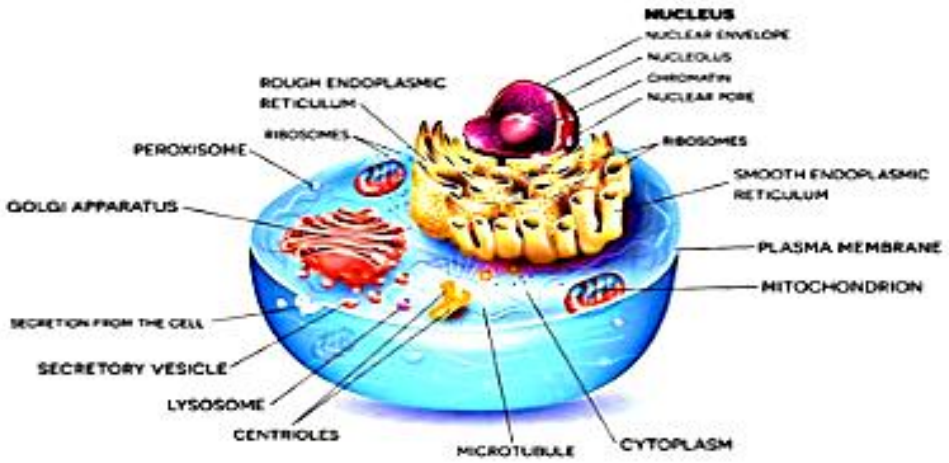
# CHAPTER - 2

# STRUCTURE OF CELL

## Points to be covered in this topic

- 2.1 Introduction
- 2.2 History
- 2.3 Types of cells
- 2.4 Plasma membrane
  - 2.4.1 Transport of material across the membrane
- 1.5 Organelles





## 2.1 INTRODUCTION

- A cell are the body's **smallest function units.** All **living organisms are made up of cells.**
- The study of cells from its basic structure to the functions of every **cell organelle is called cytology.**
- They may be made up of a **single cell (unicellular), or many cells (multicellular).**
- They are known as **building blocks of all living beings.**

Cell → Tissue → Tissue System → Organ → Organ System → Body

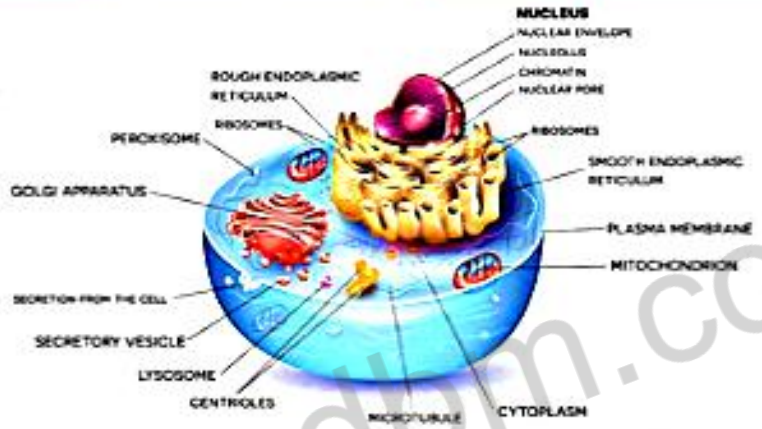



**Fig.2.1: Anatomy of cells**



## 2.2 HISTORY

- **Robert Hooke** discovered the cell in **1665.** He gave the name of his discovery "cells" which means "a small room" in Latin.
- **Anton Van Leeuwenhoek observed** cells under another **compound microscope** with higher magnification. This time, he observed that the cells exhibited some form of movement (motility).
- In 1883, **Robert Brown,** a botanist, provided the very first insights into the cell structure. He was able to describe the nucleus **present in the cells of orchids.**

## 2.3 TYPES OF CELLS

➢ **The cells of the living kingdom may be divided into two categories**

### 1. Prokaryotes (Greek: pro – before; karyon –nucleus)

- Prokaryotes have no typical nucleus and subcellular components.
- Bacteria and blue green algae belong to the prokaryotes.

