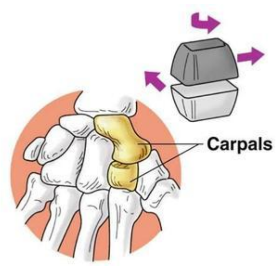
(iv)Pivot: Rounded or conical surfaces of one bone fit into a ring of one or tendon allowing rotation. Example is the joint between the axis and atlas in the neck.



(v) Hinge**:** A convex projection on one bone fits into a concave depression in another permitting only flexion and extension as in the elbow and knee joints.



(vi) Gliding**:** Flat or slightly flat surfaces move against each other allowing sliding or twisting without any circular movement. This happens in the carpals in the wrist and the tarsal's in the ankle.



Gliding joint

The Muscular System

The muscular system is the biological system of humans that produces movement. Muscle is composed of fibers, nerves and connective tissues and account for over 40% of the body weight. The fibers contract to produce tension on the associated tissues or *tendons.* Muscle tissue is enclosed in facia, which in turn is attached to other structures including *ligament*. The muscular system is controlled through the nervous system, although some muscles, like cardiac muscle, can be completely autonomous. Movement is generated through the contraction and relaxation of specific muscles.

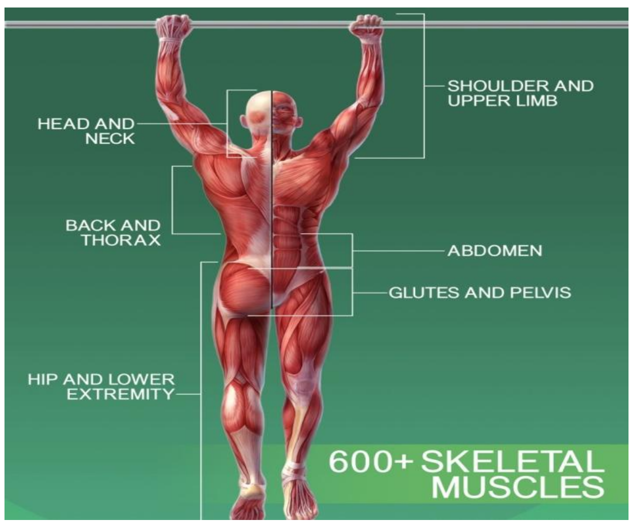
The muscular system is composed of specialized cells called *muscle fibers*. Their predominant function is contractibility. Muscles, where attached to bones or internal organs and blood vessels, are responsible for movement. Nearly all movement in the body is the result of muscle contraction. Muscular system is an important system of human body because without it, life will completely stop. Muscles produce not only those movements that are under the control of our will and that we can see and feel, but also those movements that are responsible for activities like breathing, digestion of food, pumping of blood etc. There are three types of muscles: skeletal, smooth and cardiac.

The *longest muscle* in the human body is the *Sartorius*. It runs from the waist down across the front of thigh to the knee. Its purpose is to flex the hip and knee. The *largest muscle* in the body is the *gluteus maximus* (buttocks muscles). It moves the thighbone away from the body and straightens out the hip joint.

FUNCTIONS OF MUSCLES

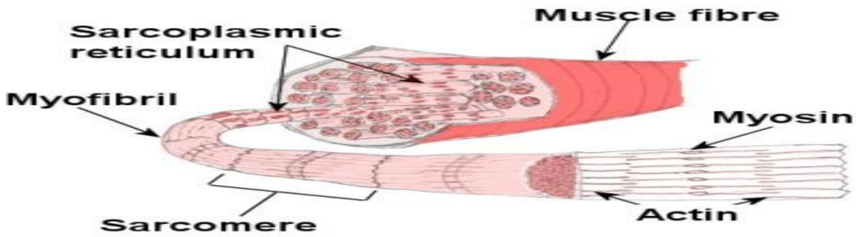
The muscles play a major role in the body, from producing movement, maintaining posture, stabilizing joints, assisting in the circulation of blood in the body and generating heat. Muscles are used in every body movement performed such as heart beat, food being digested and all body movements.

1. Producing Movement: Muscles produce movement by the action of muscles crossing joints between the bones of the skeleton, the muscles are connected to the joints/bones via tendons.
2. Maintaining Posture: The muscles define how well our bones and body are stabilized.
3. Stabilizing Joints: Muscles play a role in the stabilization of the joints. The muscles limit movement in a joint or provide balance the joint for a more stable joint.
4. Generating Heat: Muscles also produce heat within the body when they contract. This heat causes blood vessels in the skin to dilate, which will increase the blood flow to the skin. The heat that the muscles produce is energy with only around 20-25% of this energy being efficient mechanical energy. The other 75-80% of the energy is lost as heat through the skin.
5. Assistance in Blood Circulation: When muscles contract they produce chemicals that act on the arterioles dilating them, regulating the blood flow for the required exercise being carried out.

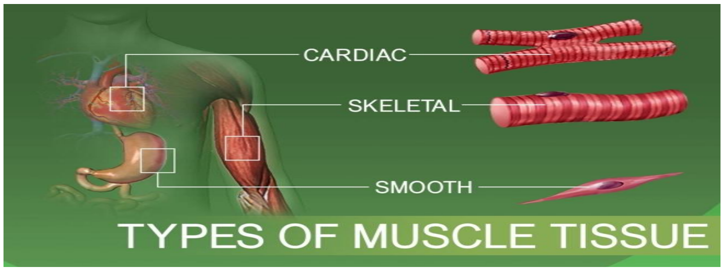


MUSCLE STRUCTURE

The organs of the muscular system are the muscles. The muscle is composed of subunits called fascicles. Fascicles are bundles of individual muscle fibers. Each Fascicule contains anywhere between 10 and 100 muscle fibers. Muscle fibers can range from 10 to 80 micrometers in diameter and may be up to 35cm long. These fibers are held together by fibrous connective tissue. Each of the muscles is made of muscle tissue. Capillaries penetrate this tissue to keep the muscles supplied with oxygen and nutrients that are needed to fuel contraction. Muscle tissue is made up of bundles of muscle cells, which are long, strong threadlike fibers called myofibrils. Sarcomeres are the basic contractile subunit of myofibrils.

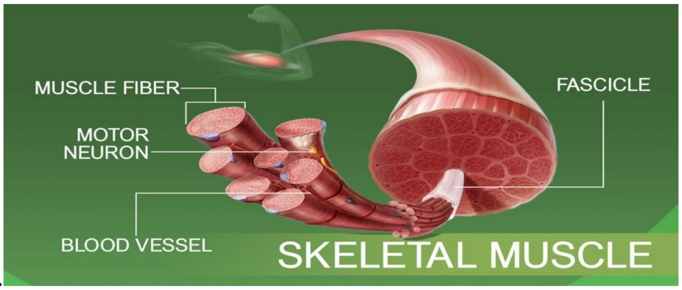


TYPES OF MUSCLE TISSUE: There are three types of muscle tissue - **skeletal, cardiac, and smooth muscle** About half of the body's weight is muscle (40%). In the muscular system, muscle tissue is categorized into three distinct types: **skeletal, cardiac, and smooth**. Each type of muscle tissue in the human body has a unique structure and a specific role. **Skeletal muscle** moves bones and other structures. **Cardiac muscle** contracts the heart to pump blood. **The smooth muscle tissue** that forms organs like the stomach and bladder changes shape to facilitate bodily functions.



