

**Function organization of the human body**

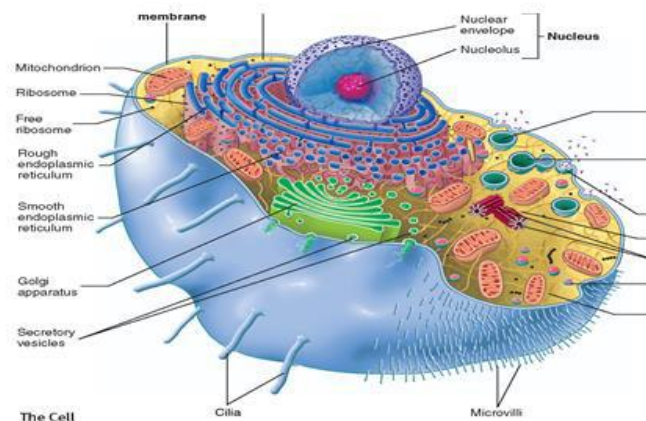
The goal of physiology is to explain the physical and chemical factors that are responsible for the origin, development, and progression of life. Each type of life, from the simple virus to the largest tree or the complicated human being, has its own functional characteristics. Therefore, the vast field of physiology can be divided into viral physiology, bacterial physiology, cellular physiology, plant physiology, human physiology, and many more subdivisions.

**Human****Physiology:**

In human physiology, we attempt to explain the specific characteristics mechanisms of the human body that make it a living being. The basic living unit of the body is the cell. Each organ is an aggregate of many different cells held together by intercellular supporting structure.

**CELL**

Cell is defined as the structural and functional unit of the living body because it has all the characteristics of life.



**TISSUES** The tissue is defined as the group of cells having similar function. The tissues are classified into four major types which are called the primary tissues.

1- The primary tissues include 1. Muscle tissue – skeletal muscle, smooth muscle and cardiac muscle

2. Nervous tissue – neurons and supporting cells

3. Epithelial tissue – squamous, columnar and cuboidal epithelial cells
4. Connective tissue – connective tissue proper, cartilage, bone and blood.

**ORGANS** An organ is defined as the structure that is formed by two or more primary tissues. Some organs are composed of all the four types of primary tissues. The organs may be tubular like intestine or hollow like stomach.

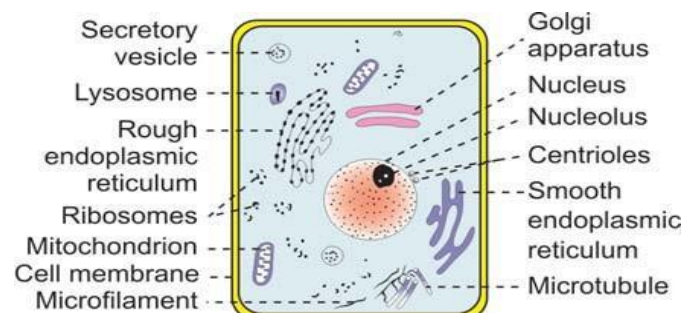
## SYSTEMS

The system is defined as group of organs functioning together to perform a specific function of the body. For example, digestive system is made out of groups of organs like esophagus, stomach, intestine etc., which is concerned with digestion of food particles.

## STRUCTURE OF THE CELL

Each cell is formed by a cell body and a cell membrane or plasma membrane that covers the cell body. The important parts of the cell are :

- a. Cell membrane
- b. Nucleus
- c. Cytoplasm with organelles



## CELL MEMBRANE

The cell membrane is a protective sheath that envelops the cell body. It separates the fluid outside the cell called extracellular fluid (ECF) and the fluid inside the cell called intracellular fluid (ICF). It is a semipermeable membrane and allows free exchange of certain substances between ECF and ICF .