## 2. Eukaryotes (Greek: Eue - true, karyon - nucleus)

- Eukaryotes have nucleus is covered by nuclear membrane.
- Animals, plants and fungi belong to the eukaryotes
- Eukaryotic cells are much larger than prokaryotes.
- Unlike prokaryotes, eukaryotes have a variety of other membrane-bound organelles (subcellular elements) in their cytoplasm, including:
  - ✓ **Mitochondria**
  - ✓ **Lysosomes**
  - ✓ **Endoplasmic reticulum**
  - ✓ **Golgi complexes**

**Table 1.1 Difference between Prokaryotic and Eukaryotic cell**

| S.NO | CHARACTERISTIC | PROKARYOTIC CELL | EUKARYOTIC CELL |
|---|---|---|---|
| 1. | **Size** | Small (generally 1-10 μm) | Large (generally 10-100 μm) |
| 2. | **Cell membrane** | Cell is enveloped by a rigid cell wall | Cell is enveloped by a flexible plasma membrane |
| 3. | **Sub-cellular organelles** | Absent | Distinct organelles are found (e.g., mitochondria, nucleus, lysosomes) |
| 4. | **Nucleus** | Not well defined; DNA is found as nucleoid, histones are absent | Nucleus is well defined, surrounded by a membrane; DNA is associated with histones |
| 5. | **Energy metabolism** | Mitochondria absent, enzymes of energy metabolism bound to membrane | Enzymes of energy metabolism are located in mitochondria |
| 6. | **Cell division** | Usually, fission and no mitosis | Mitosis |
| 7. | **Cytoplasm** | Organelles and cytoskeleton absent | Contains organelles and cytoskeleton (a network of tubules and filaments) |
| 8. | **Membrane bounded organelles** | Absent | Present |
| 9. | **Ribosome** | 70s ribosome present | 80s ribosome present |

## 2.4 PLASMA MEMBRANE

### 1. Cell Membrane (Plasma Membrane)

- Plasma membrane is best described by using fluid mosaic model by **S.J. Singer and G. L. Nicolson.**
- The plasma membrane consists of two layers of phospholipids with proteins and sugars embedded in them. In addition to **phospholipids, the lipid cholesterol is also present.**
- The phospholipid molecules have a head, which is electrically **charged and hydrophilic (meaning 'water- loving'), and a tail, which has no charge and is hydrophobic (meaning 'water-hating',).**

### ✓ Function

- Acts as a barrier separating inside and outside of the cell.
- Controls the flow of substances into and out of cell.
- Helps identify the cell to other cells.
- Participates in intercellular signaling.


**Fig.2.2: Structure of Plasma membrane**



### 2.4.1. Transport of material across the membrane

- The movement of materials across membranes takes many routes but the mechanisms are categorized as either **passive or active transport mechanisms.**


**Fig.2.3: Classification of Drug transport**

(i) **Passive Transport**
(ii) **Active transport**

## (i) Passive Transport

- Moves molecules along a concentration gradient.
- No cellular energy required

### Mechanisms of Passive Transport:

(a) Diffusion
(b) Osmosis

**(a) Diffusion** - Movement of solute molecules from high solute concentration to low solute Concentration.

➢ **There are two types of diffusion**

i. Simple Diffusion
ii. Facilitated Diffusion

### i. Simple Diffusion

- Substances pass **directly through the cell membrane.**
- The cell membrane has limited permeability to **small polar molecules, water, and ions.**

### ii. Facilitated Diffusion

- Substances must pass through transported **proteins to get through the cell membrane.**
- The cell membrane is **selectively permeable.**
- Carrier proteins bind to the molecule that they **transport across the membrane.**

**(b) Osmosis-** Movement of solvent water from **high solvent concentration to low solvent Concentration.**

## (ii) Active transport

- Moves molecules against a concentration gradient.
- Requires cellular energy.
- Active transport mechanism include the