1. **SKELETAL MUSCLE (VOLUNTARY MUSCLE)**

The Human Body has over 600 skeletal muscles that move bones and other structures. Skeletal muscles attach to and move bones by contracting and relaxing in response to voluntary messages from the nervous system. It is a voluntary muscle, because a person controls its use, such as in the flexing of an arm or the raising of a foot. Skeletal muscle tissue is composed of long cells called muscle fibers that have a striated appearance. Muscle fibers are organized into bundles supplied by blood vessels and innervated by motor neuron



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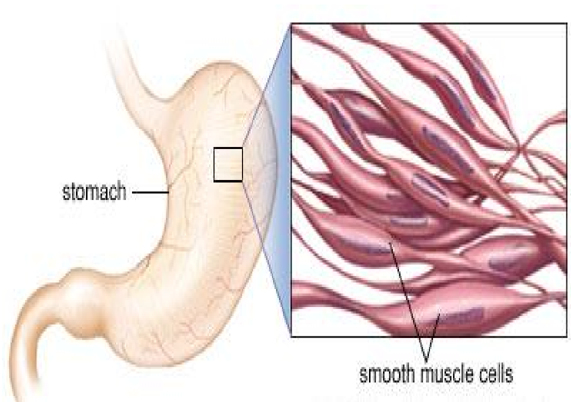
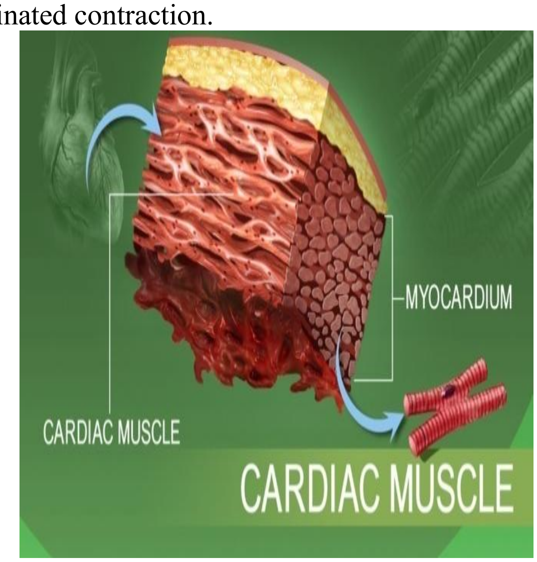
1. **SMOOTH MUSCLE (INVOLUNTARY MUSCLE):**

The walls of many human organs contract and relax automatically. Smooth muscle is found in the walls of hollow organs throughout the body. Smooth muscle contractions are involuntary movements, because a person generally cannot consciously control them. These involuntary movements triggered by impulses that travel through the autonomic nervous system to the smooth muscle tissue. The arrangement of cells within smooth muscle tissue allows for contraction and relaxation with great elasticity. The smooth muscle in the walls of organs like the urinary bladder and the uterus allow those organs to expand and relax as needed. The smooth muscle of the alimentary canal (the digestive tract) facilitates the peristaltic waves that move swallowed food and nutrients. In the eye smooth muscle changes the shape of the lens to bring objects into focus. Artery walls include smooth muscle that relaxes and contracts to move blood through the body.



2. CARDIAC MUSCLE:

A special type of muscle, the cardiac muscle, is found only in the heart. It is involuntary like the smooth muscle. A cardiac muscle contract in response to signals from the cardiac conduction system. The heart wall is composed of three layers. The middle layer, the myocardium, is responsible for the heart's pumping action. Cardiac muscle, found only in the myocardium, contracts in response to signals from the cardiac conduction system to make the heart beat. Cardiac muscle is made from cells called cardiocytes. Like skeletal muscle cells cardiocytes have a striated appearance, but their overall structure is shorter and thicker. Cardiocytes are branched, allowing them to connect with several other cardiocytes, forming a network that facilitates coordinated contraction.



UNIT-IV
DIGESTIVE SYSTEM

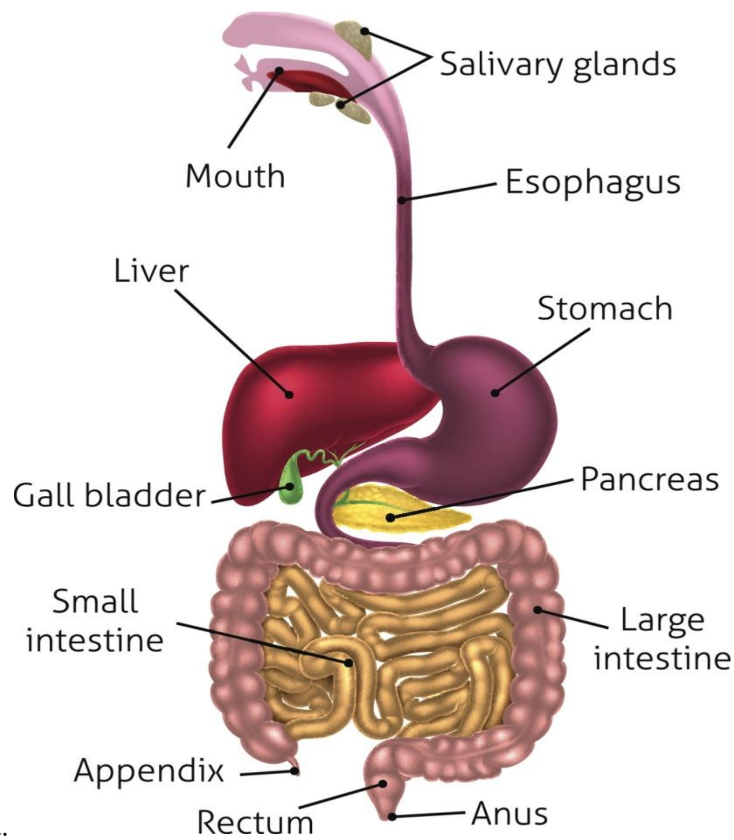
The digestive system is a group of organs working together to convert food into energy and basic nutrients to feed the entire body. Food passes through a long tube inside the body known as the alimentary canal or the gastrointestinal tract (GI tract). The alimentary canal is made up of the **oral cavity,**

pharynx, esophagus, stomach, small intestines, and large intestines. In addition to the alimentary canal, there are several important accessory organs that help your body to digest food but do not have food pass through them. Accessory organs of the digestive system include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.

STRUCTURE: There are four layers of the Gastro-intestinal Tract.

The GI tract contains four layers. The innermost layer is the **mucosa**, underneath this is the **submucosa**, followed by the **muscularis propria** and finally, the outermost layer - the **adventitia**. The structure of these layers varies, in different regions of the digestive system, depending on their function.

Mucosa: A lining **epithelium**, including glandular tissue, an underlying layer of loose connective tissue called the **lamina propria**, which provides vascular support for the epithelium, and often contains mucosal glands. Products of digestion pass into these capillaries. Lymphoid follicles, and plasma cells are also often found here. Finally, a thin double layer of smooth muscle is often present **- the muscularis mucosa** for



local movement of the mucosa.

Submucosa: A loose connective tissue layer, with larger blood vessels, lymphatics, nerves, and can contain mucous secreting glands.

Muscularis propria (externa) smooth muscle layer: There are usually two layers; the inner layer is circular, and the outer layer is longitudinal. These layers of smooth muscle are used for peristalsis (rhythmic waves of contraction), to move food down through the gut.

Adventia layer (or serosa) :Outermost layer of loose connective tissue - covered by the visceral peritoneum.Contains blood vessels, lymphatics and nerves.

PARTS OF DIGESTIVE SYSTEM:

Mouth: Food begins its journey through the digestive system in the mouth, also known as the oral cavity. **Inside** the mouth are many accessory organs that aid in the digestion of food—the tongue, teeth, and salivary glands. Teeth chop food into small pieces, which are moistened by saliva before the tongue and other muscles push the food into the pharynx.