**COMPOSITION OF CELL MEMBRANE** The cell membrane is composed of three types of substances:

1. Proteins (55%)
2. Lipids (40%)
3. Carbohydrates (5%).

## STRUCTURE OF CELL MEMBRANE

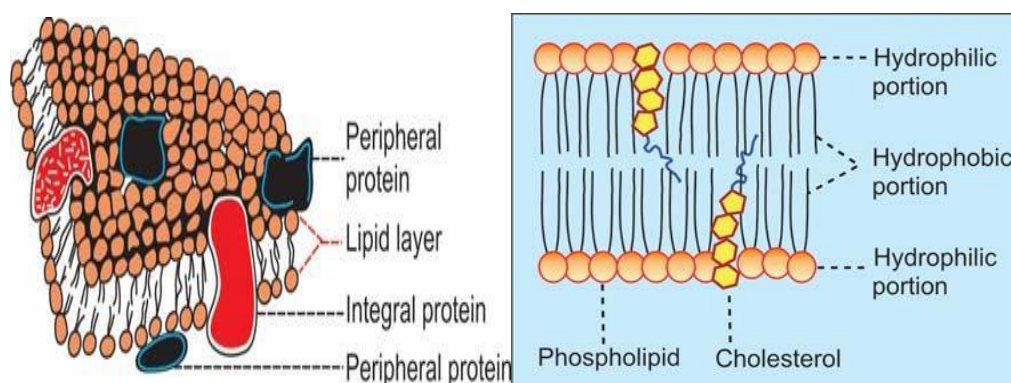
The cell membrane is a unit membrane having the 'fluid mosaic model' i.e., the membrane is a fluid with mosaic of proteins (mosaic means pattern formed by arrangement of different colored pieces of stone, tile, glass or other such materials) **lipids and carbohydrates**. The electron microscopic study reveals three layers in the cell membrane namely, one electron lucent lipid layer in the center and two electron dense layers on either side of the central layer. **Carbohydrate molecules are found on the surface of the cell membrane.**

### Lipid Layer of Cell Membrane:

It is a bi-layered structure formed by a thin film of lipids. It is fluid in nature and the portions of the membrane along with the dissolved substances move to all areas of the cell membrane.

### The major lipids are:

1. Phospholipids
2. Cholesterol



**Functions of lipid layer:** The lipid layer is semi permeable in nature and allows only the fat-soluble substances like oxygen, carbon dioxide and alcohol to pass through it. It does not allow the water-soluble materials like glucose, urea and electrolytes to pass through it.

**Protein Layers of the Cell Membrane:** The protein layers of the cell membrane are the electron dense layers situated on either side of the central lipid layer. The protein substances present in these layers are mostly glycoproteins. These protein molecules are classified into two categories:

- a. Integral proteins
- b. Peripheral proteins

### **Functions of protein layers**

1. Integral proteins provide structural integrity of the cell membrane
2. Channel proteins provide route for diffusion of water-soluble substances like glucose and electrolytes
3. Carrier proteins help in transport of substances across the cell membrane
4. Receptor proteins serve as receptor sites for hormones and neurotransmitters
5. Enzymes: some of the protein molecules form the enzymes which control chemical reactions within the cell membrane
6. Antigens: Some proteins act as antigens and induce the process of antibody formation.

**Carbohydrates of the Cell Membrane** Carbohydrate molecules form a thin loose covering over the entire surface of the cell membrane called glycocalyx. Some carbohydrate molecules are attached with proteins and form glycoproteins and some are attached with lipids and form glycolipids.

### **Functions of carbohydrates**

1. The carbohydrate molecules are negatively charged and do not permit the negatively charged substances to move in and out of the cell.
2. The glycocalyx from the neighboring cells helps in the tight fixation of cells with one another.
3. Some of the carbohydrate molecules form the receptors for some hormones.

### **FUNCTIONS OF CELL MEMBRANE**

1. Protective function: Cell membrane protects the cytoplasm and the organelles present in the cytoplasm.
2. Selective permeability: Cell membrane acts as a semipermeable membrane which allows only some substances to pass through it and acts as a barrier for other substances.
3. Absorptive function: Nutrients are absorbed into the cell through the cell membrane.
4. Excretory function: Metabolites and other waste products from the cell are excreted out through the cell membrane.
5. Exchange of gases: Oxygen enters the cell from the blood and carbon dioxide leaves the cell and enters the blood through the cell membrane.
6. Maintenance of shape and size of the cell: Cell membrane is responsible for the maintenance of shape and size of the cell.

**CYTOPLASM:** The cytoplasm is the fluid present inside the cell. It contains a clear liquid portion called cytosol which contains various substances like proteins, carbohydrates, lipids and electrolytes. Apart from these substances, many organelles are also present in cytoplasm. The cytoplasm is distributed as peripheral ectoplasm just

beneath the cell membrane and inner endoplasm between the ectoplasm and the nucleus.

