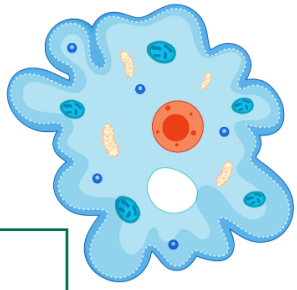
01 Cell : The Unit of Life

01. INTRODUCTION



- **What is it** that makes an organism living, or **what is it** that an inanimate (Non-living) thing does not have which a living thing has? The answer to this is the presence of **the basic unit of life – the cell in all living organisms.**

NCERT Question :
Cell is the basic unit of life. Discuss in brief.

- All organisms are composed of cells-
  - **(i) Unicellular organisms –** Single cell
  - **(ii) Multicellular organisms –** Many cells

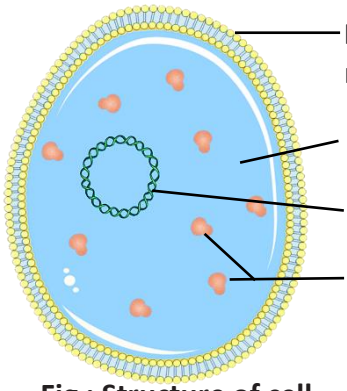
02. WHAT IS A CELL ?

- Unicellular organisms are capable of-
  - (i) Independent existence.
  - (ii) Performing the essential functions of life.
- Anything less than a complete structure of a cell does not ensure independent living. Hence, cell is the **fundamental structural** and **functional** unit of all living organisms.

NCERT Question :
Multicellular organisms have division of labour. Explain.

Ans. Division of labour is the differentiation of certain parts of the cell to carry out different functions for increased efficiency and higher survival. In multicellular organisms, distinct organs and organ systems carry out distinct metabolic activities. However, in unicellular organisms, a single cell performs all the metabolic activities. In the human body, there is a separate system to carry out functions such as circulation, respiration, locomotion, excretion and digestion. Even in a particular system, there are different organs for different functions. For example, in the digestive system, the teeth and mouth are responsible for mastication. The stomach is responsible for killing the bacteria in food. The small intestine is responsible for digestion and absorption. Thus, multicellular organisms have division of labour.

BASIC COMPONENTS OF A CELL :



Plasma membrane – delimiting (boundary) structure of cell and medium for exchange.

Cytoplasm – semi fluid matrix. Main arena for all cellular activities (metabolism)

Genetic material – DNA

Ribosomes – protein factory of cell. Universal organelle.

Fig : Structure of cell

HISTORY OF CELL :

- **Robert Hooke** – Discovered and termed cell. He observed cell wall of dead cells in cork slice.
- **Anton Von Leeuwenhoek** – Saw and described a **live cell *e.g.*** Bacteria, Algal cells, sperms.
- **Robert Brown** – Discovered nucleus.
- The invention of the microscope and its improvement leading to the electron microscope revealed all the structural details of the cell.

03. CELL THEORY

- In 1838, **Matthias Schleiden**, a German botanist, examined a large number of plants and observed that all **plants are composed of different kinds of cells which form the tissues of the plant**.
- At about the same time, **Theodore Schwann** (1839), a British zoologist, studied different types of animal cells and **reported that cells had a thin outer layer which is today known as the plasma membrane**. He also concluded, based on his studies on plant tissues, that the **presence of cell wall is a unique character of the plant cells.**
- **Schwann** proposed the **hypothesis** that the bodies of animals and plants are composed of cells and products of cells.
- Schleiden and Schwann together formulated the cell theory. **This theory however, did not explain as to how new cells were formed.**
- **Rudolf Virchow** (1855) first explained that cells divided and new cells are formed from pre-existing cells **(*Omnis cellula-e cellula*)**. He modified the hypothesis of Schleiden and Schwann to give the cell theory a final shape.
- Cell theory as understood today is:
  (i) All living organisms are composed of cells and products of cells.
  (ii) All cells arise from pre-existing cells.

04. AN OVERVIEW OF CELL

- You have earlier observed cells in an onion peel and/or human cheek cells under the **microscope**.
- The **onion cell** which is a typical plant cell, has a distinct cell wall as its outer boundary and just within it is the cell membrane.
- The **cells of the human cheek** have an outer membrane as the **delimiting structure of the cell**.
- Inside each cell is a dense membrane bound structure called **nucleus**. This nucleus contains the chromosomes which in turn contain the genetic material, DNA.
- Cells that have **membrane bound nuclei** are called **eukaryotic** whereas cells that **lack a membrane bound nucleus are prokaryotic.**
- In both prokaryotic and eukaryotic cells, a semi-fluid matrix called **cytoplasm** occupies the volume of the cell. The cytoplasm is the main arena of cellular activities in both the plant and animal cells. Various **chemical reactions** occur in it to **keep the cell in the 'living state'**.

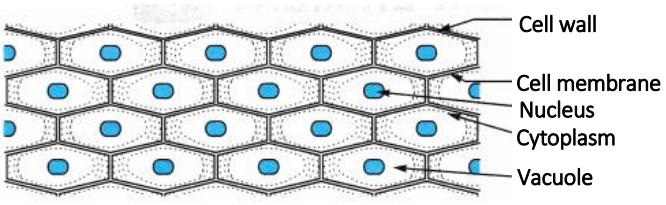


Fig : Cell structure of Onion peel (plant cell)

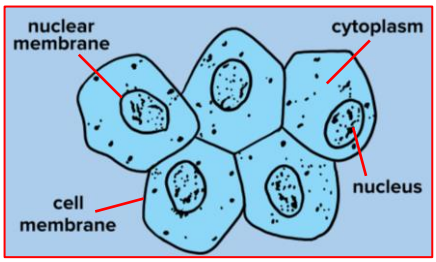


Fig : Cell structure of Human cheek (animal cell)

- Besides the nucleus, the eukaryotic cells have other membrane bound distinct structures called **organelles** like the endoplasmic reticulum (ER), the Golgi complex, lysosomes, mitochondria, microbodies. The prokaryotic cells lack such membrane bound organelles, and nucleus absent.
- Ribosomes are non-membrane bound organelles found in all cells both eukaryotic as well as prokaryotic cell. Within the eukaryotic cell, ribosomes are found not only in the cytoplasm but also on rough ER and within the two organelles chloroplasts (in plants) and mitochondria.
- Animal cells contain another non-membrane bound organelle called centriole / centrosome which helps in cell division.

Size & Shape of Cell :

- Cells **differ greatly** in size, shape and activities. For example, **Mycoplasmas**, the smallest cells, are only 0.3 µm in length while **bacteria** could be 3 to 5 µm. The largest isolated single cell is the **egg of an ostrich**.

- Among multicellular organisms, **human red blood cells** are about 7.0 µm in diameter. Nerve cells are some of the longest cells.
- Cells also vary greatly in their shape. They may be disc-like, polygonal, columnar, cuboid, thread like, or even irregular. The shape of the cell may vary with the function they perform.