- ✓ **Sodium/Potassium pump**
- ✓ **Bulk transport**

## ✓ Bulk Transport

- Bulk transport of substances is accomplished by

### i. Endocytosis - movement of substances into the cell.

- Endocytosis occurs when the plasma membrane envelops food particles and liquids.
  - ✓ **Phagocytosis (Cell eating) -** the cell takes in particulate matter.
  - ✓ **Pinocytosis (Cell drinking)** - the cell takes in only fluid.
  - ✓ **Receptor-mediated endocytosis -** specific molecules are taken in after they bind to a receptor

### ii. Exocytosis - Movement of materials out of the cell.

## 2.5 ORGANELLES

- Organelles literally meaning **'small organs'**, have individual and highly specialised functions, and are often enclosed by their own membrane within the cytoplasm. They include the **Nucleus, Mitochondria, Ribosomes, Endoplasmic Reticulum, Golgi apparatus, Lysosomes and Cytoskeleton.**



### 1. Nucleus

- **Robert Brown in 1831** discovered the nucleus in the cell.
- A nucleus is defined as a double-membrane **eukaryotic cell organelle** that contains the genetic material.
- It is the **largest structure, present almost in the centre of a cell.**
- It is **more or less spherical in shape.**
- It is bounded by **nuclear membrane.**
- The nucleus contains: **(a) Nucleolus (b) Chromatin**

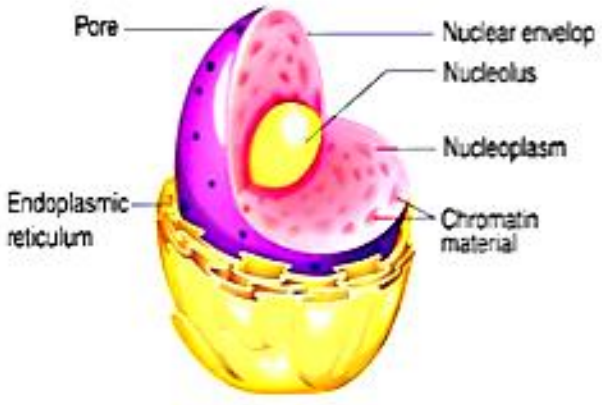



**Fig.2.4: Structure of Nucleus**

## ✓ Function

i. It helps in inheritance of features from **parents to next generation in the form of DNA** molecules present in chromosomes which are present in it.
ii. It controls which protein and what amount of it will be synthesized in the cell.
iii. It plays a **central role in the cell division.**
iv. **Cell reproduction cannot take place without a nucleus.**

## 2. Mitochondria

- **Albert Von Kolliker** discovered mitochondria.
- Mitochondria synthesis energy rich compound ATP, they are also known as the **"Powerhouse of the cell,"** mitochondria (singular: mitochondrion) are a double membrane-bound organelle found in most eukaryotic organisms.

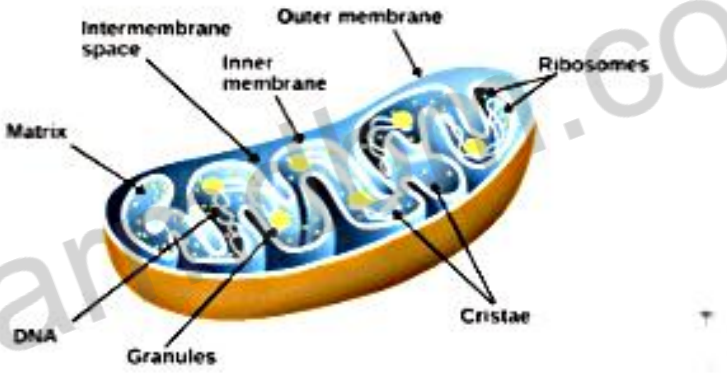



**Fig.2.5: Structure of Mitochondria**

- They are found inside the cytoplasm and essentially function as the cell's **"digestive system."**

## ✓ Function

i. The mitochondria performs the most important function such as **oxidation, dehydration, oxidative phosphorylation.**
ii. Regulates the **metabolic activity of the cell.**
iii. Promotes the **growth of new cells and cell multiplication.**
iv. Helps in **detoxifying ammonia in the liver cells.**
v. Plays an important role in **apoptosis or programmed cell death.**
vi. Responsible for building certain parts of the blood and various **hormones like testosterone and oestrogen.**

## 3. Ribosomes

- **George E. Palade** in **1955** discovered ribosomes.
- Ribosomes are one of the most important cell organelles composed of **RNA and protein** that converts genetic code into **chains of amino acids.**
- They are granular in structure and are made up of two parts - A large subunit and a small subunit.
- In 70S and 80S ribosomes, 'S' refers to Svedberg's Unit which stands for sedimentation coefficient.

