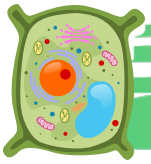
# PARMAR SSC

# CELL

## Lecture - 1



BY PARMAR SIR

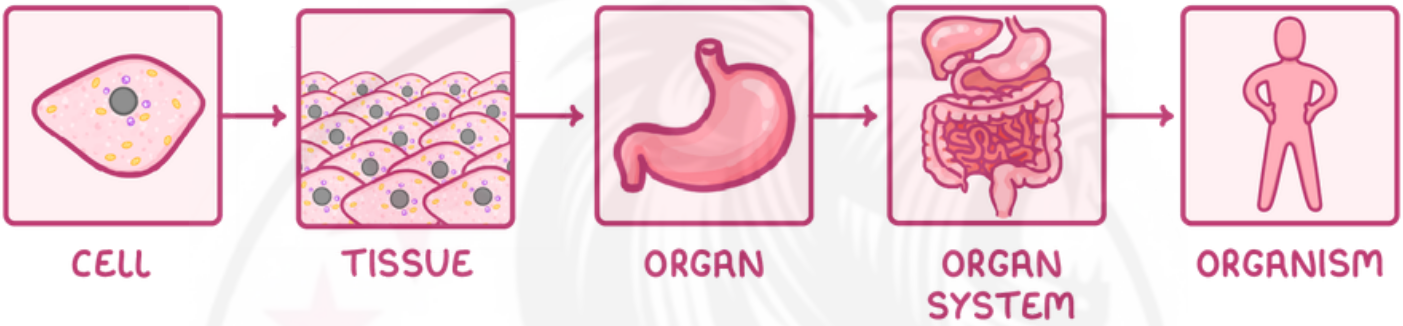


# FUNDAMENTALS OF CYTOLOGY



- The study of cell is called: Cytology
  Cyto: Cell
  Logy: Study

- Cell is the structural and functional unit of life and the basic building block of all living organisms.




## Discovery of Cell

- **Dead cell:** Robert Hooke (in cork) ➜ Father of Cytology (1665).
- **Living cell:** Antonie van Leeuwenhoek (in pond water) in 1674.

## Cell Theory

- In 1838, Matthias Schleiden and Theodor Schwann formulated the cell theory, stating that all living organisms are composed of cells, and the cell is the basic unit of life.

- Exception: Viruses
- Viruses do not follow the Cell Theory.
- They lack a cellular structure (no protoplasm, no organelles).
- They consist merely of genetic material (DNA or RNA) wrapped in a protein coat (Capsid).
- They are considered semi-living because they require a host cell to replicate.

- In 1855, Rudolf Virchow published his famous Cell Theory "**omnis cellula e cellula**", which means new cells are formed from the pre-existing cells.

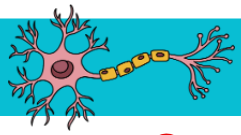
# Key Cellular Facts (Human & General)



**Largest cell in human:** Ovum (female sex cell).



**Smallest cell in human:** Sperm (Male sex cell).



**Largest Cell in male:** Neuron (also the longest cell).



**Smallest cell in women:** RBC



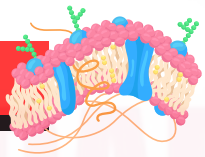
**Largest cell:** Ostrich's egg.



**Smallest cell:** Mycoplasma (bacteria)

# PARTS OF CELL

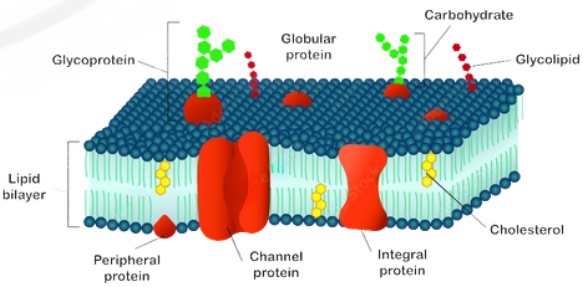
## Cell Membrane



- The cell membrane is also called the plasma membrane.
  - It is a thin, elastic, and flexible structure.
  - It is the outermost covering of the cell in animal cells (in plant cells, it lies just beneath the cell wall).

### Functions:

- It acts as a protective barrier – like a bodyguard.
  - It gives shape to the cell.
  - It holds and protects the internal contents.
  - It controls movement of substances in and out (acts as a selectively permeable membrane)

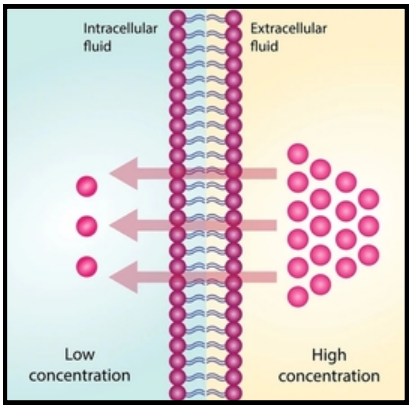



Composition: Proteins (50%) + Lipids (50%).

- Phospholipids
- Cholesterol

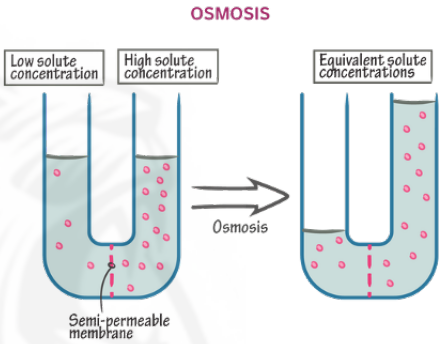
Lipids are organic molecules that are insoluble in water but soluble in non-polar organic solvents; they include fats and waxes.

## Movement across Cell Membrane

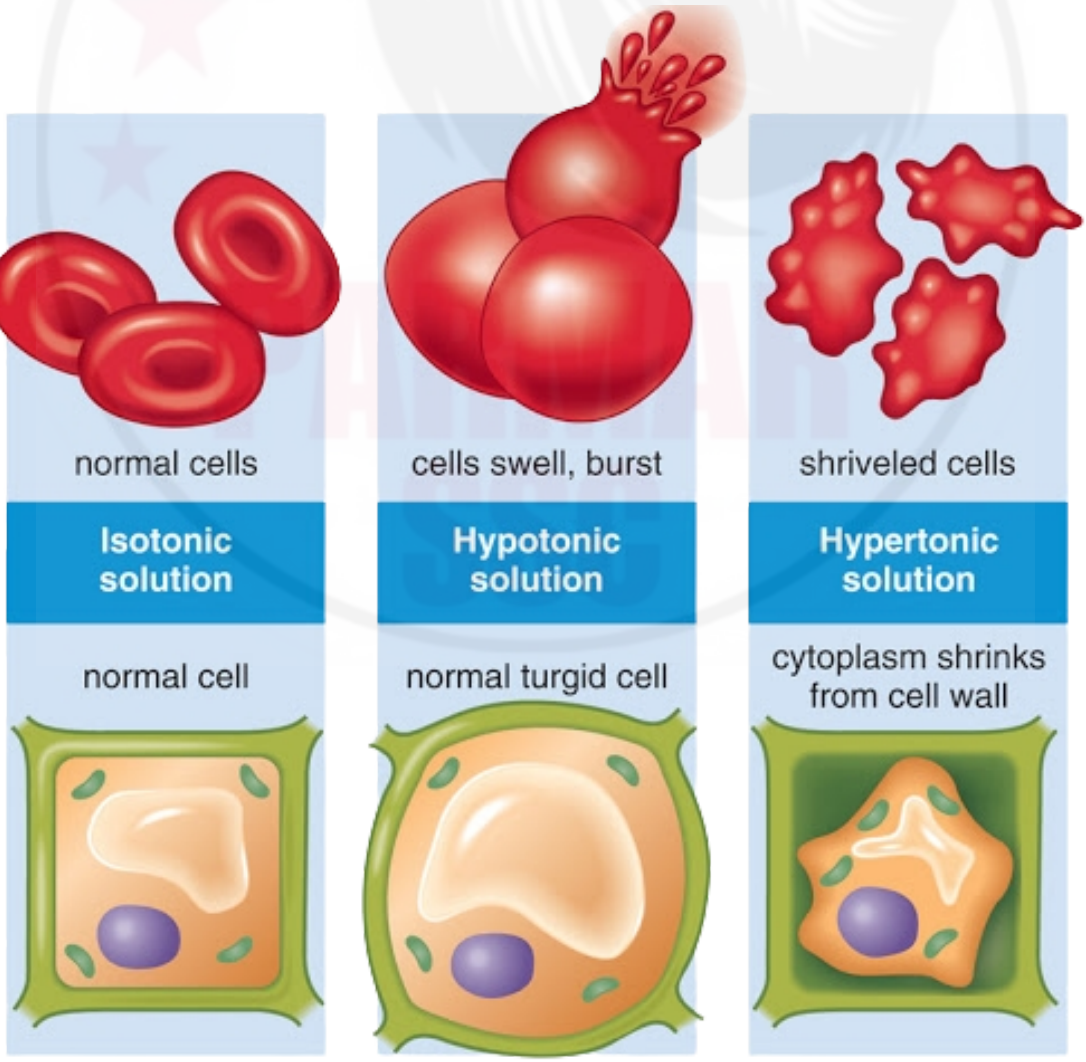



- **Diffusion:** Spontaneous movement of molecules from a region of higher concentration to lower concentration.
  - **Rate of Diffusion:** *Gases > Liquids > Solids* (e.g., diffusion of incense stick smell).