Teeth: The teeth are 32 small, hard organs found along the anterior and lateral edges of the mouth. Each tooth is made of a bone-like substance called dentin and covered in a layer of enamel—the hardest substance in the body. Teeth are living organs and contain blood vessels and nerves under the dentin in a soft region known as the pulp. The teeth are designed for cutting and grinding food into smaller pieces.

Tongue: The tongue is located on the inferior portion of the mouth just posterior and medial to the teeth. It is a small organ made up of several pairs of muscles covered in a thin, bumpy, skin-like layer.The outside of the tongue contains many rough papillae for gripping food as it is moved by the tongue's muscles. The taste buds on the surface of the tongue detect taste molecules in food and connect to nerves in the tongue to send taste information to the brain. The tongue also helps to push food toward the posterior part of the mouth for swallowing.

Salivary Glands: Surrounding the mouth are 3 sets of salivary glands. The salivary glands are accessory organs that produce a watery secretion known as saliva. Saliva helps to moisten food and begins the digestion of carbohydrates. The body also uses saliva to lubricate food as it passes through the mouth, pharynx, and esophagus.

Pharynx: The pharynx, or throat, is a funnel-shaped tube connected to the posterior end of the mouth. The pharynx is responsible for the passing of masses of chewed food from the mouth to the esophagus. The pharynx also plays an important role in the respiratory system, as air from the nasal cavity passes through the pharynx on its way to the larynx and eventually the lungs. Because the pharynx serves two different functions, it contains a flap of tissue known as the epiglottis that acts as a switch to route food to the esophagus and air to the larynx.

Esophagus: It is approximately 20 cm long. The esophagus is a muscular tube connecting the pharynx to the stomach that is part of the upper gastrointestinal tract. It carries swallowed masses of chewed food along its length. At the inferior end of the esophagus is a muscular ring called the lower esophageal sphincter or cardiac sphincter. The function of this sphincter is to close of the end of the esophagus.

Stomach: The stomach is a muscular sac that is located on the left side of the abdominal cavity, just inferior to the diaphragm. In an average person, the stomach is about the size of their two fists placed next to each other. This major organ acts as a storage tank for food so that the body has time to digest large meals properly.The stomach also contains hydrochloric acid and digestive enzymes that continue the digestion of food that began in the mouth.Mixes food with Digestive Juices that contain enzymes to break down carbohydrates,Proteins and Lipids.Acid (HCl) in the stomach Kills Bacteria.Food found in the stomach is called Chyme.

Small Intestine: The small intestine is a long, thin tube about 1 inch in diameter and about 10 feet long that is part of the lower gastrointestinal tract. It is located just inferior to the stomach and takes up most of the space in the abdominal cavity. The entire small intestine is coiled like a hose and the inside surface is full of many ridges and folds called villi. The villi are covered in microvilli which further increases surface area for absorption. These folds are used to maximize the digestion of food and absorption of nutrients.By the time food leaves the small intestine, around 80% of all nutrients have been extracted from the food that entered it.

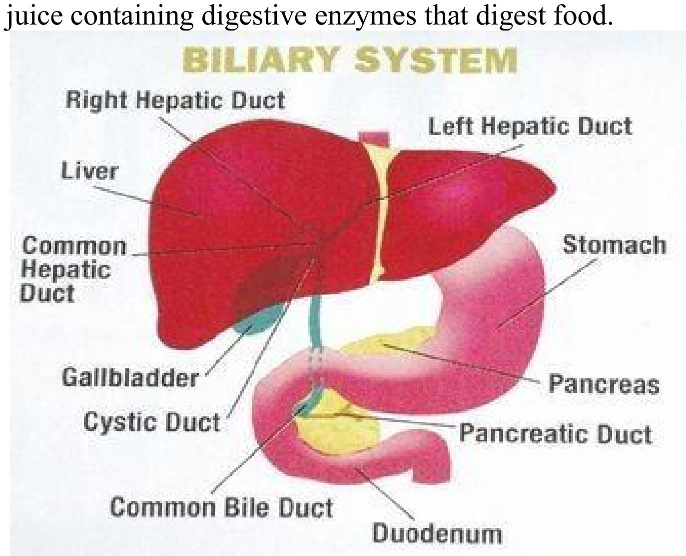
Liver: The liver is a roughly triangular accessory organ of the digestive system located to the right of the stomach, just inferior to the diaphragm and superior to the small intestine. The liver weighs about 3 pounds and is the second largest organ in the body. The liver has many different functions in the body, but the main function of the liver in digestion is the production of bile and its secretion into the small intestine. Which performs many important functions to keep the body pure of toxins and harmful substances. The liver consists of four lobes. Liver produces bile, a substance needed to digest fats by breaking them into smaller molecules so that they can be absorbed more easily in the small intestine. Bile is carried through the liver to the gall bladder by tubes called bile ducts.

Functions of Liver:

- The liver plays an active role in the process of digestion through the production of bile. Bile is a mixture of water, bile salts and the pigment bilirubin. Liver produce bile which is stored in the gallbladder. When food containing fats reaches the duodenum, first part of small intestine, the gallbladder releases bile. Bile is released into the duodenum where it emulsifies large masses of fat. The emulsification of fats by bile turns the large clumps of fat into smaller pieces that have more surface area and are therefore easier for the body to digest.
- Detoxifies the chemicals, drugs and toxins that enter the body
- Converts stored sugar to functional sugar when the body's glucose levels fall below normal

Gall bladder: The gallbladder is a small, pear-shaped organ located just posterior to the liver. The gallbladder is used to store and recycle excess bile from the small intestine so that it can be reused for the digestion of subsequent meals.. It stores bile produced by the liver before it is released into the small intestine to breakdown fat and ammonia into harmless substances. After meals, the gallbladder is empty and flat, like a deflated balloon and before a meal, the gallbladder may be full of bile and about the size of a small pear. Removing the gallbladder causes no observable problems with health or digestion yet there may be a small risk of diarrhea and fat mala.

Pancreas: The pancreas is a large gland located just inferior and posterior to the stomach. It is about 6 inches long and shaped like short, lumpy snake with its "head" connected to the duodenum and its "tail" pointing to the left wall of the abdominal cavity. The pancreas secretes digestive enzymes into the small intestine to complete the chemical digestion of foods. The pancreas, liver and gall bladder are accessory organs for digestion. The pancreas produces enzymes that help digest food, liver produces bile that helps to absorb fat and the gall bladder stores the bile. It is an endocrine gland providing several important hormones insulin and glucagon which circulate in the blood. Groups of specialized cells are present in pancreas called islets of langerhans which control blood sugar levels through secreting glucagon to increase the levels of glucose and insulin to decrease it. It is also a digestive organ producing pancreatic juice containing digestive enzymes that digest food.



Large Intestine: The large intestine is a long, thick tube about 2 ½ inches in diameter and about 5 feet long. It is located just inferior to the stomach and wraps around the superior and lateral border of the small intestine. The large intestine absorbs water and contains many symbiotic bacteria that aid in the breaking down of wastes to extract some small amounts of nutrients. Feces in the large intestine exit the body through the anal canal.The digestive system is responsible for taking whole foods and turning them into energy and nutrients to allow the body to function, grow, and repair it.

PROCESS OF DIGESTION

The six primary processes of the digestive system include:

1. Ingestion of food
2. Secretion of fluids and digestive enzymes
3. Mixing and movement of food
4. Digestion of food into smaller pieces
5. Absorption of nutrients
6. Excretion of wastes

Actions of Digestive (GI) Tract:

1. **Ingestion**-Occurs when material enters via the mouth
2. **Secretion**-Release of water acids, buffers, enzymes & salts by epithelium of GI tract and glandular organs
3. **Mechanical Processing**-Crushing / Shearing – makes material easier to move through the tract
4. **Digestion**-Chemical breakdown of food into small organic compounds for absorption
5. **Absorption**-Movement of organic substrates, electrolytes, vitamins & water across digestive epithelium
6. **Excretion**-Removal of waste products from body fluids.