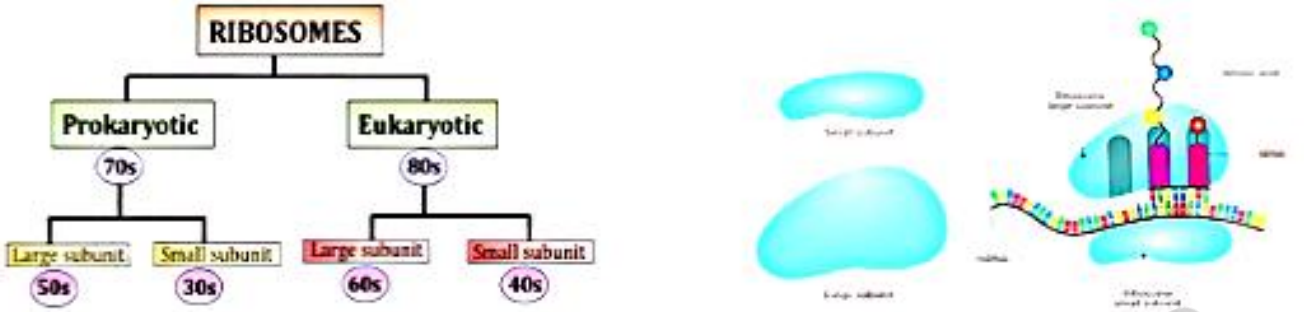



**Fig.2.6: Structure of Ribosomes**

### ✓ Function

- It assembles **amino acids to form proteins** that are essential to carry out cellular functions.
- The DNA produces **mRNA by the process of DNA transcription.**
- The mRNA is synthesized in the nucleus and transported to the cytoplasm for the process of **protein synthesis.**
- The **tRNA then synthesizes proteins.**



## 4. Endoplasmic Reticulum (ER)

- Endoplasmic reticulum is a **network of closed and flattened single membrane-bound intracellular structure**. ER lumen is the enclosed compartment between ER membranes which are physiologically active.
- **There are two types**

i. **Rough Endoplasmic Reticulum**
ii. **Smooth Endoplasmic Reticulum**

### i. Rough Endoplasmic Reticulum

- Granular or Rough ER contains granules called ribosomes on its surface.
- Its primary function is to synthesise the proteins.

✓ **Function**

- The second most important function after protein synthesis and protein folding is protein sorting.

**ii. Smooth Endoplasmic Reticulum**

- Agranular or Smooth ER does not contain granules on its surface.

✓ **Function**

i. Smooth ER is responsible for the synthesis of essential lipids such as phospholipids and cholesterol.
ii. Smooth ER is also responsible for the production and secretion of steroid hormones.
iii. It is also responsible for the metabolism of carbohydrates.
iv. The smooth ER store and releases calcium ions.