- **Osmosis:** Movement of water from higher concentration to lower concentration through a semi-permeable membrane.
  - Cell absorbs water through osmosis, No energy is required, and it lasts until equilibrium is reached.




- **Active Transport (Reverse Osmosis):** Movement of molecules from lower to higher concentration. This requires cellular energy.



| Type | Description | Effect on Cell | Solute vs Solvent |
|---|---|---|---|
| Isotonic | Normal solution | No change in cell size | Solute = Solvent |
| Hypotonic | Dilute solution | Cell swells (turgidity) | Solute < Solvent |
| Hypertonic | Concentrated solution | Cell shrinks (plasmolysis) | Solute > Solvent |

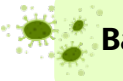
**Turgor pressure causes enlargement and extensive growth of cells.**

## Cell Wall



- It is only present in plant/bacteria/fungus/algae.
- The cell wall is not a living structure.
- The cell wall allows the free passage of molecules, unlike the selectively permeable cell membrane.
- It provides rigidity and shape to the cell.
- It offers structural support and protection to the cell.

### Materials of Cell Wall:



**Bacteria: Peptin/Peptidoglycan.**



**Fungi: Chitin.**



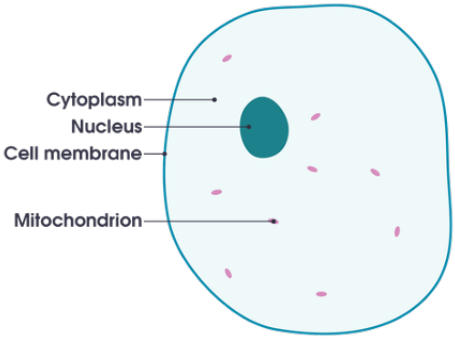
**Plant: Cellulose.**



**Algae: Cellulose/Pectin.**

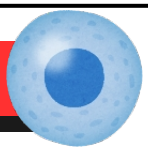
## Cytoplasm



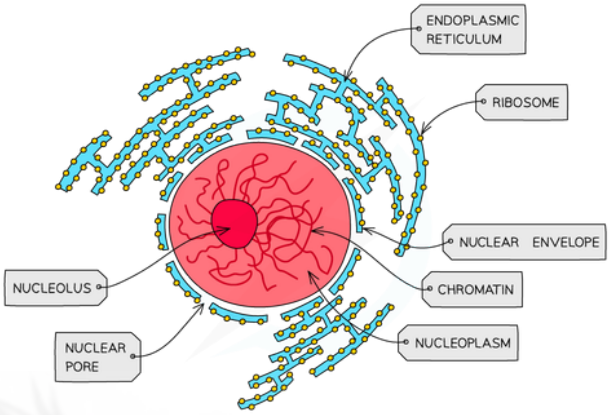


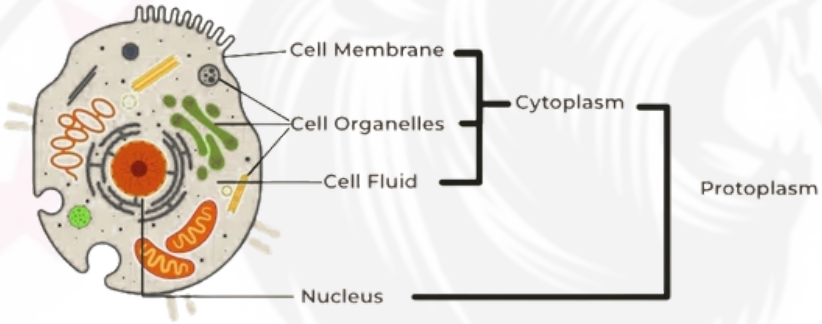

- It is the fluid that fills up the cells, located between the plasma membrane and nuclear envelope.
- Cell organelles are present in cytoplasm.
- **Cytosol:** The aqueous (water-based) fluid portion.
- **Cytoplasmic Inclusions:** Non-living components (pigments, nutrients, etc.).

## Nucleus



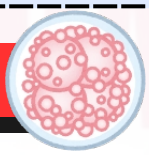
- Known as "**Brain of the Cell**", it controls the activities of different cell organelles.
- **Discovered by: Robert Brown in 1831.**
- The nucleus is found in the center of the cell.
- The nucleus is the largest organelle **(double-membraned)** in a **eukaryotic cell.**
- The nucleus is enclosed by a double-layered nuclear membrane, which separates the nucleus from the cytoplasm. It permits materials between nucleoplasm and cytoplasm.

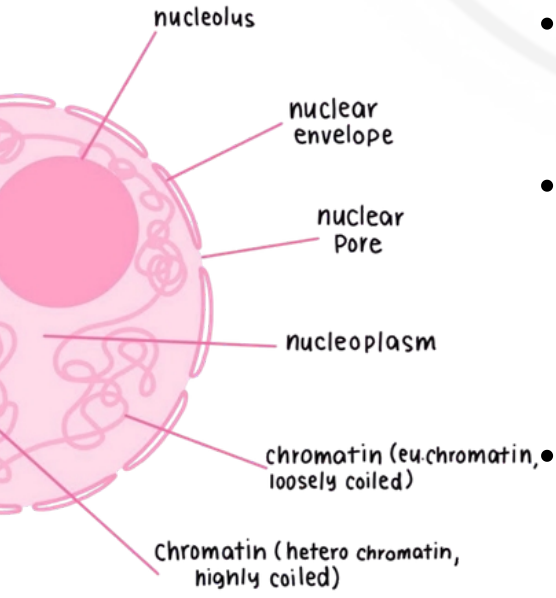



The protoplasm is the living material of the cell and composed of biomolecules like nucleic acids, proteins, lipids and carbohydrates.

## Nucleoplasm



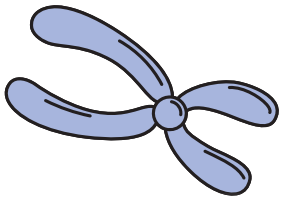


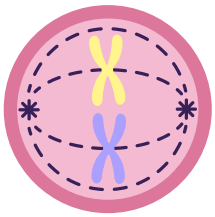

- A type of protoplasm (term coined by Purkinje in 1839).
- Composed of thick fluid and constitutes chromatin fibers made up of DNA and usually found in the nucleus of eukaryotic cells.
- **Contents:**
  - **Nucleolus:** A distinct, non-membrane-bound structure responsible for ribosome biogenesis.
  - **Chromatin material:** Complex of DNA and proteins (primarily histones).
- **Forms:**
  - **Euchromatin:** Loosely packed, transcriptionally active.
  - **Heterochromatin:** Tightly packed, transcriptionally inactive.

## Chromosomes

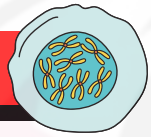


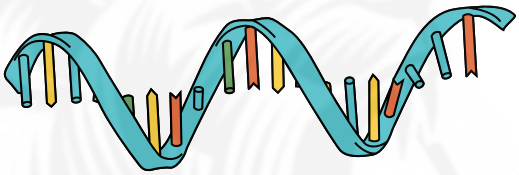
- Chromosomes are thread-like structures in the nucleus of cells that contain DNA and genes.
- They carry genetic information from cell to cell.
- **Components:** DNA and Proteins (Histones).
- **Total:** 46 Chromosomes (23 pairs) in a human being.
- 22 pairs (autosomal).
- 1 pair (sex pair: XX for female and XY for male).





