Name of Unit	Introduction to Human Body, Cellular level and Tissue Level of Organization
Course/Subject Name:	Human Anatomy and Physiology-I
Course/Subject Code:	BP101T
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Learning Outcome of Module 01

LO	Learning Outcome (LO)	Course Outcome Code
LO1	To understand basic term related to anatomy and physiology.	BP101.1
LO2	To recognize the various homeostatic mechanisms	BP101.1
LO3	To understand structure of cell and its organelles	BP101.1
LO4	To understand structure of cell and its functions	BP101.1
LO5	To understand the general principal of cell communication	BP101.1
LO6	To understand classification of tissue and its functions	BP101.2

Table of Content

Topic
Introduction to human body • Definition and scope of anatomy and Physiology. • Level of structural organization and body system. • Basic life process and Homeostasis. • Basic Anatomical Terminology **Cellular Level of Organization** • Structure and function of cell. • Transport across cell membrane. • Cell division and cell junction • General principles of cell communication, Signaling Pathway **Tissue Level of Organization** • Classification of tissues, Structure and Function of Connective, Epithelial, Muscular and Nervous Tissue.

INTRODUCTION TO HUMAN BODY

Human beings are the most complex living organisms. The human body is made up of many smaller parts/organs that work in an organized manner to ensure that the body is always working. The study of human body involves two major principles- Anatomy and Physiology. They provide us the basic knowledge of structure, size, shape, location and functioning of various organs all of which are very important to understand human body.

Branches of Science: There are two branches of sciences.

Anatomy

Physiology

Anatomy and physiology provides that deals with the study of structures of different body parts and their functions

Anatomy: is composed of two words *ana* (up) and *tomy* (process of cutting). Anatomy is the science of body structures and the relationships among them.

Physiology: physiology is composed of two words *physio* (nature) and *logy* (study of). Physiology is the science of body *functions i.e.* How the body parts work.

Homeostasis: (*homeo*-sameness and *stasis*-standing still) is the condition of equilibrium (balance) in the body's internal environment even if outside conditions are continuously changing. Homeostasis is a dynamic condition. In response to changing conditions, the body's equilibrium can shift in a narrow range to maintain life. Homeostasis is maintained mainly by negative and positive feedback systems.

Anatomy: is composed of two words *ana* (up) and *tomy* (process of cutting). Anatomy is the science of body structures and the relationships among them.

Subdivisions of anatomy:

Developmental biology: It is the study of complete development of an individual from fertilization of an egg to death.

Cell biology: It is the study of cell structure and functions.

Histology: It is the study of microscopic structure of tissues.

Gross anatomy: It is the study of cell structures without using a microscope.

Systemic anatomy: It is the study of specific systems of body such as nervous or respiratory systems.

Regional anatomy: It is the study of specific regions of the body such as head or chest.

Radiographic anatomy: It is the study of body structures with the help of x-rays.

Pathological anatomy: It is the study of structural changes associated with disease.

Embryology: It is the study of first eight weeks of human development.

Physiology: physiology is composed of two words *physio* (nature) and *logy* (study of). Physiology is the science of body *functions i.e.* how the body parts work.

Subdivisions of physiology:

Respiratory physiology: It is the study of functioning of lungs and air passageways.

Renal physiology: It is the study of functioning of the kidneys.

Immunology: It is the study of defense mechanism of body against disease-causing agents.

Exercise physiology: It is the study of changes in cell and organ functions as a result of exercise.

Neurophysiology: It is the study of functioning of the nervous system.

Pathophysiology: It is the study of functional changes associated with disease and aging.

Cardiovascular physiology: It is the study of functioning of heart and blood vessels.

Endocrinology: It is the study of hormones and how they control body functions.

SCOPE:

Scope of anatomy and physiology includes study of various organs and systems of human body.

1. Integumentary System: Study of Skin and structures associated with it, such as hair, nails, sweat glands and oil glands.

2. Skeletal System: Study of bones and joints.

3. Muscular System: Study of muscles.

4. Nervous System: Study of brain, spinal cord, nerves and special sense organs like eyes and ears.

5. Endocrine System: Study of hormone-producing glands cells.

6. Cardiovascular System: Study of blood, heart and blood vessels.

7. Digestive System: Study of organs of gastrointestinal tract, mouth, pharynx, esophagus, stomach, small and large intestines, anus and accessory organs salivary glands, liver, gallbladder and pancreas.

8. Urinary System: Study of kidneys, ureters, urinary bladder and urethra.

9. Lymphatic System: Study of Lymphatic fluid (lymph) and vessels including spleen, thymus, lymph nodes and tonsils.

10. Respiratory System: Study of pharynx (throat), larynx (voice box), trachea (windpipe) and lungs.

11. Reproductive Systems: Study of testes, ovaries and associated organs.

LEVELS OF STRUCTURAL ORGANIZATIONS

The vital processes of human body are controlled and maintained by different levels of structural organizations. These levels of structural organizations show an increase in structural complexity and function.There are six fundamental levels of organizations:

Chemical level

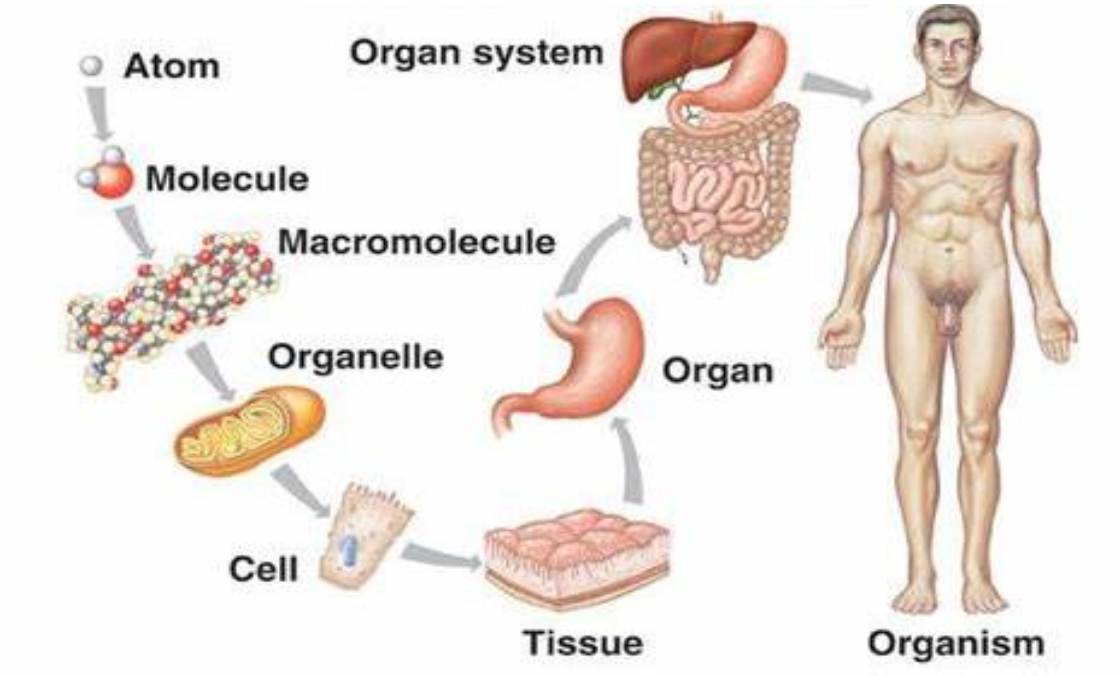
Cellular level

Tissue level

Organ level

System level

Organism level



Levels of structural organizations of human body

Chemical Level:

It is the most basic level of organization. It includes atoms; the smallest unit of matter that participates in chemical reactions. Two or more atoms join together to form molecules. Certain atoms like, carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), calcium (Ca^{+}) and sulfur (S) are crucial for maintaining life.

Cellular Level:

The cell constitute of most basic structural and functional unit of human body. The different molecules combine together to form cells. Human body contains muscle cells, nerve cells and epithelial cells. Each cell varies greatly in structure and function. Each type of cell performs a specific task.

Tissue Level:

Tissues are the groups of cells that works together to perform a particular function. Human body contains four basic types of tissue: epithelial tissue, connective tissue, muscular tissue and nervous tissue.

Organs Level:

Different types of tissue combines together to form organ. Organs are composed of two or more different types of tissues having specific functions and recognizable shapes. Examples of organs are the stomach, skin, bones, heart, liver, lungs and brain.

System Level:

A group of organs combines together to form a system. The organs of a system work together to perform a major physiological function of the body. Organs of digestive system are mouth, salivary glands, pharynx (throat), esophagus, stomach, small intestine, large intestine, rectum (necessary digestive organs), liver, gall bladder and pancreas (accessory digestive organs).

The human body comprises of eleven organs system such as Integumentary system, Skeletal system, Lymphatic system, Digestive system, Respiratory system, Muscular system, Nervous system, Endocrine system, Cardiovascular system, Urinary system, Reproductive system (Male and Female) and Special sensory organs.

Organism Level:

It is the highest level of structural organization; All the parts of the human body functioning together constitute the total organism i.e. human body. An organism is capable of independently performing vital functions necessary for life.

SYSTEMS OF THE HUMAN BODY

Human beings are contiguous living systems. The different systems are interconnected and dependent on each other. They cannot function separately. An organs system is composed of groups of structures that work together to perform common task or specific functions.

Nervous system:

Organs: Brain, spinal cord and nerves

Functions:

- It coordinates voluntary and involuntary actions and transmits signals between different parts of its body.
- It maintains homeostasis.

Cardiovascular System:

Organs: Blood, heart, and blood vessels.

Functions:

- Heart pumps blood through blood vessels.
- Blood carries oxygen and nutrients to cells and carbon dioxide and wastes away from cells.
- Helps to regulate acid-base balance, temperature, and water content of body fluids.

Digestive System:

Organs: Mouth, pharynx, oesophagus, stomach, small and large intestines, and anus; accessory organs such as salivary glands, liver, gall bladder and pancreas.

Functions:

- Mechanical and chemical breakdown of food.
- Absorption of nutrients.
- Elimination of solid wastes.

Urinary System:

Organs: Kidneys, ureters, urinary bladder and urethra.

Functions:

- Produces, stores and eliminates urine.
- Eliminates wastes and regulates volume and chemical composition of blood.
- Helps to maintain the acid-base balance of body fluids.
- Maintains mineral balance of body

Respiratory System:

Organs: Lungs, pharynx, larynx, trachea and bronchial tubes.

Functions:

- Transfers oxygen from inhaled air to blood and carbon dioxide from blood to exhaled air.
- Helps to regulate acid-base balance of body fluids.
- Production of sound by vocal cord.

Lymphatic System:

Organs: Lymph, lymph vessels, spleen, thymus, lymph nodes and tonsils.

Functions:

- Returns proteins and fluid to blood.
- Carries lipids from gastrointestinal tract to blood.
- Lymphatic cells protects against disease causing microbes.

Endocrine System:

Organs: Pineal gland, hypothalamus, pituitary gland, thymus, thyroid gland, parathyroid glands, adrenal glands, pancreas, ovaries and testes.

Function:

- Regulates different body activities by releasing hormones.

Male Reproductive System:

Organs: Testes, epididymis, ductus deferens and penis.

Functions:

- Produces and releases sex hormones.
- Produces stores and transports sperm.
- Discharges sperm in the female reproductive tract.

Female Reproductive System:

Organs: Ovaries, uterine tubes, uterus, and vagina.

Functions:

- Produces ova necessary for fertilization.
- Transports ova to the site of fertilization.
- Enables sperm to enter the body.
- Provides favorable environment for the developing embryo.

Muscular system:

Organs: Skeletal muscle and tendons.

Functions:

- Produces body movements, such as walking and running.
- Stabilizes body posture.
- Generation of heat.

Integumentary System:

Organs: Skin, hairs, nails, sebaceous glands and sweat glands.

Functions:

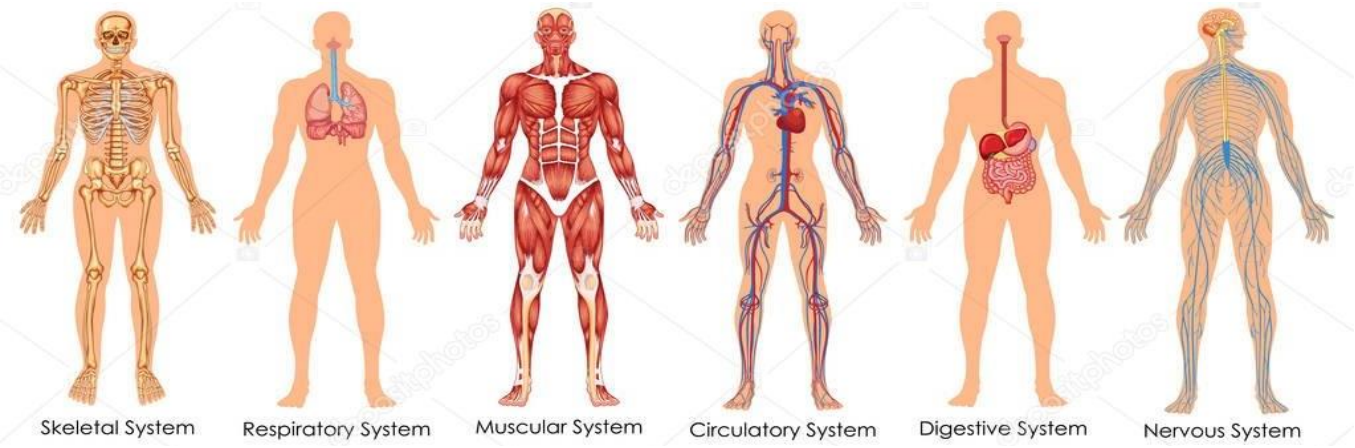
- Protects underlying tissues.
- Prevents loss of body fluids.
- Maintains normal body temperature.
- Secretion of substances such as salt, water and organic wastes.

Special Sense Organs:

Organs: Eyes, ears, skin, tongue and nose.

Functions:

- Detects changes in the body's internal and external environments
- Vision
- Hearing
- Smell
- Taste
- Touch sensations



The systems of human body

BASIC ANATOMICALTERMINOLOGY

Regional Names The human body is divided into several major regions

Head: The head consists of the skull and face. The skull encloses and protects the brain; the face is the front portion of the head that includes the eyes, nose, mouth, forehead, cheeks, and chin.

Neck: The neck supports the head and attaches it to the trunk.

Trunk: The trunk consists of the chest, abdomen, and pelvis.

Upper limb: Each upper limb attaches to the trunk and consists of the shoulder, armpit, arm, forearm, wrist and hand.

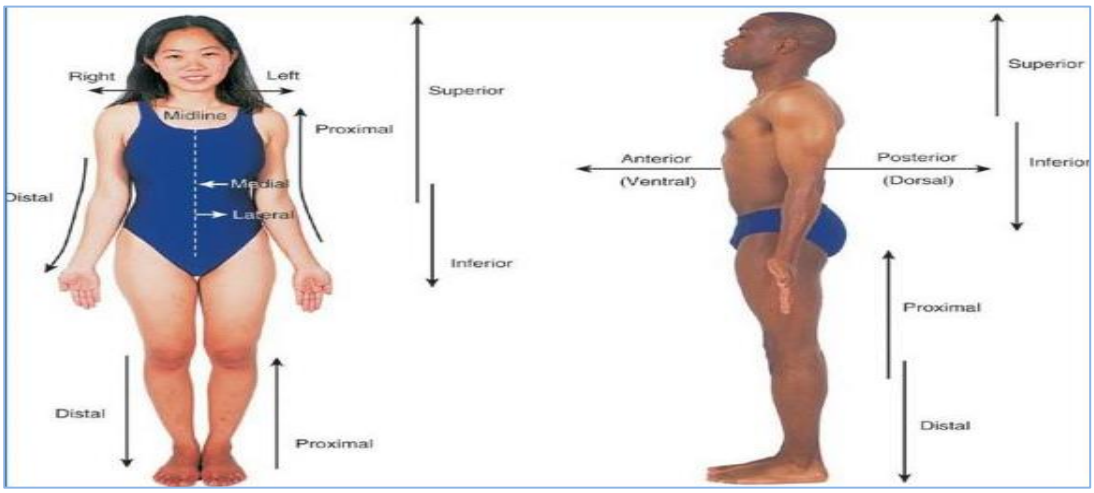
Lower limb: Each lower limb also attaches to the trunk and consists of the buttock, thigh, leg, ankle and foot.

Descriptive terms used in Anatomy: Arrangement of various parts of the body may be:

Symmetric: e.g., limbs, eyes, ear, and lungs. Their arrangement on the right side and left side are similar.

Asymmetric: e.g., Spleen and liver. The spleen lies entirely on the left side. The liver lies mostly on the right side.

The study of anatomy is done in anatomical positions, the body is erect, the head facing towards, arms by the sides and the palms of the hand facing towards. The following are few important terms that are used to describe the human body.



Median Line (mid sagittal plane): The central plane divides the body into two halves i.e. left and right.

- Median: Nearer to the median line.
- Lateral: Away from the median line.
- Superior: Nearer to the head.
- Inferior: Nearer to the foot.
- Anterior: Nearer to the front surface of the body.
- Posterior: Nearer to the back surface of the body.
- Proximal: Nearer to the origin of the structure.
- Distal: Away from the origin of the structure.
- Superficial: Nearer to the skin surface.
- Deep: Deeper from the skin surface

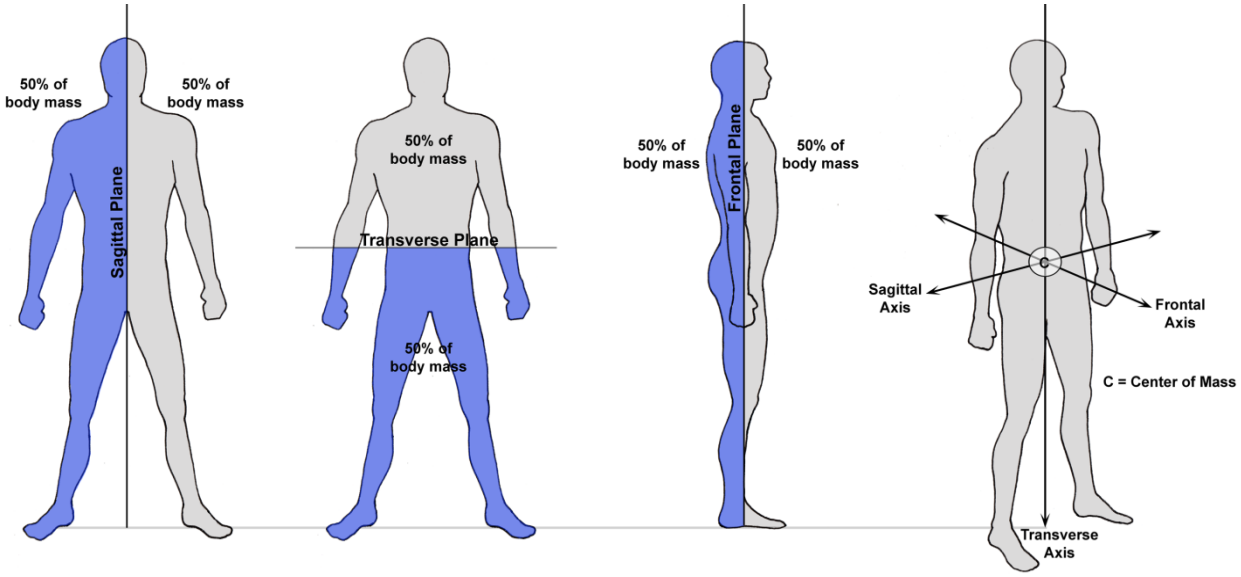
Planes and Sections

Sagittal Plane: A sagittal plane is a vertical plane that divides the body or an organ into right and left sides.

Midsagittal plane: When sagittal plane passes through the midline of the body or an organ and divides it into equal right and left sides, it is called a midsagittal plane or a median plane.

Parasagittal Plane: If the sagittal plane does not pass through the midline but instead divides the body or an organ into unequal right and left sides, it is called a parasagittal plane.

Frontal Plane: A frontal or coronal plane divides the body or an organ into anterior (front) and posterior (back) portions.



Plane and Section of Human Body

Transverse Plane: A transverse plane divides the body or an organ into superior (upper) and inferior (lower) portions. It is also called cross-sectional or horizontal plane. Sagittal, frontal, and transverse planes are all at right angles to one another.

An **oblique plane** passes through the body or an organ at an angle other than right angle (other than 90˚)
Anatomical Position

BASIC LIFE PROCESSES

Responsiveness:

It is the body's ability to detect and respond to changes. For example, a decrease in body temperature represents a change in the internal environment. Turning your head toward the sound of squealing brakes is a response to change in the external environment. Different cells in the body respond to environmental changes in different ways. For example, nerve cells respond by generating electrical signals known as action potentials.

Metabolism:

It is the sum of all the chemical processes that occur in the body. Catabolism is the breakdown of complex chemical substances into simpler components. Anabolism is the building up of complex chemical substances from smaller components. For example, digestive processes catabolize (split) proteins in food into amino acids. These amino acids are used to anabolize (build) new proteins that make-up human body.

Movement:

Movement includes motion of the whole body, individual organs, single cells, and even tiny structures inside cells. For example, the co-ordinated action of leg muscles moves the whole body from one place to

another when we walk or run. When a body tissue is damaged or infected, certain white blood cells move from the blood into the affected tissue to help clean up and repair the area.

Growth:

It is an increase in the body size that results from an increase in the size of existing cells, an increase in the number of cells or both. For example, in a growing bone, mineral deposition accumulates between bone cells, causing the bone to grow in length and width.

Differentiation:

It is the development of a cell from an unspecialized to a specialized state. For example, red blood cells and several types of white blood cells all arise from the same unspecialized cells in red bone marrow. Such cells divide, undergo differentiation and give rise to cells known as stem cells. Through differentiation process, a fertilized egg develops into an embryo, and then into a fetus, an infant, a child, and finally an adult.

Reproduction:

It refers either to the formation of new cells for tissue growth, repair or rep or to the production of a new individual. In humans, fertilization of an ovum by a sperm cell develops into embryo.