## **ORGANELLES IN CYTOPLASM**

All the cells in the body contain some common structures called organelles in the cytoplasm. Some organelles are bound by limiting membrane and others do not have limiting membrane. The organelles carry out the various functions of the cell.

### **1. ENDOPLASMIC RETICULUM**

Endoplasmic reticulum is made up of tubules and microsomal vesicles. These structures form an interconnected network which acts as the link between the organelles and cell membrane. Types of Endoplasmic Reticulum The endoplasmic reticulum is of two types namely, rough endoplasmic reticulum and smooth endoplasmic reticulum.

#### **Functions of rough endoplasmic reticulum**

It is concerned with the protein synthesis in the cell, especially those secreted from the cell leukocytes.

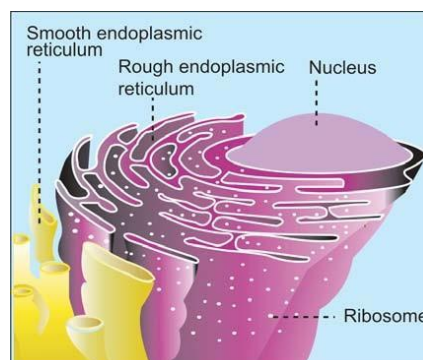
It also plays an important role in degradation of worn out cytoplasmic organelles like mitochondria. It wraps itself around the worn out organelles and forms a vacuole which is often called the autophagosome. It is digested by lysosomal enzymes.

#### **Functions of smooth endoplasmic reticulum**

- i. It is responsible for synthesis of cholesterol and steroid
- ii. It is concerned with various metabolic processes of the cell because of the presence of many enzymes on the outer surface
- iii. It is concerned with the storage and metabolism of calcium
- iv. It is also concerned with catabolism and detoxification of toxic substances like some drugs and carcinogens (cancer producing substances) in liver.

#### **Rough endoplasmic reticulum and smooth endoplasmic reticulum**

are interconnected and continuous with one another. Depending upon the activities of the cells, the rough endoplasmic reticulum changes to smooth endoplasmic reticulum and vice versa

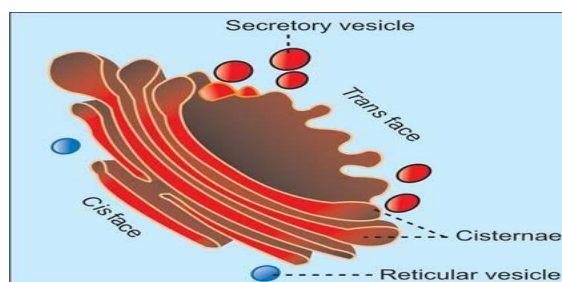


## GOIGI APPARATUS

The Golgi apparatus is situated near the nucleus. It has two ends or faces namely, *cis* face and *trans* face. The *cis* face is positioned near the endoplasmic reticulum. The reticular vesicles from endoplasmic reticulum enter the Golgi apparatus through *cis* face. The *trans* face is situated near the cell membrane. The processed substances make their exit from Golgi apparatus through *trans* face.

### Functions of Golgi Apparatus

- i. It is concerned with the processing and delivery of substances like proteins and lipids to different parts of the cell.
- ii. It functions like a post office because, it packs the processed materials into the secretory granules, secretory vesicles, and lysosomes
- iii. It also functions like a shipping department of the cell because it sorts out and labels the materials for distribution to their proper destinations.



## Lysosomes

These are small globular structures filled with enzymes. These enzymes are synthesized in rough endoplasmic reticulum and transported to the Golgi apparatus.

### Lysosomes are of two types:

- i. Primary lysosome which is pinched off from Golgi apparatus. It is inactive in spite of having the hydrolytic enzymes.
- ii. Secondary lysosome which is active lysosome formed by the fusion of a primary lysosome with phagosome or endosome.