## DNA





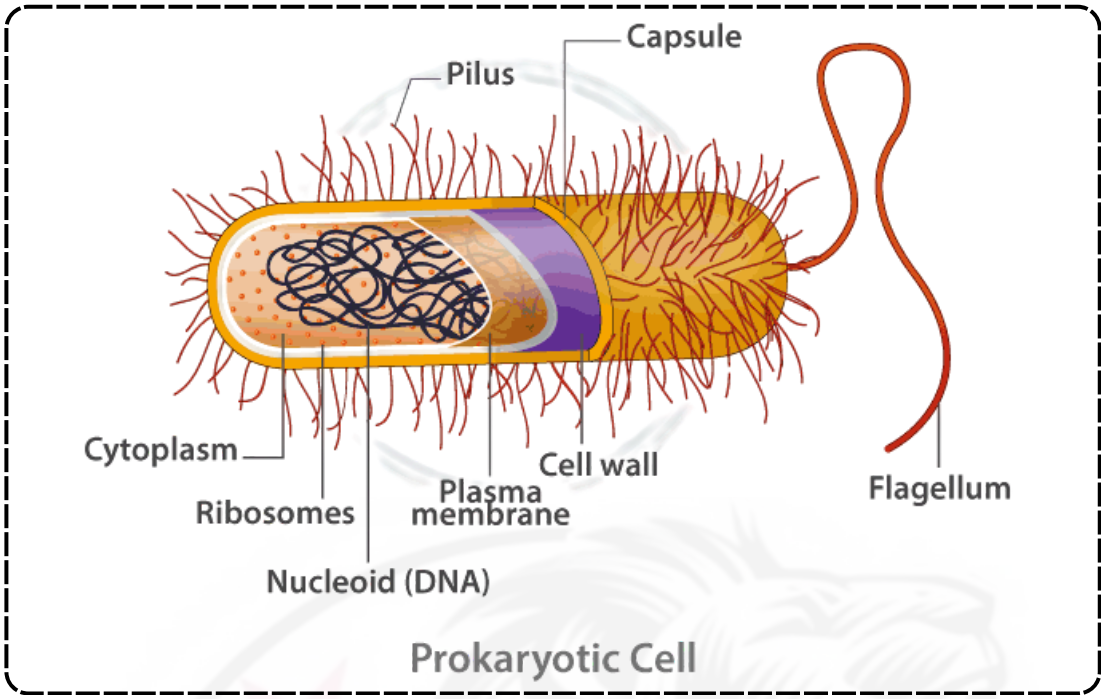


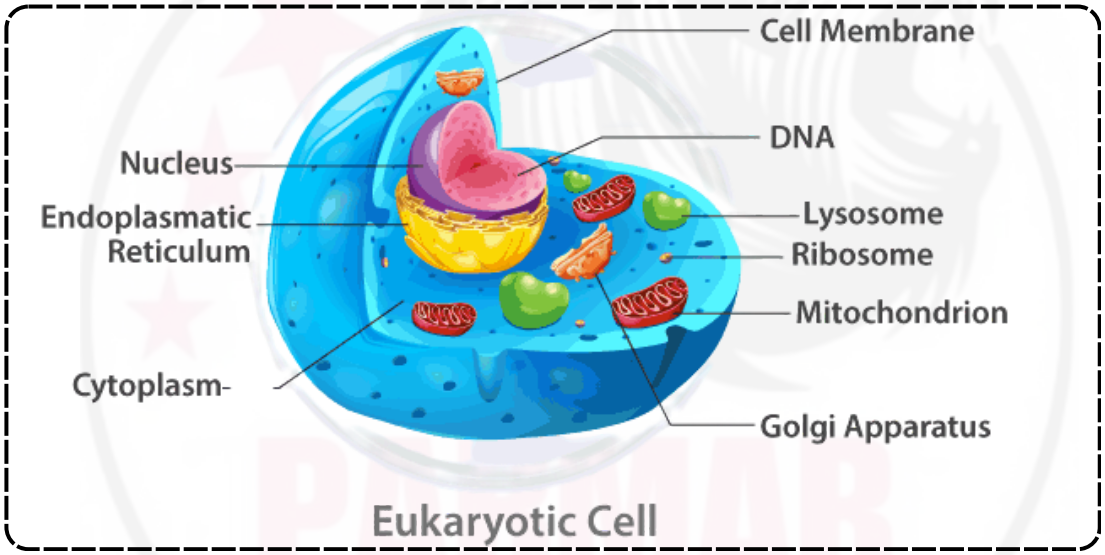
- DNA carries genetic information.
- **Genes:** Functional segments of DNA responsible for transmitting information from one generation to the next.
- **Discovery:** Friedrich Miescher (1869).
- **Double-helical structure:** Watson and Crick (1953).

# Types of Cell

| Prokaryotic Cell | Eukaryotic Cell |
|---|---|
| Size: 1-10 $\mu m$ | Size: 10-100 $\mu m$ |
| Nucleus absent | Nucleus present |
| Nucleolus absent | Nucleolus present |
| Cell organelles is absent | Cell organelles present |
| Chromosome: single | Chromosome: more than one |
| E.g. Bacteria, Cyanobacteria, Mycoplasma | E.g. Plant and animal cell |

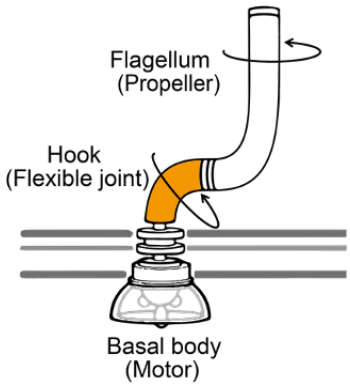
- **Common to both**: Cell membrane, Cytoplasm, Ribosomes
- **Nucleoid** – Membrane-lacking nuclear region in bacterial cell.




# Bacterial Flagellum

- Flagella are microscopic hair-like structures involved in the locomotion of a cell.
- The flagella is a helical structure composed of flagellin protein.
- The flagella structure is divided into three parts: Basal body, Hook, and Filament.



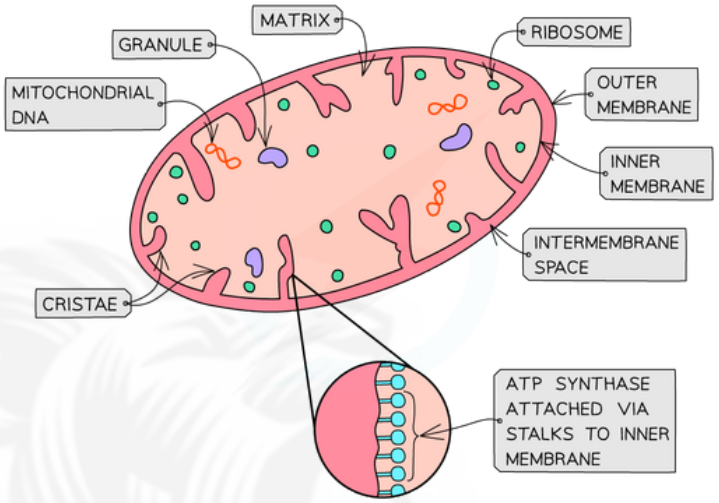

- **Basal Body:** It is attached to the cell membrane and cytoplasmic membrane.
- **Hook:** It is a broader area present at the base of the filament.
- **Filament:** Thin hair-like structure arising from the hook.

# CELL ORGANELLES

## Mitochondria



- **Discovered by:** Kolliker in 1857.
- **Length:** 1-2 um (1 micro metre: $10^{-6}$ m).
- **Diameter:** 0.1-0.6 um.
- Mitochondria is involved in apoptosis (programmed cell death).
- It is also known as "**Powerhouse of the cell**" responsible for ATP (Adenosine Triphosphate) synthesis to make energy. ATP is also called as energy currency of the cell.