Respiration:

Respiration involves the exchange of oxygen and carbon dioxide between the cells and the external environment. It includes ventilation, the diffusion of oxygen and carbon dioxide, and the transport of the gases in the blood. Cellular respiration deals with the cell's utilization of oxygen and release of carbon dioxide in its metabolism

Digestion: Digestion process involves breaking down complex ingested foods into simple molecules that can be absorbed into the blood and utilized by the body for energy source.

Excretion:

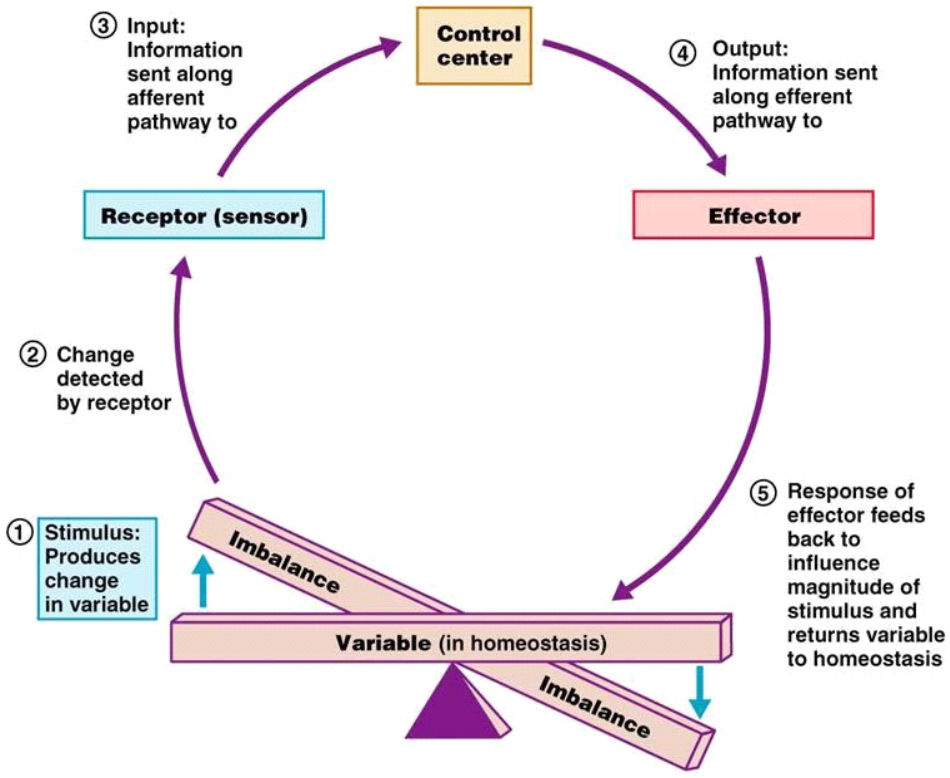
Excretion is the process that removes the waste products of digestion and metabolism from the body.

HOMEOSTASIS

HOMEO= SAME ***STASIS= STANDING***

Homeostasis refers to the maintenance of constant internal environment of the body **Homeostasis** is the state of steady internal, physical, and chemical conditions maintained by living systems**.** This dynamic state of equilibrium is the condition of optimal functioning for the organism and includes many variables, such as body temperature and fluid balance, being kept within certain pre-set limits (homeostatic range). Other variables include the pH of extracellular fluid, the concentrations of sodium, potassium and calcium ions, as well as that of the blood sugar level, and these need to be regulated despite changes in the environment, diet, or level of activity. Each of these variables is controlled by one or more regulators or homeostatic mechanisms, which together maintain life.

Homeostatic mechanisms:- For the functioning of homeostatic mechanism, the body must recognize the deviation of any physiological activity from the normal limits. Fortunately, body is provided with appropriate **detectors** or **sensors,** which recognize the deviation. These detectors sense the deviation and alert the **integrating center.** The integrating center immediately sends information to the concerned **effectors** to either accelerate or inhibit the activity so that the normalcy is restored.



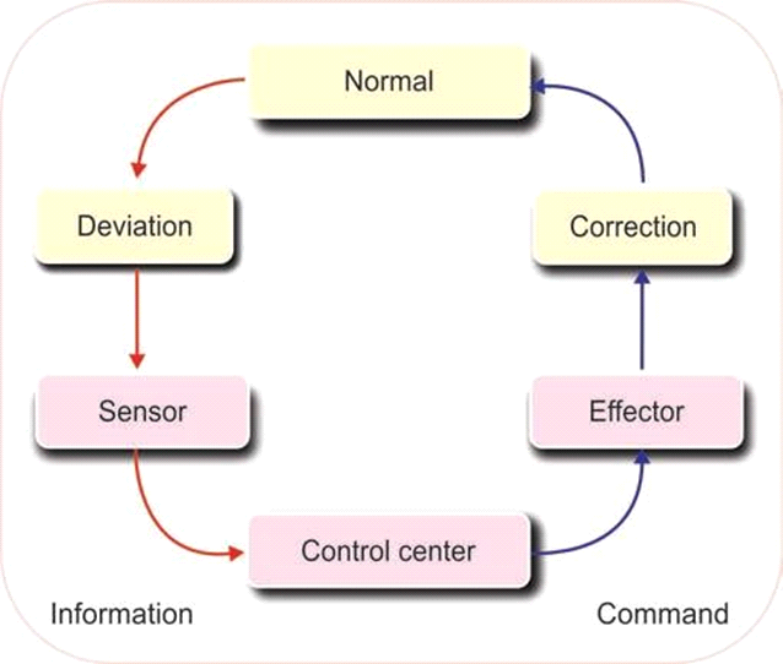
Homeostasis

The Home Heating System

1. When the temperature of a room decreases below a set point, the thermostat electrically starts the furnace.

2. As the temperature of the room rises to the set point, the thermostat shuts down the furnace.

3. As the room cools, step one is repeated.



Components of homeostatic system

There are three components to this system:

1. The **Sensor** which detects the stress.

2. The **Control Center** which receives information from the **sensor** and sends a message to the **Effector**.

3. The **Effector** which receives the message from the control center and produces the response which reestablishes homeostasis.

MECHANISM OF ACTION OF HOMEOSTATIC SYSTEM

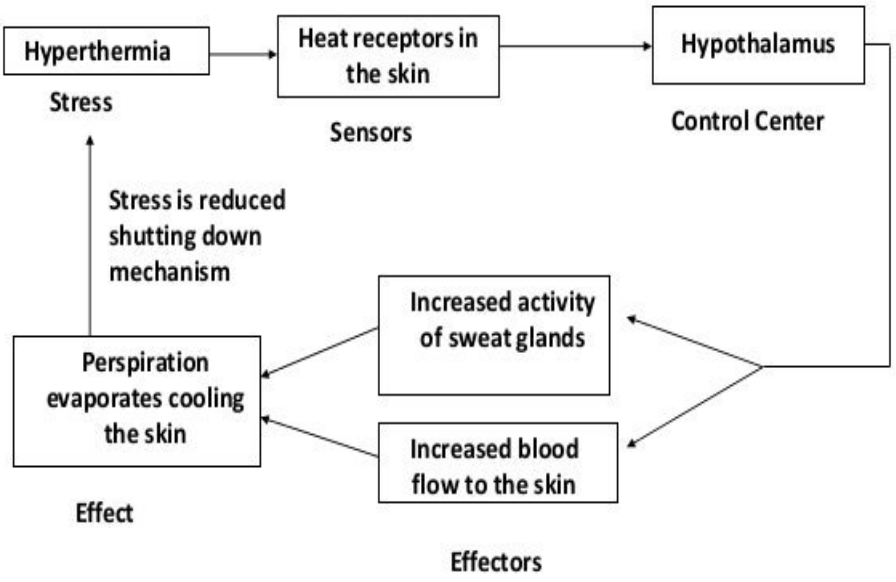
Homeostatic mechanism in the body is responsible for maintaining the normalcy of various body systems. Whenever there is any change in behavioral pattern of any system, the effectors bring back the normalcy either by inhibiting and reversing the change or by supporting and accelerating the change depending upon requirement of the situation. This is achieved by means of feedback signals. Feedback is a process in which some proportion of the output signal of a system is fed (passed) back to the input. This is done more often intentionally in order to control the behavior pattern of the system. Whenever any change occurs, system receives and reacts to two types of feedback:

1. Negative feedback

2. Positive feedback.

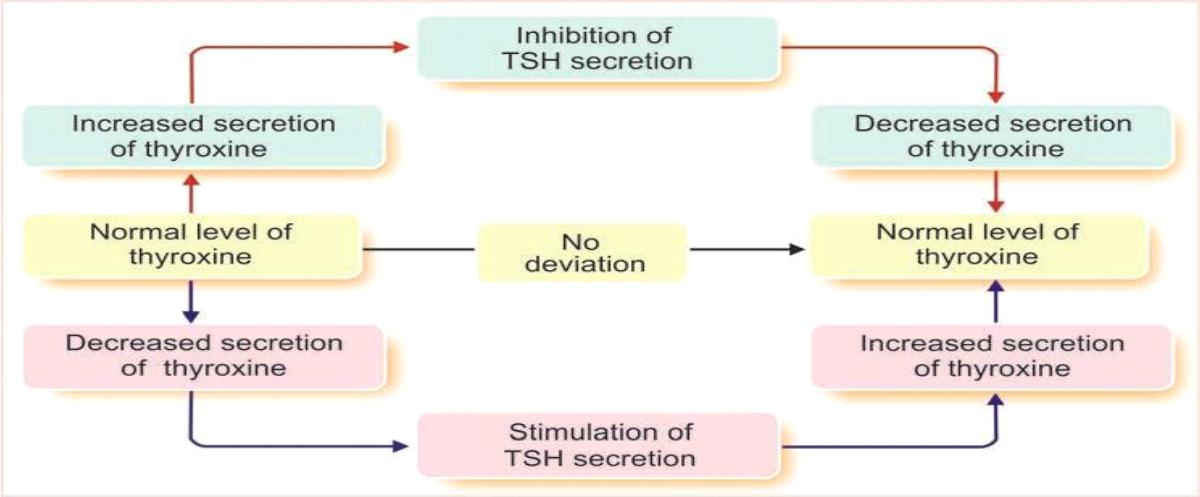
NEGATIVE FEEDBACK

Negative feedback is the one to which the system reacts in such a way as to arrest the change or reverse the direction of change. After receiving a message, effectors send negative feedback signals back to the system. Now, the system stabilizes its own function and makes an attempt to maintain homeostasis



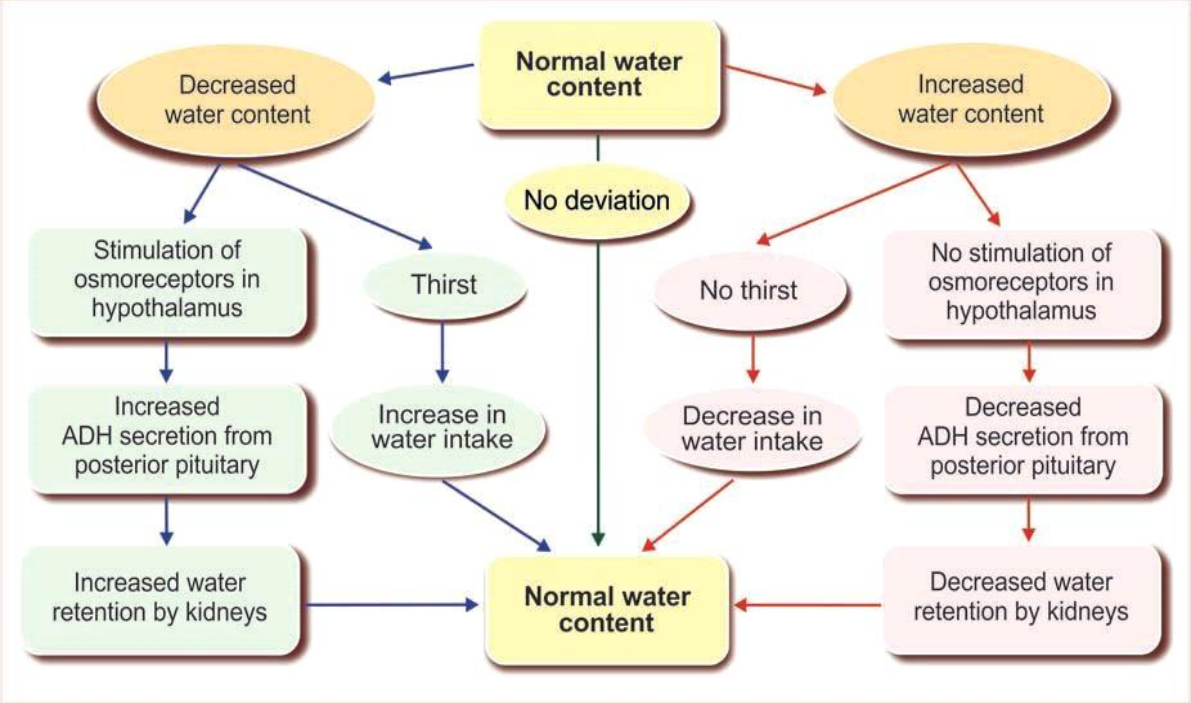
Homeostatic Regulation of Body Temperature through Negative Feedback

In case of Hyperthermia heat receptors in the skin act as sensors and send information to Hypothalamus (Control Center) , then it activate the TRC (Temperature regulating center) which Increased activity of sweat glands Increased blood flow to the skin (Effectors), Hence Perspiration (sweat) evaporates cooling the skin Stress is reduced shutting down mechanism.



Negative feedback mechanism – secretion of thyroxine

Many homeostatic mechanisms in the body function through negative feedback. For example, thyroid-stimulating hormone (TSH) released from pituitary gland stimulates thyroid gland to secrete thyroxine. When thyroxine level increases in blood, it inhibits the secretion of TSH from pituitary so that, the secretion of thyroxin from thyroid gland decreases



Negative feedback mechanism – maintenance of water balance.

ADH = Antidiuretic hormone.

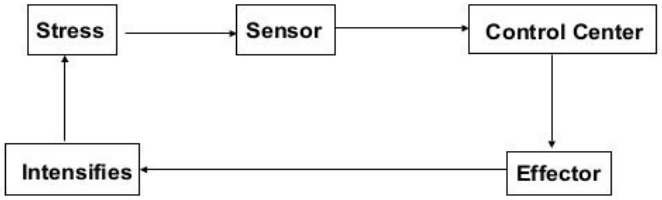
On the other hand, if thyroxine secretion is less, its low blood level induces pituitary gland to release TSH. Now, TSH stimulates thyroid gland to secrete thyroxine. Another example for negative feedback mechanism is maintenance of water balance in the body

POSITIVE FEEDBACK MECHANISMS

Homeostatic systems utilizing positive feedback exhibit two primary characteristics:

1. Time limitation – Processes in the body that must be completed within a constrained time frame are usually modified by positive feedback.

2. Intensification of stress – During a positive feedback process, the initial imbalance or stress is intensified rather than reduced as it is in negative feedback.



Typical Positive Feedback Process

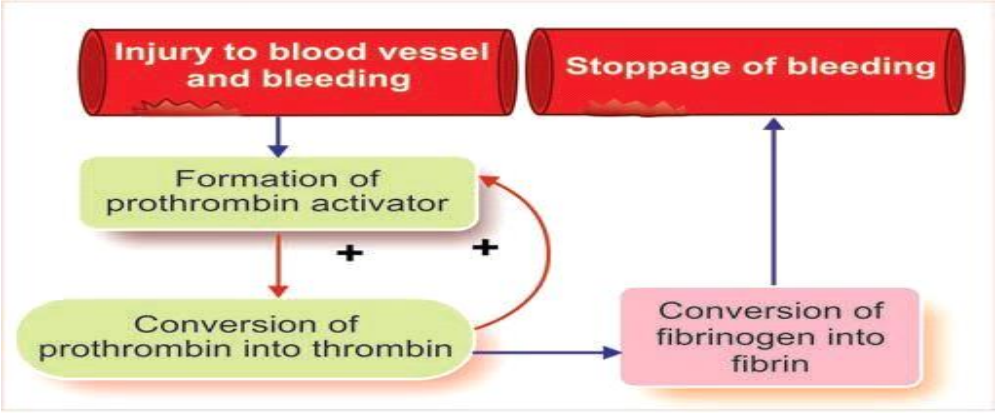
One of the positive feedbacks occurs during the blood clotting. Blood clotting is necessary to arrest bleeding during injury and it occurs in three stages.

The three stages are:

i. Formation of prothrombin activator

ii. Conversion of prothrombin into thrombin

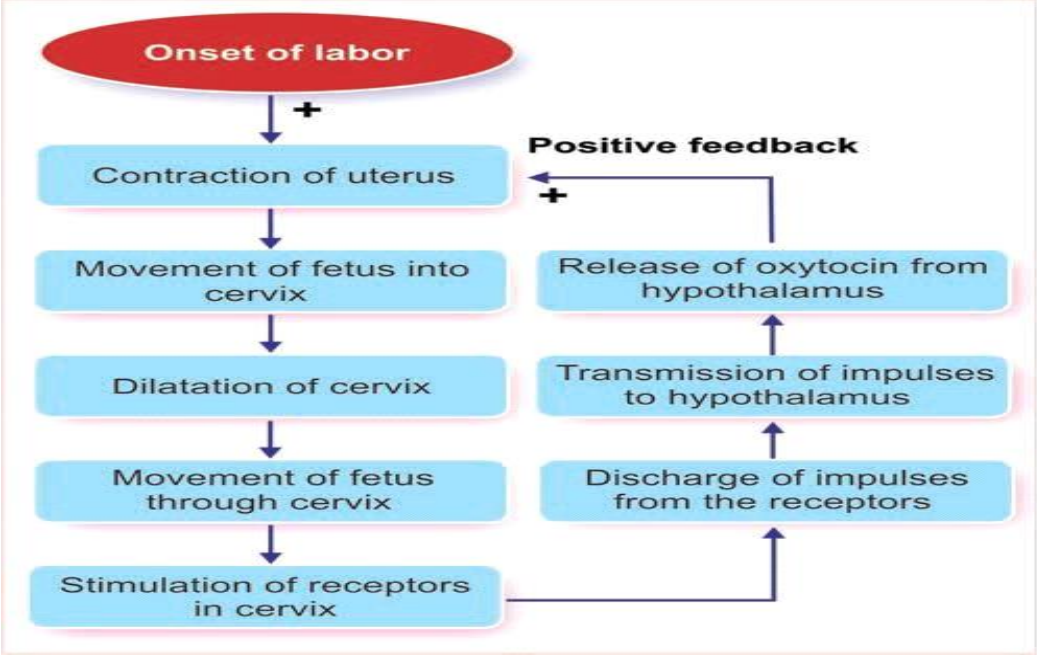
iii. Conversion of fibrinogen into fibrin.



Positive feedback mechanism – coagulation of blood.

Once formed, thrombin induces the formation of more prothrombin activato.r

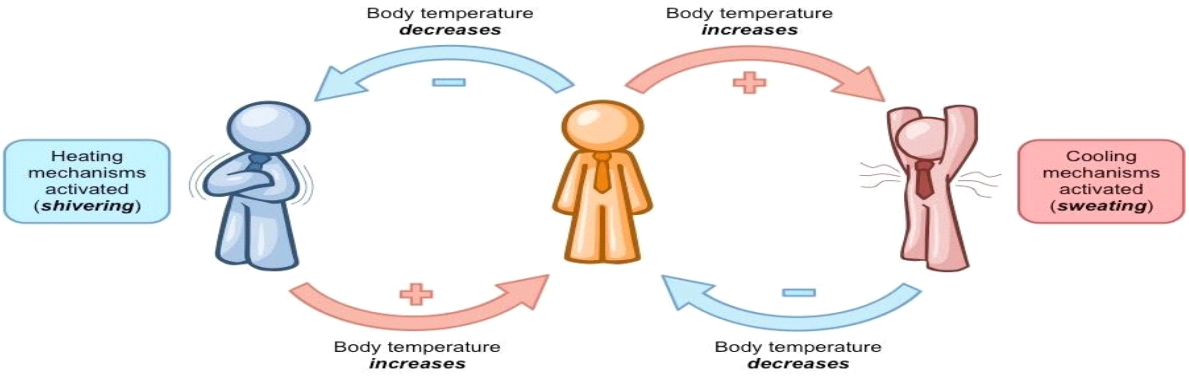
Thrombin formed in the second stage stimulates the formation of more prothrombin activator in addition to converting fibrinogen into fibrin. It causes formation of more and more amount of prothrombin activator so that the blood clotting process is accelerated and blood loss is prevented quickly.



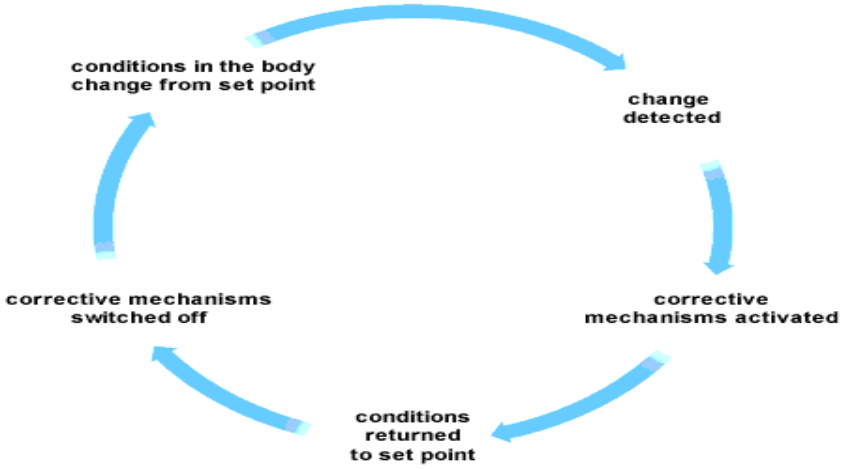
Positive feedback mechanism – parturition

Homeostatic Regulation of Child Birth through Positive Feedback:- Pressure of Fetus on the Uterine Wall then nerve endings in the uterine wall carry afferent messages to the hypothalamus that lead to production and release of Oxytocin into the Blood which increasing strength of uterine contractions. The birth of the child will bring this process to a close.