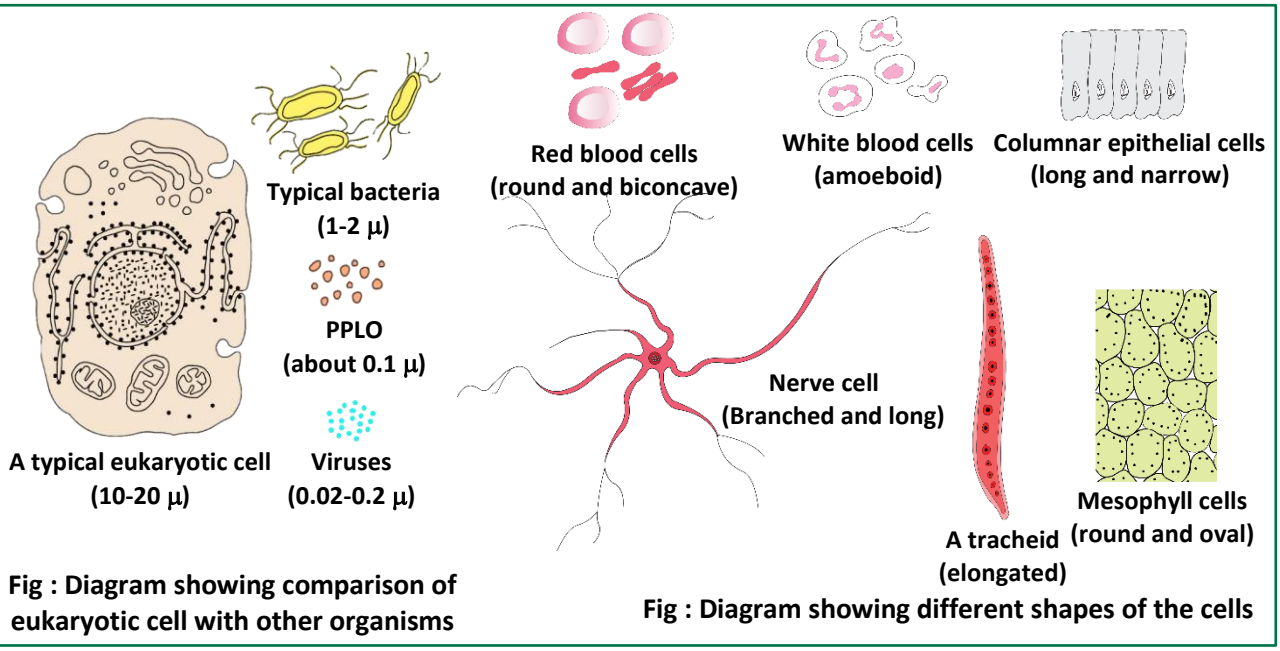


Fig : Diagram showing comparison of eukaryotic cell with other organisms

Fig : Diagram showing different shapes of the cells

05. PROKARYOTIC CELL

NCERT Question :

What are the characteristics of prokaryotic cells?

- The prokaryotic cells are represented by **bacteria, blue-green algae, mycoplasma** and **PPLO** (Pleuro Pneumonia Like Organisms).
- There is **no well-defined nucleus**. The genetic material is basically **naked**, not enveloped by a nuclear membrane. No organelles, like the ones in eukaryotes, are found in prokaryotic cells except for ribosomes. Prokaryotes have something unique in the form of inclusions. **All prokaryotes have a cell wall** surrounding the cell membrane **except in mycoplasma.**
- In **addition to the genomic DNA** (the single chromosome/circular DNA), many bacteria have small circular DNA outside the genomic DNA. These smaller DNA are called **plasmids**. The plasmid DNA confers certain unique **phenotypic characters** to such bacteria. One such character is **resistance to antibiotics**.
- The fluid matrix filling the cell is the cytoplasm.

- Plasmid DNA is also used to monitor **bacterial transformation** with foreign DNA.
- Prokaryotes are generally smaller and multiply more rapidly than the eukaryotic cells. They **may vary greatly in shape and size**. The four basic shapes of bacteria are **bacillus** (rod like), **coccus** (spherical), **vibrio** (comma shaped) and **spirillum** (spiral).
- The organisation of the prokaryotic cell is fundamentally similar even though prokaryotes exhibit a wide variety of shapes and functions.

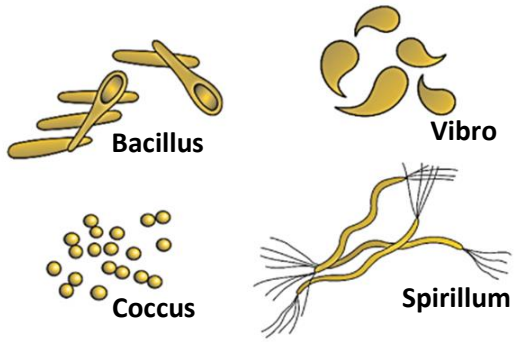


Fig : Shapes of Bacteria

PROKARYOTIC CELL ENVELOPE AND ITS MODIFICATIONS :

- **Most prokaryotic cells**, particularly the bacterial cells, have a chemically complex cell envelope. The **cell envelope** consists of a tightly bound **three layered structure** i.e., the outermost **glycocalyx** followed by the **cell wall** and then the **plasma membrane**. Although each layer of the envelope performs distinct function, they act together as a single protective unit.
- Bacteria can be classified into two groups **on the basis** of the **differences in the cell envelopes** and the **manner** in which **they respond to the staining procedure developed by Gram** viz., those that take up the gram stain are **Gram positive** and the others that do not are called **Gram negative** bacteria.
- **Glycocalyx differs in composition and thickness** among different bacteria. It could be a loose sheath called the **slime layer** in some, while in others it may be thick and tough, called the **capsule**. The **cell wall** determines the shape of the cell and provides a strong structural support to prevent the bacterium from bursting or collapsing.
- The plasma membrane is **selectively-permeable** in nature and interacts with the outside world. This membrane is **similar structurally to that of the eukaryotes.**

NCERT Question :

What is a mesosome in a prokaryotic cell? Mention the functions that it performs.

- A special membranous structure - **mesosome (Characteristic of prokaryotes)** which is formed by the extensions of plasma membrane into the cell. These extensions are in the **form of vesicles, tubules and lamellae**. **They help in cell wall formation, DNA replication and distribution to daughter cells. They also help in respiration, secretion processes, to increase the surface area of the plasma membrane and enzymatic content.**

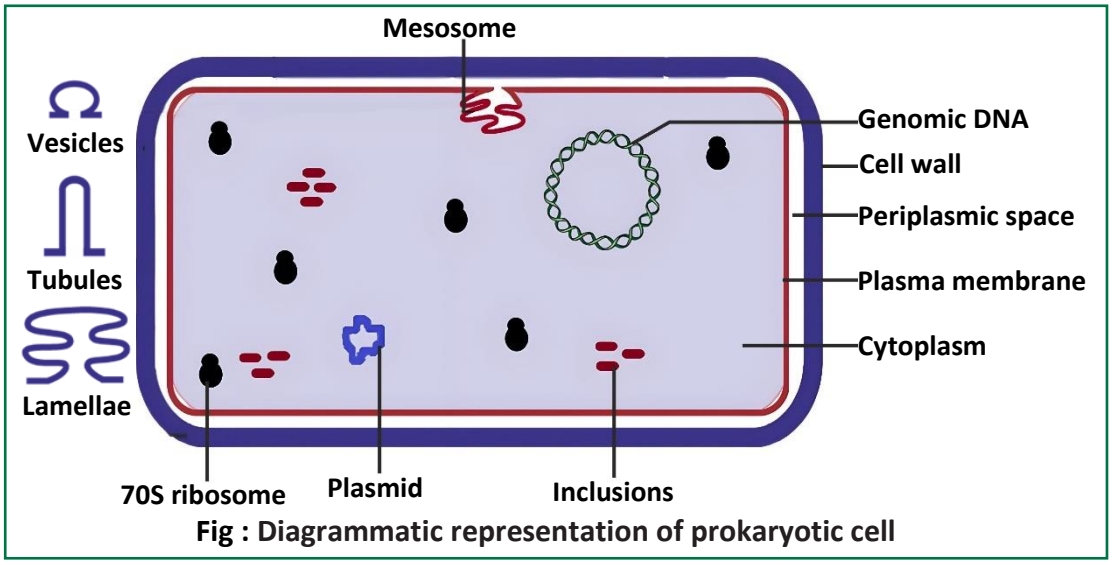


Fig : Diagrammatic representation of prokaryotic cell

- **In some prokaryotes like cyanobacteria, there are other membranous extensions into cytoplasm called chromatophores which contain pigments.**
- Bacterial cells may be **motile** or **non-motile**. If motile, they have thin filamentous extensions from their cell wall called **flagella**. Bacteria show a **range in the number and arrangement of flagella**. Bacterial flagellum is composed of three parts – **filament, hook** and **basal body**. The **filament is the longest portion** and extends from the cell surface to the outside.
- Besides flagella, **Pili** and **Fimbriae** are also surface structures of the bacteria but do not play a role in motility. The **pili** are elongated tubular structures made of a special protein. The **fimbriae** are small bristle like fibres sprouting out of the cell. In some bacteria, they are known to help attach the bacteria to rocks in streams and also to the host tissues.