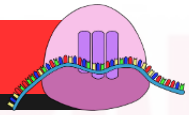

**Two membranes:**

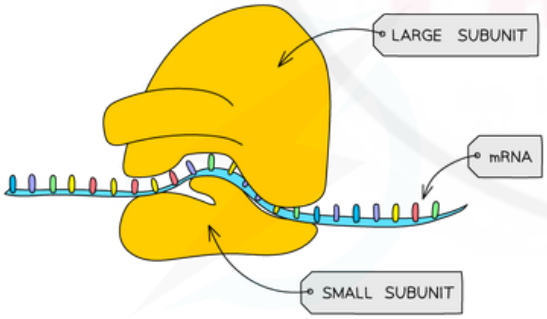
1. Outer membrane (porous in nature) and
2. Inner membrane (responsible for ATP synthesis).

- Mitochondria has its own DNA and ribosomes.
- Shape is like a "sausage".




## Ribosomes



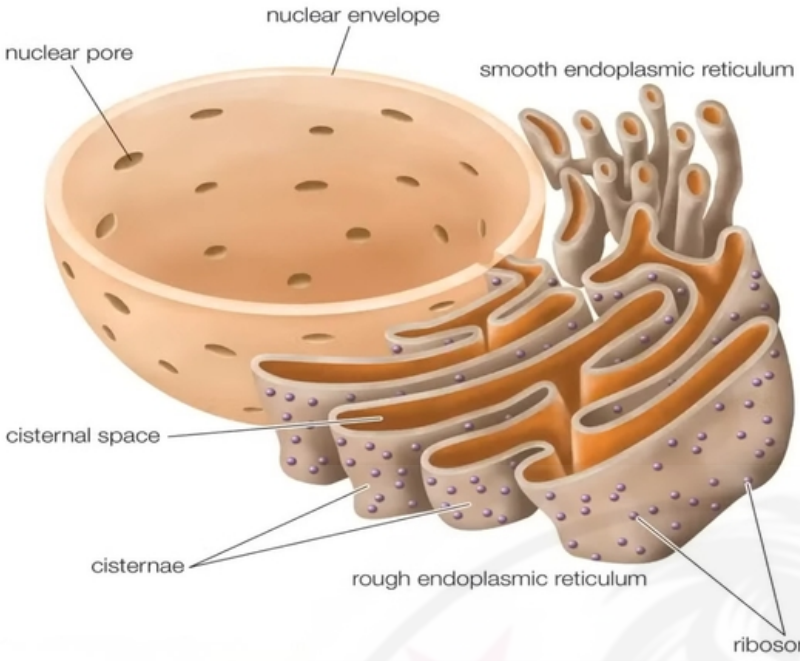


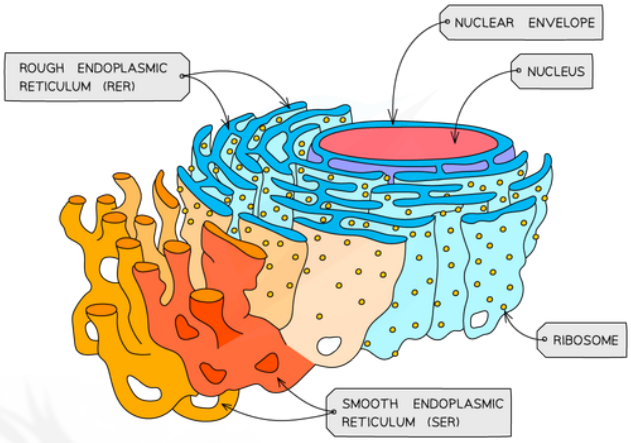

- Ribosomes do not have membrane.
- They are essential cell structures for protein synthesis.
- **Discovered by:** George E. Palade (1955).

## Endoplasmic Reticulum



- They are a network of sac-like structures.
- They are attached to the plasma membrane on one side and the outer nuclear membrane on the other.
- Endoplasmic reticulum serves as transport between the cytoplasm and nucleus.
- It detoxifies poisons and drugs (SER in the liver through the enzyme cytochrome P450).
- **Types:** Long tubules, vesicles, and cisternae.



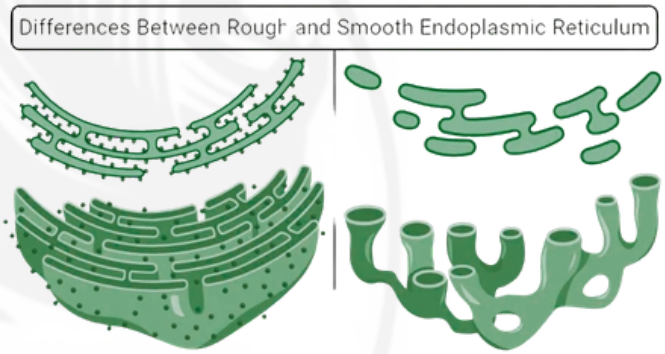

## Functions

1. **Rough Endoplasmic Reticulum**

- It is characterized by ribosomes on its surface, which are responsible for protein synthesis.

2. **Smooth Endoplasmic Reticulum**

- It is characterized by the absence of ribosomes and plays a crucial role in synthesizing lipids and fats. Ribosomes are absent here.

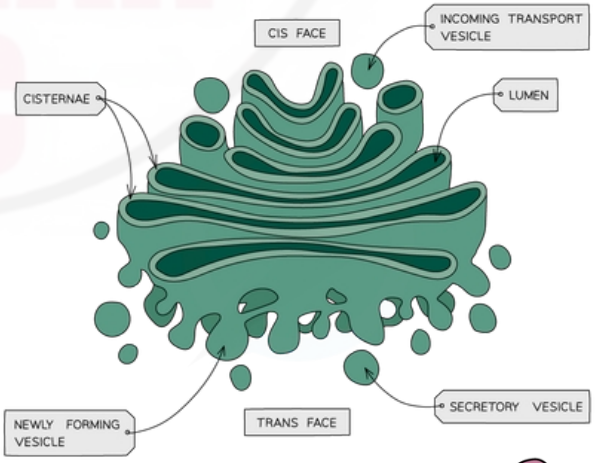



## Golgi Bodies



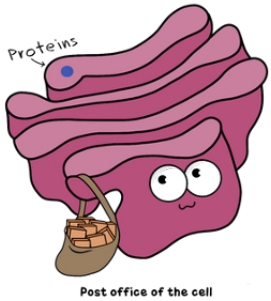
- Discovered by: Camillo Golgi (1898).
- It consist of vesicles, cisternae, and vacuoles.
- Golgi bodies has two distinct faces.

1. **Cis face:** Convex, faces towards the nucleus (receiving side).
2. **Trans face:** Concave, faces towards plasma membrane (mature/shipping side).



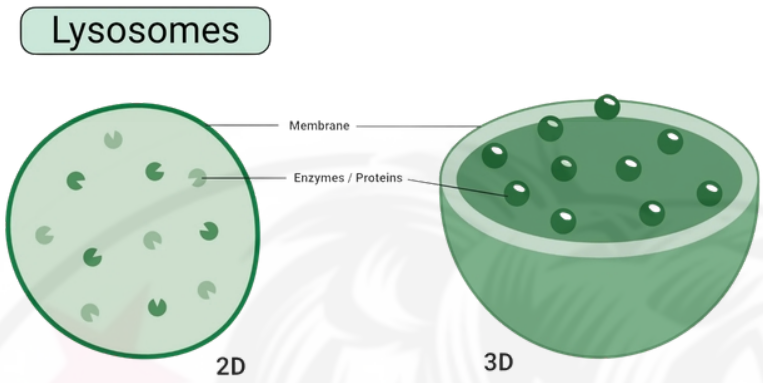

## Functions

- It responsible for packaging and despatching of proteins and lipids (also known as "Post Office" of the cell).
- It is involved in forming complex sugar from simple sugars
- It forms lysosomes.



## Lysosomes

- It is known as "**suicide bag of the cell**".
- Lysosomes are filled with digestive enzymes (made in RER) that acts as waste disposal system of cell.
- When the cells get damaged, lysosomes may burst leading to enzymes digesting their own cell.




## Vacuoles

- Vacuoles are membrane bound solid or liquid filled sac-like structures.

### In plants

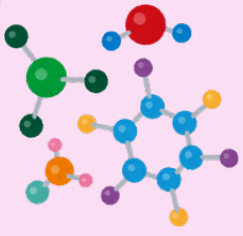
- They are large and distinct and occupy significant portion of cell volume (50-90%)
- They store cell sap.
- They provide turgidity and rigidity to the cell.
- In plant cells, vacuoles are generally considered permanent, large, and central structures.