Positive feedback "mini-loops" are built into pathway to speed up production of chemicals needed to form the clot. Entire sequence of clotting is a negative feedback pathway: Feedback in Coagulation.



Negative feedback & Positive feedback



Positive feedback

Harmful Effects of Positive Feedback Positive feedback can be harmful. Two specific examples of these harmful outcomes would be:

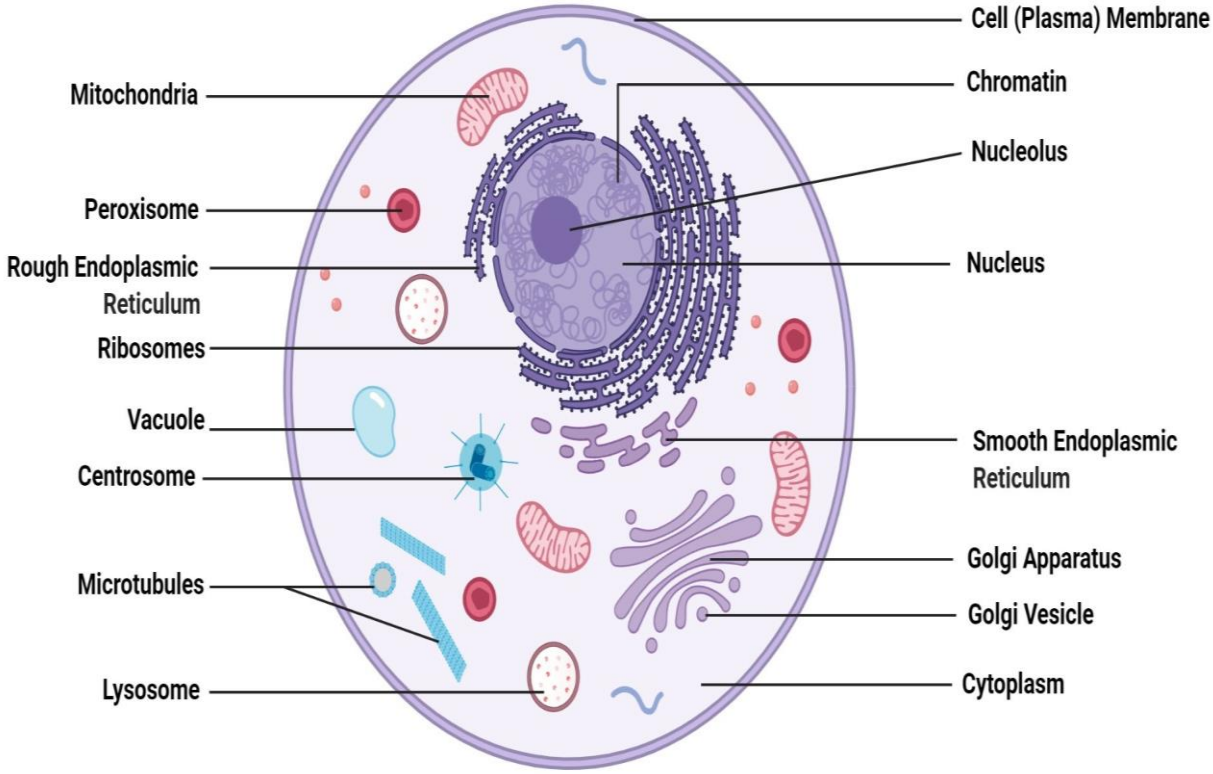
1. Fever can cause a positive feedback within homeostasis that pushes the body temperature continually higher. If the temperature reaches 45 degrees centigrade cellular proteins denature bringing metabolism to a stop and death.

2. Chronic hypertension can favor the process of atherosclerosis which causes the openings of blood vessels to narrow. This, in turn, will intensify the hypertension bring on more damage to the walls of blood vessels.

CELLULAR LEVEL OF ORGANIZATION

THE CELL

Cells are the body's smallest structural and functional units. They are grouped together to form tissues, each of which has a specialized function, e.g. blood, muscle, bone. Different tissues are grouped together to form organs, e.g. the heart, stomach and brain. Organs are grouped together to form systems, each of which performs a particular function that maintains homeostasis and contributes to the health of the individual. It is mainly divided into 3 parts: **Plasma membrane, Cytoplasm** and **Nucleus**



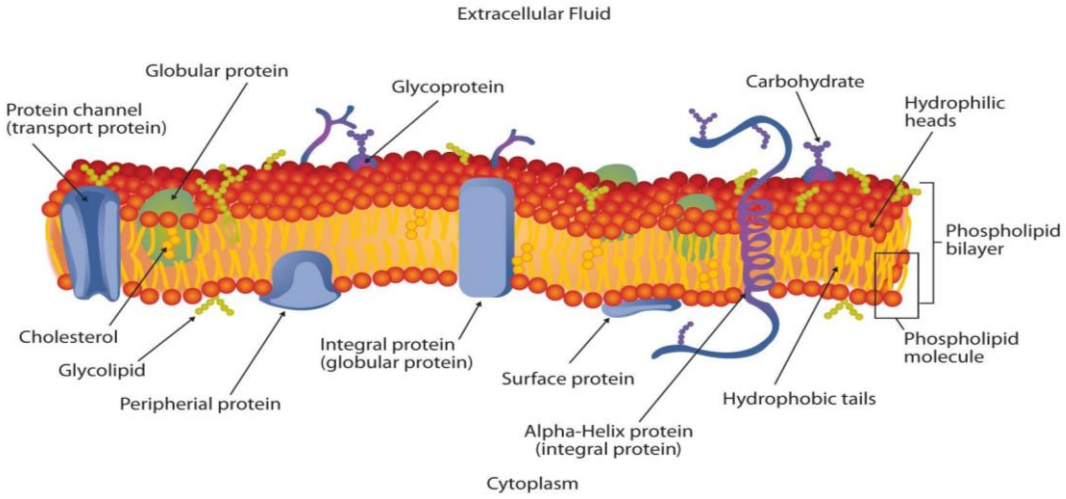
CELL

I.PLASMA MEMBRANE:

The plasma membrane, a flexible yet sturdy barrier that surrounds and contains the cytoplasm of a cell, is described by using a structural model called the fluid mosaic model.

Structure of the Plasma Membrane:

The Lipid Bilayer: The basic structural framework of the plasma membrane is the ***lipid bilayer*****,** two back-to-back layers made up of three types of lipid molecules—phospholipids, cholesterol, and glycolipids. About 75% of the membrane lipids are ***phospholipids*** **(**lipids that contain phosphorus). Present in smaller amounts are ***cholesterol*** (about 20%), a steroid with an attached -OH (hydroxyl) group, and various ***glycolipids*** (about 5%), lipids with attached carbohydrate groups.



Structure of the Plasma Membrane

The bilayer arrangement occurs because the lipids are **amphipathic** molecules, which means that they have both polar and nonpolar parts. In phospholipids, the polar part is the phosphate containing "head," which is hydrophilic (water loving). The nonpolar parts are the two long fatty acid "tails," which are hydrophobic (water fearing) hydrocarbon chains. Because "like seeks like," the phospholipid molecules orient themselves in the bilayer with their hydrophilic heads facing outward.

In this way, the heads face a watery fluid on either side—cytosol on the inside and extracellular fluid on the outside. The hydrophobic fatty acid tails in each half of the bilayer point toward one another, forming a nonpolar, hydrophobic region in the membrane's interior.

II. CYTOPLASM: It consists of all cellular contents with in the plasma membrane except for the entire nucleus. It has two components: **Cytosol** and **Organelles**

1. CYTOSOL:

The cytosol (intracellular fluid) is the fluid portion of the cytoplasm that surrounds organelles and constitutes about 55% of total cell volume. Although it varies in composition and consistency from one part of a cell to another, cytosol is 75–90% water plus various dissolved and suspended components. Among these are different types of ions, glucose, amino acids, fatty acids, proteins, lipids, ATP, and waste products.

The cytosol is the site of many chemical reactions required for a cell's existence

2. ORGANELLES:

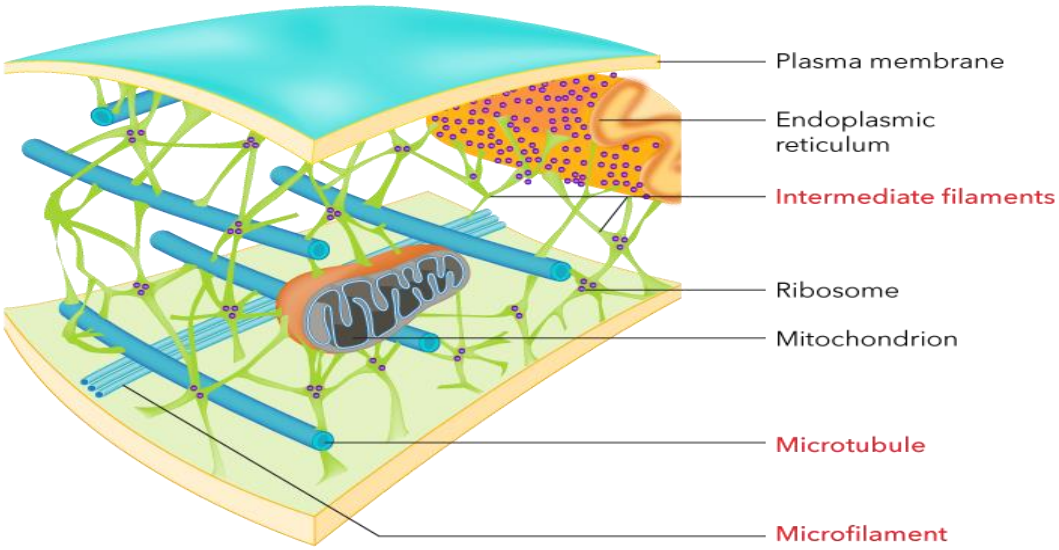
Organelles are specialized structures within the cell that have characteristic shapes; they perform specific functions in cellular growth, maintenance, and reproduction. They include: the nucleus, mitochondria, ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes and the cytoskeleton.

A. CYTOSKELETON:

The cytoskeleton is a network of protein filaments that extends throughout the cytosol. Three types of filamentous proteins contribute to the cytoskeleton's structure, as well as the structure of other organelles.

Functions:

1. Serves as a scaffold that helps to determine a cell's shape and to organize the cellular contents.
2. Aids movement of organelles within the cell, of chromosomes during cell division, and of whole cells such as phagocytes.



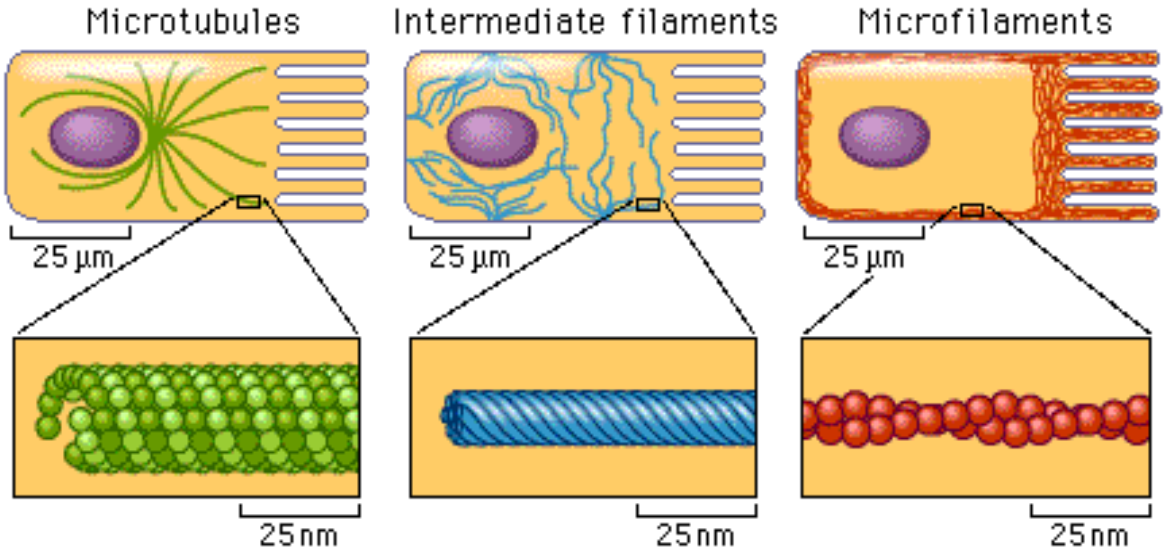
Cytoskeleton

In the order of their increasing diameter, these structures are:

Microfilaments: These are the thinnest elements of the cytoskeleton. They are composed of the protein actin, and are most prevalent at the edge of a cell. Microfilaments have two general functions: They help generate movement and provide mechanical support that is responsible for the basic strength and shapes of cells.

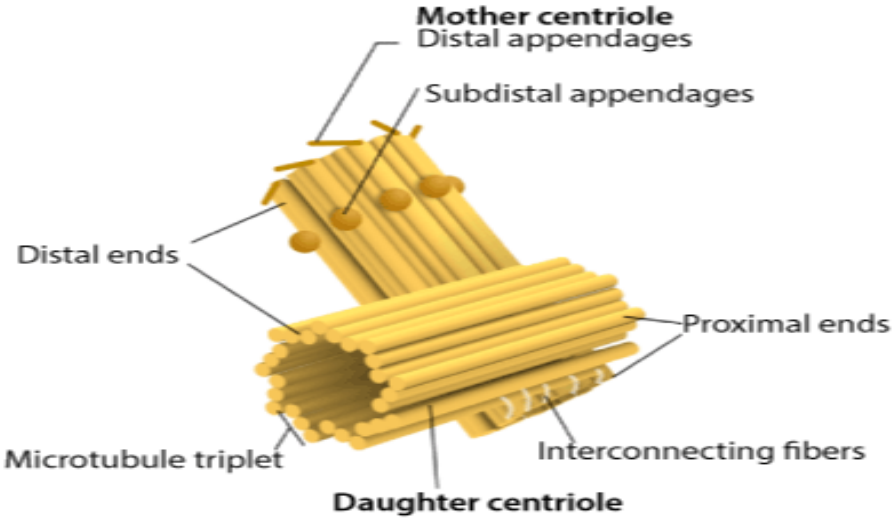
Intermediate filaments: these filaments are thicker than microfilaments but thinner than microtubules. Several different proteins can compose intermediate filaments, which are exceptionally strong. They are found in parts of cells subject to mechanical stress, help stabilize the position of organelles such as the nucleus, and help attach cells to one another.

Microtubules: These are the largest of the cytoskeletal components and are long, unbranched hollow tubes composed mainly of the protein tubulin. The assembly of microtubules begins in an organelle called the centrosome. Microtubules help determine cell shape. They also function in the movement of organelles such as secretory vesicles, of chromosomes during cell division, and of specialized cell projections, such as cilia and flagella.



B. CENTROSOME:

The centrosome, located near the nucleus, consists of two components: a pair of centrioles and pericentriolar material. The two centrioles are cylindrical structures, each composed of nine clusters 5



C. CILIA AND FLAGELLA:

Microtubules are the dominant components of cilia and flagella, which are motile projections of the cell surface.

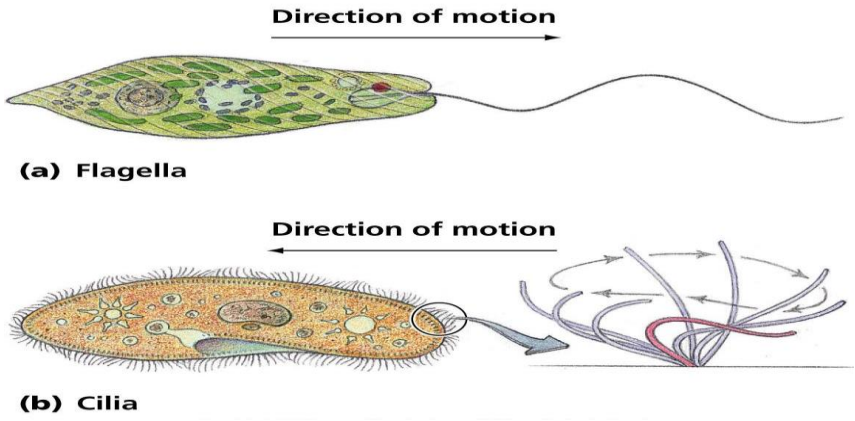
Cilia are numerous, short, hair like projections that extend from the surface of the cell. Each cilium contains a core of 20 microtubules surrounded by plasma membrane.

Flagella are similar in structure to cilia but are typically much longer. Flagella usually move an entire cell. A flagellum generates forward motion along its axis by rapidly wiggling in a wavelike pattern.

The only example of a flagellum in the human body is a sperm cell's tail, which propels the sperm toward the oocyte in the uterine tube.

Functions:

1. Cilia move fluids along a cell's surface.
2. A flagellum moves an entire cell.



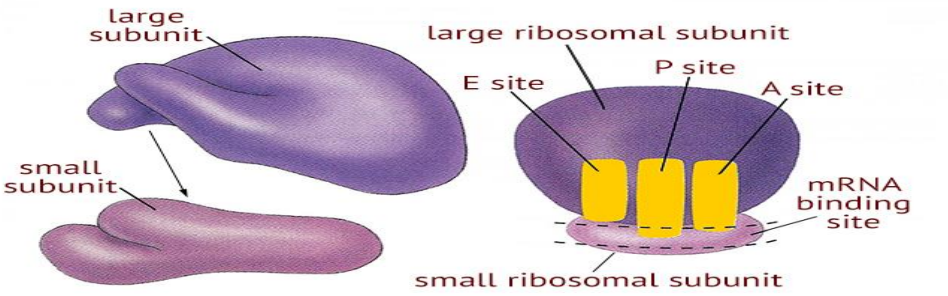
D. RIBOSOMES:

Ribosomes are the sites of protein synthesis. The name of these tiny organelles reflects their high content of one type of ribonucleic acid. vStructurally, a ribosome consists of two subunits, one about half the size of the other. The large and small subunits are made separately in the nucleolus, a spherical body inside the nucleus. Once produced, the large and small subunits exit the nucleus separately, then come together in the cytoplasm.

Some ribosomes are attached to the outer surface of the nuclear membrane and to an extensively folded membrane called the endoplasmic reticulum. These ribosomes synthesize proteins destined for specific organelles, for insertion in the plasma membrane, or for export from the cell. Other ribosomes are "free" or unattached to other cytoplasmic structures. Free ribosomes synthesize proteins used in the cytosol. Ribosomes are also located within mitochondria, where they synthesize mitochondrial proteins.

Functions:

1. Ribosomes associated with endoplasmic reticulum synthesize proteins destined for insertion in the plasma membrane or secretion from the cell.
2. Free ribosomes synthesize proteins used in the cytosol.



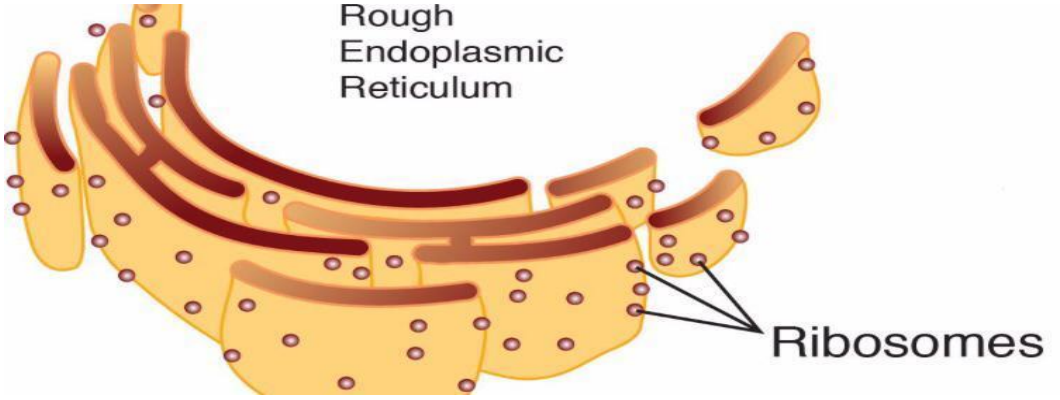
Ribosomes

E. ENDOPLASMIC RETICULUM:

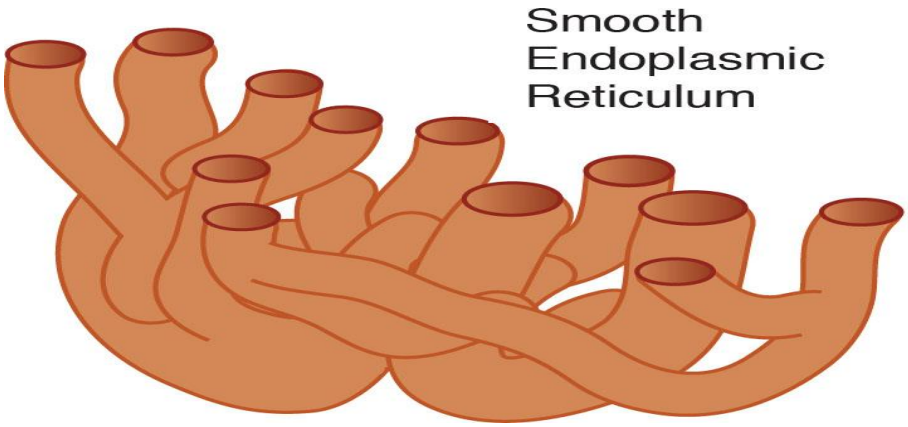
The endoplasmic reticulum or ER is a network of membranes in the form of flattened sacs or tubules. The ER extends from the nuclear envelope (membrane around the nucleus), to which it is connected, throughout the cytoplasm.

Cells contain two distinct forms of ER, which differ in structure and function.

Rough ER is continuous with the nuclear membrane and usually is folded into a series of flattened sacs. The outer surface of rough ER is studded with ribosomes, the sites of protein synthesis. Rough ER produces secretory proteins, membrane proteins, and many organellar proteins.