### Functions of Lysosomes

- i. Digestion of unwanted substances with the help of hydrolytic enzymes like proteases, lipases, amylases and nucleases, lysosome digests and removes the unwanted substances.
- ii. Removal of excess secretory products in the cells  
Lysosomes in the cells of the secretory glands play an important role in the removal of excess secretory products by degrading the secretory granules.
- iii. Secretory function – Secretory lysosomes

Recently, lysosomes having secretory function called secretory lysosomes are found in some of the cells, particularly in the cells of immune system. The conventional lysosomes are modified into secretory lysosomes by combining with secretory granules Peroxisomes.

Peroxisomes are otherwise called as microbodies. These are pinched off from endoplasmic reticulum. Peroxisomes contain some oxidative enzymes such as catalase, urate oxidase and D-amino acid oxidase.

### **Functions of Peroxisomes**

- i. Degrade the toxic substances like hydrogen peroxide and other metabolic products by means of detoxification
- ii. Form the major site of oxygen utilization in the cells
- iii. Break down the excess fatty acids
- iv. Accelerate gluconeogenesis from fats
- v. Degrade purine to uric acid
- vi. Participate in the formation of myelin and bile acids.

### **Centrosome AND CENTRIOLES**

The centrosome is situated near the center of the cell close to the nucleus. It consists of two cylindrical structures called centrioles which are responsible for the movement of chromosomes during cell division.

### **Secretory VESICLES**

The secretory vesicles are globular structures, formed in the endoplasmic reticulum, and processed and packed in Golgi apparatus. When necessary, the secretory vesicles rupture and release the secretory substances into the cytoplasm.

### **MITOCHONDRION**

The mitochondrion is a rod or oval shaped structure with a diameter of 0.5 to 1  $\mu$ . It is covered by a double layered membrane.

### **Functions of Mitochondrion**

- i. The mitochondrion is called the 'power house of the cell' because it produces the energy required for the cellular functions. The energy is produced by oxidation of the food substances like proteins, carbohydrates and lipids by the oxidative enzymes in cristae. During oxidation, water and carbon dioxide are produced with release of energy. The released energy is stored in mitochondria and used later for synthesis of ATP.
- ii. The components of respiratory chain in the mitochondrion are responsible for the synthesis of ATP by utilizing the energy through oxidative phosphorylation. The ATP molecules diffuse throughout the cell from mitochondrion. Whenever energy is needed for cellular activity, the ATP molecules are broken down



## **ORGANELLES WITHOUT LIMITING MEMBRANE**

### **RIBOSOMES**

The ribosomes are small granular structures with a diameter of 15 nm. The ribosomes are made up of proteins (35%) and RNA (65%). The RNA present in ribosomes is called ribosomal RNA (rRNA).

#### **Functions of Ribosomes**

Ribosomes are called protein factories because of their role in the synthesis of proteins. Messenger RNA (mRNA) passes the genetic code for protein synthesis from nucleus to the ribosomes. The ribosomes, in turn arrange the amino acids into small units of proteins. The ribosomes attached with endoplasmic reticulum are involved in the synthesis of proteins like the enzymatic proteins, hormonal proteins, lysosomal proteins and the proteins of the cell membrane. The free ribosomes are responsible for the synthesis of proteins in hemoglobin, peroxisome and mitochondria.

### **Cytoskeleton**

The cytoskeleton of the cell is a complex network that gives shape, support and stability to the cell. It is also essential for the cellular movements and the response of the cell to external stimuli. The cytoskeleton consists of three major protein components viz.

- a. Microtubules
- b. Intermediate filaments
- c. Microfilaments

### **Microtubules**

Microtubules are straight and hollow tubular structures formed by bundles of globular

#### **Functions of microtubules**

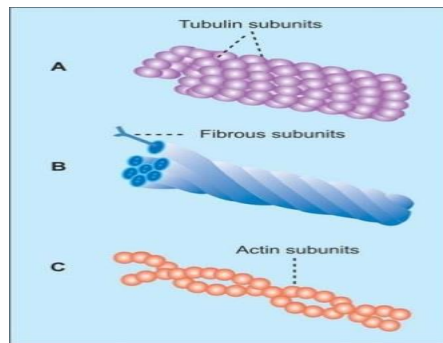
Microtubules:

- i. Determine the shape of the cell
- ii. Give structural strength to the cell
- iii. Responsible for the movements of centrioles and the complex cellular structures like cilia
- iv. Act like conveyer belts which allow the movement of granules, vesicles, protein molecules and some organelles like mitochondria to different parts of the cell
- v. Form the spindle fibers which separate the chromosomes during mitosis

#### **Intermediate Filaments**

The intermediate filaments form a network around the nucleus and extend to the periphery of the cell. These filaments are formed by fibrous proteins and help to maintain the shape of the cell. The adjacent cells are connected by intermediate





filaments by desmosomes.