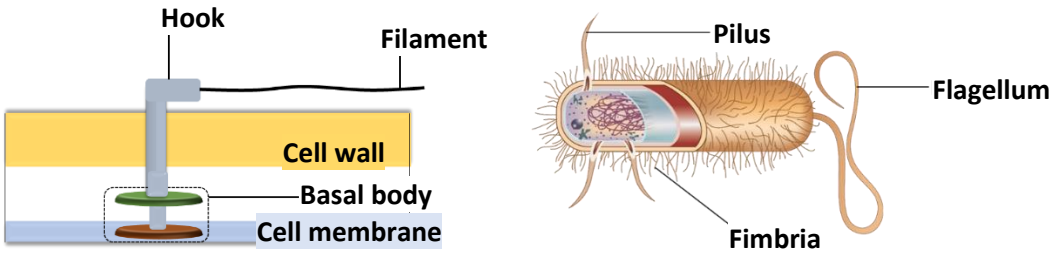


Fig : Structure of Bacteria

PROKARYOTIC RIBOSOMES AND INCLUSION BODIES :

- In prokaryotes, ribosomes are **associated with the plasma membrane** of the cell. They are about 15 nm by 20 nm in size and are made of two subunits - 50S and 30S units which when present together form 70S prokaryotic ribosomes.
- Ribosomes are the site of protein synthesis. Several ribosomes may attach to a single mRNA and form a chain called **polyribosomes** or **polysome**. mRNA translate into proteins with the help of these ribosomes.

- The ribosomes of a polysome translate the mRNA into proteins.

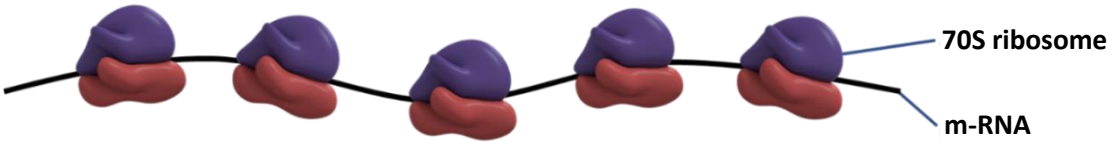


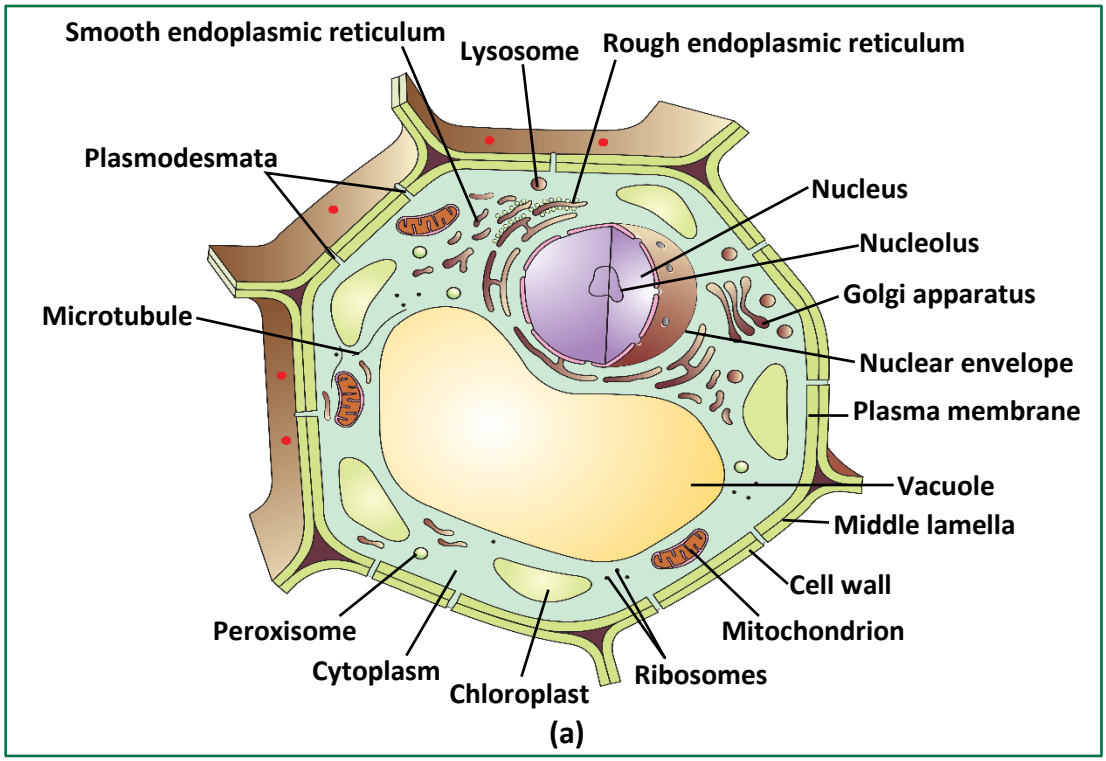
Fig : Polyribosomes

Inclusion bodies: Reserve material in prokaryotic cells are stored in the cytoplasm in the form of inclusion bodies. These are not bounded by any membrane system and lie free in the cytoplasm, e.g., phosphate granules, cyanophycean granules and glycogen granules. **Gas vacuoles** are found in blue green and purple and green photosynthetic bacteria.

CHARACTERS	PROKARYOTES	EUKARYOTES
NUCLEUS	Non-membrane bound	Membrane bound
MEMBRANE BOUND ORGANELLES	Absent	Present
RIBOSOMES	Present (**70S**)	Present (**80S**). In mitochondria and chloroplast **70S** ribosomes are also present.
SIZE	Generally smaller	Generally larger
MULTIPLICATION	More rapid	Less rapid
CHROMOSOME	False	True

06. EUKARYOTIC CELLS

- The eukaryotes include all the protists, plants, animals and fungi. **In eukaryotic cells there is an extensive compartmentalisation of cytoplasm through the presence of membrane bound organelles.**
- Eukaryotic cells possess an **organised nucleus** with a nuclear envelope. In addition, eukaryotic cells have a variety of complex locomotory and cytoskeletal structures. Their **genetic material is organised into chromosomes.**
- All eukaryotic cells are not identical.
- Plant and animal cells are different as the former possess cell walls, plastids and a large central vacuole which are absent in animal cells.
- Animal cells have centrioles which are absent in all higher plants.



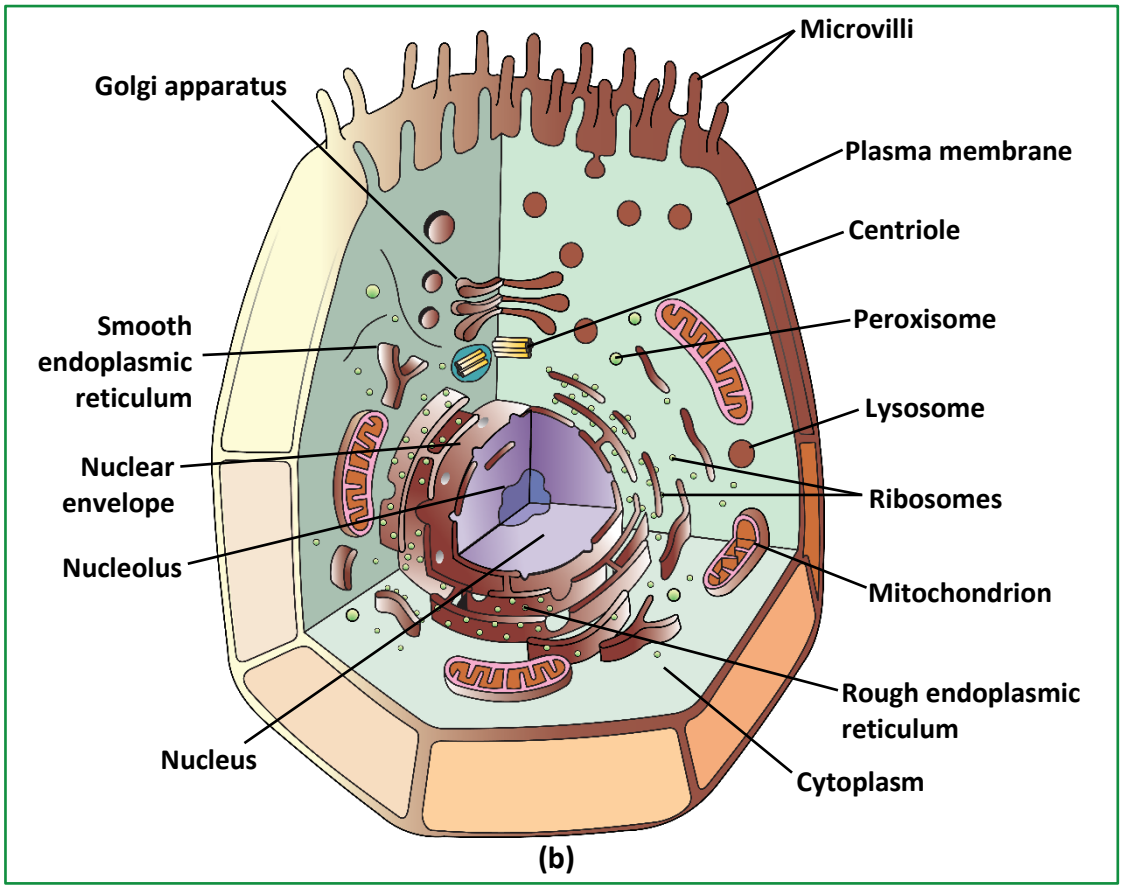


Fig : Diagram showing : (a) Plant cell (b) Animal cell

CHARACTERS	PLANT CELL	ANIMAL CELL
CELL WALL	Present	Absent
SAP VACUOLE	Present	Absent
PLASTIDS	Present	Absent
CENTRIOLES	Absent	Present