Smooth ER extends from the rough ER to form a network of membrane tubules. Unlike rough ER, smooth ER does not have ribosomes on the outer surfaces of its membrane. Smooth ER does not synthesize proteins, but it does synthesize fatty acids and steroids, such as estrogens and testosterone. In liver cells, enzymes of the smooth ER help release glucose into the bloodstream and inactivate or detoxify lipid-soluble drugs or potentially harmful substances.



Functions:

1. Rough ER synthesizes glycoproteins and phospholipids that are transferred into cellular organelles, inserted into the plasma membrane, or secreted during exocytosis.

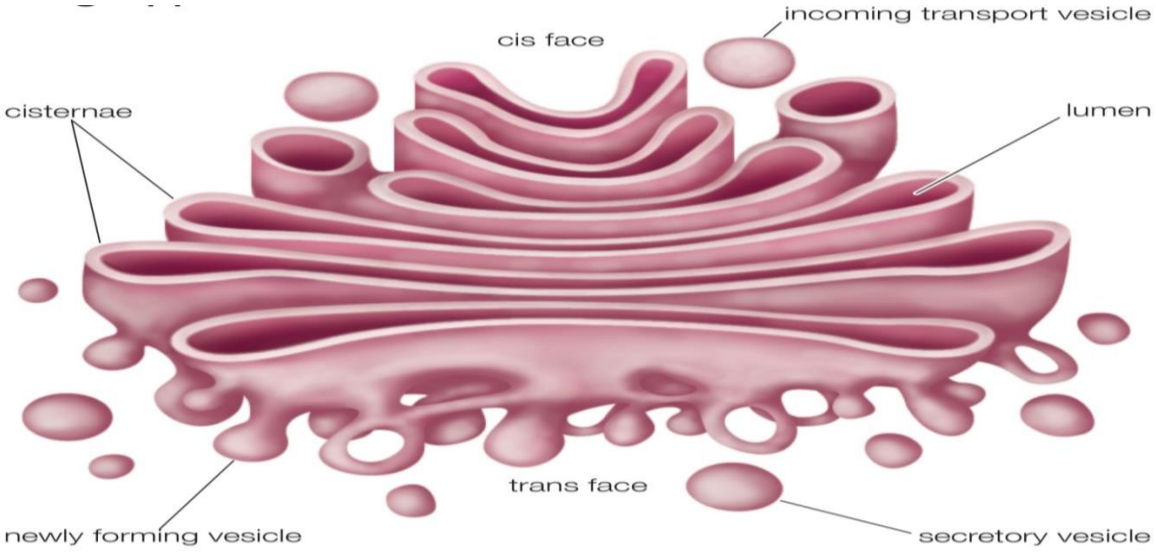
2. Smooth ER synthesizes fatty acids and steroids, such as estrogens and testosterone; inactivates or detoxifies drugs and other potentially harmful substances; removes the phosphate group from glucose-6-phosphate; and stores and releases calcium ions that trigger contraction in muscle cells.

F. GOLGI COMPLEX:

Most of the proteins synthesized by ribosomes attached to rough ER are ultimately transported to other regions of the cell. The first step in the transport pathway is through an organelle called the Golgi complex. It consists of 3 to 20 cisternae, small, flattened membranous sacs with bulging edges that resemble a stack of pita bread. The cisternae are often curved, giving the Golgi complex a cuplike shape. The convex entry or cis face is a cisterna that faces the rough ER. The concave exit or trans face is a cisterna that faces the plasma membrane. Sacs between the entry and exit faces are called medial cisternae.

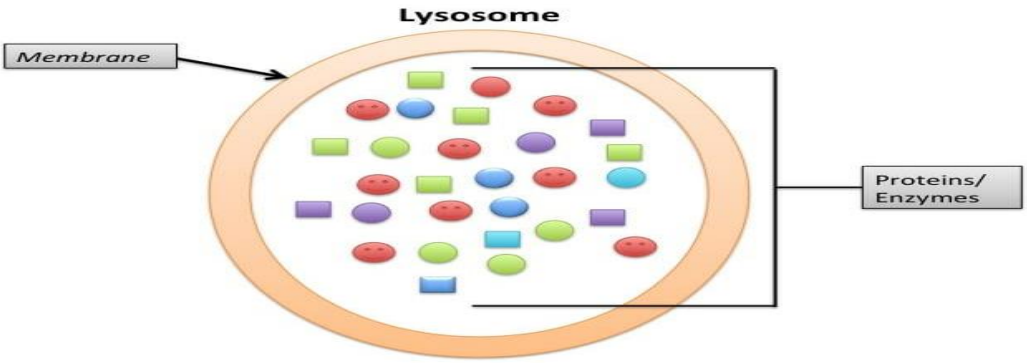
Functions:

1. Modifies, sorts, packages, and transports proteins received from the rough ER.
2. Forms secretory vesicles that discharge processed proteins via exocytosis into extracellular fluid; forms membrane vesicles that ferry new molecules to the plasma membrane; forms transport vesicles that carry molecules to other organelles, such as lysosomes.



G. LYSOSOMES: (*Lyso*= dissolving, *somes*=bodies)

Lysosomes are membrane-enclosed vesicles that form from the Golgi complex. A lysosome can engulf another organelle, digest it, and return the digested components to the cytosol for reuse. In this way, old organelles are continually replaced. The process by which entire worn-out organelles are digested is called autophagy.

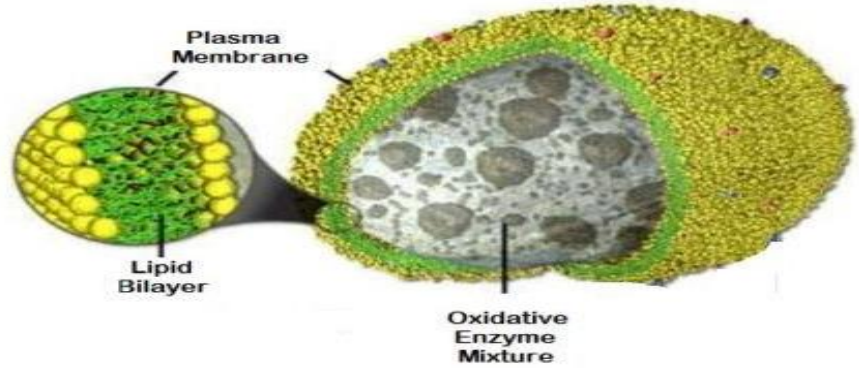


Functions:

1. Digest substances that enter a cell via endocytosis and transport final products of digestion into cytosol.
2. Carry out autophagy, the digestion of worn-out organelles.
3. Carry out autolysis, the digestion of entire cell.
4. Carry out extracellular digestion.

H. PEROXISOMES:

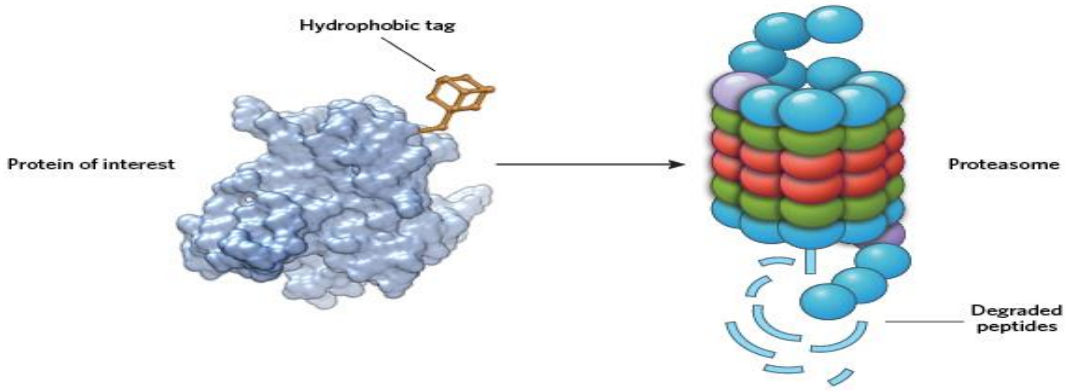
Another group of organelles similar in structure to lysosomes, but smaller, are the peroxisomes Peroxisomes, also called microbodies, contain several oxidases, enzymes that can oxidize (remove hydrogen atoms from) various organic substances.



I. PROTEASOMES:

Lysosomes degrade proteins delivered to them in vesicles. Cytosolic proteins also require disposal at certain times in the life of a cell. Continuous destruction of unneeded, damaged, or faulty proteins is the function of tiny barrel-shaped structures consisting of four stacked rings of proteins around a central core called proteasomes.

Proteasomes were so named because they contain myriad proteases, enzymes that cut proteins into small peptides.

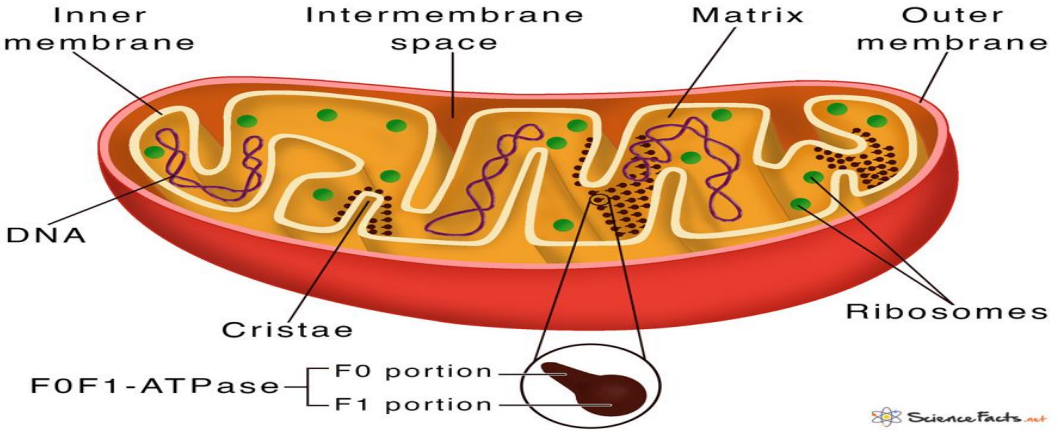


Proteasomes

J. MITOCHONDRIA:

Mitochondria are referred to as the "powerhouses" of the cell.

A mitochondrion consists of an outer mitochondrial membrane and an inner mitochondrial membrane with a small fluid-filled space between them. Both membranes are similar in structure to the plasma membrane. The inner mitochondrial membrane contains a series of folds called cristae. The central fluid-filled cavity of a mitochondrion, enclosed by the inner mitochondrial membrane, is the matrix. The elaborate folds of the cristae provide an enormous surface area for the chemical reactions that are part of the aerobic phase of cellular respiration, the reactions that produce most of a cell's ATP. The enzymes that catalyze these reactions are located on the cristae and in the matrix of the mitochondria.



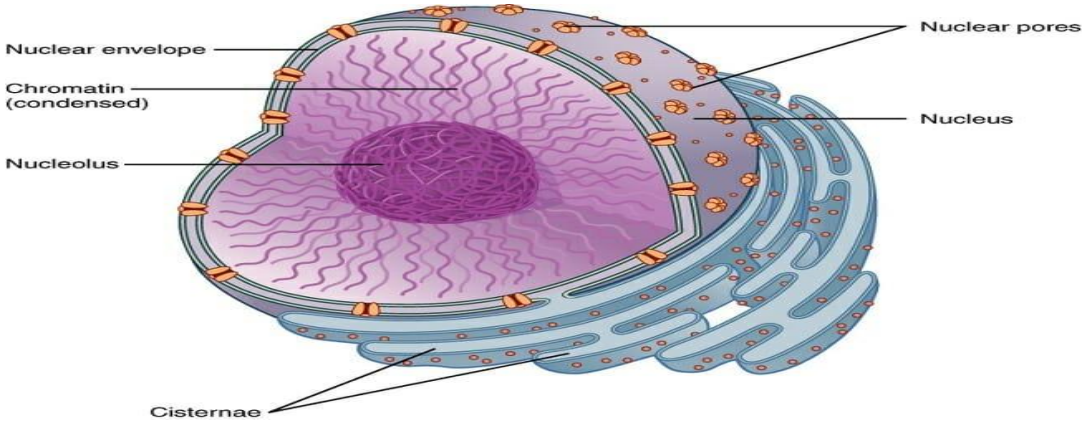
III. NUCLEUS:

The nucleus is a spherical or oval-shaped structure that usually is the most prominent feature of a cell. A double membrane called the nuclear envelope separates the nucleus from the cytoplasm. Both layers of the nuclear envelope are lipid bilayers similar to the plasma membrane. The outer membrane of the nuclear envelope is continuous with rough ER and resembles it in structure. Many openings called nuclear pores extend through the nuclear envelope. Each nuclear pore cons rrangement of proteins surrounding a large central opening that is about 10 times wider than the pore of a channel

protein in the plasma membrane. Nuclear pores control the movement of substances between the nucleus and the cytoplasm.

Inside the nucleus are one or more spherical bodies called nucleoli that function in producing ribosomes. Each nucleolus is simply a cluster of protein, DNA, and RNA; it is not enclosed by a membrane. Nucleoli are the sites of synthesis of rRNA and assembly of rRNA and proteins into ribosomal subunits. Nucleoli are quite prominent in cells that synthesize large amounts of protein, such as muscle and liver cells.

Nucleoli disperse and disappear during cell division and reorganize once new cells are formed. Within the nucleus are most of the cell's hereditary units, called genes, which control cellular structure and direct cellular activities. Genes are arranged along chromosomes. Human somatic (body) cells have 46 chromosomes, 23 inherited from each parent. Each chromosome is a long molecule of DNA that is coiled together with several proteins. This complex of DNA, proteins, and some RNA is called chromatin. The total genetic information carried in a cell or an organism is its genome.



Nucleus

FUNCTIONS OF A CELL: The following are the important functions performed by a cell

1. Ingestion and assimilation: The cell ingests chemical substances like amino acids from intercellular or interstitial fluid. These substances are used to build up complicated substances like proteins.

2. Growth and repair: The ingested and assimilated materials are used to synthesize new protoplasm. This leads to an increase in the size and growth of the cell. Also worn out parts of the cell are replaced by this process.

3. Metabolism involves two processes:

a) Anabolism is in which the ingested and assimilated food material is used for growth and repair.

b) Catabolism is in which food material is broken down to release energy for various functions of the cell.

4. Respiration: It involves the transport of oxygen from the lungs through blood to the tissues and the removal of waste products like carbon dioxide.

This is essential for the survival and functions of a cell.

5. Excretion: The cell eliminates waste products resulting from catabolism into the interstitial fluid. These products are carried by blood for elimination through the lungs and kidneys.

6. Irritability and contractility: The cell is active using these two functions. The cell responds to any stimulus (like physical, chemical, thermal, electrical).

TRANSFER OF MATERIAL ACROSS THE PLASMA MEMBRANE

It is divided into two sub-headings;

Movement of Small Molecules across the Membrane:

(A) Diffusion

- ✓ Simple diffusion
- ✓ Facilitated diffusion
- ✓ Osmosis

(B) Active transport

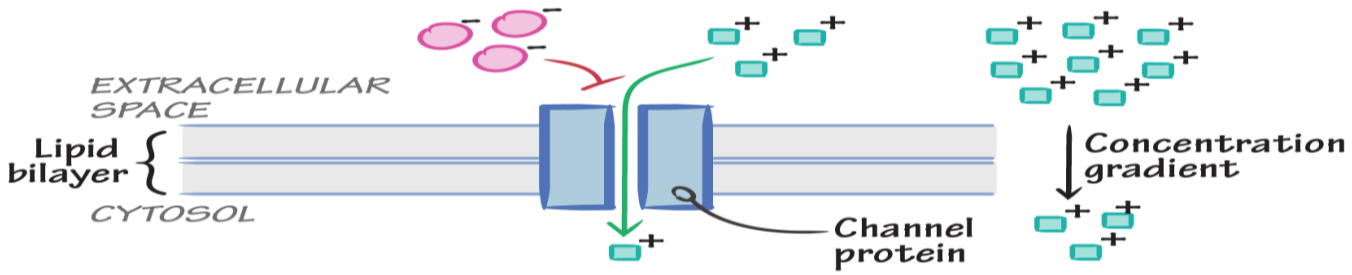
Movement of large molecules across the membrane

- ✓ Endocytosis
- ✓ Exocytosis

Simple Diffusion or Passive transport:

It is a passive process where the solute molecules in a solution are carried in the direction of their concentration gradient i.e. from higher concentration to lower concentration without utilization of energy. Substances moves across the cell membrane by three basic mechanisms.

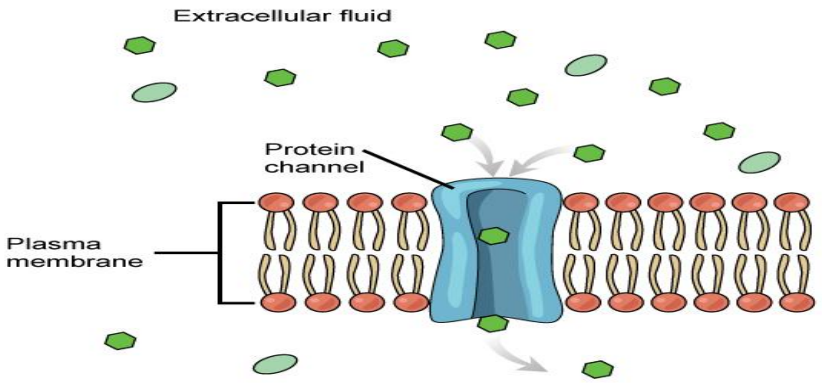
- The molecules remains in the aqueous phase and diffuse through aqueous channels or pores in the membrane.
- The molecule leaves the aqueous phase on one side of the membrane, dissolves in lipid bilayer and crosses it and again enters the aqueous phase on opposite side of membrane.
- The molecules combine with carrier molecules and help them across the cell membrane. inside of cell



Passive transport

Facilitated Diffusion:

It also called as carrier-mediated diffusion. The carrier protein facilitates the diffusion of the substances to the other side of membrane. Energy is not required for such transfer. Many lipid insoluble substances like certain vitamins, glucose, urea cross the membrane by this process. The transfer is in the direction of concentration gradient, from higher concentration to lower concentration. This transfer achieved through the structural changes in the protein, when it binds with the material to be transferred.



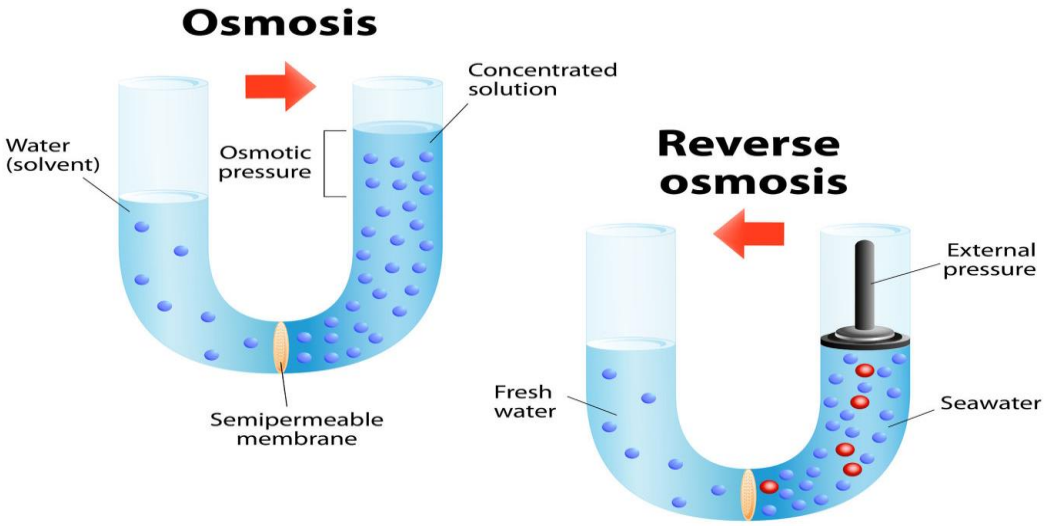
Facilitated diffusion

Osmosis:

Osmosis is defined as movement of solvent molecules across a semi-permeable membrane from an area of higher concentration to an area of lower concentration. Osmosis occurs only when a membrane is permeable to water but it is not permeable to certain solutes. Consider a U-shaped tube containing a selectively permeable membrane that separates the left and right arms of the tube. A volume of water is poured into the left arm, and the same volume of a solution containing a solute that cannot pass through the membrane is poured into the right arm. Because the water concentration is higher on the left arm and lowers on the right arm, the net movement of water molecules (osmosis) occurs from left to right. Water moves down its concentration gradient. At the same time, the membrane prevents diffusion of the solute from right arm into the left arm. As a result, the volume of water in the left arm decreases and the volume of solution in the right arm increases.

Hydrostatic pressure: Pressure excreted by a liquid is known as hydrostatic pressure this pressure forces water molecules to move back into the left arm.

Osmotic pressure: Pressure excreted by the solute on a semipermeable membrane through which it cannot penetrate. The osmotic pressure of a solution is proportional to the concentration of the solute two and particles that cannot cross the membrane. Higher the solute concentration, higher is the solution's osmotic pressure.