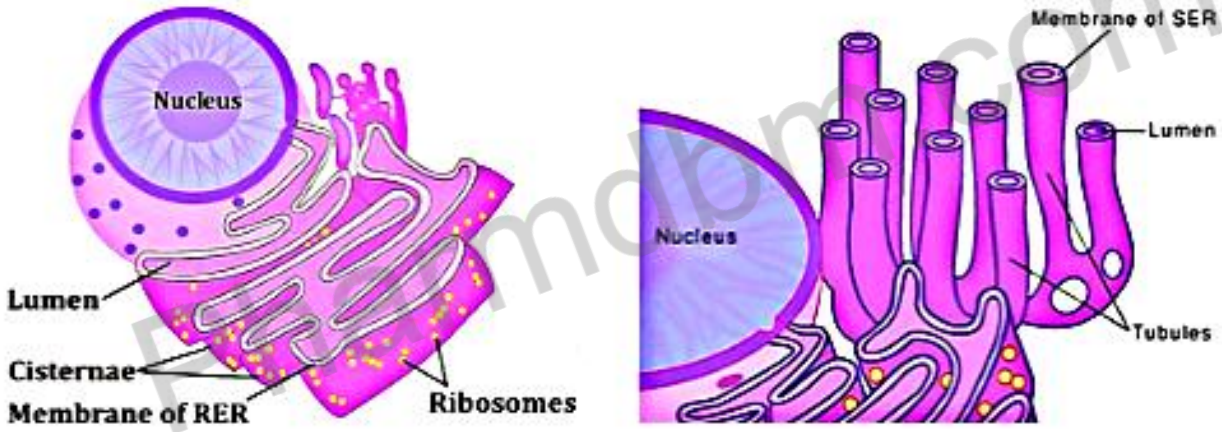



**Fig.2.7: Structure of Rough & Smooth Endoplasmic Reticulum**

## 5. Golgi bodies

- **Camillo Golgi (1898)** discovered Golgi bodies as a series of stacked membrane.
- A Golgi body, also known as a Golgi apparatus, is a cell organelle that **helps process and package proteins and lipid molecules, especially proteins destined to be exported from the cell.**

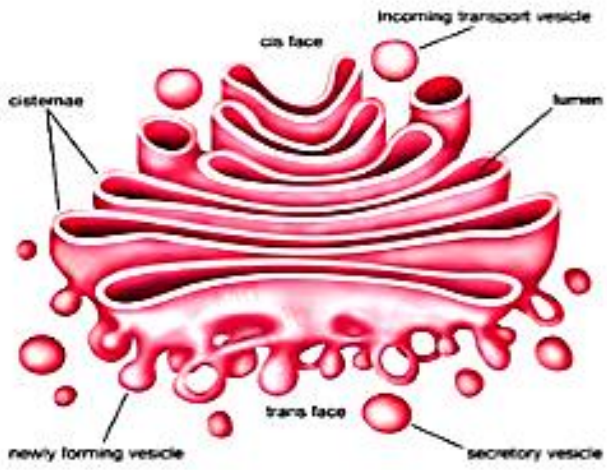



**Fig.2.8: Structure of Golgi Apparatus**

- It has two faces, one receiving face this is called **cis-face.** The other face is, through which the vesicles leave the Golgi apparatus, called **trans-face.**

### ✓ Functions

i. The Golgi apparatus is involved in the formation of lysosomes, vesicles that contain proteins and remains within the cell.
ii. It performs the function of **packaging material.**
iii. It acts as an important site for the **formation of glycoproteins and glycolipids.**
iv. It helps in the production of **complex carbohydrates other than glycogen and starch.**
v. It helps in the **formation of cell wall.**

## 6. Lysosome

- **Christian De Duve in 1955** discovered Lysosomes.
- Lysosomes are an important cell organelle found within eukaryotic animal cells.
- Due to their peculiar function, they are also known as the **"suicide bags"** of the cell.
- "Lysosomes are **sphere-shaped sacs filled** with **hydrolytic enzymes** that have the capability to break down many types of biomolecules."

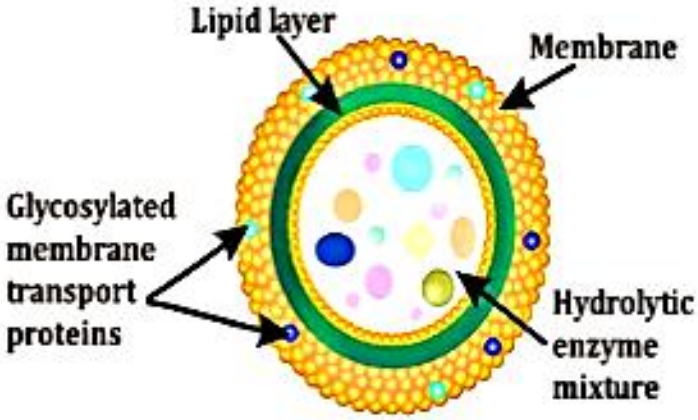



**Fig.2.9: Structure of Lysosomes**

### ✓ Function

i. Release **enzymes outside of the cell (exocytosis)** which may serve the purpose of destroying materials around the cell.
ii. Break-down 'digestion' of materials from inside the cell **(Autophagy).**
iii. Break-down 'digestion' of materials from outside the cell **(Heterophagy).**