Ingestion: The first function of the digestive system is ingestion, or the intake of food. The mouth is responsible for this function, as it is the orifice through which all food enters the body. The mouth and stomach are also responsible for the storage of food as it is waiting to be digested. This storage capacity allows the body to eat only a few times each day and to ingest more food than it can process at one time.
Secretion: In the course of a day, the digestive system secretes around 7 liters of fluids. These fluids include saliva, mucus, hydrochloric acid, enzymes, and bile. Saliva moistens dry food and contains salivary amylase, a digestive enzyme that begins the digestion of carbohydrates. Mucus serves as a protective barrier and lubricant inside of
the GI tract. Enzymes are like tiny biochemical machines that disassemble large macromolecules. Hydrochloric acid helps to digest food chemically and protects the body by killing bacteria present in our food. Molecules like proteins, carbohydrates, and lipids into their smaller components. Finally, bile is used to emulsify large masses of lipids into tiny globules for easy digestion.
Mixing and Movement: The digestive system uses 3 main processes to move and mix food:

1. Swallowing: Swallowing is the process of using smooth and skeletal muscles in the mouth, tongue, and pharynx to push food out of the mouth, through the pharynx, and into the esophagus.

2. Peristalsis: Peristalsis is a muscular wave that travels the length of the GI tract, moving partially digested food a short distance down the tract. It takes many waves of peristalsis for food to travel from the esophagus, through the stomach and intestines, and reach the end of the GI tract.

Segmentation: Segmentation occurs only in the small intestine as short segments of intestine contract like hands squeezing a toothpaste tube. Segmentation helps to increase the absorption of nutrients by mixing food and increasing its contact with the walls of the intestine.

Digestion: Digestion is the process of turning large pieces of food into its component chemicals.

Mechanical digestion is the physical breakdown of large pieces of food into smaller pieces. This mode of digestion begins with the chewing of food by the teeth and is continued through the muscular mixing of food by the stomach and intestines. Bile produced by the liver is also used to mechanically break fats into smaller globules. While food is being mechanically digested it is also being chemically digested as larger and more complex molecules are being broken down into smaller molecules that are easier to absorb.

Chemical digestion begins in the mouth with salivary amylase in saliva splitting complex carbohydrates into simple carbohydrates. The enzymes and acid in the stomach continue chemical digestion, but the bulk of chemical digestion takes place in the small intestine. The pancreas secretes an incredibly strong digestive cocktail known as pancreatic juice, which is capable of digesting lipids, carbohydrates, proteins and nucleic acids. By the time food has left the duodenum, it has been reduced to its chemical building blocks—fatty acids, amino acids, monosaccharide's, and nucleotides. The main enzyme-producing structures of the human digestive system are the salivary glands, stomach, pancreas, liver and small intestine.

Absorption: Once food has been reduced to its building blocks, it is ready for the body to absorb. Absorption begins in the stomach with simple molecules like water and alcohol being absorbed directly into the bloodstream. Most absorption takes place in the walls of the small intestine, which are densely folded to maximize the surface area in contact with digested food. Small blood and lymphatic vessels in the intestinal wall pick up the molecules and carry them to the rest of the body. The large intestine is also involved in the absorption of water and vitamins B and K before feces leave the body.

Excretion: The final function of the digestive system is the excretion of waste in a process known as defecation. Defecation removes indigestible substances from the body so that they do not accumulate inside the gut. The timing of defecation is controlled voluntarily by the conscious part of the brain, but must be accomplished on a regular basis to prevent a backup of indigestible mate.

EXCRETORY SYSTEM

Excretion is the removal of wastes from the body. In humans, excretion mainly occurs through excretory or urinary system consisting of a pair of kidneys, a pair of urethras, urinary bladder and urethra. As a normal consequence of being alive, every cell in the body produces metabolic wastes includes excess water and salts, carbon dioxide and urea. Urea is a toxic compound that is produced when acids are used for energy. The process by which these metabolic wastes are removed from the body is called excretion.

The job of the excretory system is to remove various waste produced by the body. The removal is known as excretion. It is important for the body to remove these various waste, also known as toxic, because toxic build up can lead to severe death. About sixty percent of your body contains water. A portion of the water is in the tissues and cells. The water contains salt. the salt needs to be kept at the right concentrations. If there is little salt the body feeds it more, if there is too much salt the body gets rid of the salt not needed. This is the task of the two Kidneys.

Function of the urinary system:

The urinary system removes certain salts and nitrogenous wastes.

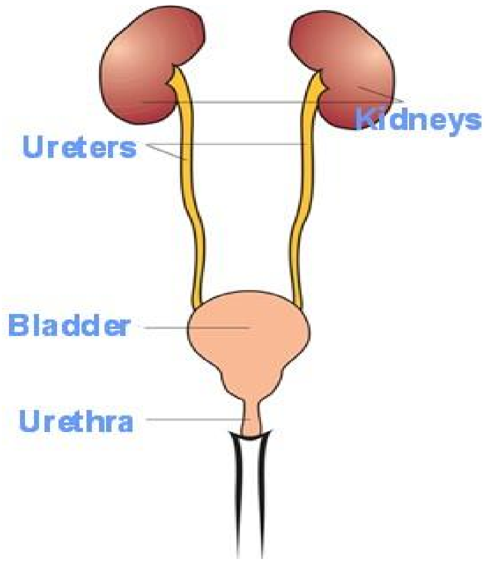
Also helps maintain the normal concentrations of water and electrolytes within body fluids.

Regulates the pH and volume of body fluids.

Helps control red blood cell production and blood

Pressure. **KIDNEYS**:

Kidneys are the bean shaped organs present on either side of the vertebral column in the abdominal cavity. Kidneys remove nitrogenous wastes such as urea, salts and excess water and excrete them in the form of urine. This is done with the help of millions of nephrons present in the kidney. Nephron is the main functional unit of the kidney which is responsible for filtering the blood and removing the waste substances as urine.



Three distinct regions of Kidney

Renal cortex

The **renal cortex** is the outer portion of the **kidney** between the **renal** capsule and the **renal** medulla. In the adult, it forms a continuous smooth outer zone with a number of projections (**cortical** columns) that extend down between the pyramids. The **renal cortex** is the part of the **kidney** where ultra filtration occurs.

Renal medulla

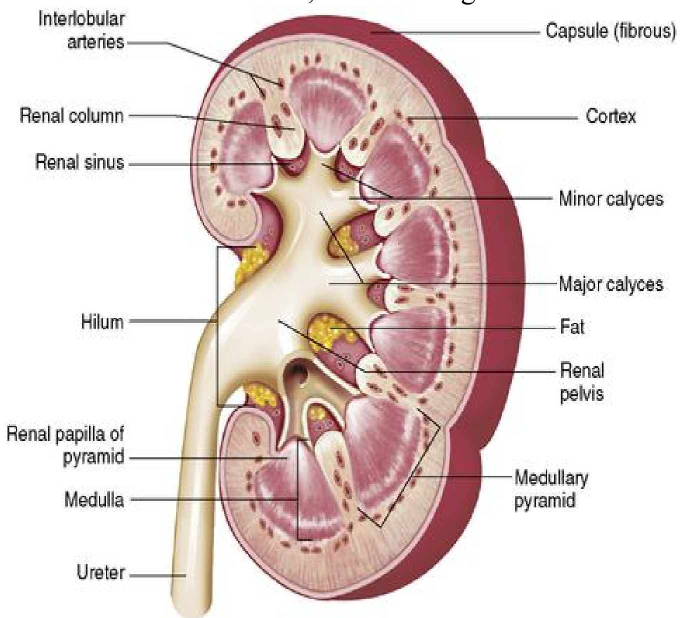
Renal medulla is a darker reddish-brown area. The medulla has many basically triangular regions with a striped appearance, the **Medullary pyramids.** The broader base of each pyramid faces toward the cortex; its tip, the apex, points toward the inner region of the kidney. The pyramids are separated by extensions of cortex like tissue, the renal columns.