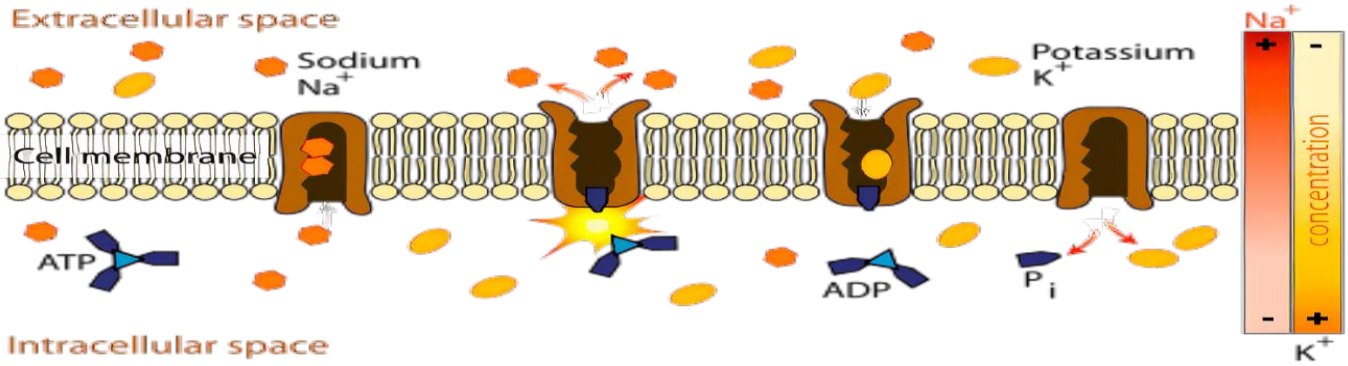
Osmosis

Active Transport:

When the material is transported out against the concentration gradient i.e. from eldsam lower concentration to higher concentration with utilization of energy then the process called as active transport. Energy is obtained from the hydrolysis of ATP. Active transport is of two types:

(a) Primary Active Transport:

Energy is derived from hydrolysis of ATP which changes the shape of carrier protein. The carrier protein pumps a substance across a plasma membrane against its concentration gradient.

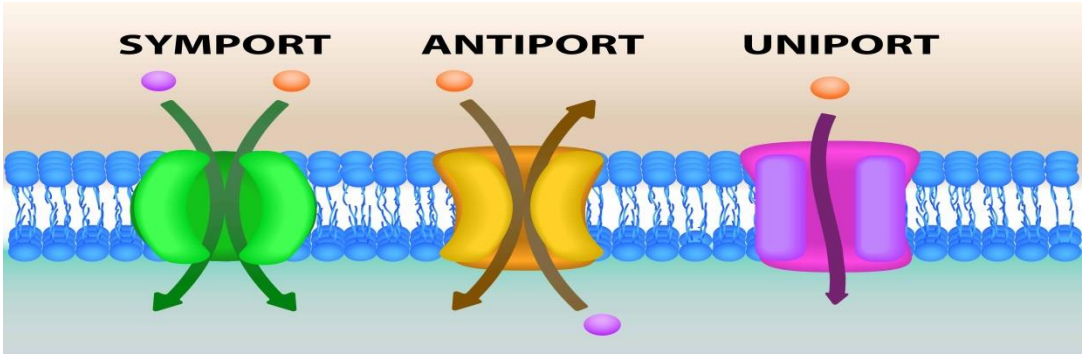


Primary active transport

(b) Secondary Active Transport:

In this process, the electrochemical potential difference created by pumping ions out of the cell is used to transport molecules across the membrane. The electrochemical gradient is used to drive other substances across the plasma membrane against their concentration gradient. A symport is an active transport protein that transports two different molecules across the cell membrane at the same time. The material

transferred along with some ions is called as symport or co-transport. An anti-port is an active transport protein that transports two molecules in opposite directions against their concentration gradients.



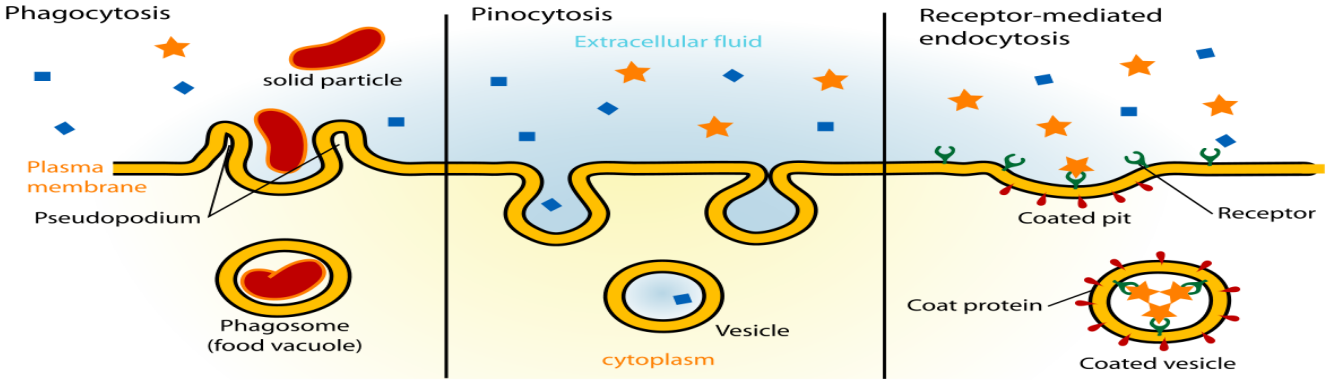
Secondary active transport

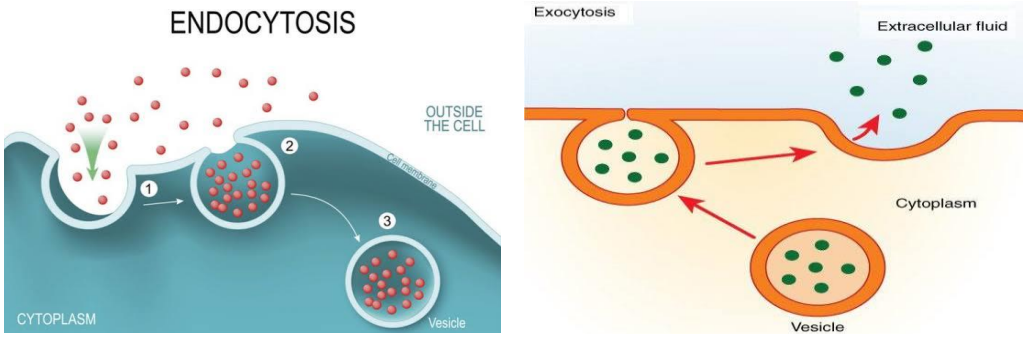
Endocytosis:

It is a transport mechanism which involves engulfing extracellular materials within a segment of the cell membrane to form a vesicle called as corpuscular or vesicular transport. For example, Macromolecular nutrients like fats and starches, oil soluble vitamins A, D, E, K and drugs such as insulin. Endocytosis includes two types of processes:

(a) Phagocytosis: It is a form of endocytosis in which the cell engulfs large solid particles, such as worn out cells, whole bacteria or viruses.

(b) Pinocytosis: It is a form of endocytosis in which tiny droplets of extracellular fluid are taken up.





Endocytosis& Exocytosis

Exocytosis:

Undigested substance called as residual body is excreted through the cell membrane by a process called as exocytosis. The undigested substances produced within the cytoplasm may be enclosed in a membrane to form vesicle called as exocytic vesicle. These cytoplasm exocytic vesicles fuse with the internal surface of the plasma membrane. The vesicle then ruptures releasing their content into the extracellular space and their membranes are left behind and refused.

CELL DIVISION

Cell division is the process by which a parent cell divides into two or more daughter cells. These cells divide once in approximately every 24 hours. The duration of cell cycle can vary with organism and the cell type. The two types of cell division are:

✓ Somatic cell division

✓ Reproductive cell division

Somatic cell division: A cell undergoes a nuclear division called mitosis and a cytoplasmic division called cytokinesis to produce two identical cells, each with the same number and kind of chromosomes as the original cell.

Reproductive cell division: A cell undergoes a division called as meiosis, in which the number of chromosomes in the nucleus is reduced by half. This mechanism produces gametes- the cells needed to form the next generation of sexually reproducing organisms.

Somatic Cell Division:

Cell Cycle:

The cell cycle is an orderly sequence of events by which a somatic cell duplicates its contents and divides in two. Human cell, contain 23 pairs of chromosomes with a total of 46 chromosomes. One member of each pair is inherited from each parent. The two chromosomes that make up each pair are called homologous chromosomes. Somatic cells contain two sets of chromosomes; they are called diploid cells, denoted as 2n.

The cell cycle is divided into two basic phases:

✓ Interphase: When a cell is not dividing.

✓ Mitotic phase: When a cell is dividing.

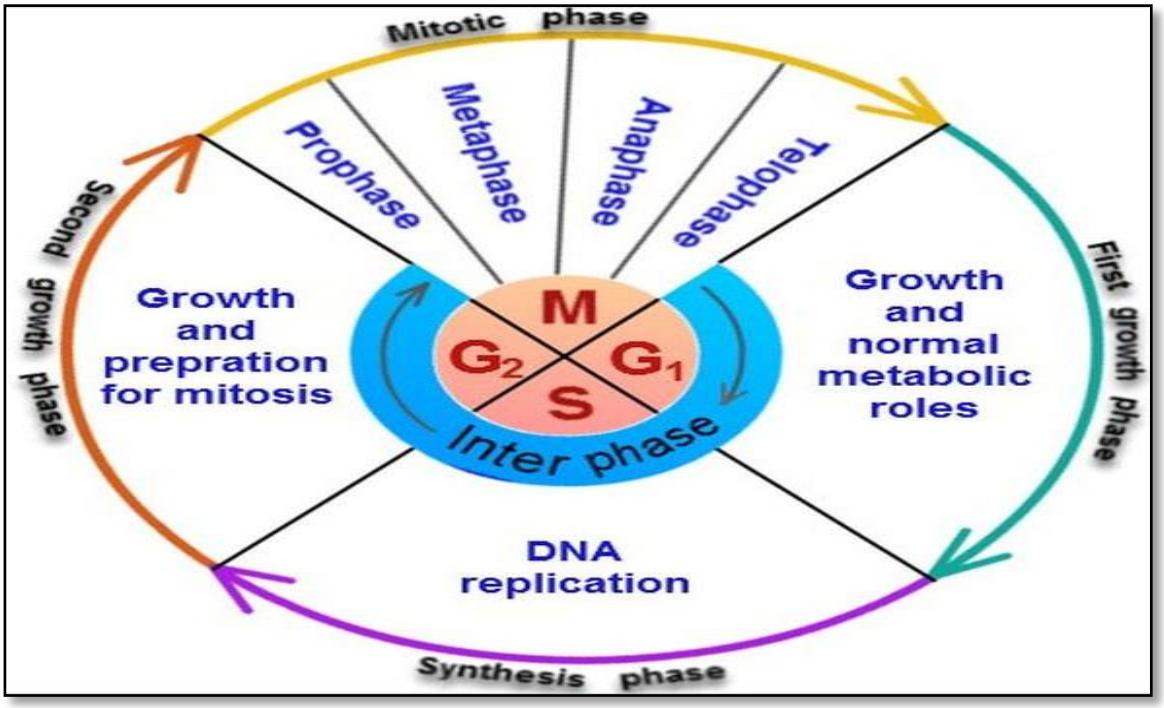
Interphase:

During interphase replication of DNA takes place and additional cell organelles and cytosolic components are formed.

Interphase is a state of high metabolic activity; it is during this time that the cell grows.

Interphase consists of three phases: G_1, S, and G_2.

G_1 phase: It is the interval between the mitotic phase and the S phase. During G_1, the cell is metabolically active; it replicates most of its organelles and cytosolic components but not its DNA. Replication of centrosomes also begins in the G_1 phase. G_1 phase lasts 8 to 10 hours.



Cell division

S phase: It is the interval between G_1 and G_2 lasts about 8 hours. During the S phase, DNA replication occurs. As a result, the two identical cells formed during cell division will have the same genetic material.

G_2 phase: It is the interval between the S phase and the mitotic phase. It lasts for 4 to 6 hours. During G_2 phase, cell growth continues, enzymes and other proteins are synthesized in preparation for cell division, and replication of centrosomes is completed. Once a cell completes its activities during the G_1, S, and G_2 phases of interphase, the mitotic phase begins.

Mitotic (M) Phase:

This is the most dramatic period of the cell cycle, involving a major reorganization of virtually all components of the cell. Since, the number of chromosomes in the parent and progeny cells is the same, it is also called as equational division. The mitotic phase of the cell cycle consists of a nuclear division (mitosis) and a cytoplasmic division (cytokinesis) to form two identical cells. The process results in the exact distribution of genetic information.

It is divided into four stages:

Prophase

Metaphase

Anaphase

Telophase

Prophase:

In early prophase, the chromatin fibers condense and shorten into chromosomes. Each prophase chromosome consists of a pair of identical strands called chromatids. A constricted region called a centromere holds the chromatid pair together. At the outside of each centromere is a protein complex known as kinetochore. In late prophase, tubulins in the pericentriolar material of the centrosomes start to form the mitotic spindle, a football shape of microtubules that attach to the Kinetochore. As the microtubules lengthen, they push the centrosomes to the ends of the cell so that the spindle extends from pole to pole. The nucleolus disappears and the nuclear envelope breaks down.

Metaphase:

During metaphase, the microtubules of the mitotic spindle align the centromeres of the chromatid pairs at the exact center of the mitotic spindle called as metaphase. This arrangement of the chromosomes at the metaphase plate ensures that each nucleus after cell division will receive one copy of each chromosome.

Anaphase:

During anaphase, the centromeres split, separating the two members of each chromatid pair, which move toward opposite poles of the cell. Once separated, the chromatids are termed chromosomes. As the chromosomes are pulled by the microtubules of the mitotic spindle during anaphase appears V-shaped.

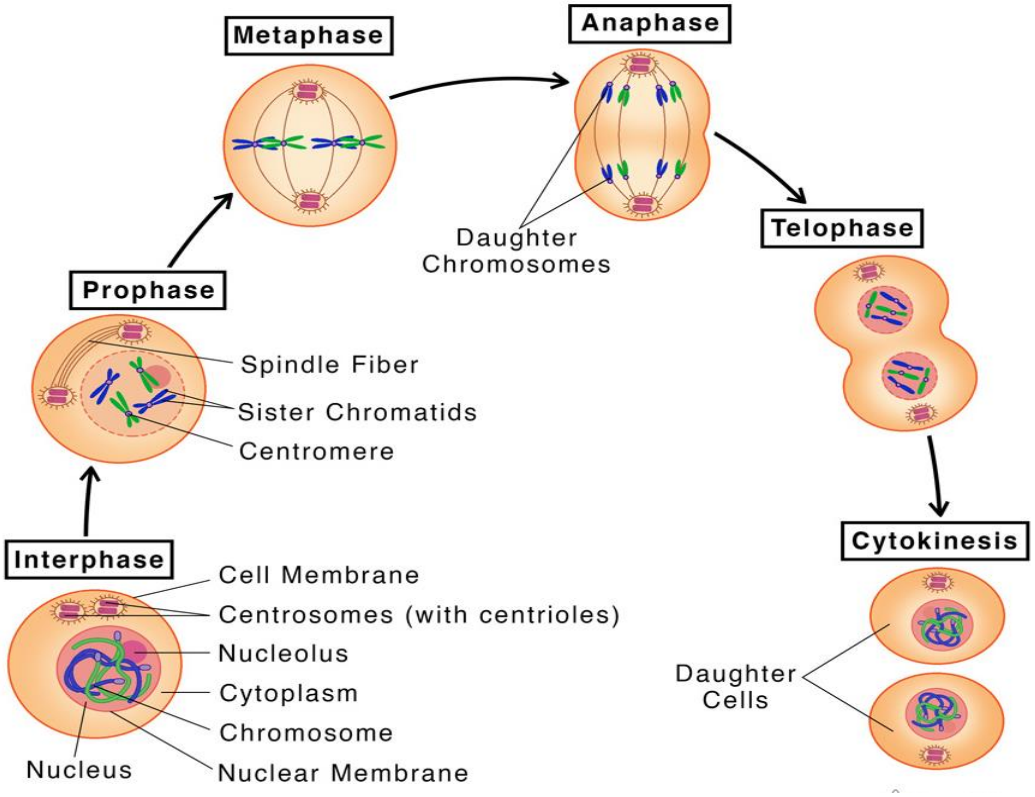
Telophase:

Telophase begins after chromosomal movement stops. The identical sets of chromosomes, now at opposite poles of the cell, uncoil and forms thread-like chromatin. A nuclear envelope forms around each chromatin mass, nucleoli reappear and the mitotic spindle breaks up.

Cytokinesis:

Division of a cell's cytoplasm and organelles into two identical cells is called cytokinesis. Process usually begins in late anaphase with the formation of cleavage furrow, a slight indentation of the plasma membrane, and is completed after telophase. The cleavage furrow usually appears midway between the centrosomes and extends around the periphery of the cell. Actin microfilaments that lie just inside the plasma membrane form a contractile ring that pulls the plasma membrane progressively inward. When cytokinesis is complete, interphase begins. The sequence of events can be summarized as

G_1 phase → S phase → G_2 phase → Mitosis → Cytokinesis



Stages of mitosis

CELL JUNCTIONS

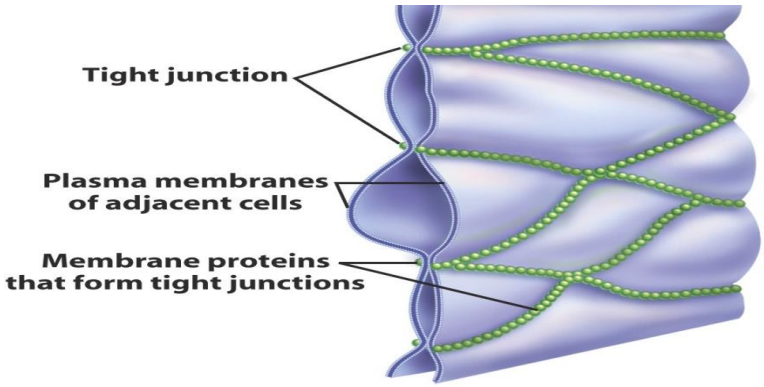
Cell junctions are also called as intercellular bridge. Cell junctions are contact points between the plasma membranes of tissue cells. Cell junctions consist of multi-protein complexes that provide contact between neighboring cells or between a cells and the extracellular matrix. There are five different types of cell junctions:

- Tight junctions
- Adherens junctions
- Hemidesmosomes
- Desmosomes
- Gap Junctions

Tight Junctions

It acts as barriers that regulate the movement of water and solutes between epithelial layers. The cells of epithelial tissues that line the stomach, intestines and urinary bladder have many tight junctions to retard the passage of substances between cells and prevent the leaking of contents into the blood or surrounding tissues. Tight junctions present in different types of epithelia are selective for solutes of differing size, charge and polarity. These are composed of a branching network of sealing strands acting independently

from the others. Each strand is formed from a row of trans-membrane proteins embedded in both plasma membranes, with extracellular domains joining one another directly. The major proteins present are claudins and occludins. These associate with different peripheral membrane proteins such as ZO-1 located on the plasma membrane, which anchor the strands to the actin component of the cytoskeleton.



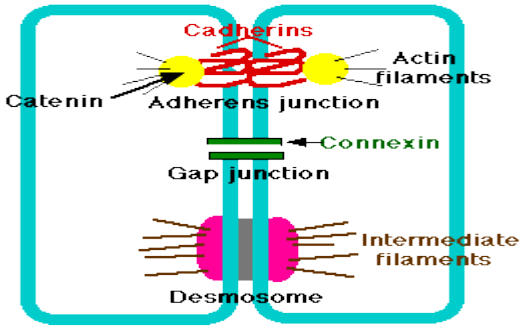
Tight junctions

Functions:

- They hold the cells together.
- Tight junctions help to maintain the polarity of cells by preventing the lateral diffusion of proteins between the apical and lateral/basal surfaces.
- Tight junctions prevent the passage of molecules and ions through the space between plasma membranes of adjacent cells.

Adherens Junctions:

These are also called as intermediate junction or belt desmosome. These are protein complexes that occur at cell-cell junctions in epithelial and endothelial tissues. Adherens junctions contain plaque, a dense layer of proteins on the inside of the plasma membrane that attaches both to membrane proteins and microfilaments of the cytoskeleton.



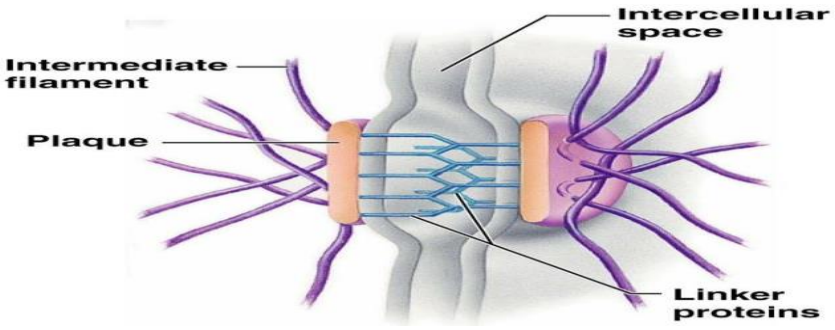
Adherens junctions

The trans-membrane glycoproteins present in adherens junctions called as cadherins that joins the cells. In epithelial cells, adherens junctions forms the extensive zones called as adhesion belts. Adherens

junctions helps to epithelial surfaces to resist separation during various contractile such as movement of food through the intestines.

Desmosomes

Desmosomes contain plaque and trans-membrane glycoproteins such as cadherins that extend into the intercellular space between adjacent cell membranes and attach cells to one another. A desmosome plaque attaches to cytoskeleton known as intermediate filaments that consist of keratin protein. The intermediate filaments extend from desmosomes on one side of the cell across the cytosol to desmosomes on the opposite side of the cell. Such a type of structural arrangement helps in the stability of cells and tissues. These types of junctions are more common in the epidermis (the outermost layer of the skin) and cardiac muscle cells of the heart.

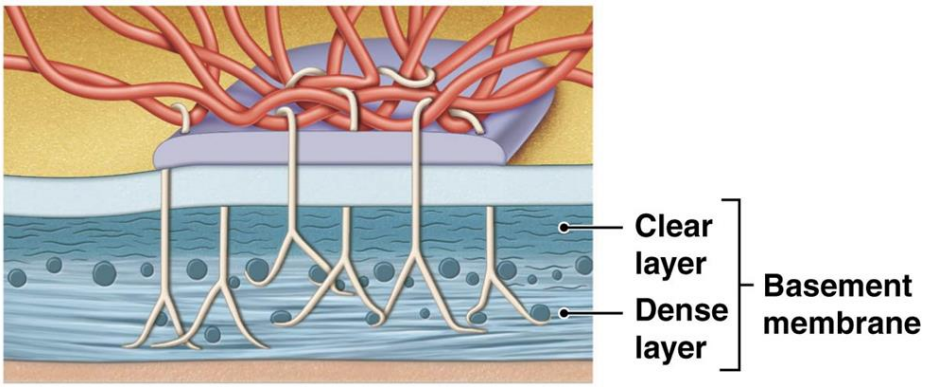


Desmosomes

Hemidesmosomes:

Hemidesmosomes resemble like desmosomes but they do not link the adjacent cells. The structure of hemidesmosomes is like half of a desmosome The trans-membrane glycoproteins present in hemidesmosomes are integrins. To the inner side of plasma membrane, integrins attaches to the intermediate filaments made up of keratin protein. To the outer side of plasma membrane, the integrins attaches to the protein laminin present in the basement membrane.