## Microfilaments

Microfilaments are long and fine thread like structures which are made up of non-tubular contractile proteins called actin and myosin. Actin is more abundant than myosin.

## Functions of microfilaments

Microfilaments:

- i. Give structural strength to the cell
- ii. Provide resistance to the cell against the pulling forces
- iii. Responsible for cellular movements like contraction, gliding and cytokinesis (partition of cytoplasm during cell division).

## NUCLEUS

Nucleus is present in those cells which divide and produce enzymes. The cells with nucleus are called eukaryotes and those without nucleus are known as prokaryotes (e.g. red blood cells). Prokaryotes do not divide or synthesize the enzymes.

Most of the cells have only one nucleus (uninucleated). Few types of cells like skeletal muscle cells have many nuclei (multinucleated). Generally the nucleus is located near the center of the cell. It is mostly spherical in shape. However, the shape and situation of nucleus vary in different cells.

## Nuclear Membrane

The nucleus is covered by a double layered membrane called nuclear membrane. It encloses the fluid called nucleoplasm. Nuclear membrane is porous and permeable in nature and it allows nucleoplasm to communicate with the cytoplasm

## Nucleoplasm

It is a gel like ground substance and contains large quantities of the genetic material in the form of DNA. The DNA is made up of chromatin threads. These chromatin threads become the rod shaped chromosomes just before the cell division.

## Nucleoli

One or more nucleoli are present in each nucleus. The nucleolus contains RNA and some proteins, which are similar to those found in ribosomes. The RNA is synthesized by chromosomes and stored in the nucleolus.

### **FUNCTIONS OF NUCLEUS**

1. Controls all the activities of the cell
2. Synthesizes RNA
3. Forms subunits of ribosomes
4. Sends genetic instruction to the cytoplasm for protein synthesis through mRNA
5. Controls the cell division through genes
6. Stores the hereditary information (in genes) and transforms this information from one generation of the species to the next.

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### **CELL DEATH the cell death occurs by two distinct processes**

1. Necrosis
2. Apoptosis.

**APOPTOSIS** is defined as the programmed cell death under genetic control. Originally apoptosis (means 'falling leaves' in Greek) refers to the process by which the leaves fall from trees in autumn. It is also called 'cell suicide' since the genes of the cell play a major role in the death. This type of programmed cell death is a normal phenomenon and it is essential for normal development of the body. The main function of apoptosis is to remove unwanted cells without causing any stress or damage to the neighboring cells.

### **The functional significance of apoptosis:**

1. Plays a vital role in cellular homeostasis. About 10 million cells are produced every day in human body by mitosis. An equal number of cells die by apoptosis. This helps in cellular homeostasis
2. Useful for removal of a cell that is damaged by a virus or a toxin beyond repair
3. An essential event during the development and in adult stage.
  - i. A large number of neurons are produced during the development of central nervous system. But up to 50% of the neurons are removed by apoptosis during the formation of synapses between neurons
  - ii. Apoptosis is responsible for the removal of tissues of webs between fingers and toes during developmental stage in fetus
  - iii. It is necessary for regression and disappearance of duct systems during sex differentiation in fetus
  - iv. The cell that loses the contact with neighboring cells or basal lamina in the epithelial tissue dies by apoptosis. This is essential for the death of old enterocytes shed into the lumen of intestinal glands
  - v. It plays an important role in the cyclic sloughing of the inner layer of endometrium resulting in menstruation
  - vi. Apoptosis removes the auto-aggressive T cells and prevents autoimmune diseases.

### **NECROSIS**

Necrosis (means 'dead' in Greek) is the uncontrolled and unprogrammed death of cells also called 'cell murder' because the cell is killed by extracellular or external events. after necrosis,

Causes for Necrosis Common causes of necrosis are injury, infection, inflammation, infarction and cancer. Necrosis is induced by both physical and chemical events such as heat, radiation, trauma, hypoxia due to lack of blood flow, and exposure to toxins.