(1) CELL-MEMBRANE OR BIO-MEMBRANE:

Cell membrane + Cell Organelles membrane = Bio-membranes

- The detailed structure of the membrane was studied only **after the advent of the electron microscope in the 1950s**. Meanwhile, chemical studies on the cell membrane, especially in human red blood cells (RBCs), enabled the scientists to deduce the possible structure of plasma membrane.
- Biochemical investigation clearly revealed that the cell membranes possess **lipid, protein and carbohydrate.**
- The ratio of protein and lipid varies considerably in different cell types.
- **Human erythrocyte** membrane has approximately 52% protein and 40% lipids.
- Structurally cell membrane of prokaryotes is similar to the eukaryotes.
- These studies showed that the cell membrane is mainly composed of lipids and proteins.
- The major lipids are phospholipids that are arranged in a bilayer. Also, the lipids are arranged within the membrane with the polar head towards the outer sides and the hydrophobic tails towards the inner part.
- This ensures that the nonpolar tail of saturated hydrocarbons is protected from the aqueous environment.
- In addition to phospholipids membrane also contains cholesterol, the lipid component of the membrane mainly consists of phosphoglycerides.

Structure of Biomembrane:

(i) Fluid mosaic model :

- By Singer & Nicolson (1972)
- This is latest & most widely accepted model for the structure of cell membrane.

- According to fluid mosaic model proteins are arranged in phospholipid layer as mosaic pattern.
- **"Protein iceberg in a sea of phospholipid"**
- **"Gulab Jamun (protein) in a concentrated solution (phospholipid) of sugar"**

(a) Lipids

- **Phospholipid** is the main component of cell membrane because it **forms continuous structural frame** of cell membrane.
- Phospholipid layer **provides fluidity** to plasma membrane because phospholipids are rich in **unsaturated fatty acid**.

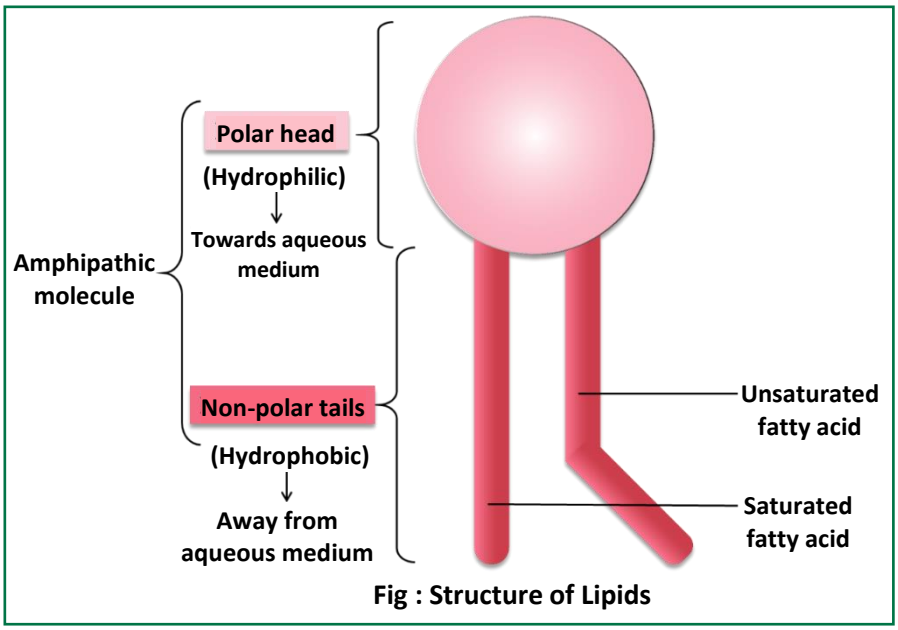


Fig : Structure of Lipids

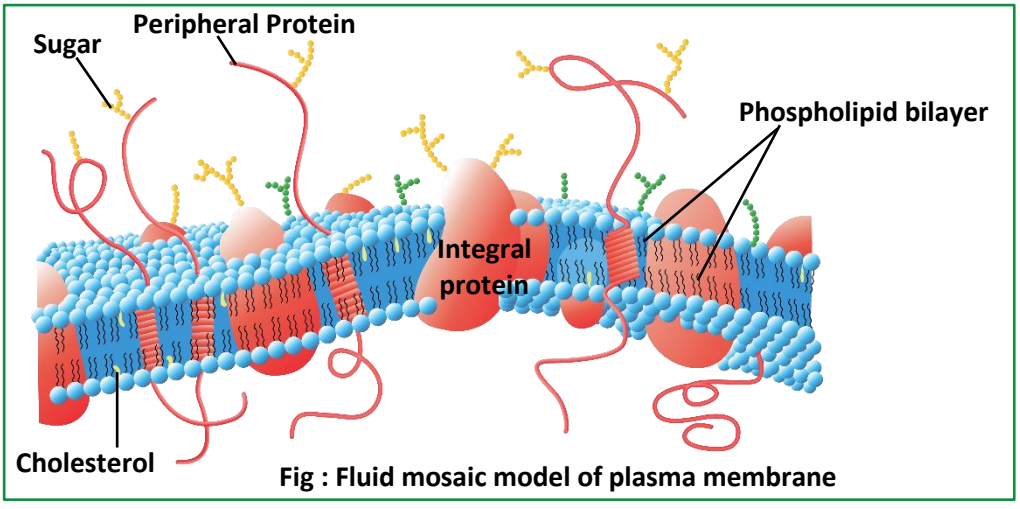
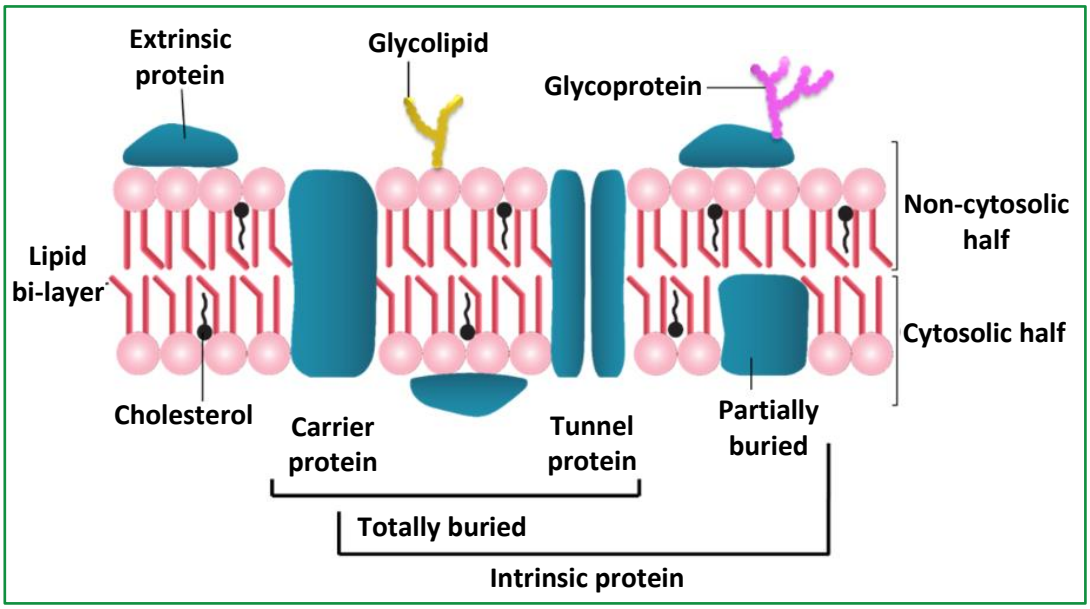


Fig : Fluid mosaic model of plasma membrane



- **Cholesterol** is also present in plasma membrane. Cholesterol are more rigid than phospholipid. So it **helps in stability** of membrane structure.
- The **Quasifluid** nature of lipid enable **lateral movement of protein with in the overall bilayer**. This ability to move within the membrane is measured as its, **fluidity**.
- The fluid nature of the membrane is also important in various function like **cell growth, formation of intercellular junction, endocytosis, secretion, cell division etc.**

Proteins :

Two types of protein are present in plasma membrane. **(On the basis of ease of extraction)**

1. **Extrinsic or peripheral protein :-**

   These are superficially arranged on the surface of lipid layer and can be separated easily. These proteins have enzymatic activity.