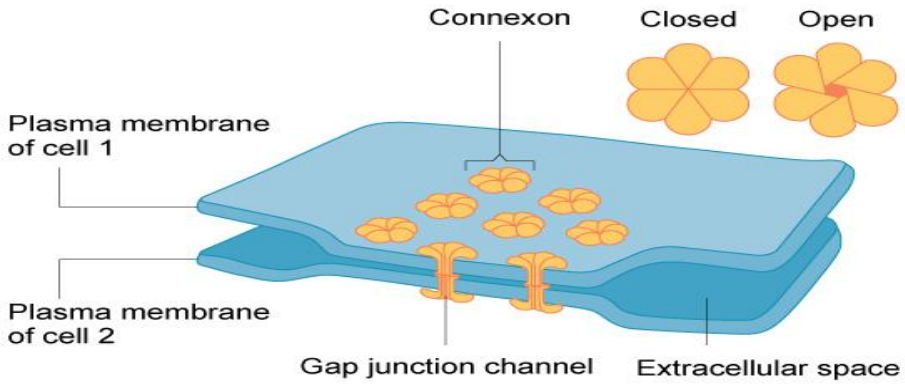
Hence, it plays an important role in anchoring cells to the basement membrane.



Hemidesmosomes

Gap Junctions:

The membrane proteins present in gap junctions are called as connexins, form tiny fluid-filled tunnels called connexons that connect neighbouring cells. The plasma membranes of gap junctions are separated by a very narrow intercellular gap (2 to 4 nm). Through the connexons the ions and small molecules can diffuses from the cytoplasm of one cell to another cell. A gap junction allows the communication of cells with one another. Gap junctions enable nerve or muscle impulses to spread rapidly among nervous cells. Dissolved substances such as ions or glucose can pass through the gap junctions.



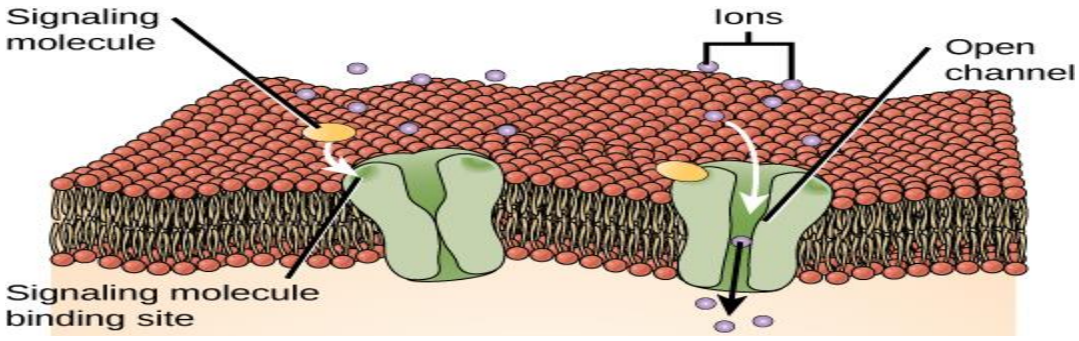
Gap junctions

GENERAL PRINCIPLES OF CELL COMMUNICATION

Cell signaling is part of any communication process that governs basic activities of cells and co-ordinates cell actions. It is the ability of cells to perceive and correctly respond to their microenvironment is basis of development, tissue repair, immunity and homeostasis. Communication between cells is common in nature.The cells of multicellular organisms uses a variety of molecules as signals, such as peptides, proteins, amino acids, nucleotides, steroids and lipids.

Cell Surface Receptors:

Any cell of a multicellular organism is exposed to variety of signals. At any time, hundreds of different chemical signals in the environment surrounding the cell.

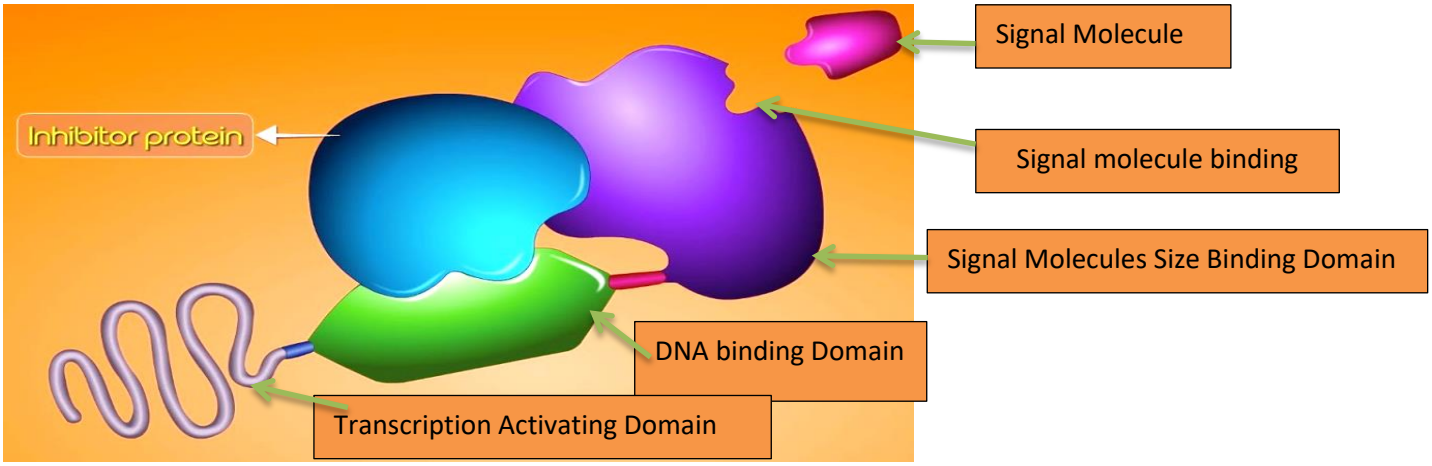


Cell surface receptors bind with specific molecules

The receptor proteins are located on or within the cell having a three-dimensional shape that fits in to specific signal molecule. When a signal molecule binds with receptor protein of the right shape, the activation of receptor occurs. This binding produces a change in the receptor protein's shape, producing a response in the cell.

Intracellular Receptors:

Many cell signals are lipid soluble or very small molecules that can readily pass across the plasma membrane of the target cell and into the cell, where they interact with a receptor. Some cell signals bind to protein receptors present in the cytoplasm whereas; others pass across the nuclear membrane as well and bind to receptors within the nucleus. These intracellular receptors may trigger a variety of responses in the cell, depending on the receptor



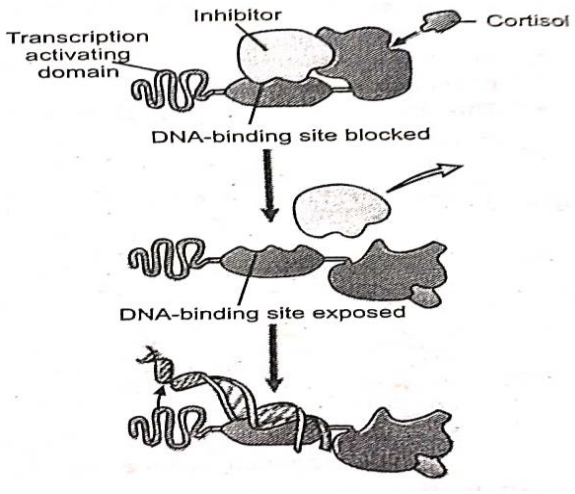
Gene-regulating intracellular receptor

Receptors that Act as Gene Regulators:

Some of the intracellular receptors act as regulators of gene transcription. For example, receptors for steroid hormones, such as cortisol, estrogen, and progesterone. All of these receptors have a DNA binding site. In inactive state, the receptor cannot bind with DNA because an inhibitor protein occupies the binding site. As the signal molecule binds to another site on the receptor, the inhibitor is released and the DNA binding site is exposed. DNA binding domain The receptor then binds to a specific nucleotide sequence on the DNA, which activates a particular gene, usually located adjacent to the regulatory site.

Receptors that Act as Enzymes

The other intracellular receptors act as enzymes. For example, Nitric oxide (NO). A small gas molecule NO diffuses out of the cells where it is produced and passes directly into neighbouring cells, where it binds with guanylyl cyclase enzyme. Binding of NO to the receptor activates the enzyme, enabling it to catalyze the synthesis of guanosine monophosphate GMP, an intracellular messenger molecule that produces cell-specific responses such as the relaxation of smooth muscle cells



Intracellular receptors regulate gene transcription

Cell Surface Receptors:

Most of the signal molecules are water-soluble such as peptide hormones, neurotransmitters and proteins that act as growth factors during development.

Water soluble signal molecules cannot diffuse through cell membranes.

Therefore, for generation of responses, they must bind to receptor proteins on the surface of cell.

These cell surface receptors convert the extracellular signal to an intracellular signal, by binding with the signal molecule by producing a change within the cytoplasm of cell.

These are of three types;

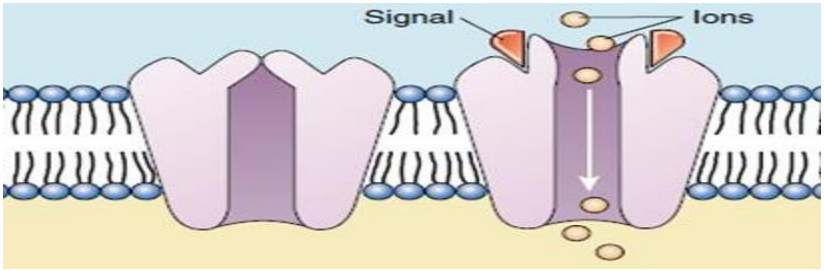
✓ Chemically gated ion channels

✓Enzymatic receptors

✓ G-protein linked receptors

Chemically Gated Ion Channels:

These are the protein receptors through which ions passes. In the plasma membrane many protein molecules are embedded. At the centre of protein pore is present that connects the extracellular fluid with the cytoplasm. The size of pore is big so that ions can easily pass through it, so the protein functions as an ion channel.

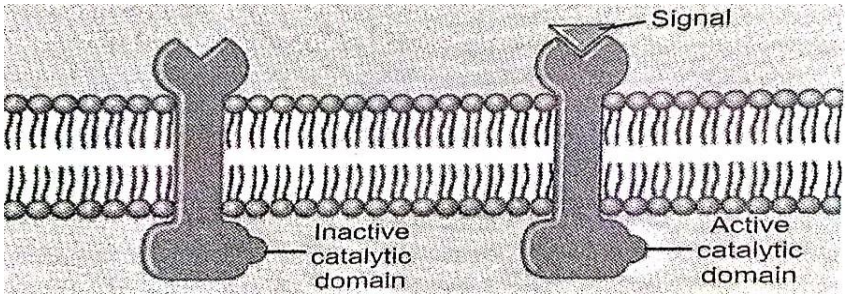


Chemically gated ion channels

The channel is known as chemically gated because it opens when a chemical (neurotransmitter) binds with it. When a chemically gated ion channel gets opens, different variety of ion such as sodium, potassium, calcium, chloride flows across the membrane depending on the structure of the channel.

Enzymatic Receptors:

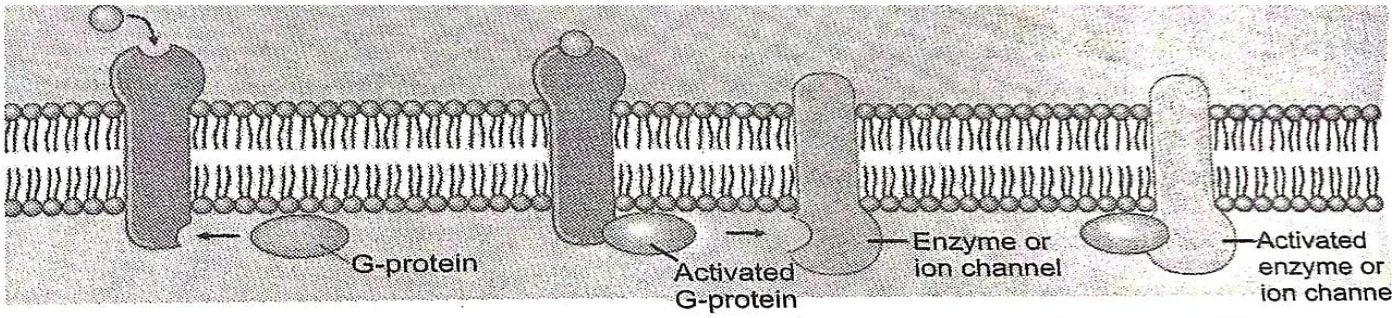
Many cell surface receptors either act as enzymes or are directly linked to enzyme. When a signal molecule binds to the enzymatic receptor, it activates the enzyme. The enzymes that get activates called as protein kinases, which add phosphate groups to the proteins. The enzymatic receptor consists of signal trans-membrane protein; the portion that binds to signal molecule lies outside the cell, and the portion that carries out the enzyme activity is exposed to the cytoplasm.



Enzymatic receptors

G-protein Linked Receptors:

G-protein linked receptors acts indirectly on enzymes or ion channels in the plasma membrane with the help of protein, called a guanosine triphosphate (GTP) binding protein, or G-protein. In this type, G-proteins are used to transmit signal from the membrane surface into the inside of cell. G-proteins are the mediators that initiate a diffusible signal in the cytoplasm. They form a link between the cell surface receptor and signal pathway within the cytoplasm. As the signal arrives, it finds the G-protein present in the G-protein linked receptor on the cytoplasmic side of the plasma membrane. Once the signal molecule binds to the receptor, the shape of G-protein linked receptor get changes. This change in receptor shape twists the G protein, causing it to bind GTP. The G-protein can now diffuse from the receptor.The "activated" complex of a G-protein with attached GTP is then free to initiate a number of events.



G-Protein Linked Receptors

FORMS OF INTRACELLULAR SIGNALLING

Cell signalling can be classified as mechanical and biochemical based on the type of the signal. Mechanical signals are the forces exerted on the cell and produced by the cell. Biochemical signals are the biochemical molecules such as proteins, lipids, ions and gases. These signals can be classified based on the distance between signalling and responder cells. Signalling between and amongst cells is divided into the following:

- Contact dependant signalling
- Paracrine signalling
- Synaptic signalling
- Autocrine signalling

Contact Dependant Signalling:

Gap junctions in animals are connections between the plasma membranes of neighbouring cells. These water filled channels allow small signalling molecules, called intracellular mediators, to diffuse between the two cells. Small molecules, such as calcium ions (Ca^{2+}), are able to move between cells, but large molecules, like proteins and DNA, cannot fit through the channels. The specificity of the channels ensures that the cells remain independent, but can quickly and easily transmit signals. The transfer of signaling molecules communicates the current state of the cell that is directly next to the target cell; this allows a group of cells to co-ordinate their response to a signal that only one of them may have received.

Paracrine Signalling:

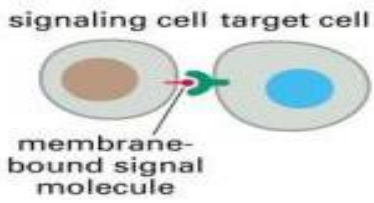
Signals that act locally between cells that are close together are called paracrine signals. Paracrine signals move by diffusion through the extracellular matrix. These types of signals usually elicit quick responses and last for short duration. Paracrine ligand molecules are quickly degraded by enzymes or removed by neighbouring cells. Paracrine signalling plays an important role in early development, co-ordinating the activities of clusters of neighbouring cells. One example of paracrine signalling is the transfer of signals across synapses between nerve cells.

Synaptic Signalling:

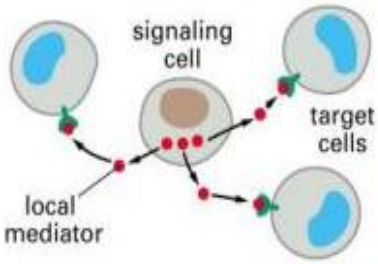
The cells of the nervous system provide rapid communication with distant cells. Their signal molecules, neurotransmitters, do not travel to the distant cells through the circulatory system like hormones. The long, fiber like extensions of nerve cells release neurotransmitters from their tips very close to the target cells. The narrow gap between the two cells is called a chemical synapse.

Endocrine Signalling:

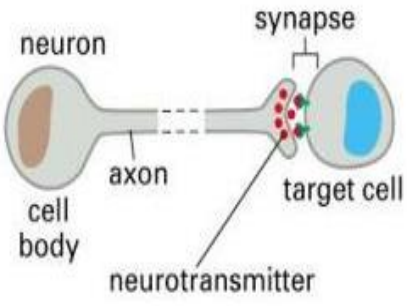
Signals from distant cells are called endocrine signals; they originate from endocrine cells. In human body, many endocrine cells are located in endocrine glands such as the thyroid gland, hypothalamus and pituitary gland. These types of signals usually produce a slower response, but have a longer lasting effect. The ligands released in endocrine signalling are called as hormones, signalling molecules that are produced in one part of the body, but affect other body regions some distance away. Hormones travel the large distances between endocrine cells and their target cells via the bloodstream, which is a relatively slow way to move throughout the body.



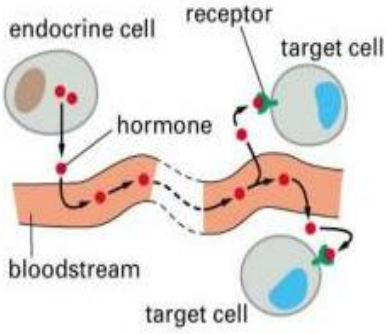
Contact Dependent



Paracrine



Synaptic



Endocrine

Cell Signaling

TISSUE LEVEL OF ORGANIZATION

TISSUE: A tissue is a group of cells that usually have a common origin and function together to carry out specialized activities.

Histology: (histo = tissue; logy = study of) is the science that deals with the study of tissues.

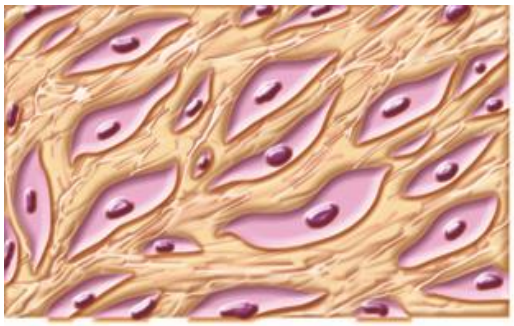
TYPES OF TISSUES: Body tissues can be classified into four basic types according to structure and function:

l. Epithelial tissue: It covers body surfaces and lines hollow organs, body cavities, and ducts. It also forms glands.

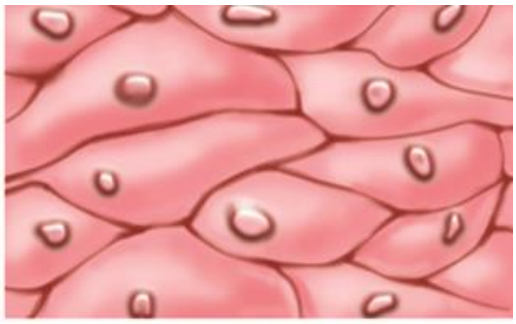
2. Connective tissue: It protects and supports the body and its organs. Connective tissue bind organs together, store energy reserves as fat, and help provide immunity to disease- causing organisms.

3. Muscular tissue: It generates the physical force needed to make body structures move and generates body heat.

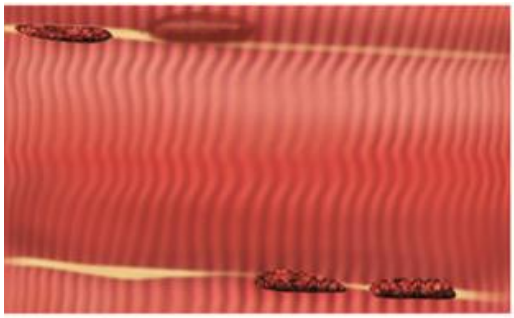
4. Nervous tissue: It detects changes in a variety of conditions inside and outside the body and responds by generating action potentials (nerve impulses) that activate muscular contractions and glandular secretions.