### In Animals

- In animal cells, vacuoles are smaller, more numerous, and often temporary.
- They store glucose, glycogen, and protein.

**Cell sap**

- Cell sap consists of:
- Amino acids
- Sugars
- Organic acids



Waste products are temporarily stored in vacuoles.

## Peroxisomes

- It breakdowns very long chain of fatty acid through beta oxidation
- It contains oxidative enzymes (E.g. Catalase) that convert harmful hydrogen peroxide into water and oxygen. It acts as free radical scavengers, helping to detoxify the cell.

## Plastids

- Plastids are only present in plant cell and not in animal cell.
- It has its own DNA and ribosomes.

# Types of Plastids

### Chloroplasts

- Chloroplasts are green plastids that contain chlorophyll, the pigment responsible for photosynthesis
- They also contain yellow and orange pigments like Xanthophyll and Carotenes
- Chlorophyll molecules contain magnesium ($Mg^{2+}$), which is essential for capturing solar energy during food synthesis (photosynthesis)

### Chromoplasts

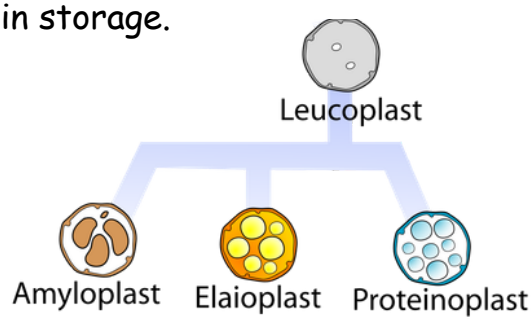
- Chromoplasts contains different types of pigments, which provides colour.
- **E.g.** Red colour in tomato which is due to lycopene, red colour in chilli which is due to capsanthin.

- Anthocyanin ➜ pigments responsible for colors of fruits & veges
- Yellow ➜ Xanthophyll

### Leucoplasts

- Leucoplasts are colourless plastids, mainly involved in storage.
- They are of three types.

1. **Amyloplast:** Storage of carbohydrates
2. **Aleuroplast:** Storage of proteins
3. **Elaioplast:** Storage of fats