2. **Intrinsic or integral protein :-**

   These proteins are tightly bound with phospholipid. Thus, they can not be easily removed from membrane.

   (i) Partially buried – Incompletely buried through the thickness of membrane.

   (ii) Totally buried – Totally buried through the complete thickness of membrane. (Carrier Proteins and Tunnel Proteins.)

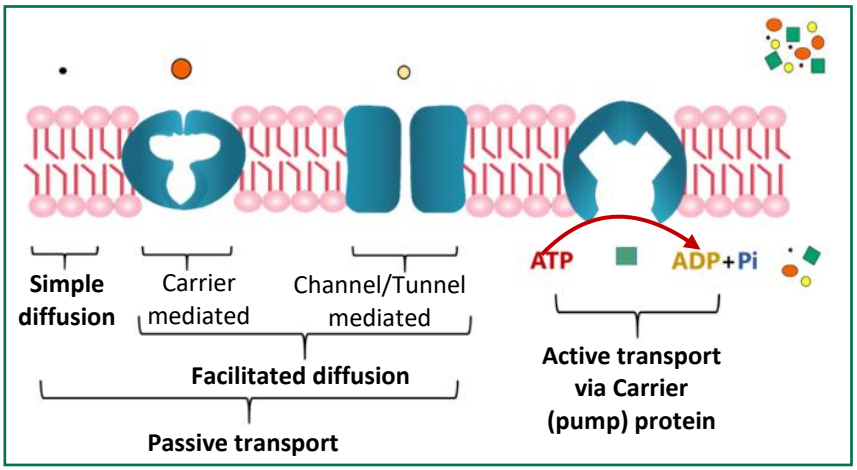
Carbohydrates (Oligosaccharides) :

- Oligosaccharides (sugar), the **glycolipids & glycoproteins on the outer surface** of plasma membrane are involved in **cell to cell recognition**.

- Best example of cell recognition is "Fertilization (where sperm & egg recognize each other)" and "Blood group Antigens".

Transportation Across The Plasma Membrane :

- **One of the most important functions** of the plasma membrane is the **transport of the molecules across it**. The membrane is selectively permeable to some molecules present on either side of it.



- Many molecules can move briefly across the membrane without any requirement of energy and this is called the **passive transport**.

NCERT Question :

How do neutral solutes move across the plasma membrane? Can the polar molecules also move across it in the same way? If not, then how are these transported across the membrane?

Ans. Neutral solutes are able to pass through the lipid bilayer of a plasma membrane as they are lipid soluble. The rate of movement depends on the concentration gradient and the lipid solubility of the neutral solutes. Polar molecules require special hydrophilic areas for their passage. They get transported by facilitated diffusion (carrier and tunnel proteins) and active transport by utilising ATP.

- **Neutral solutes** may move across the membrane by the process of **simple diffusion** along the concentration gradient, i.e., from higher concentration to the lower. **Water** may also move across this membrane from higher to lower concentration. Movement of water by diffusion is called **osmosis**.
- As the **polar molecules** cannot pass through the nonpolar lipid bilayer, they require a **carrier protein** of the membrane to facilitate their transport across the membrane.

- **Ions** are transported across the plasma membrane along the concentration gradient through **tunnel proteins**.
- A few ions or molecules are transported across the membrane against their concentration gradient, i.e., from lower to the higher concentration. Such a transport is an energy dependent process, in which ATP is utilised and is called **active transport**, ***e.g.***, **Na^+/K^+ Pump**.

Bulk Transport :

(I) Endocytosis :

(a) Pinocytosis or Cell Drinking: Ingestion of liquid material by plasmalemma in the form of vesicles or bag like structure (Pinosome) is called pinocytosis.

(b) Phagocytosis or Cell eating: Ingestion of solid complex materials by membranes in the form of vesicles (Phagosome) is called Phagocytosis.

(II) Exocytosis/Emiocytosis/Cell Vomiting :

Egestion of waste materials from cell through plasma membrane.

(2) CELL WALL :

- A **non-living rigid structure**.
- It forms an outer covering for the plasma membrane of Bacteria, some Protistan, Fungi, Algae and Plants.
- **Algae** have cell wall, made of cellulose, galactans, mannans and minerals like calcium carbonate, while **in other plants** it consists of cellulose, hemicellulose, pectins and proteins.
- Cellulose is a main constituent of plant cell wall. Hemicellulose, Cutin, Pectin, Lignin, Suberin are also present in plant cell wall.

Primary Cell Wall :

- Cell wall of young plant cell
- Thin, elastic & capable of growth
- Composed of cellulose, hemicellulose & pectin
- Gradually diminishes as cell matures

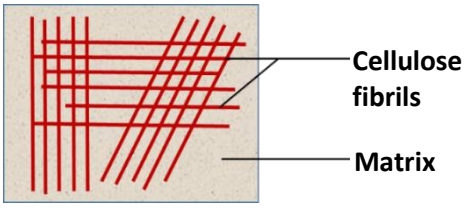


Fig : Primary Cell Wall

Secondary Cell Wall :

- Formed on the inner (towards membrane) side of cell
- Rigid, thick
- Composed of cellulose, hemi-cellulose, pectin, cutin, lignin & suberin
- Absent in meristem cells

Middle Lamella :

- The middle lamella is a layer mainly composed of calcium pectate which holds or glues the different neighbouring cells together.
- Common layer between two cells
- Composed of Ca & Mg pectates (Plant cement). Amount of Calcium is more.

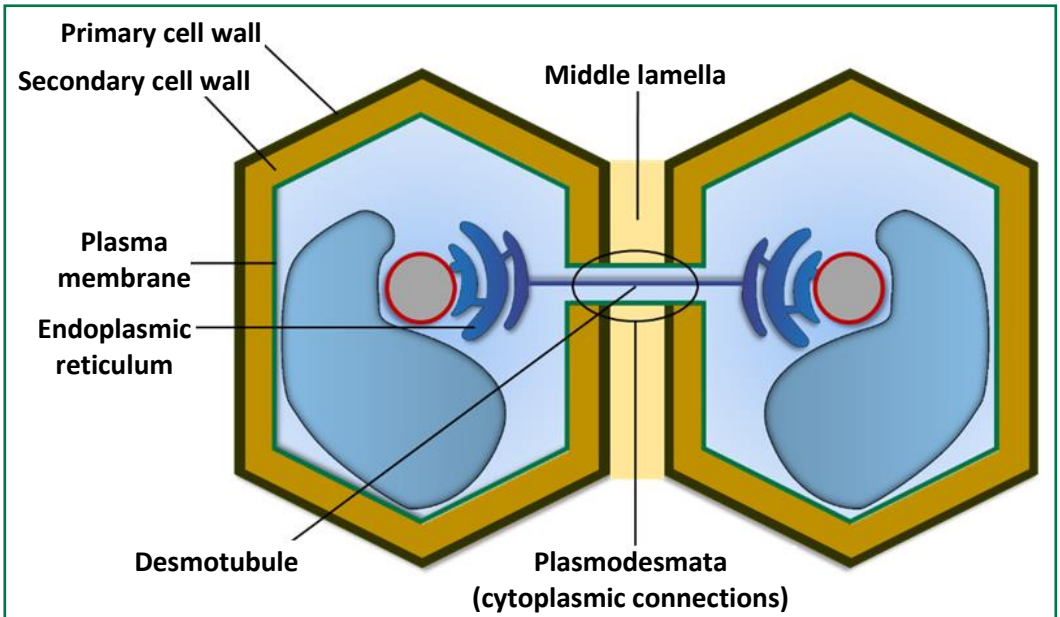


Fig : Cell Wall

Plasmodesmata :

- Name proposed by Strasburger (1901). These are cytoplasmic connections between two adjacent plant cells. Plasmodesmata are characteristic of multi-cellular plants.
- E.R. tubules (Desmotubules) help to maintain continuity of cytoplasm. The cell wall and middle lamella may be traversed by plasmodesmata which connect the cytoplasm of neighbouring cells.