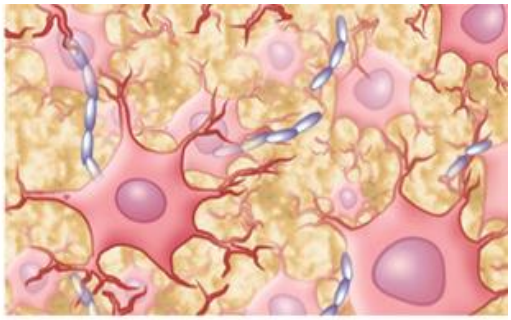
Connective tissue



Epithelial tissue



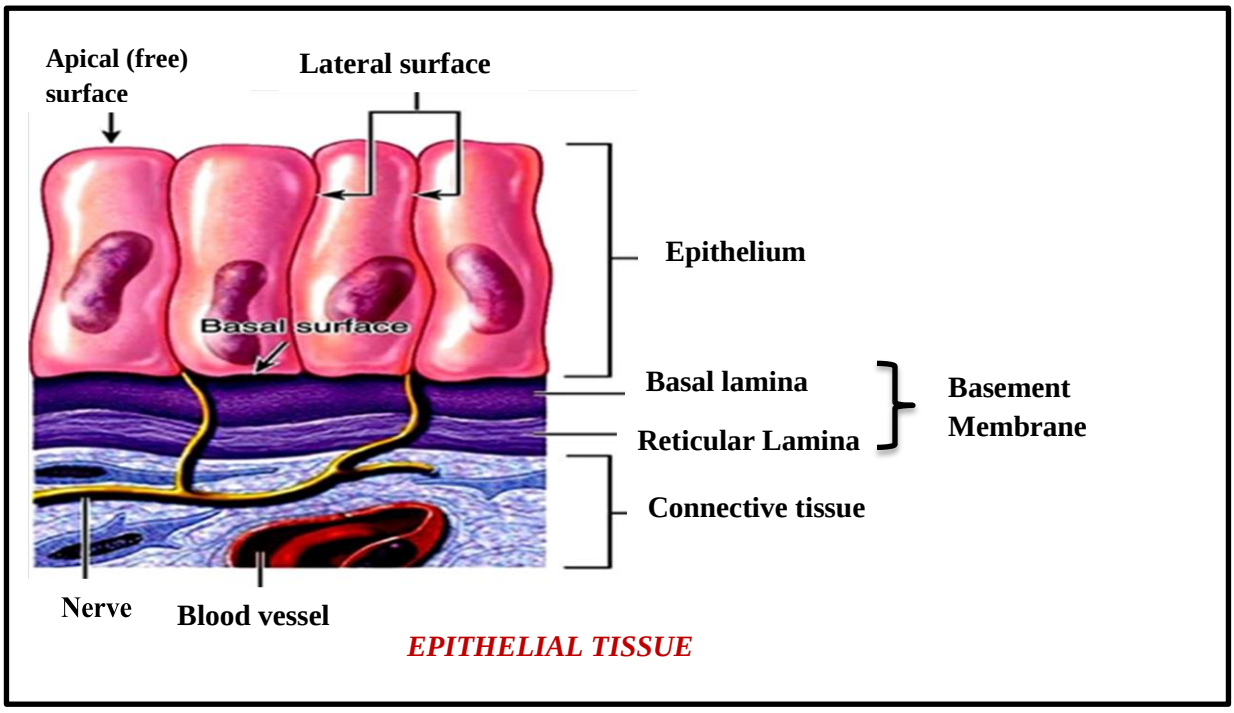
Muscle tissue



Nervous tissue

TYPES OF TISSUE

1 EPITHELIAL TISSUE: (Epithel = Covering, laid on) Epithelial tissue consists of cells arranged in tissue play different roles in body like protection, filtration, secretion, absorption and excretion.



EPITHELIAL TISSUE

Classification of epithelial tissues: Depending upon arrangement of cells and cell shapes, epithelium can be divided as:

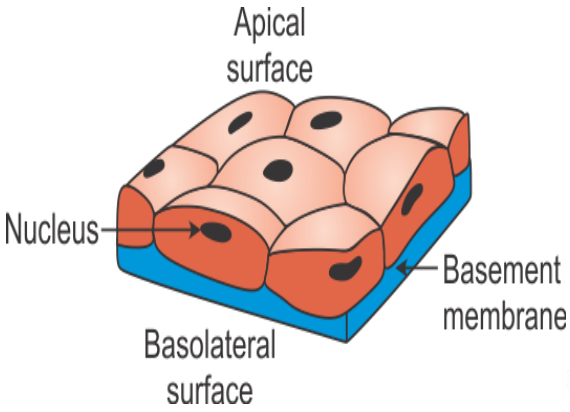
SIMPLE EPITHELIUM	STRATIFIES EPITHELIUM	GLANDULAR EPITHELIUM
Simple Squamous Epithelium	Stratifies Squamous Epithelium	Endocrine Glands
Simple Cuboidal Epithelium	Stratifies Cuboidal Epithelium	Exocrine Glands
Simple Columnar Epithelium	Stratifies Columnar Epithelium	
Pseudo stratified Columnar	Transitional Epithelium	

1.SIMPLE EPITHELIUM: It contains single layer of cells and is of 4 types

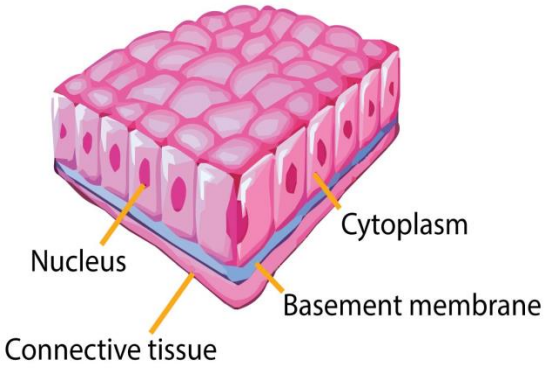
- **Simple Squamous Epithelium**
- **Simple Cuboidal Epithelium**
- **Simple Columnar Epithelium**
- **Pseudostratified Columnar**

a) Simple Squamous Epithelium: This tissue consists of a single layer of flat cells that resembles a tiled floor when viewed from the apical surface. The nucleus of each cell is a flattened oval or sphere and is

centrally located. Simple squamous epithelium is present at sites where the processes of filtration (such as blood filtration in the kidneys) or diffusion (such as diffusion of oxygen into blood vessels of the lungs) occur. It is not found in body areas that are subject to mechanical stress (wear and tear).



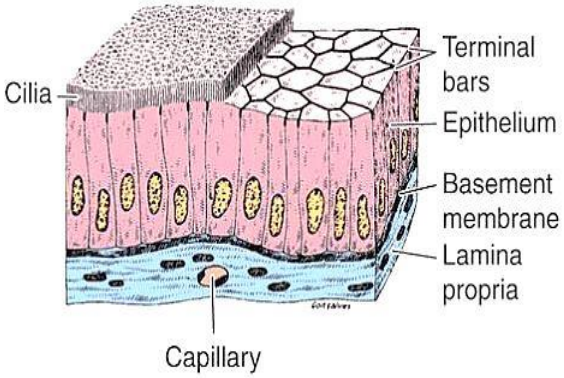
Simple Squamous Epithelium



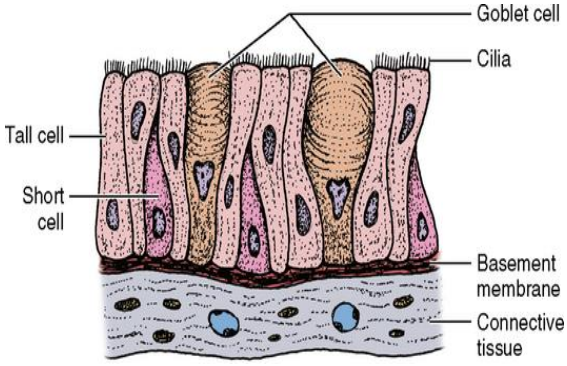
Simple cuboidal epithelium

b) Simple cuboidal epithelium: It consists of single layer of cube shaped cells having round and centrally located nucleus. This epithelium is found in organs such as the thyroid gland and kidneys and performs the functions of secretion and absorption.

c) Simple columnar epithelium: The cells of simple columnar epithelium appear like columns (taller than they are wide), with oval nuclei near the base. These play role in absorption and secretion. Examples: Goblet cells that produce mucous. Simple columnar epithelium cells can be ciliated (containing hair on surface) e.g. present in bronchioles and uterus etc.



Simple Columnar epithelium



Pseudostratified columnar epithelium

d) Pseudostratified Columnar Epithelium: Pseudostratified columnar epithelium appears to have several layers because the nuclei of the cells are at various depths. Even though all the cells are attached to the basement membrane in a single layer, some cells do not extend to the apical surface. When viewed from the side, these features give the false impression of a multilayered tissue-thus the name pseudostratified epithelium (pseudo= false). In pseudostratified ciliated columnar epithelium, the cells

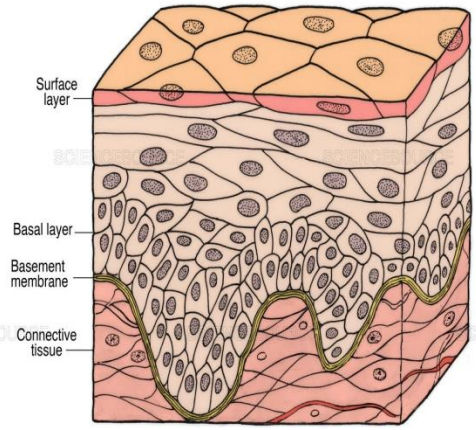
secrete mucus or bear cilia. The secreted mucus traps foreign particles and the cilia sweep away mucus for eventual elimination from the body. Pseudostratified nonciliated columnar epithelium contains cells without cilia and lacks mucus cells

2. STRATIFIED EPITHELIUM:

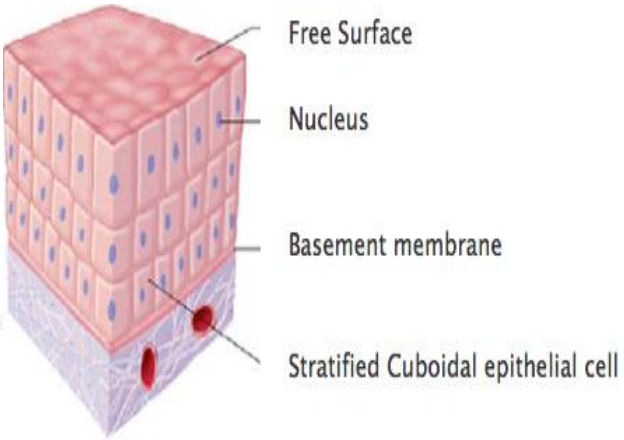
It contains multiple layers of cells. It is more durable an can better protect underlying tissues and is of 4 types:

- **Stratifies Squamous Epithelium**
- **Stratifies Cuboidal Epithelium**
- **Stratifies Columnar Epithelium**
- **Transitional Epithelium**

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



Stratified squamous epithelium

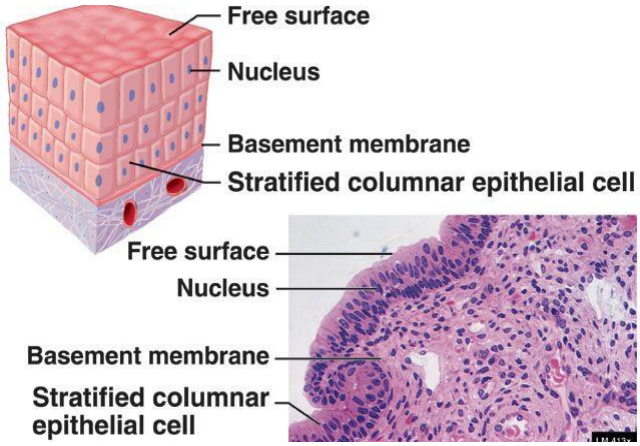


Stratified Cuboidal epithelium

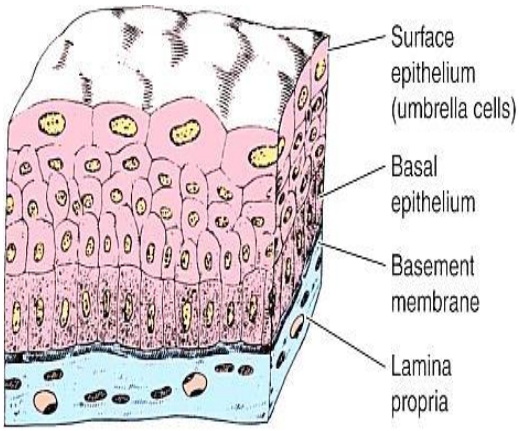
b) Stratified Cuboidal epithelium: This is a fairly rare type of epithelium in which cells in the upper layer are cuboidal. Stratified cuboidal epithelium serves a role in protection, secretion and absorption.

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

d) Transitional epithelium: Transitional epithelium is present only in the urinary system. In its relaxed or upstretched state, transitional epithelium looks like stratified cuboidal epithelium. As the tissue is stretched, its cells become flatter, giving the appearance of stratified squamous epithelium. It allows the urinary bladder to stretch to hold a variable amount of fluid rupturing

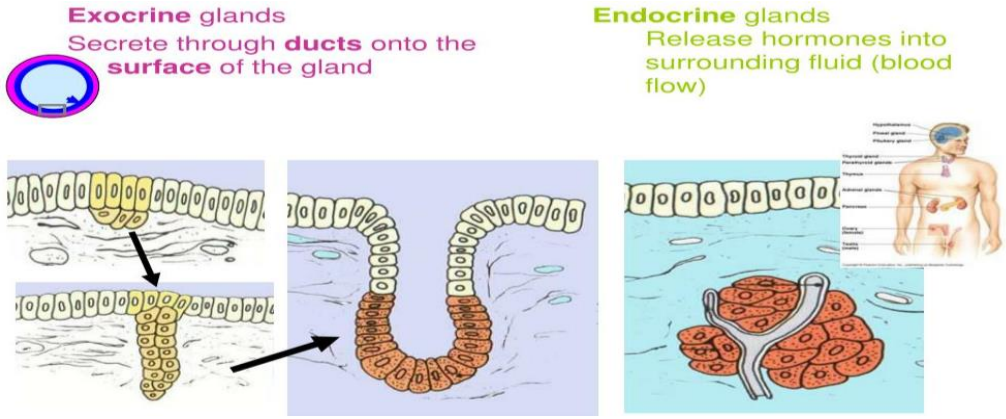


Stratified Columnar epithelium



Transitional epithelium

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

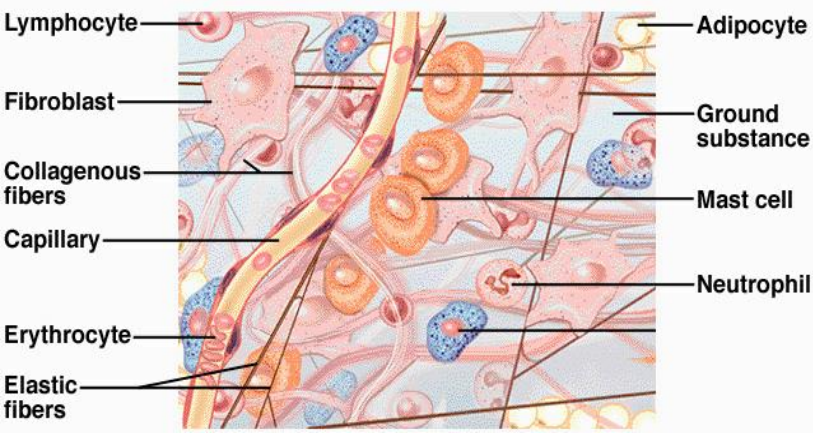


a) Endocrine Glands: (endo = inside; crine = secretion) These are the glands whose secretions (hormones) enter the interstitial fluid and then diffuse directly into the bloodstream without flowing through a duct. The pituitary, thyroid, and adrenal glands are examples of endocrine glands.

b) Exocrine glands: (Exo = outside; crine = secretion) These glands secrete their products into ducts that empty onto the skin surface or the lumen of a hollow organ. The secretions of exocrine glands include

mucus, sweat, oil, earwax, saliva, and digestive enzymes. Examples of exocrine glands include sudoriferous (sweat) glands, which produce sweat to help lower body temperature and salivary glands, which secrete saliva.

CONNECTIVE TISSUE: Connective tissue is one of the most abundant and widely distributed tissues in the body. It binds together, supports and strengthens other body tissues; protects and insulates internal organs; serves as the major transport system within the body (blood, a fluid connective tissue); is the primary location of stored energy reserves (adipose or fat tissue); and is the main source of immune responses.



Characteristics of connective tissue:

- Connective tissues are highly vascularized i.e. they have rich blood supply except cartilage, tendons and ligaments.
- The cells present in connective tissue are widely spaced.
- The space present between cells is filled with a material called extracellular matrix.
- Extracellular material is produced by connective tissue cells and is made up of ground substance and fibers**.**
- The ground substance is made up of adhesive proteins, polysaccharides and water. The adhesive proteins act as glue to attach cells. Polysaccharides and water form a jelly like material which also helps the cells to bind together.

Basically there are three types of fibers present in connective tissue:

1.Collagen fiber: (Colla = glue) These are strong and flexible fibers which are made up of **collagen protein**. These are abundantly present in bones, cartilage, ligament and tendons.

2.Elastic fibers: These fibers are stretchable and return to original shape after stretching. These are smaller in diameter than collagen fibers and are made up of **Elastin protein**.

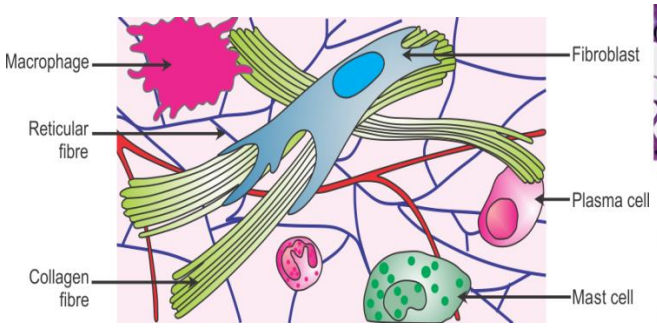
3.Reticular Fibers: (Reticul = Net) These are made up of collagen fibers which much thinner in diameter and are branched. These provide support in the walls of blood vessels and form a network around the cells in some tissues, supporting framework of many soft organs, such as the spleen and lymph nodes.

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

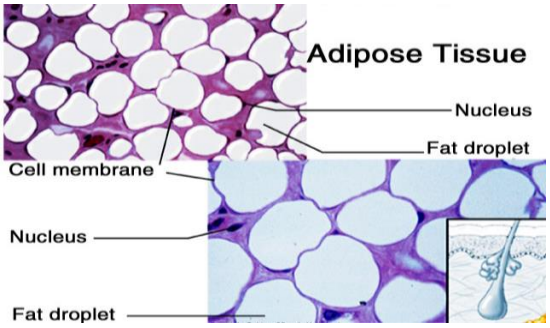
1. **Loose connective tissue**
   a. Areolar connective tissue
   b. Adipose tissue
   c. Reticular connective tissue
2. **Dense connective tissue**
   a. Dense regular connective tissue
   b. Dense irregular connective tissue
   c. Elastic connective tissue
3. **Cartilage**
   a. Hyaline cartilage
   b. Fibrocartilage
   c. Elastic cartilage
4. **Bone tissue**
5. **Liquid connective tissue**

1. LOOSE CONNECTIVE TISSUE: In loose connective tissue, fibers present between cells are loosely arranged. Loose connective tissue contains more cells and fewer fibers.

a). Areolar connective tissue: (Areola = space) This is one of the most widely distributed connective tissue in body. It contains several types of cells and all the three types of fibers embedded in ground substance. Due to areolar nature, it acts as reservoir for water, salts andnutrient. It is also called packing material as it is present in almost every body structure e.g. skin, mucous membrane. Its function is to provide strength, elasticity and support.



Areolar connective tissue

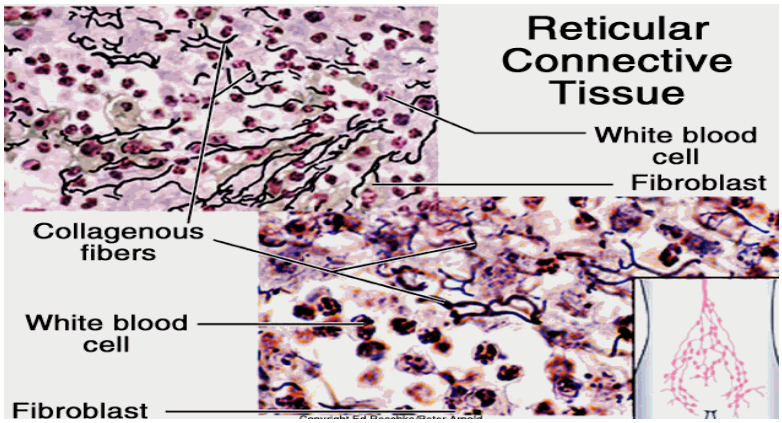


Adipose connective tissue

b). Adipose connective tissue: *(Adipo -fat*) This tissue is made up of specific cells called Adipocytes. These adipocytes are specialized to store fat and triglycerides. Cytoplasm and nucleus in adipocytes are

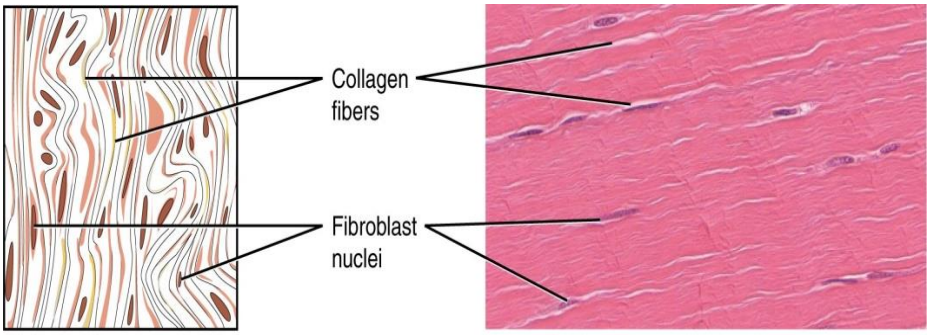
pushed toward periphery and hence the cell can store a drop of fat in remaining space. Adipose tissue forms layer beneath skin which insulates the body from heat and cold, protects the kidney by capsule of fat and cushions eye ball socket. It also serves as energy reserve, supports and protects several organs.

c). Reticular connective tissue: It is delicate network of reticular fibers and reticular cells which forms internal framework of certain soft organs like liver and spleen. It functions to filter and remove worn out blood cells and microbes in lymph nodes.

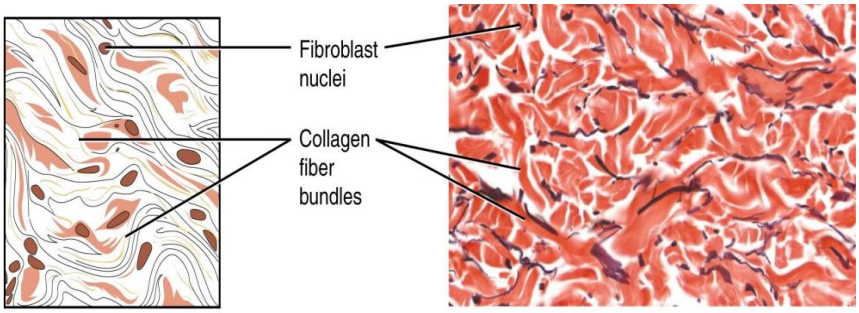


2. DENSE CONNECTIVE TISSUE: Dense connective tissue contains more numerous, thicker and denser fibers which are packed more closely and fewer cells than loose connective tissue. Cells present mainly in dense connective tissue are fibroblast. There are three types: dense regular connective tissue, dense irregular connective tissue and elastic connective tissue.