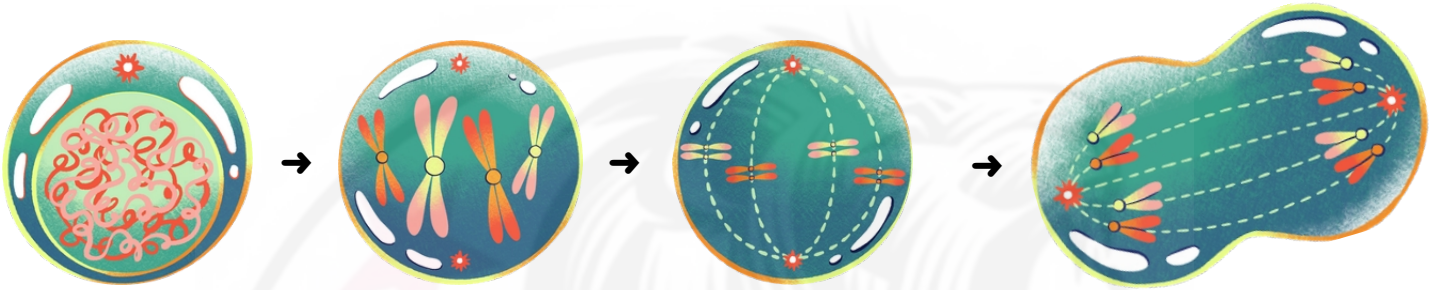


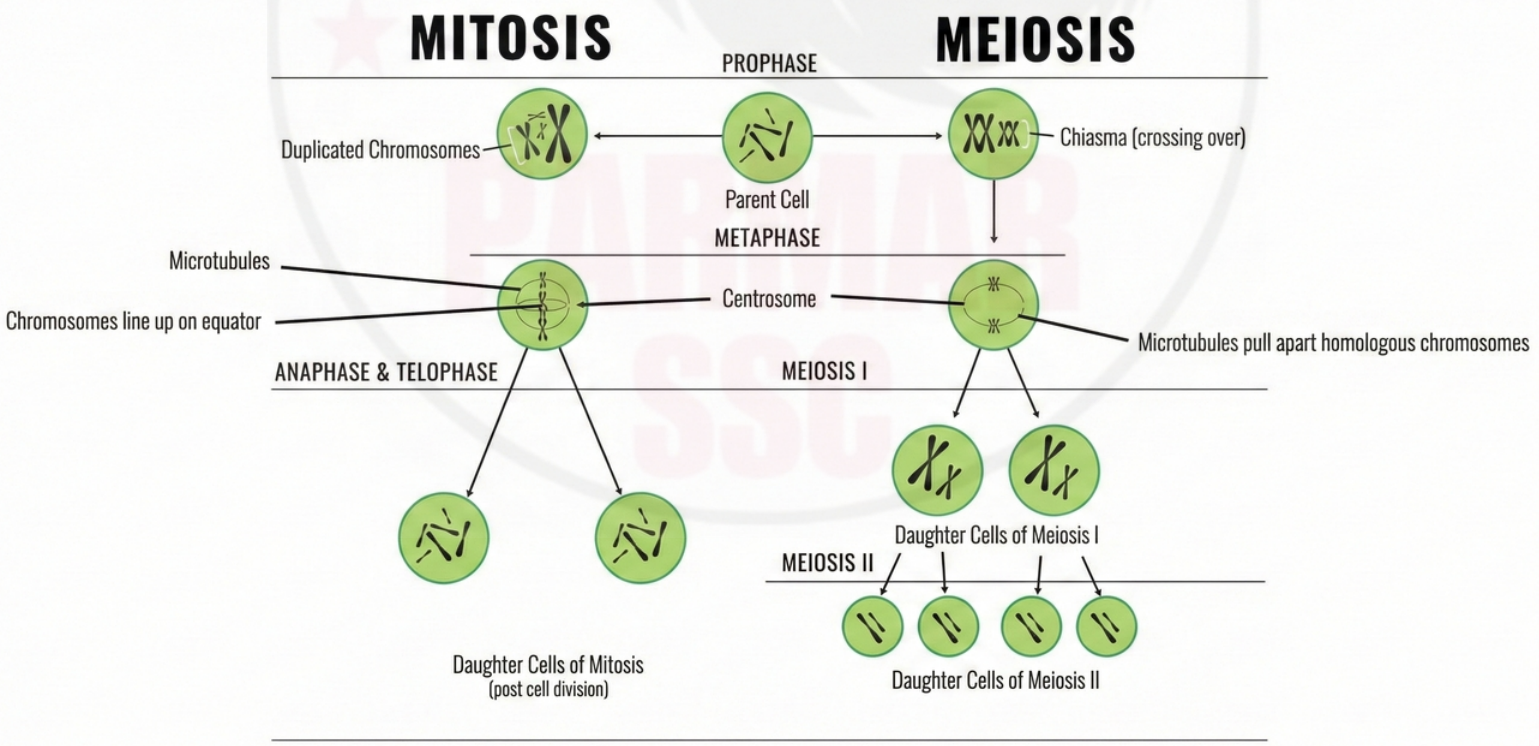
# CELL DIVISION

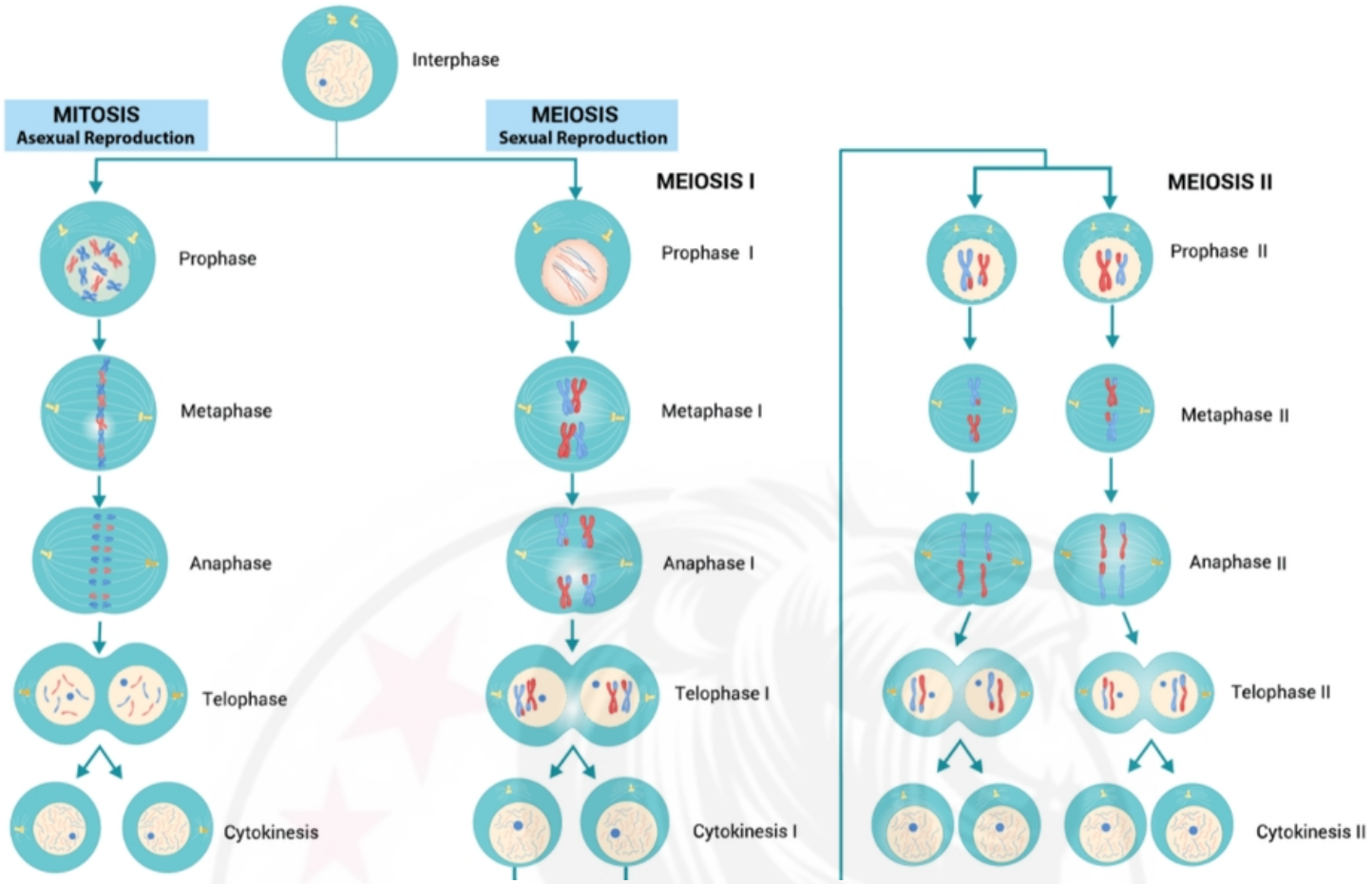
- Cell division is the process where a parent cell divides into two or more daughter cells

## Reason for division

1. Growth of organism
2. To replace old, dead, and injured cell
3. Gamete formation (Meiosis)

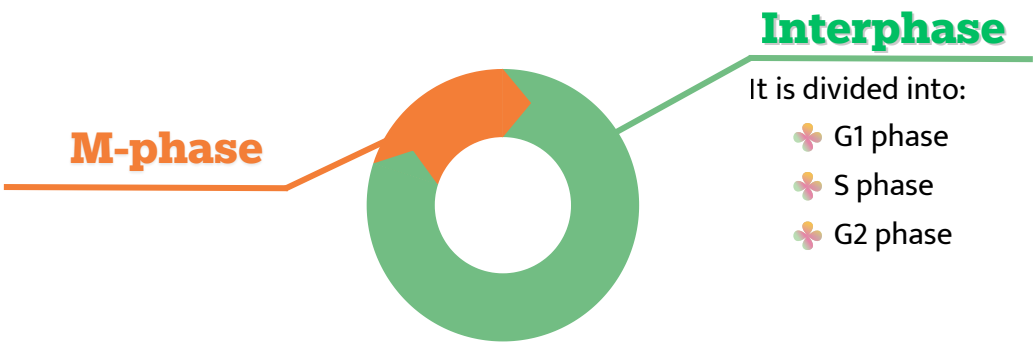







| Mitosis | Meiosis |
|---|---|
| Occurs in somatic cells (body cells) | Occurs in germ cells (reproductive cells) |
| The nucleus divides only once | The nucleus divides twice |
| Produces two daughter cells | Produces four daughter cells |
| Daughter cells are diploid (2n) → same no. of chromosomes as the parent cells | Daughter cells are haploid (n) → half the no. of chromosomes as the parent cells |
| Cells are genetically identical to each other and to the parent cell | Cells are genetically different from each other and from the parent cell |
| Responsible for growth, repair, and asexual reproduction | Responsible for formation of gametes (egg and sperm cells) |
| No genetic variation occurs | Genetic variation occurs due to crossing over and independent assortment |
| Malfunction can lead to cancer (uncontrolled cell division) | Malfunction can lead to genetic disorders such as: Down's syndrome, Klinefelter's syndrome, Turner's syndrome |

# PARTS OF THE CELL CYCLE




## G1 PHASE (GAP 1)

**What happens?**

The cell grows and performs its normal functions, preparing for DNA replication

## S PHASE SYNTHESIS

**What happens?**

The cell replicates its DNA, creating two identical copies of each chromosome

## G2 PHASE (GAP 2)

**What happens?**

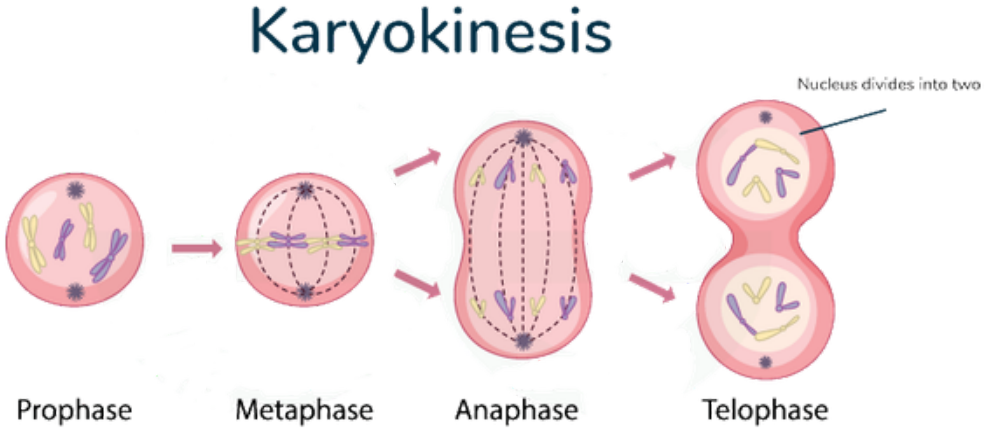
The cell continues to grow and prepares for mitosis, ensuring that DNA replication is complete and that the cell is ready to divide

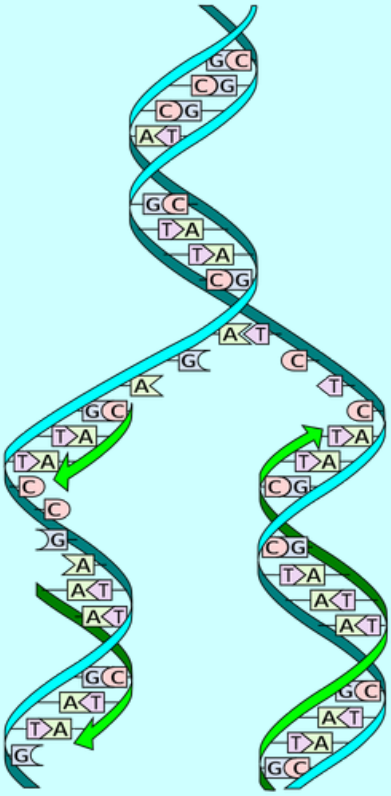
## M PHASE MITOTIC PHASE

**What happens?**

This phase involves the division of the cell's nucleus and cytoplasm

- **Prophase** – Chromosomes condense and become visible.
- **Metaphase** – Chromosomes align at the cell's equator.
- **Anaphase** – Sister chromatids separate and move to opposite poles.
- **Telophase** – Two new nuclei form.