Functions of Cell Wall :

- Cell wall gives **shape to the cell.**
- It **protects** the cell **from mechanical damage** and **infection.**
- It also helps in **cell-to-cell interaction.**
- It provides **barrier** to **undesirable macromolecules.**

BEGINNER'S BOX-1

INTRODUCTION, WHAT IS A CELL?, CELL THEORY, AN OVERVIEW OF CELL, PROKARYOTIC CELLS, EUKARYOTIC CELLS (CELL WALL, CELL MEMBRANE)

1. Proteins, present in plasma membrane are classified as integral and peripheral on the basis of:-
(1) Density and size (2) Ease of extraction from membrane
(3) Structure (4) Quantity
BCL217

2. Which of the following cell organelles is found in both eukaryotic as well as prokaryotic cells?
(1) Lysosome (2) Ribosome (3) Golgi complex (4) Mitochondria
BCL218

3. According to most widely accepted model of plasma membrane :-
(1) Liquid protein layer is surrounded by phospholipids
(2) Lipid are arranged in fluid layer of proteins
(3) Proteins are arranged in fluid layer of phospholipids
(4) Liquid phospholipid layer is surrounded by proteins
BCL219

4. Which of the following layers is found closest to the cytoplasm?
(1) Middle lamella (2) Primary wall (3) Cell membrane (4) Secondary wall
BCL220

5. Who first saw and described a living cell?
(1) Robert Hooke (2) Robert Brown
(3) Matthias Schleiden (4) Anton Von Leeuwenhoek
BCL221

6. Who first explained that new cells arise from pre-existing cells?
(1) Robert Brown (2) Schleiden (3) Schwann (4) Rudolf Virchow
BCL222

7. Main arena for cellular activities is: -
(1) Cytoplasm (2) Cell membrane (3) Nucleus (4) DNA
BCL223

8. Which of the following is the smallest cell?
(1) Nerve cell (2) WBC (3) Mycoplasma (4) Egg of Ostrich
BCL224

9. In prokaryotes, extensions differentiated form of cell membrane into the cell is called -
(1) Mesosome (2) Polysome (3) Ribosome (4) Cell wall
BCL225

10. Mesosome helps in -
(1) Cell wall formation (2) Respiration
(3) Secretion process (4) All of the above
BCL226

11. Prokaryotes have _____ type of ribosomes.
(1) 80s (2) 70s (3) 30s (4) 50s
BCL227

12. Which of the following is absent in almost all higher plants?
(1) Vacuole (2) Cell wall (3) Centrioles (4) Nucleus
BCL228

13. Human RBC membrane has _____ protein.
(1) 40% (2) 72% (3) 52% (4) 80%
BCL229

14. Passive transport includes :-
(1) Simple diffusion (2) Carrier mediated diffusion
(3) Tunnel mediated diffusion (4) All of these
BCL230

15. Transport of substances through lipid bi-layer is known as :-
(1) Simple diffusion (2) Carrier mediated diffusion
(3) Tunnel mediated diffusion (4) Active transport
BCL231

(3) ENDOMEMBRANE SYSTEM :

- While each of the membranous organelles is distinct in terms of its structure and function, many of these are considered together as an **endomembrane system** because their functions are coordinated.
- The endomembrane system includes Endoplasmic reticulum (ER), Golgi complex (GC), Lysosomes and Vacuoles because their functions are coordinated.
- Since the functions of the **mitochondria**, **chloroplast** and **peroxisomes** are not coordinated with the above components, these are **not considered as a part of the endomembrane system**.

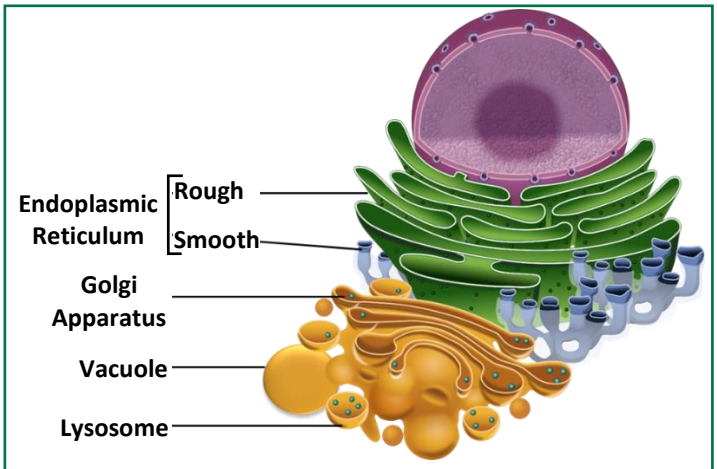


Fig : Endomembrane System

(A) ENDOPLASMIC RETICULUM (SYSTEM OF MEMBRANES) :

- Electron microscopic studies of eukaryotic cells reveal the presence of a network or reticulum of tiny tubular structures scattered in the cytoplasm is called the endoplasmic reticulum (ER).
- ER divide the **intracellular space** into two distinct compartments i.e. **Luminal** (inside ER) and **extra luminal** (cytoplasm) compartments.

Components of E.R. :

- **Cisternae -** long flattened and unbranched units arranged in stacks
- **Tubules** - irregular, often branched tubes bounded by membrane
- **Vesicles -** oval membrane bound structures
- The ER often shows ribosomes attached to their outer surface. The endoplasmic reticulum bearing ribosomes on their surface is called **rough endoplasmic reticulum (RER)**. In the absence of ribosomes, they appear smooth and are called **smooth endoplasmic reticulum (SER)**.

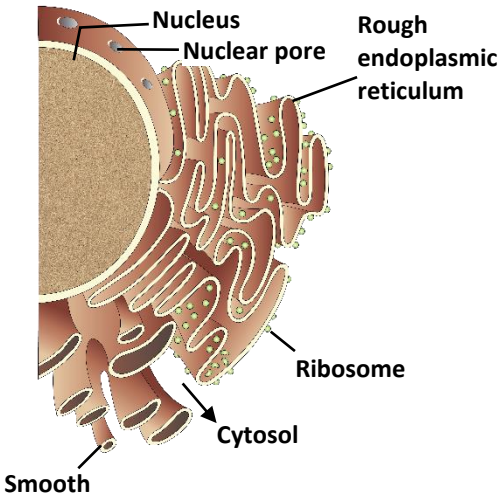


Fig : Endoplasmic reticulum

	Rough E.R. (Granular)	Smooth E.R. (Agranular)
Ribosomes	80S, ribosomes binds by their larger subunit, with the help of two glycoproteins (**Ribophorin I** and **II** on the surface of Rough E.R.)	Ribosomes and Ribophorins are absent
Components	Mainly cisternae	Mainly tubules
Occurrence	Abundantly occurs in cells which are actively engaged in protein synthesis and secretion	Abundantly occurs in cells concerned with glycogen and lipid metabolism

Functions of Endoplasmic Reticulum :

- **RER** is frequently observed in the cells actively involved in **protein synthesis and secretion**. They are extensive and continuous with the outer membrane of the nucleus.
- The **SER** is the **major site for synthesis of lipid**. In animal cells lipid-like **steroidal hormones** are synthesised in SER.
- **Mechanical support :** Microfilaments, Microtubules and E.R. forms endoskeleton of cell.
- **Intracellular exchange :-** E.R. forms intracellular conducting system. Transport of materials in cytoplasm from one place to another may occur through the E.R.
- At some places E.R. is also connected to plasma membrane, so E.R. can secrete the materials outside the cell.
- **Detoxification :** Smooth ER is concerned with detoxification of drugs, pollutants and steroids. Cytochrome P450 in E.R. act as enzyme which function in detoxification of drugs and other toxins.

(B) GOLGI APPARATUS :

- **Camillo Golgi** (1898) first observed densely stained reticular structure near the nucleus. These were later named Golgi bodies after him.
- The cytoplasm surrounding Golgi body have fewer or no other organelles. It is called Golgi ground substance or zone of exclusion.
- Golgi body is also known as **dictyosome** in plant cells.

(i) Structure :

Golgi complex is made up of three parts –

(a) Cisternae :– These are flat disc shaped sac like structures with diameter of 0.5 μm to 1.0 μm. Many cisternae are arranged in a stack parallel to each other.

- Dense opaque material inside cisternae is called Nodes.
- Varied number of cisternae are present in Golgi complex.
- The Golgi cisternae are concentrically arranged near the nucleus.
- Convex surface of cisternae which is towards the nucleus is called **cis- face or forming face.**
- Concave surface of cisternae which is towards the membrane is called **trans-face or maturing face**.
- The cis and trans faces of the organelle are entirely different but inter connected.