Renal pelvis

Medial to the hilus is flat, basin like cavity, the renal pelvis. The pelvis is continuous with the ureter leaving the hilus. Extensions of the pelvis, calyces, form cup-shaped areas that enclose the tips of the pyramids. The calyces collect urine, which continuously drains from the tips of the pyramids into the renal pelvis. Urine then flows from the pelvis into the ureter, which transports it to the bladder for temporary storage.

BLOOD SUPPLY

The arterial supply of each kidney is the renal artery. As the renal artery approaches the hilus, it divides into segmental arteries. Once inside the pelvis, the segmental arteries break up into lobar arteries, each of which gives off several branches called inter lobar arteries, which travel through the renal columns to reach the cortex. At the cortex-medulla junction, inter lobar arteries give off the arcuate arteries, which curve over the medullary pyramids. Small interlobular arteries then branch off the arcuate arteries and run outward to supply the cortical tissue. Venous blood draining from the kidney flows through veins that trace the pathway of the arterial supply but in a reverse direction ± interlobular veins to arcuate veins to inter lobar veins to the renal vein, which emerges from the kidney hilus. (There are no lobar or segmental



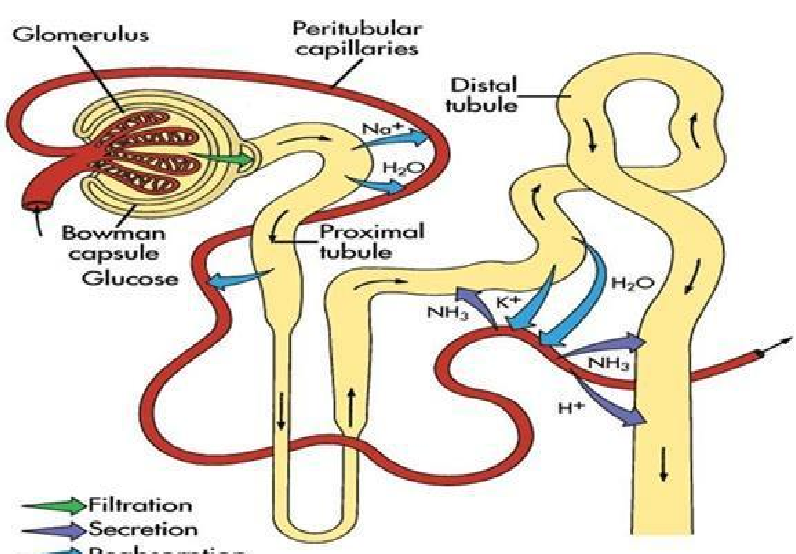
veins.)

Structure of the Nephron:

Bowman's capsule: Bowman's capsule (or the **Bowman capsule**, **capsula glomeruli**, or **glomerular capsule**) is a cup-like sack at the beginning of the tubular component of a nephron in the kidney that performs the first step in the filtration of blood to form urine. It is the first part of nephron which is a network of small blood vessels called capillaries where filtering of blood occurs. Glomerulus is surrounded by a cup shaped structure called Bowman's capsule which collects the filtered fluid called glomerular filtrate.

The nephron begins with Bowman's capsules, which surrounds the glomerulus and collects the filtered fluid called glomerular filtrate and further processed along the nephron to form urine. Glomerulus is a ball of capillaries arising from an afferent arteriole of the renal artery where filtering of blood occurs. Leaving the glomerulus is an efferent arteriole, which forms the peritubular capillaries, where reabsorption takes place. These spread over the nephron to later form a venule that joins others to make up the renal vein. The Bowman's capsule is named after Sir William Bowman. Items filtered out of the blood into the Bowman's capsule are Glucose (but must be returned to the blood by active transport at the loop of Henle), urea, salts and water. Items that remain in the blood are RBCs, WBCs, Platelets and large chemicals like hormones.

Bowman's capsule leads to the proximal convoluted tubule, the loop of Henle, and the distal convoluted tubule, which joins a collecting duct. The afferent arteriole also connects with the distal convoluted tubule, forming the juxtaglomerular complex**.**



Renal tubule -It is a long narrow tube where the filtered fluid from the Bowman's capsule is processed and converted into urine. Renal tubule is divided into proximal tubule, henle's loop and distal tubule.

The proximal tubule- It is the first part of the tubule which is coiled or folded. Hence, called as proximal convoluted tubule. Glomerular filtrate from Bowman's capsule passes into proximal convoluted tubule where useful substances are reabsorbed into the blood.

The loop of Henle- After reabsorption in proximal convoluted tubule, the fluid enters into the U-shaped henle's loop consisting of descending limb and ascending limb.

The distal tubule- This part is also coiled. Hence, called distal convoluted tubule which receives the fluid from henle's loop.

Collecting ducts- The distal convoluting tubules of many individual nephrons converge into a single collecting duct which passes the fluid into ureter as urine**.**

PHYSIOLOGY OF FORMATION OF URINE

Kidneys are the organs which form urine which is composed of water, electrolytes and various waste products that are filtered out of the blood.

Urine formation includes three processes- Glomerular filtration, Selective reabsorption and tubular secretion

Glomerular filtration: As blood passes through the glomeruli, much of its fluid containing both useful substances and dissolved waste materials come out of the blood through the membranes where it is filtered and then flows into Bowman's capsule. This process is called glomerular filtration and the filtered fluid is called glomerular filtrate.

Selective reabsorption: Reabsorption is the movement of filtered substances out of the renal tubules back into the blood. Substances reabsorbed are water, glucose, salts like sodium, chloride, calcium, potassium, bi carbonates, sulphates, phosphates etc. Reabsorption begins in the proximal convoluted tubules, continues in loop of henle, distal convoluted tubules and collecting tubules. This is necessary to maintain fluid and electrolyte balance and to maintain the pH of the blood.

Tubular secretion: Secretion is the process by which substances move into the distal convoluted tubules from the blood. Secretion is the reverse of reabsorption where reabsorption moves substances out of the tubules into the blood and secretion moves substances out of the blood into the tubules. Substances which are moved from blood into the tubules are hydrogen, sodium and potassium ions, urea, uric acid and creatinine which mix with water and are passed in the urine.

The remaining wastes, now called urine are transported out through the collecting tubule to an area known as the renal pelvis (a collecting area) where the urine then passes into the ureter.

II. URETERS

The ureters are two tubes 10-12 inches in length and one half inch in diameter. They are composed of smooth muscle tissue, and they extend from the renal pelvis of each kidney to the posterior portion of the urinary bladder. Their function is to conduct urine from the kidneys to the urinary bladder. At the junction where the ureters join the bladder, a valve-like structure prevents the urine from flowing back to the ureters.

III.URINARY BLADDER

The bladder is a muscular bag-like organ that is located in the front center of the pelvic cavity. Its purpose is to store and expel urine. Normal storage capacity is about 250 ml., although it can hold up to 1000 ml. When the bladder fills, nerves in the muscular wall are stimulated, thus the urge to urinate. Micturition and to void are terms that also mean urination.

IV.URETHRA

The urethra is a tube about l to 1.5 inches in length in the female, which extends from the bladder to the outside of the body through an opening called the urinary ureatus. The urethra of the male is an S-shaped tube between 8 to 10 inches in length. The function of urethra is to transport urine to the outside.