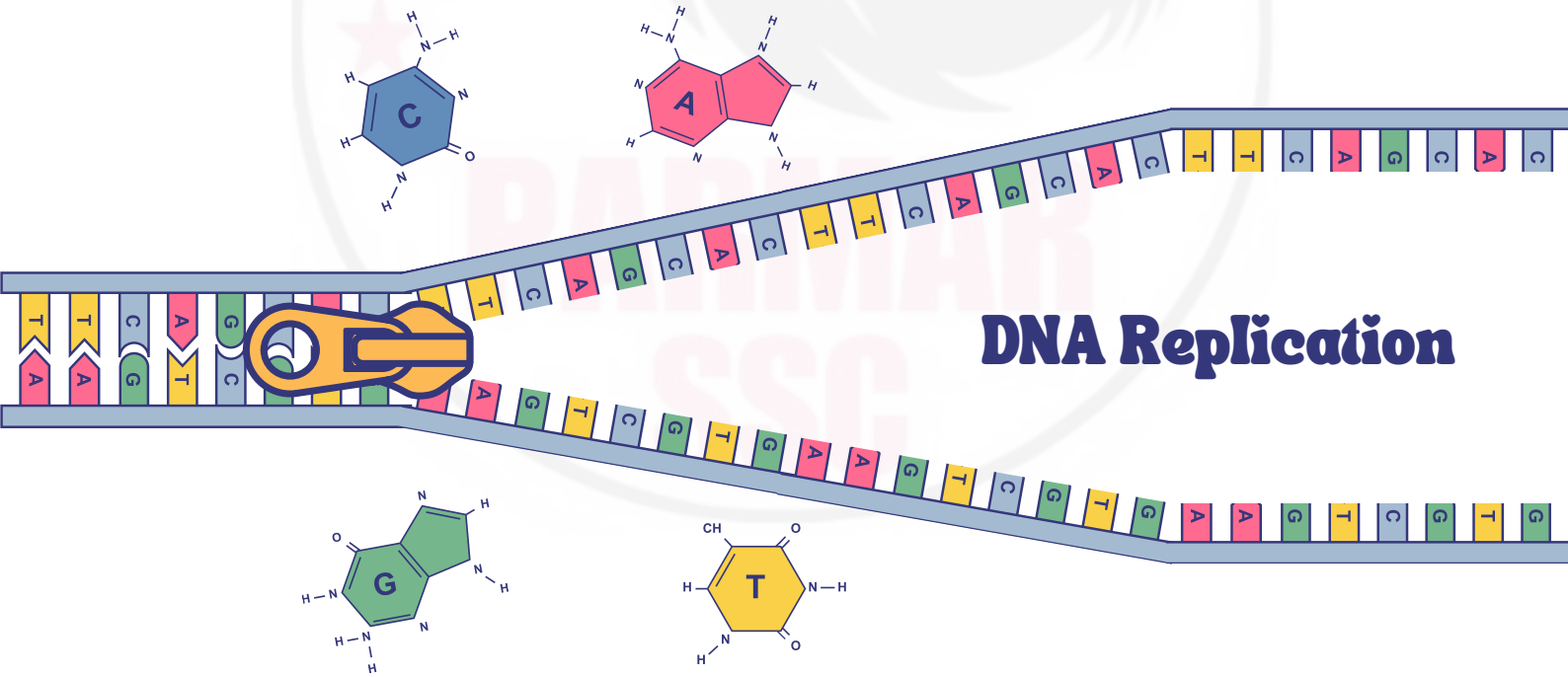




## NUCLEOTIDE

PHOSPHATE  DEOXYRIBOSE  NITROGENOUS BASE

GUANINE — CYTOSINE
ADENINE — THYMINE




**DNA replication is a process by which cell makes an exact copy of its DNA before cell division. This ensures that each new cell gets the same genetic information.**

# Enzymes Essential for DNA Replication in Animal Cell

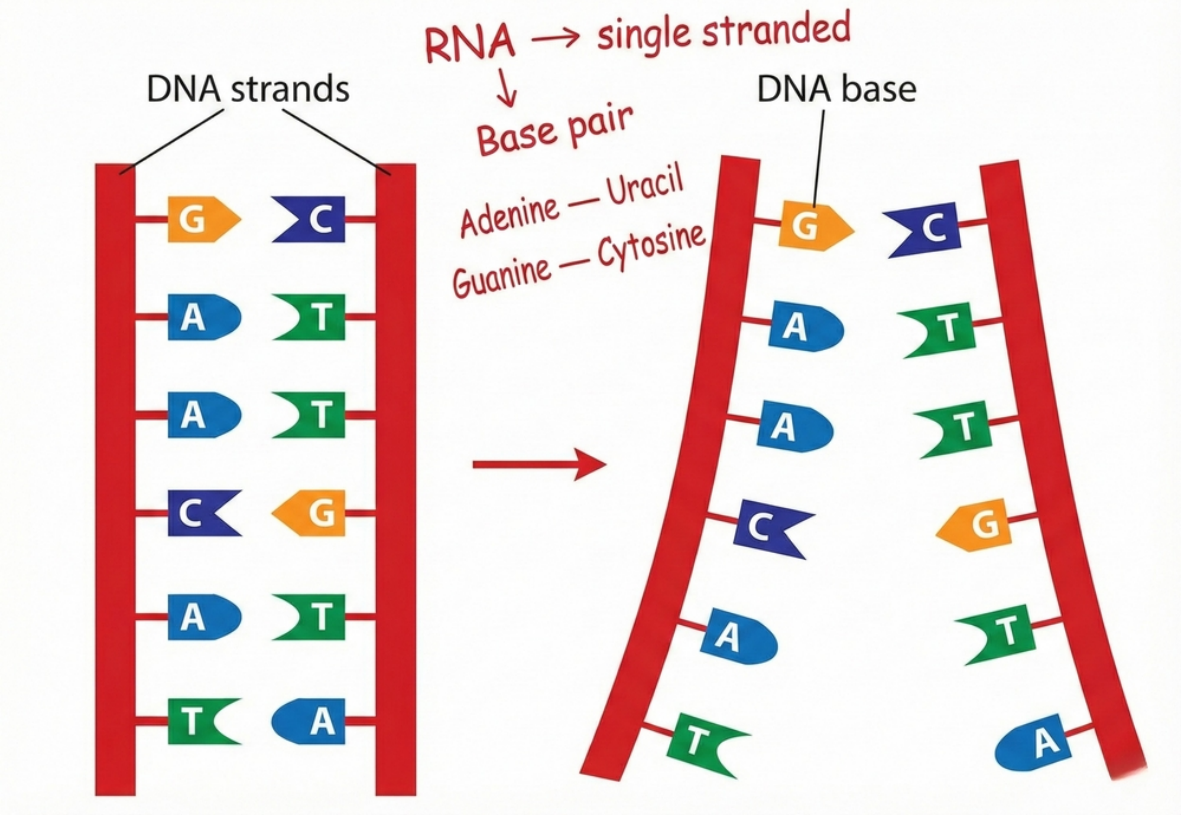
| Helicase | Topoisomerase |
|---|---|
| This is an unwinding enzyme. It "unwinds" or "unzips" the double-stranded DNA | This enzyme prevents DNA from getting tangled (avoid supercoiling) |

| DNA Primase | DNA Polymerase |
|---|---|
| This enzyme initiates DNA replication (new strands are produced) | This enzyme doubles the amount of DNA in a cell during cell division (builder) |

**DNA Ligase: This enzyme facilitates the joining of DNA strand together (gluer)**

## Semi Conservative DNA Replication

It is the process of duplicating DNA to create two new double stranded DNA molecules, each with one original strand, and one new strand