(b) Tubules :– These are branched and irregular tube like structures associated with cisternae.

(c) Vesicles :– Transition vesicle and Mature vesicle.

- Golgi body receive the materials from E.R. through it's cis face and these material are modified by Golgi body for **e.g.** Formation of glycolipid and glycoproteins **i.e.** glycosylation/glycosidation.

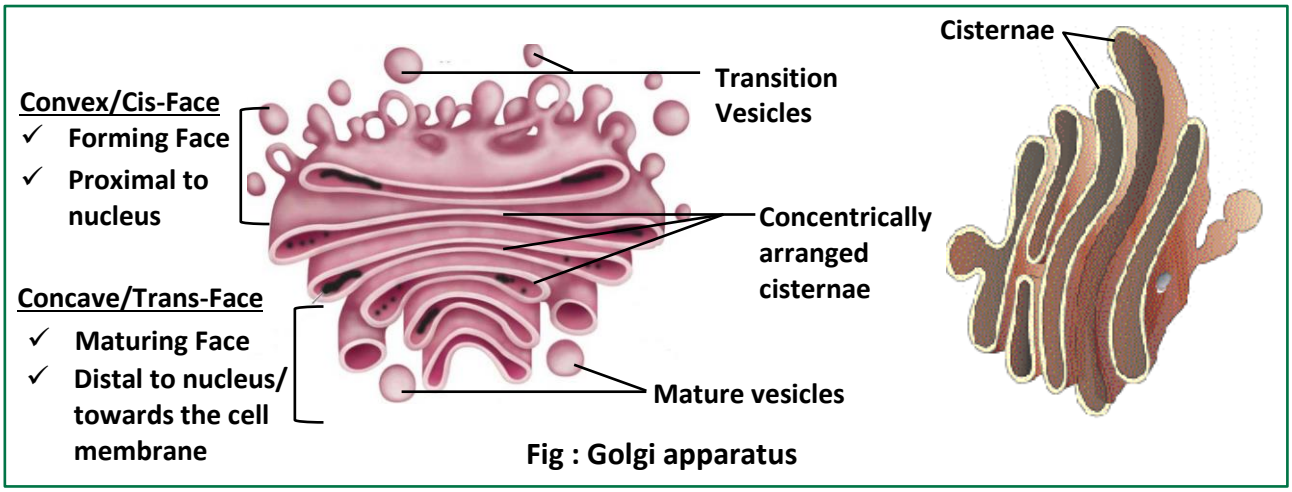


Fig : Golgi apparatus

(ii) Function of Golgi Complex :

- The Golgi apparatus principally performs the function of **packaging materials**, to be delivered either to the intra-cellular targets or secreted outside the cell. Materials to be packaged in the form of vesicles from the ER fuse with the cis face of the Golgi apparatus and move towards the maturing face. This explains, why the Golgi apparatus remains in close association with the endoplasmic reticulum.
- A number of proteins synthesised by ribosomes on the endoplasmic reticulum are modified in the cisternae of the Golgi apparatus before they are released from its trans face. Golgi apparatus is the important site of formation of **glycoproteins** and **glycolipids.**
- Most of the macromolecules which are to be sent outside the cell, move through the Golgi body. So Golgi body is termed as "**Director of macromolecular traffic in cell**" or middle men of cell.
  - Formation of Lysosome – It is collective function of Golgi body and E.R.
  - Synthesis of some cell wall materials.
  - Cell plate formation during cytokinesis.
  - Formation of acrosome on sperms.

NCERT Question :

Both lysosomes and vacuoles are endomembrane structures, yet they differ in terms of their functions. Comment.

(C) LYSOSOME :

- These are **membrane bound vesicular structures** formed by the process of packaging in the Golgi apparatus.
- The isolated lysosomal vesicles have been found to be very rich in almost all types of hydrolytic enzymes (hydrolases – lipases, proteases, carbohydrases and nucleases) **optimally active at the acidic pH** (pH=5).
- Membrane of lysosome has an **active H^+ pump mechanism** which produce acidic pH in lumen of lysosome
- Lysosomes are highly **polymorphic cell organelle**. Because lysosomes have **different physiological states**.

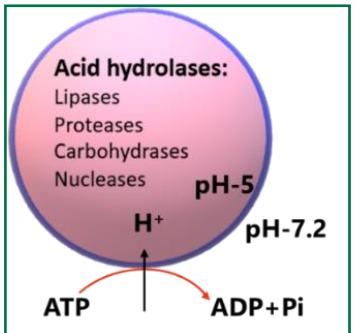


Fig : Lysosome

- These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.

Types of Lysosomes :

1. **Primary Lysosomes Or Storage Granules :** These lysosomes store enzyme Acid Hydrolases in the inactive form. These are newly formed lysosomes.
2. **Secondary Lysosomes :**
   - **(a) Digestive vacuoles or Heterophagosomes -** These lysosomes formed by the fusion of primary lysosomes and phagosomes. These are secondary Lysosomes.
   - **(b) Autophagic Lysosomes or Autophagosomes -** Lysosomes containing cell organelles to be digested are known as autophagosomes.
3. **Tertiary Lysosomes Or Residual Bodies :** Lysosomes containing undigested material are called residual bodies. These may be eliminated by exocytosis.

(D) VACUOLE :

- The vacuole is the membrane-bound space found in the cytoplasm. It contains water, sap, excretory product and other materials not useful for the cell.

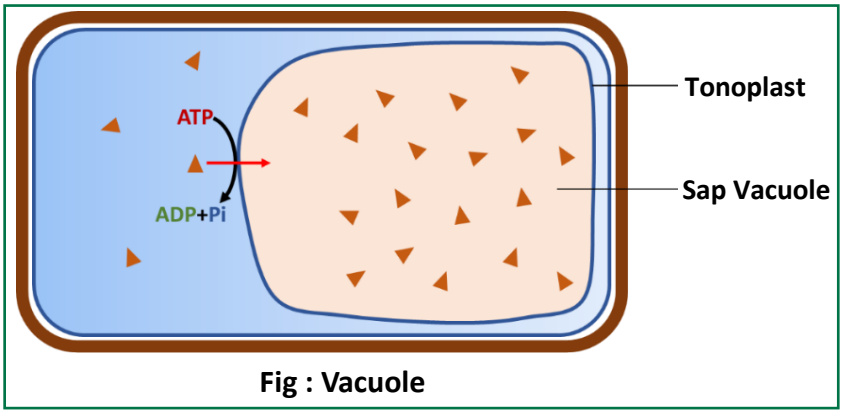


Fig : Vacuole

- In plant cells the vacuoles can occupy up to **90 per cent of the volume of the cell**.
  - The vacuole is bound by a single membrane called **tonoplast**.
  - The tonoplast facilitates the transport of a number of ions and other materials **against concentration gradients** into the vacuole, hence their concentration is significantly higher in the vacuole than in the cytoplasm.
- In Amoeba the contractile vacuole is important for excretion and osmoregulation. In many cells, as in protists, food vacuoles are formed by engulfing the food particles
- Water soluble pigment **anthocyanin** is found in cell sap/vacuole.
- In animal cell small vacuoles may be present.