Micturition:

Micturition is also known as urination. It is the process of disposing urine from the urinary bladder through the urethra to the outside of the body. The process of urination is voluntary in healthy adults whereas in infants and individuals with neurological injury, it is involuntary.

THE ENDOCRINE SYSTEM

The endocrine system is a collection of glands that produce hormones that control the bodily functions of growth and development, metabolism, tissue function, sexual function and reproduction, regulation of mood and energy levels. Glands are the collection of cells that produce substances called hormones that act as chemical messengers in the body to move information and instructions from one group of cells to other.

Endocrine glands: Endocrine glands are the glands of the endocrine system that secrete their products, hormones directly into the blood rather than through a duct.

The major endocrine glands in humans are

- Hypothalamus
- Pituitary gland
- Thyroid gland
- Parathyroid gland
- Adrenal gland
- Pineal gland
- Thymus gland
- Reproductive glands-testes and ovaries.

Hypothalamus:

The **hypothalamus** is a part of the brain located superior and anterior to the brain stem and inferior to the thalamus. It serves many different functions in the nervous system and is also responsible for the direct controlof the endocrine system through the pituitary gland. The hypothalamus secrete the following hormones Thyrotropin-releasing hormone (TRH)

Growth hormone-releasing hormone (GHRH)
Growth hormone-inhibiting hormone (GHIH)
Gonadotropin-releasing hormone (GnRH)
Corticotropin-releasing hormone (CRH)
Oxytocin
Antidiuretic hormone (ADH)

All of the releasing and inhibiting hormones affect the function of the anterior pituitary gland.TRH stimulates the anterior pituitary gland to release thyroid-stimulating hormone. GHRH and GHIH work to regulate the release of growth hormone—GHRH stimulates growth hormone release, GHIH inhibits its release. GnRH stimulates the release of follicle stimulating hormone.CRH stimulates the release of adrenocorticotropic hormone.The last two hormones—oxytocin and antidiuretic hormone are produced by the hypothalamus and transported to the posterior pituitary where they are stored and later released.

Pituitary gland:

It is a small pea sized structure located at the base of the brain. It is called as the master gland of the endocrine system as it controls the functions of the other endocrine glands.Pituitary gland secretes a number of hormones which include

Growth hormone (HGH)-stimulates growth and reproduction.
Thyroid stimulating hormone (TSH)-stimulates thyroid gland.
Follicle stimulating hormone (FSH)-stimulates ovaries and testes to produce ova and sperms.
Luteinizing hormone (LH)-stimulates ovaries and testes to produce reproductive hormones estrogens in females and testosterone in males.
Prolactin-stimulates milk production after child birth.
Oxytoxin-triggers uterine contractions during child birth and stimulate milk production.

Thyroid gland:

It is a butterfly shaped gland located in the neck.The gland produces two iodine containing hormones T3 (tri iodothyroxine) and T4 (thyroxine) to regulate growth and development through the rate of metabolism.Thyroid hormones affect many vital body functions like immune strength, hormonal balance, quality of skin and hair, fertility, mood elevation and emotional balance.Over production of thyroid hormones leads to hyperthyroidism causing Grave's disease and insufficient thyroid hormone production leads to hypothyroidism due to iodine deficiency.An enlarged thyroid gland is called goiter which can be due to hypo or hyperthyroidism.

Parathyroid Glands:

The parathyroid glands are the masses of glandular tissue found on the posterior side of the thyroid gland. The parathyroid glands produce the hormone parathyroid hormone (PTH), which is involved in calcium ion homeostasis. PTH is released from the parathyroid glands when calcium ion levels in the blood drop below a set point.

Adrenal glands:

These are the pair of small, triangular glands located on the top of the kidneys. These glands release the following hormones:

Glucocorticoids, which regulate metabolism

Mineralocorticoids, which regulate the concentration of mineral ions

Androgens such as testosterone which lead to male secondary sex characteristics

Epinephrine or adrenaline and non-epinephrine or non-adrenaline regulates the heart rate, breathing rate and blood pressure

Pineal gland:

The pineal gland is a small pinecone-shaped mass of glandular tissue found just posterior to the thalamus of the brain. The pineal gland produces the hormone melatonin that helps to regulate the human sleep-wake cycle known as the circadian rhythm. The activity of the pineal gland is inhibited by stimulation from the photoreceptors of the retina. This light sensitivity causes melatonin to be produced only in low light or darkness. Increased melatonin production causes humans to feel drowsy at night time when the pineal gland is active.

Thymus:

The thymus is a soft, triangular-shaped organ found in the chest posterior to the sternum. The thymus produces hormones called thymosins that help to train and develop T-lymphocytes during fetal development and childhood. The T-lymphocytes produced in the thymus go on to protect the body from pathogens throughout a person's entire life.The thymus becomes inactive during puberty and is slowly replaced by adipose tissue throughout a person's life.

Pancreas:

It is a glandular organ in the digestive system located beneath the stomach. It is an endocrine gland providing several important hormones insulin and glucagon which circulate in the blood. Groups of specialized cells are present in pancreas called islets of langerhans which control blood sugar levels through secreting glucagon to increase the levels of glucose and insulin to decrease it.

UNIT-V

Acid Base Balance and Fluid and Electrolyte Regulation

People are watery creatures. More precisely, we are salt-watery creatures, though not as salty as the oceans. Water, the fluid medium of the human body, makes up 55% to 70% of the total body weight. Infants are more watery than adults, and adult men are more watery than women.

Water compartments:

Most of the water of the body, about two-thirds of the total water volume, is found within individual cells and is called **intracellular fluid** (ICF). The remaining third is called **extracellular fluid** (ECF) and includes blood plasma, lymph, tissue fluid, and the specialized fluids such as cerebrospinal fluid, synovial fluid, aqueous humor, and serous fluid. Water constantly moves from one fluid site in the body to another by the processes of filtration and **osmosis**. These fluid sites are called **water compartments.** The chambers of the heart and all of the blood vessels form one compartment and the water within are called plasma. By the process of filtration in capillaries, some plasma is forced out into tissue spaces (another compartment) and is then called tissue fluid. When tissue fluid enters cells by the process of osmosis, it has moved to still another compartment and is called intracellular fluid. The tissue fluid that enters lymph capillaries is in yet another compartment and is called lymph. The other process (besides filtration) by which water moves from one compartment to another is osmosis, which is the diffusion of water through a semi-permeable membrane. Water will move through cell membranes from the area of its greater concentration to the area of its lesser concentration.

Water intake and output

Most of the water the body requires comes from the ingestion of liquids; this amount averages 1600 mL per day. The food we eat also contains water. Even foods we think of as somewhat dry, such as bread, contain significant amounts of water. The daily water total from food averages 700 mL. The last source of water, about 200 mL per day, is the metabolic water that is a product of cell respiration. The total intake of water per day, therefore, is about 2500 mL, or 2.5 liters. Most of the water lost from the body is in the form o urine produced by the kidneys; this averages 1500 mL per day. About 500 mL per day is lost in the form of sweat, another 300 mL per day is in the form of water vapor in exhaled air, and another 200 mL per day is lost in feces the total output of water is thus about 2500 mL per day. Naturally, any increase in water output must be compensated for by an increase in intake.

Regulation of water intake and output

The hypothalamus in the brain contains **osmoreceptors** that detect changes in the osmolarity of body fluids. **Osmolarity** is the concentration of dissolved materials present in a fluid. Dehydration raises the osmolarity of the blood; that is, there is less water in proportion to the amount of dissolved materials. Another way to express this is to simply say that the blood is now a more concentrated solution. When dehydrated, we feel the sensation of thirst, characterized by dryness of the mouth and throat, as less saliva is produced. Thirst is an uncomfortable sensation, and we drink fluids to relieve it. The water we drink is readily absorbed by the mucosa of the stomach and small intestine and has the effect of decreasing the osmolarity of the blood.