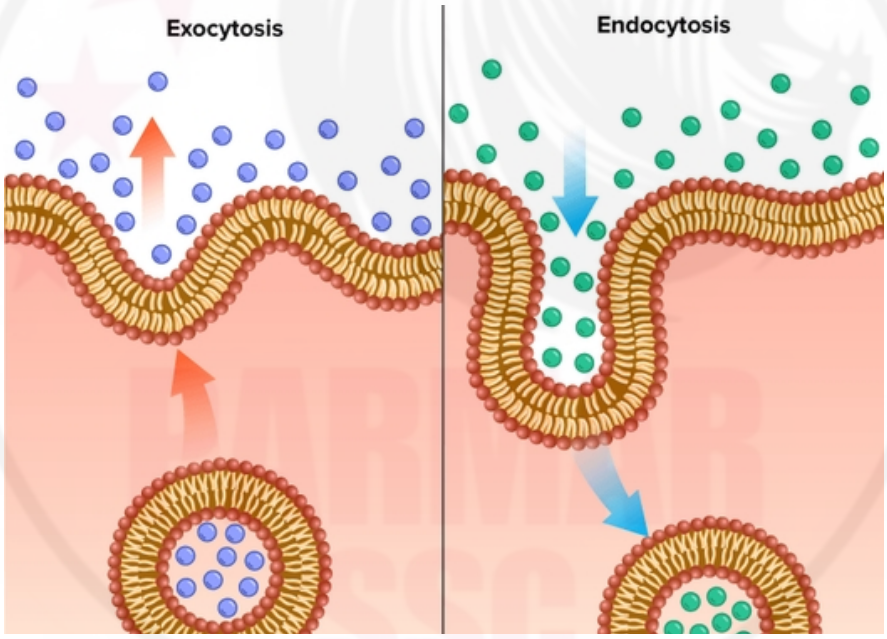
# Endocytosis vs Exocytosis

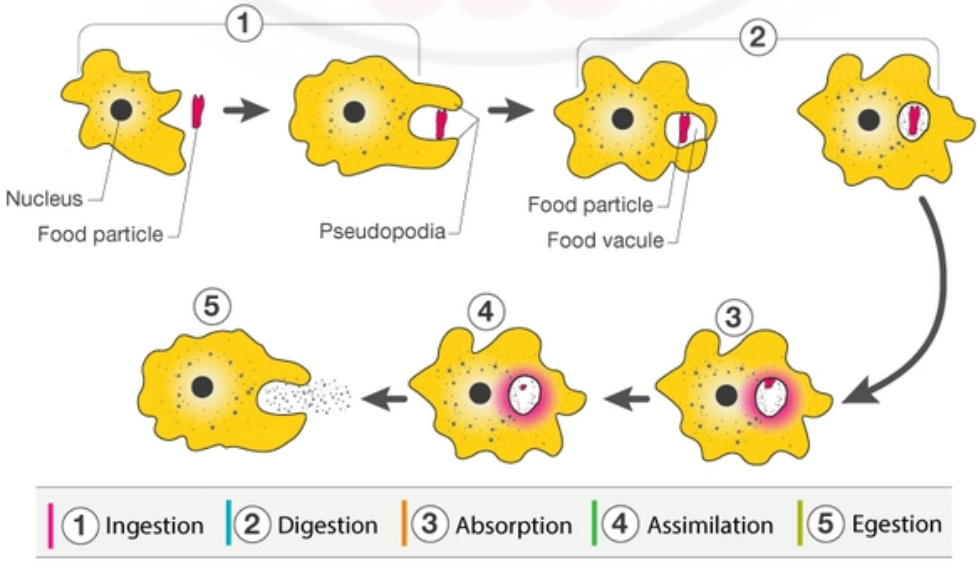
## Endocytosis

- Endocytosis is a type of active transport where a cell engulfs external materials, forming a vesicle to bring them inside
- It includes processes like phagocytosis (cell eating) and pinocytosis (cell drinking).
- **E.g.** Entrapment of food particles by Amoeba

## Exocytosis

- Exocytosis is a cellular process where a cell transports molecules out of the cell by using vesicles that fuse with the cell membrane, releasing their contents into the extracellular space
- It is also known as cell vomiting. Vomited particles are undigested residues from endocytosis → enzymes and hormones



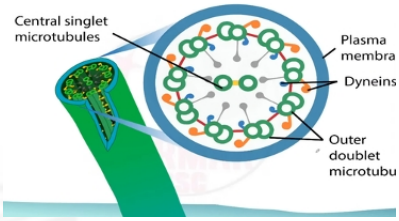



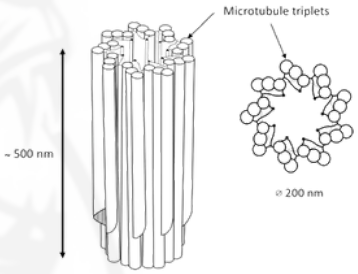
# Cytosekelton

- Cytoskeleton helps in providing structural support to cell.
- Cytoskeleton helps in cell movement.

# Centrosome

- Centrosome is also known as the Microtubule Organizing Center (MTOC) because it regulates cell division and structure.
- The centrosome is responsible for organizing microtubules, which are essential for cell structure, movement, and division.
- Each centriole is a cylindrical structure made up of microtubule arranged in 9+0 form.



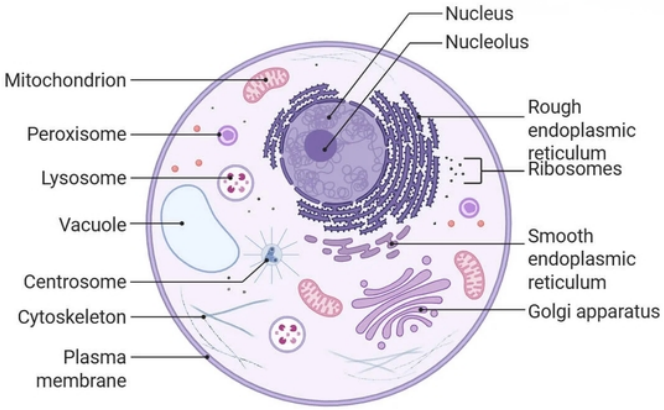




# Microtubules

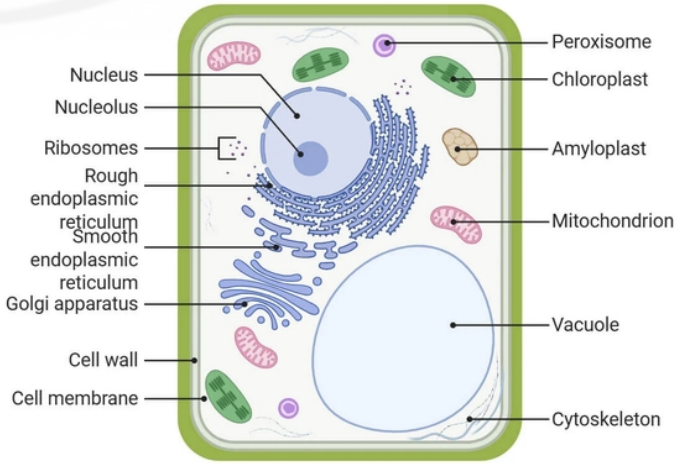
- Microtubules are hollow, cylindrical structures composed of tubulin proteins that form part of the cell's cytoskeleton, providing structural support, facilitating cell movement, and playing a crucial role in cell division.

## Animal Cell vs. Plant Cell

### Animal cell




### Plant cell



| Animal Cell | Plant Cell |
|---|---|
| Cell wall is absent | Cell wall is present |
| Mitochondria Chloroplast is absent | Chloroplast is present for photosynthesis |
| Small, irregular, or round in shape | Almost rectangular in shape |
| Small vacuoles are present | Large vacuoles are present |
| Plastids are absent | Plastids are present |
| Has more number of mitochondria | Has less number of mitochondria |
| Reserve food material is glycogen | Reserve food material starch |





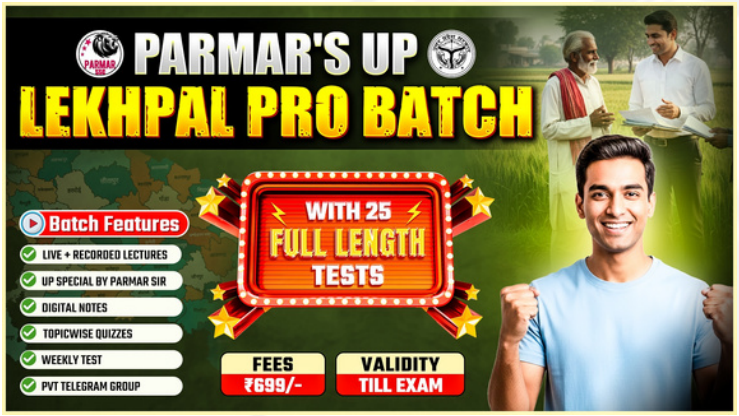


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