## 7. Cytosol and Cytoskeleton

- The cellular matrix is collectively **referred to as cytosol.**
- An extensive intracellular network of tiny protein has been called cytoskeleton. The plasma membrane is anchored to the cytoskeleton.
- The cytoplasm contains a complex network of protein filaments. The cytoplasmic filaments are of three types:

  - **Microfilaments: -** To help muscle contraction, maintain the shape of the cell and help cellular movement.
  - **Microtubules: -** They provide stability to the cell. They prevent tubules of ER from collapsing.
  - **Intermediate filaments: -** They play role in cell-to-cell attachment and help to stabilize the epithelium. They provide strength and rigidity to axons.

### ✓ Function

**Cytosol: -**

- All the chemical reactions in prokaryotes occur here.
- Transportation of molecules and Signal transduction take place in the cytosol.

**Cytoplasm: -**

- Involved in large cellular activities like cell division and glycolysis.
- Cytokinesis, nuclear division and signal transduction take place in the cytoplasm.



## 8. Peroxisomes

- Peroxisome was discovered by **Christian de Duve in 1955.**
- Peroxisomes, also known as micro bodies, are single membrane cellular organelles.
- They are spherical or oval in shape and contain the **enzyme catalase.**

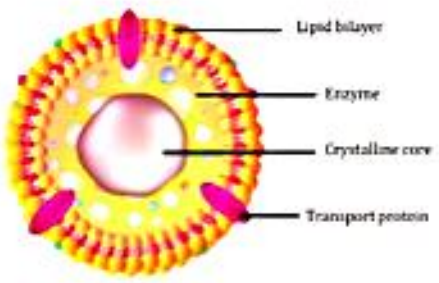



**Fig.2.10: Structure of Peroxisome**

### ✓ Function

- Catalase protects the cell from the toxic effects of $H_2O_2$ by converting it to $H_2O$ and $O_2$.
- Peroxisomes are also capable of carrying out β-oxidation of fatty acid.

## 9. Centrosome

- Centrosomes are the centre for microtubule organization.
- It is located near the nucleus.
- Centrioles are small set of microtubules which are found in pairs.

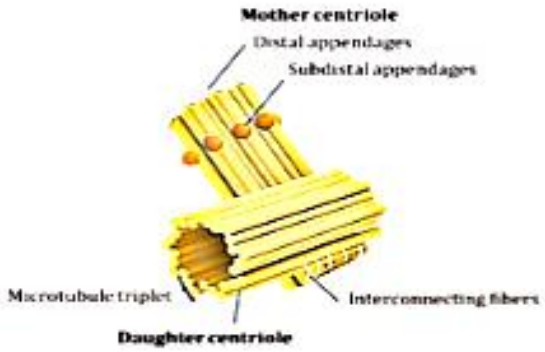



**Fig.2.11: Structure of Centrosome**

### ✓ Function

- The pericentriolar material of the centrosome contains tubulins that build microtubules in non-dividing cell.
- The pericentriolar material of the centrosome forms the mitotic spindle during cell division.

## 10. Cell extensions

- These project from the plasma membrane in some cell types and their main components are microtubules, which allow movement. They include

(i) **Microvilli** are covered in plasma membrane, which encloses cytoplasm and microfilaments. Though these are cellular extensions, there are little or no cellular organelles present in the microvilli.

**(ii) Cilia** - microscopic hair-like projections containing microtubules that lie along the free borders of some cells. They beat in unison, moving substances along the surface, e.g. in the respiratory tract, mucus and trapped particles are transported by ciliary action away from the lungs towards the mouth to be swallowed.

**(iii) Flagella** - single, long, whip-like projections containing microtubules, which form the 'tails' of spermatozoa that propel them through the female reproductive tract.