The hypothalamus is also involved in water balance because of its production of antidiuretic hormone (ADH), which is stored in the posterior pituitary gland. In a state of dehydration, the hypothalamus stimulates the release of ADH from the posterior pituitary. Antidiuretic hormone then increases the reabsorption of water by the kidney tubules. Water is returned to the blood to preserve blood volume, and urinary output decreases. The hormone aldosterone, from the adrenal cortex, also helps regulate water output. Aldosterone increases the reabsorption of Na+ ions by the kidney tubules, and water from the renal filtrate follows the Na+ ions back to the blood. Aldosterone is secreted when the Na+ ion concentration of the blood decreases or whenever there is a significant decrease in blood pressure (the rennin-angiotensin mechanism). Several other factors may also contribute to water loss.

A less common occurrence is over hydration, the presence of too much water in the body. This may happen following overconsumption of fluids. The osmolarity of the blood decreases, and there is too much water in proportion to electrolytes (or the blood is too dilute). This condition may become symptomatic and is called water intoxication. Symptoms are dizziness, abdominal cramps, nausea, and lethargy. Convulsions are possible in severe cases, and fluids must be restricted until the kidneys can excrete the excess water. A hormone that will to that is Atrial Natriuretic Peptide (ANP), which is secreted by the atria when blood volume or blood pressure increases. ANP then decreases the reabsorption of Na+ ions by the kidneys, which increases urinary output of sodium and water.

ELECTROLYTES

Electrolytes are chemicals that dissolve in water and dissociate into their positive and negative ions. Most electrolytes are the inorganic salts, acids, and bases found in all body fluids. Most organic compounds are non-electrolytes; that is, they do not ionize when in solution. Glucose, for example, dissolves in water but does not ionize; it remains as intact glucose molecules. Positive ions are called **cations**. Examples are Na+, K+, Ca+2, Mg+2, Fe+2, and H+. Negative ions are called **anions**, and examples are Cl–, HCO3–, SO4–2 (sulfate), HPO4–2 (phosphate), and protein anion Electrolytes help create the osmolarity of body fluids and, therefore, help regulate the osmosis of water between water compartments. Some electrolytes are involved in acid–base regulatory mechanisms, or they are part of structural components of tissues or part of enzymes. Some electrolytes can be stored in the body: calcium, phosphorus, and magnesium in bones and iron and copper in the liver.

Electrolytes in body fluids

The three principal fluids in the body are intracellular fluid and the extracellular fluids plasma and tissue fluid.

The major differences may be summarized as follows. In intracellular fluid, the most abundant cation is K+, the most abundant anion is HPO4–2, and protein anions are also abundant. In both tissue fluid and plasma, the most abundant cation is Na+, and the most abundant anion is Cl–. Protein anions form a significant part of plasma but not of tissue fluid.

Intake, output, and regulation

Electrolytes are part of the food and beverages we consume, are absorbed by the gastrointestinal tract into the blood, and become part of body fluids. Hormones regulate the ECF concentrations of some electrolytes. Aldosterone increases the reabsorption of Na+ ions and the excretion of K+ ions by the kidneys. The blood sodium level is thereby raised, and the blood potassium level is lowered. ANP increases the excretion of Na+ ions by the kidneys and lowers the blood sodium level. Parathyroid hormone (PTH) and calcitonin regulate the blood levels of calcium and phosphate. PTH increases the reabsorption of these minerals from bones and increases their absorption from food in the small intestine (vitamin D is also necessary). Calcitonin promotes the removal of calcium and phosphate from the blood to form bone matrix. Electrolytes are lost in urine, sweat, and feces. Urine contains the electrolytes that are not reabsorbed by the kidney tubules; the major one of these is Na+ ions. Other electrolytes are present in urine when their concentrations in the blood exceed the body's need for them. The most abundant electrolytes in sweat are Na+ ions and Cl– ions. Electrolytes lost in feces are those that are not absorbed in either the small intestine or colon.

ELECTROLYTE	PLASMA LEVEL	ICF LEVEL	FUNCTIONS

Sodium (Na^+)	136–142	**10**	Creates much of the osmotic pressure of ECF; the most abundant cation in ECF ■ Essential for electrical activity of neurons
Potassium (K^+)	3.8–5.0	**141**	Creates much of the osmotic pressure in ICF; the most abundant cation in ICF ■ Essential for electrical activity of neurons and muscle cells
Calcium (Ca^{+2})	4.6–5.5	**1**	Most (98%) is found in bones and teeth ■ Maintains normal excitability of neurons and muscle cells ■ Essential for blood clotting
Chloride (Cl^-)	95–103	**4**	Most abundant anion in ECF; diffuses easily into and out of cells; helps regulate osmotic pressure ■ Part of HCl in gastric juice
Bicarbonate (HCO_3^-)	28	**10**	Part of the bicarbonate buffer system

ACID–BASE BALANCE

An **acid** may be defined as a substance that increases the concentration of hydrogen ions (H^+) in a water solution. A **base** is a substance that decreases the concentration of H^+ ions, which, in the case of water, has the same effect as increasing the concentration of hydroxyl ions (OH^-). The acidity or alkalinity (basicity) of a solution is measured on a scale of values called **pH** (parts hydrogen). The values on the **pH scale** range from 0 to 14, with 0 indicating the most acidic level and 14 the most alkaline. A solution with a pH of 7 is neutral because itcontains the same number of H^+ ions and OH^- ions. Pure water has a pH of 7. A solution with a higher concentration of H^+ ions than OH^- ions is an acidic solution with a pH below 7. An alkaline solution, therefore, has a higher concentration of OH^- ions than H^+ ions and has a pH above 7.

The cells and internal fluids of the human body have a pH close to neutral.The normal pH range of blood is 7.35 to 7.45. The pH of tissue fluid is similar but can vary slightly above or below this range. The intracellular fluid has a pH range of 6.8 to 7.0. Notice that these ranges of pH are quite narrow; they must be maintained in order for enzymatic reactions and other processes to proceed normally. Maintenance of acid–base homeostasis is accomplished by the buffer systems in body fluids, the rate and depth of respiration, and the kidneys.

BUFFER SYSTEMS

The purpose of a **buffer system** is to prevent drastic changes in the pH of body fluids by chemically reacting with strong acids or bases that would otherwise greatly change the pH. A buffer system consists of a weak acid and a weak base. These molecules react with strong acids or bases that may be produced and change them to substances that do not have a great effect on pH.

Bicarbonate Buffer System:

The two components of this buffer system are carbonic acid (H_2CO_3), a weak acid, and sodium bicarbonate ($NaHCO_3$), a weak base. Each of these molecules participates in a specific type of reaction. If a potential pH change is created by a strong acid, the following reaction takes place:

$$\underset{\text{(strong acid)}}{HCl} + NaHCO_3 \rightarrow NaCl + \underset{\text{(weak acid)}}{H_2CO_3}$$

The strong acid has reacted with the sodium bicarbonate to produce a salt (NaCl) that has no effect on pH and a weak acid that has little effect on pH. If a potential pH change is created by a strong base, the following reaction takes place:

$$NaOH + H_2CO_3 \rightarrow H_2O + NaHCO_3$$

(strong base) (weak base)

The strong base has reacted with the carbonic acid to produce water, which has no effect on pH, and a weak base that has little effect on pH. The bicarbonate buffer system is important in both the blood and tissue fluid. During normal metabolism, these fluids tend to become more acidic, so more sodium bicarbonate than carbonic acid is needed. The usual ratio of these molecules to each other is about 20:1 ($NaHCO_3$ to H_2CO_3).