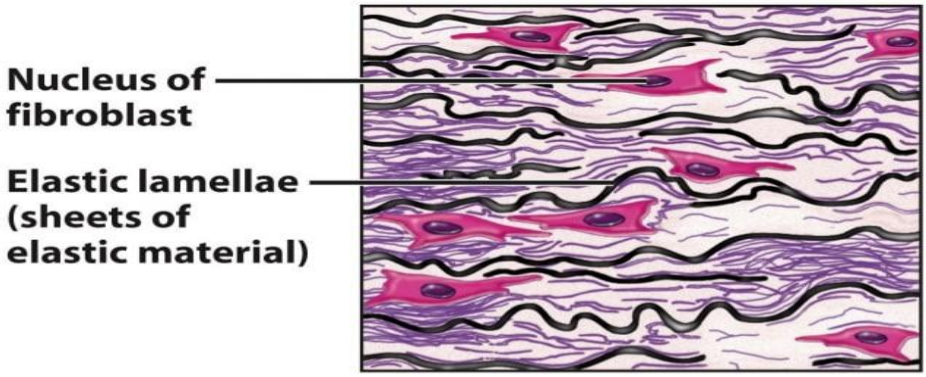
a). Dense regular connective tissue: It contains mainly collagen fibers regularly arranged in bundles and few fibroblasts are present which are arranged in rows in between the bundles of fibers. It forms tendons (attaches bone to muscle) and ligaments (attaches bone to bone). It also provides strong attachments between various structures.



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



c). Elastic connective tissue: It is made up of branched elastic fibers and fibroblasts. It is present in lungs, elastic arteries, trachea etc. Due to its elastic fibers, it allows stretching of various organs and recoils after stretching.

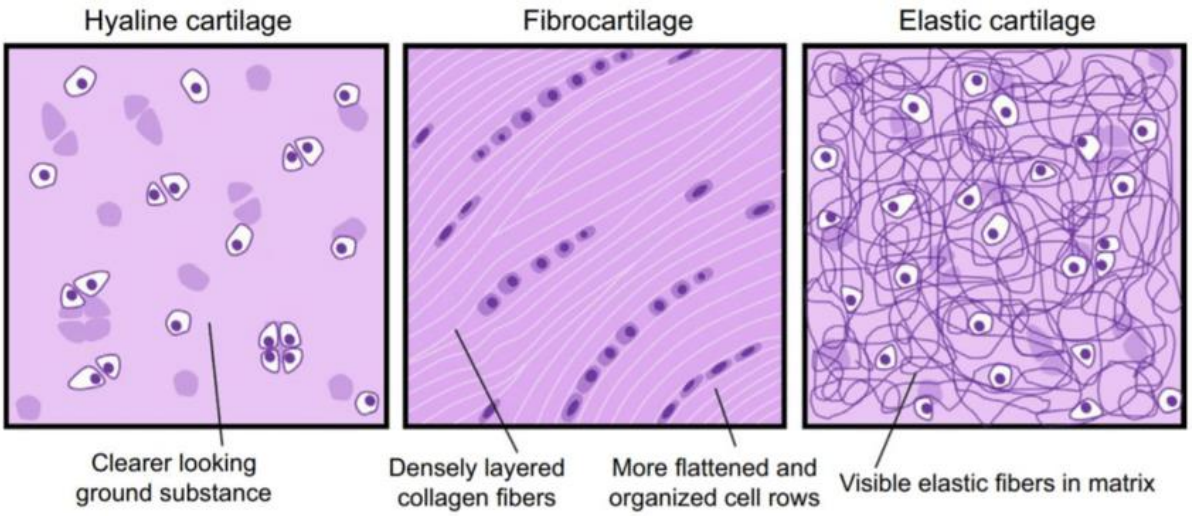


3. CARTILAGE: It consists of dense network of collagen and elastic fibers. It can bear more stress than loose and dense connective tissue. It contains few cells (chondrocytes) and large amount of extracellular material. It lacks blood supply. It is of 3 types: hyaline cartilage, elastic cartilage and, fibrocartilage.

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

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

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



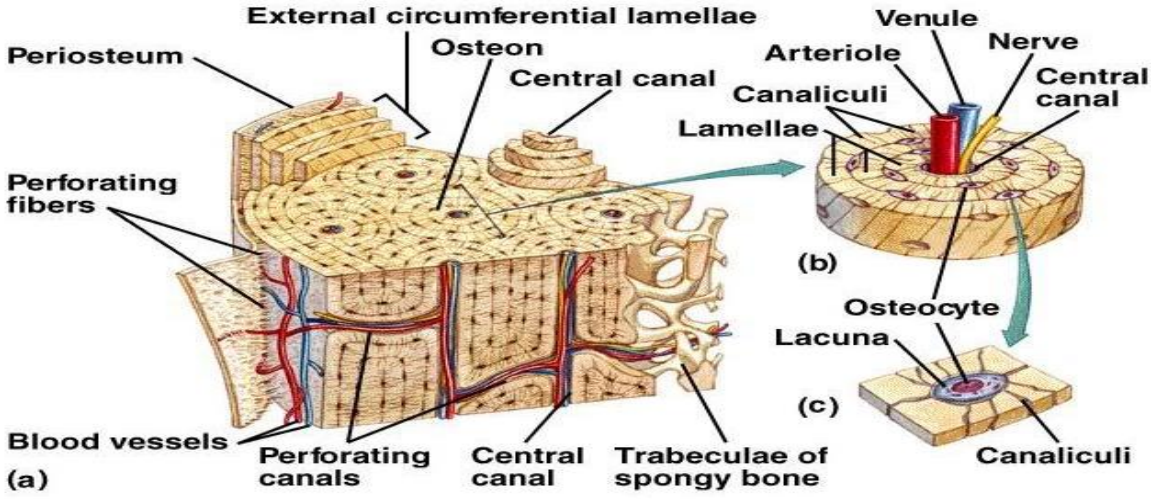
4. BONE TISSUE: The bones support soft tissues, protects delicate structures and works with skeletal muscles to generate movement. Bones store calcium and phosphorus; house red bone marrow, which produces blood cells; and contain yellow bone marrow, a storage site for triglycerides. The basic unit of compact bone is an osteon or haversian system. Each osteon has four parts:

a) The lamellae (= little plates) are concentric rings of extracellular matrix that consist of mineral salts (mostly calcium and phosphates), which give bone its hardness, and collagen fibers, which give bone its strength. The lamellae are responsible for the compact nature of this type of bone tissue.

b) Lacunae are small spaces between lamellae that contain mature bone cells called osteocytes.

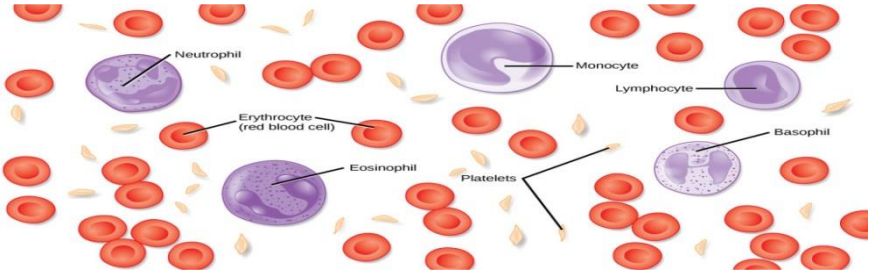
c) Canaliculi (= little canals) is networks of minute canals containing the processes of osteocytes. It provides routes for nutrients to reach osteocytes and for wastes to leave them.

d) A **central (haversian) canal** contains blood vessels and nerves.



5. LIQUID CONNECTIVE TISSUE:

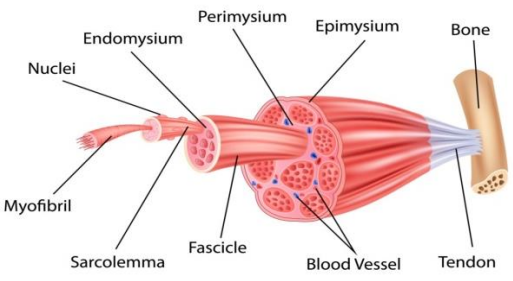
a). Blood tissue (or simply blood): It is a connective tissue with a liquid extracellular matrix. The liquid extracellular matrix is called blood plasma which is a pale yellow fluid that consists mostly of water with a wide variety of dissolved substances-nutrients, wastes, enzymes, plasma proteins, hormones, respiratory gases, and ions. Cells are suspended in the blood plasma which includes red blood cells (erythrocytes), white blood cells (leukocytes) and platelets (thrombocytes). Red blood cells transport oxygen to body cells and remove some carbon dioxide from them. White blood cells are involved in phagocytosis, immunity, and allergic reactions. Platelets participate in blood clotting.



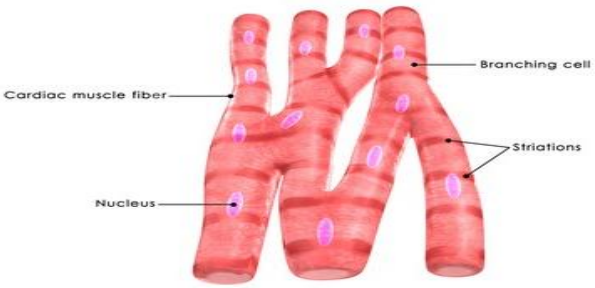
b). Lymph: It is the extracellular fluid that flows in lymphatic vessels. It is a connective tissue that consists of several types of cells in a clear liquid extracellular matrix that is similar to blood plasma but with much less protein.

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

1. Skeletal muscle tissue: It is named for its location as it is usually attached to the bones of the skeleton. It contains striations, alternating light and dark bands within the fibers that are visible under a light microscope. Skeletal muscle is considered voluntary because it can be made to contract or relax by conscious control. A muscle fiber is roughly cylindrical in shape and has many nuclei located at the periphery.



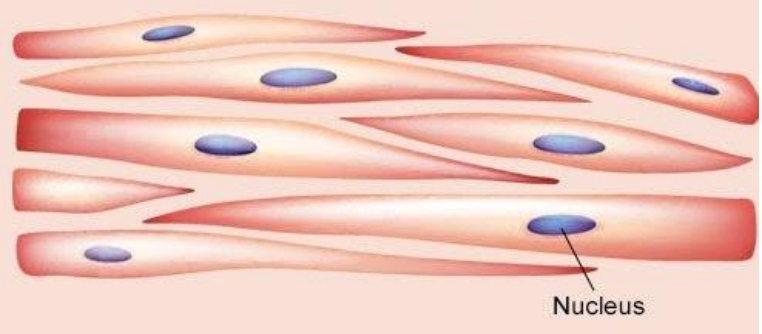
Skeletal muscle tissue



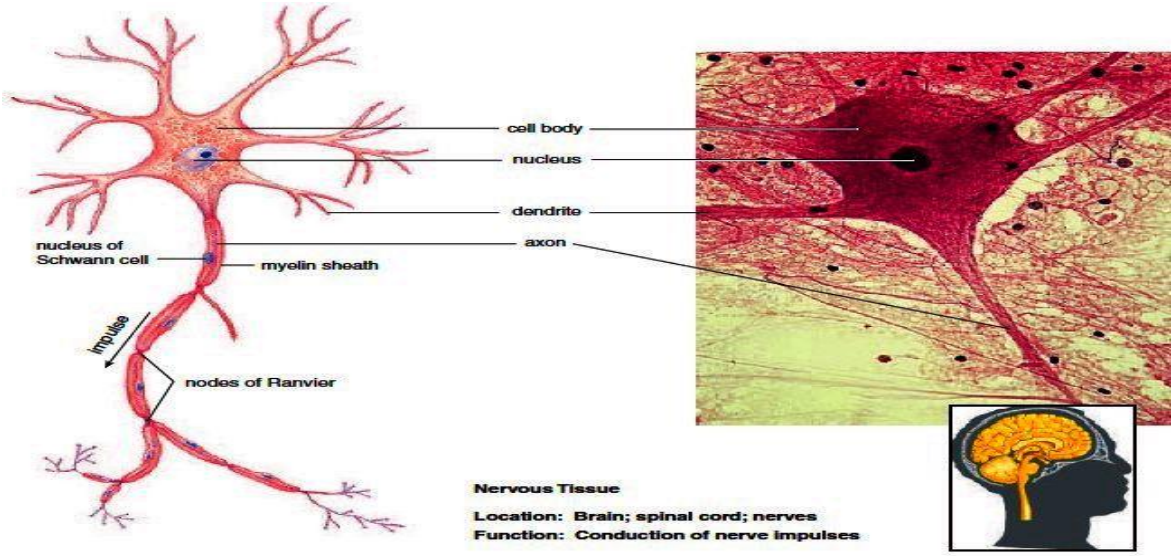
Cardiac muscle tissue

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

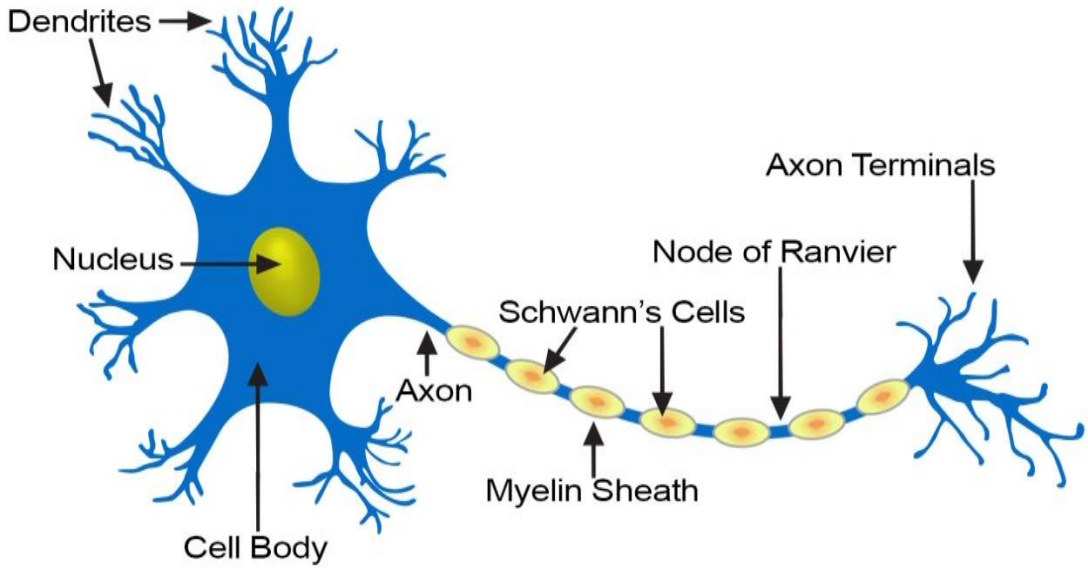
3. Smooth muscle tissue: It is located in the walls of hollow internal structures such as blood vessels, airways to the lungs, the stomach, intestines, gallbladder, and urinary bladder. Its contraction helps constriction of blood vessels, physically break down and movement of food along the gastrointestinal tract, movement of fluids through the body and eliminate wastes. Smooth muscle fibers are usually involuntary and they are non- striated (lack striations), hence named smooth. A smooth muscle fiber is small, thickest in the middle and tapering at each end. It contains a single, centrally located nucleus.



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



Neurons: Neuron is a structural and function unit of nervous system. Neurons are the cells which are sensitive to various stimuli. These convert various stimuli into electrical signals, called action potentials (nerve impulses) and conduct these action potentials to other neurons, muscle tissue or glands. Neurons consist of 3 parts:



Cell body: It contains the nucleus and other organelles.

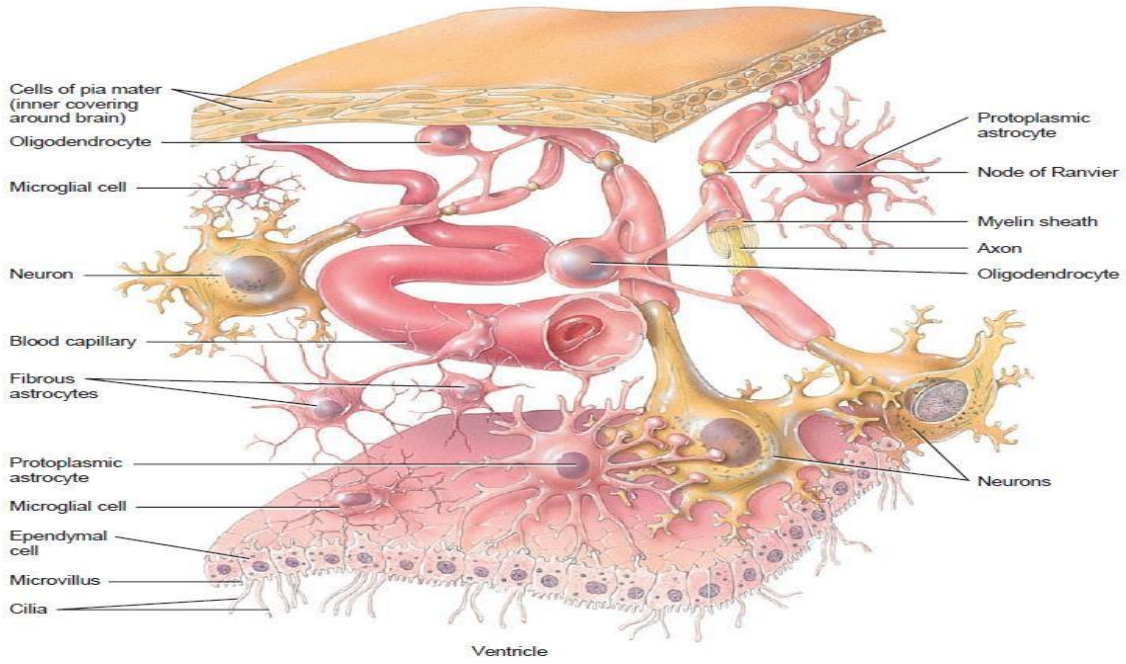
Dendrites (dendr = tree): These are tapering, branched and short processes and are the receiving portion of a neuron.

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

Neuralgia: These cells do not generate or conduct nerve impulses but provide protection and support to neurons.

Neuroglia: These cells do not generate or conduct nerve impulses but provide protection and support to neurons. Neuroglia cells are of 6 types: astrocytes, oligodendrocytes, microglia, ependymal cells, Schwann cells and satellite cells.

Astrocytes (astro = star; cyte = cell): These are star shaped cells, which have many processes and are the largest and most numerous. These provide support to neurons. Processes of astrocytes are wrapped around blood capillaries and isolate neurons of the CNS from various potentially harmful substances in blood. This is called blood brain barrier (BBB). In the embryo, astrocytes regulate the growth, migration and interconnection among neurons in the brain. Astrocytes help to maintain the appropriate chemical environment for the generation of nerve impulses. Astrocytes may also play a role in learning and memory.



Oligodendrocytes (oligo = few; dendro = tree): These resemble astrocytes, but are smaller and contain fewer processes. These are responsible for forming and maintaining the myelin sheath around CNS axons.

Myelin sheath is a multilayered lipid and protein covering around some axons that insulates them and increases the speed of nerve impulse conduction. Such axons are said to be myelinated.

Microglia (micro = small): These are small cells with slender processes that have numerous spine like projections. These function as phagocytes and remove cellular debris formed during normal development of the nervous system, microbes and damaged nervous tissue.

Ependymal cells (epen = above; dym = garment): Ependymal cells are cuboidal to columnar cells arranged in a single layer that possess microvilli and cilia. These produce and assist in the circulation of cerebrospinal fluid.

Schwann cells: They form the myelin sheath around axons and also participate in axon regeneration.

Satellite cells: These flat cells surround the cell bodies of neurons, provide structural support and regulate the exchanges of materials between cell bodies and interstitial fluid.

Long Answer Questions:

1. What is cell and explain it with neat labeled diagram?
2. Explain the events of cell division.
3. Explain different types of cell junctions.
4. Define tissue. Enlist different types of tissues. Explain in detail epithelial tissue and connective tissue.
5. Explain the structure and function of different cartilage.

Very Short Answer Questions:

1. Define and enlist different parts of cell.
2. Define anatomy and physiology.
3. Write a note on homeostasis and feedback system.
4. Enlist major body cavities along with their locations.
5. Explain different directional planes in human body
6. Enlist the process for transfer of material across the cell membrane.
7. Write short note on transport of materials across plasma membrane.
8. Write short note on cell membrane.
9. Enlist different systems of human body and give their components and function.
10. Explain different level of structural organizations.
11. Comment on positive and negative feedback system.
12. Explain different body processes.
13. Define tissue and give its different types.
14. Describe muscular tissue.
15. Write a note on nervous tissue.
16. Give types and the common locations of epithelial tissues in body.
17. Explain characteristics of epithelial tissues.
18. Explain in detail structure and functions of epithelial tissue.
19. Explain structure and function of nervous tissue.
20. Explain the structure and function of connective tissue.
21. Explain the structure of bone tissue.

Short Answer Questions

1. What is the homeostasis explain with examples?
2. Draw well labeled diagram of cell.
3. Draw well labeled diagram of cell membrane.
4. Describe transport mechanism of molecules across the cell membrane.
5. Describe the structure and functions following cell organelle**s**.
    a. Ribosome
    b. Mitochondria
    c. Endoplasmic reticulum
    d. Nucleus
6. Classify various types of tissue. Describe epithelial tissues.
7. Draw labeled diagram of neuron.
8. Name the various types muscle tissue in a body. Describe cardiac muscle tissue.
9. Name the various types connective tissue in a body.
10. Write short note on:
    a. Adipose tissue
    b. Areolar tissue
    c. Bone tissue
    d. Connective tissue proper
    e. Types of cartilage.
11. Explain internal structure of human cell.