Phosphate Buffer System

The two components of this buffer system are sodium dihydrogen phosphate (NaH_2PO_4), a weak acid, and sodium monohydrogen phosphate (Na_2HPO_4), a weak base. Let us use specific reactions to show how this buffer system works. If a potential pH change is created by a strong acid, the following reaction takes place:

$$HCl + Na_2HPO_4 \rightarrow NaCl + NaH_2PO_4$$

(strong acid) (weak acid)

The strong acid has reacted with the sodium monohydrogen phosphate to produce a salt that has no effect pH and a weak acid that has little effect on pH. If a potential pH change is created by a strong base, the following reaction takes place: $NaOH + NaH_2PO_4 \rightarrow H_2O + Na_2HPO_4$

(strong base) (weak base)

The strong base has reacted with the sodium dihydrogen phosphate to form water, which has no effect on pH, and a weak base that has little effect on pH The phosphate buffer system is important in the regulation of the pH of the blood by the kidneys .The cells of the kidney tubules can remove excess hydrogen ions by forming NaH_2PO_4, which is excreted in urine. The retained Na^+ ions are returned to the blood in the peritubular capillaries, along with bicarbonate ions. These are new bicarbonate ions that the renal cells synthesize from carbon dioxide and water.

Protein Buffer System:

This buffer system is the most important one in the intracellular fluid. Hemoglobin buffers the hydrogen ions formed during CO_2 transport. The amino acids that make up proteins each have a **carboxyl group** (COOH) and an **amine** (or amino) **group** (NH_2) and may act as either acids or bases. The carboxyl group may act as an acid because it can donate a hydrogen ion (H^+) to the fluid to counteract increasing alkalinity: The amine group may act as a base because it can pick up an excess hydrogen ion from the fluid to counteract increasing acidity: The buffer systems react within a fraction of a second to prevent drastic pH changes. However, they have the least capacity to prevent great changes in pH because a limited number of molecules of these buffers are present in body fluids. When an ongoing cause is disrupting the normal pH, the respiratory and renal mechanisms will also be needed.

RESPIRATORY MECHANISMS:

The respiratory system affects pH because it regulates the amount of CO_2 present in body fluids. As you know, the respiratory system may be the cause of a pH imbalance or may help correct a pH imbalance from some other cause.

Respiratory Acidosis and Alkalosis

Respiratory acidosis results from the failure of the lungs to eliminate Co2 as fast as it is produced. It is caused by anything that decreases the rate or efficiency of respiration. Severe pulmonary diseases are possible causes of respiratory acidosis. When CO_2 cannot be exhaled as fast as it is formed during cell respiration, excess CO_2 results in the formation of excess H^+ ions, as shown in this reaction:

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$$

The excess H^+ ions lower the pH of body fluids.

Respiratory alkalosis is causwd by low co2 levels in the blood. It is far less common but is the result of breathing more rapidly, which increases the amount of CO_2 exhaled. Because there are fewer CO_2 molecules in the body fluids, fewer H^+ ions are formed and pH tends to rise.

RESPIRATORY COMPENSATION FOR METABOLIC PH CHANGES:

Changes in pH caused by other than a respiratory disorder are called metabolic acidosis or alkalosis. In either case, the respiratory system may help prevent a drastic change in pH.

Metabolic acidosis is due to increased production of H=ions by the body or the inability of the body to form bicarbonate in the kidney. It may be caused by kidney disease, uncontrolled diabetes mellitus, excessive diarrhea or vomiting, or the use of some diuretics

Metabolic alkalosis is caused by excess of bicarbonate in the blood. It is due to loss of acids from the body. it is not common but may be caused by the overuse of antacid medications or the vomiting of stomach contents only. As the pH of body fluids begins to rise, breathing slows and decreases the amount of CO_2 exhaled

RENAL MECHANISMS:

The kidneys also help regulate the pH of extracellular fluid by excreting or conserving H^+ions and by reabsorbing (or not) Na^+ ions and HCO_3^- ions. The kidneys have the greatest capacity to buffer an ongoing pH change. Although the renal mechanisms do not become fully functional for several hours to days, once they do they continue to be effective far longer than respiratory mechanisms.

The kidneys have the greatest capacity to prevent fatal acidosis because the kidneys are able to remove H^+ ions from the body fluids and excrete them in urine. The buffer systems do not remove H^+ ions from the body, but

keep them sequestered in molecules that do not ionize readily. The respiratory system can increase exhalations to prevent more H^+ ion formation from CO_2 but cannot get rid of H^+ ions from other sources (such as ketones). Only the kidneys can actually remove H^+ ions from body fluids, as well as create new bicarbonate ions to put into the blood. Even the kidneys have limits, however, and the cause of the acidosis must be corrected to prevent death. In the case of an alkalosis, the kidney tubule cells will synthesize H^+ ions and HCO_3^- ions from CO_2 and water. But the ions to be retained and returned to the blood are the H^+ ions, and the ions excreted in urine are the bicarbonate ions; this will lower the blood pH toward the normal range.

EFFECTS OF PH CHANGES : Acidosis – When the pH falls below 7.35, and all the reserves of alkaline buffers are used up the condition is known as acidosis. A state of **acidosis** is most detrimental to the central nervous system, causing depression of impulse transmission at synapses. A person in acidosis becomes confused and disoriented, then lapses into a coma.

Alkalosis has the opposite effect and affects both the central and peripheral nervous systems. When the pH rises above 7.45 the increased alkali uses up all the acid reserve and the state of alkalosis exist. Increased synaptic transmission, even without stimuli, is first indicated by irritability and muscle twitches. Progressive alkalosis is characterized by severe muscle spasms and convulsions.

hypoxia is a condition where the tissues are not oxygenated adequately, usually due to an insufficient concentration of oxygen in the blood. The oxygen deprivation can have severe adverse effects on various body cells that need to perform important biological processes.

Signs and symptoms vary according to the cause. Generally they include dyspnea, rapid pulse, syncope, and mental disturbances.

Hypoxemia is a below-normal level of oxygen in your blood, specifically in the arteries. Hypoxemia is a sign of a problem related to breathing or circulation, and may result in various symptoms, such as shortness of breath. Several factors are needed to continuously supply the cells and tissues in your body with oxygen:

- There must be enough oxygen in the air you are breathing
- Your lungs must be able to inhale the oxygen-containing air — and exhale carbon dioxide
- Your bloodstream must be able to circulate blood to your lungs, take up the oxygen and carry it throughout your body.

A problem with any of these factors — for example, high altitude, asthma or heart disease — might result in hypoxemia, particularly under more extreme conditions, such as exercise or illness. When your blood oxygen falls below a certain level, you might experience shortness of breath, headache, and confusion or restlessness.

Hypovolemia is a decrease in the volume of blood in your body, which can be due to blood loss or loss of body fluids. Blood loss can result from external injuries, internal bleeding, or certain obstetric emergencies. Diarrhea and vomiting are common causes of body fluid loss. Fluid can also be lost as a result of large burns, excessive perspiration, or diuretics. Inadequate fluid intake can also cause hypovolemia.

Common initial symptoms of hypovolemia include: Decreased urine output, Dry mucous membranes, such as the mouth and nose, Loss of skin elasticity and Thirst.

Hypercapnia is a condition that occurs when there is too much carbon dioxide in the blood. While it is sometimes caused by things such as hypoventilation or a narcotic drug overdose, a much more common cause is COPD. Aside from COPD, there some other conditions that can lead to these high levels of carbon dioxide in the blood.

Some examples include: Severe hypercapnia may eventually lead to respiratory failure and possibly death, and symptoms include: Flushed skin, Dizziness, Rapid breathing and Increased blood pressure.