BEGINNER'S BOX-2 EUKARYOTIC CELL (ENDOMEMBRANE SYSTEM)

1. Surface of Golgi cisternae towards nucleus is ..... face and towards plasma membrane is ..... face.
(1) trans, cis (2) maturing, forming (3) maturing, trans (4) cis, maturing
BCL232

2. The Golgi apparatus remains in close association with the endoplasmic reticulum, because –
(1) materials packaged by Golgi apparatus are transported to the ER
(2) materials to be packaged by Golgi body transported to the Golgi body from ER
(3) both Golgi apparatus and ER have cisternae
(4) both Golgi apparatus and ER possess ribosomes
BCL233

3. ER divides the intracellular space into two distinct compartments, luminal ..... and extra luminal ..... compartments.
(1) Cytoplasm, inside ER (2) Inside ER, cytoplasm
(3) Nucleus, cytoplasm (4) Inside ER, nucleus
BCL234

4. Which of the following combination is correct for the enzymes of lysosomes ?
(1) Oxidative, Active at acidic pH (2) Hydrolytic, Active at basic pH
(3) Synthetic, Active at neutral pH (4) Hydrolytic, Active at acidic pH
BCL235

5. Which of the following statements is not correct for the vacuoles ?
(1) Contractile vacuoles are helpful in excretion
(2) Tonoplast facilitates the transport of ions against the concentration gradient into the cytoplasm
(3) Food vacuoles are formed by engulfing the food particles
(4) Sap vacuole is bound by a single membrane
BCL236

6. RER has _____ ribosomes attached to it.
(1) 70s (2) 50s (3) 80s (4) 30s
BCL237

7. SER is involved in :-
(1) Protein synthesis (2) Lipid metabolism
(3) Glycogen metabolism (4) Both (2) and (3)
BCL238

8. Golgi complex was discovered by :-
(1) Robert Brown (2) Schleiden (3) Camillo Golgi (4) Schwann
BCL239

9. Golgi complex is important site for the formation of :-
(1) Glycoproteins (2) Glycolipids (3) Polysome (4) Both (1) and (2)
BCL240

10. Membrane bound vesicular structures formed by the process of packaging in the Golgi apparatus are :-
(1) Lysosomes (2) RER (3) SER (4) Ribosomes
BCL241

11. Which of the following contains water, sap, excretory product and other materials not useful for the cell?
(1) RER (2) Lysosome (3) SER (4) Vacuole
BCL242

12. Membrane of sap vacuole is called :-
(1) Chloroplast (2) Tonoplast (3) Cell wall (4) Cell membrane
BCL243

(4) MITOCHONDRIA (SING. : MITOCHONDRION) :

NCERT Question :
Name two cell-organelles that are double membrane bound. What are the characteristics of these two organelles? State their functions and draw labelled diagrams of both.

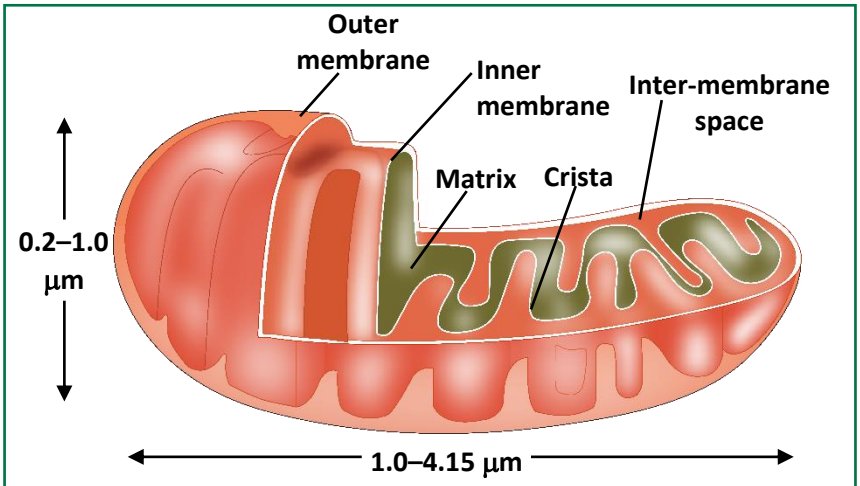


Fig : Mitochondria (Longitudinal section)

- **Power house of cell** or **ATP-mill in cell**. Most busy and active organelle in cell.
- Mitochondria unless specifically stained are not easily visible under the microscope. Mitochondria are stained by **"Janus green B"**.
- In terms of shape and size also, considerable degree of variability is observed. Typically, it is sausage-shaped or cylindrical having a diameter of 0.2-1.0µm (average 0.5µm) and length 1.0-4.1µm.
- Number of mitochondria is variable depending on the physiological activity of cells. Mitochondria are site of aerobic respiration and ATP production.

- Each mitochondrion is a **double membrane-bound structure** with the **outer membrane** and the **inner membrane** dividing its lumen distinctly into **two aqueous compartments**, i.e., the outer compartment and the inner compartment.
- The **inner compartment** filled with a dense **homogenous substance** is called the **matrix**.
- The **outer membrane** forms the continuous limiting boundary of the organelle.
- The two membranes have their **own specific enzymes** associated with the mitochondrial function.
- Inner membrane is folded into a number of fingers like projections called **cristae** (sing.: crista) towards the matrix. The cristae increase the surface area.
- In metabolically active mitochondria number of cristae is higher.

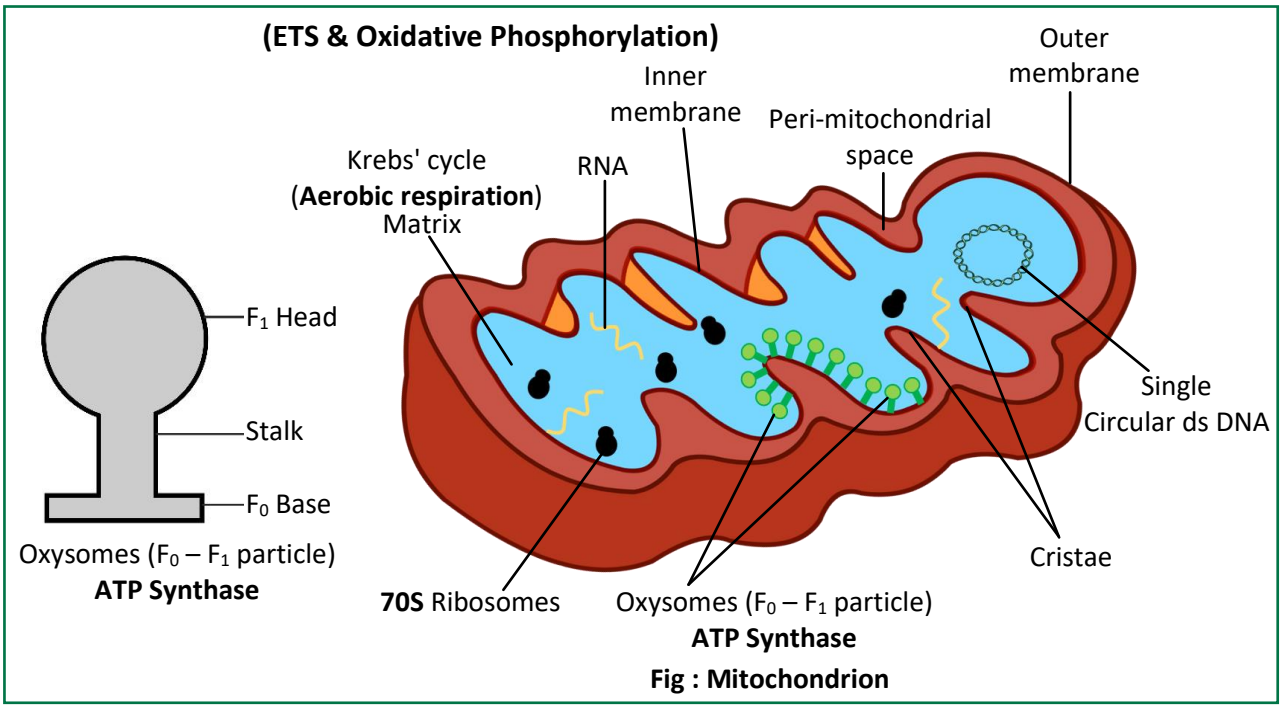


Fig : Mitochondrion

- Both membranes are separated by a space called **perimitochondrial** (Intermembrane) **space**.
- Many electron carrier like cytochromes are present in inner membrane of mitochondria, which forms Electron transport system (ETS).
- Inner membrane is studded with pin head particles called **oxysomes** or elementary particles or **F_0-F_1 particles** or **ATP Synthase**.
- Head of Oxysomes or F_1 is concerned with ***Oxidative phosphorylation*** (formation of ATP by energy of oxidation).
- Mitochondria are the sites of aerobic respiration. They produce cellular energy in the form of ATP, hence they are called 'power houses' of the cell.

- The **matrix** also possesses **double stranded single circular DNA molecule**, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins.
- Mitochondrial matrix have enzyme for Kreb's cycle (Aerobic respiration).
- **The mitochondria divide by fission.**
- Mitochondria is semiautonomous organelles of the cell.

Biogenesis of Mitochondria :

- New mitochondria arise from division of pre-existing mitochondria.
- Endosymbiotic origin from prokaryotic cells :-
  (i) Type of DNA (DNA sequences, double stranded, circular, G-C rich).
  (ii) Type of ribosome (70S).
  (iii) Divided by fission.

(5) PLASTIDS :

- Plastids are found in **all plant cells** and in **euglenoides**. These are easily observed under the microscope as they are large. They bear some specific pigments, thus imparting specific colours to the plants.
- Based on the **type of pigments** plastids can be classified into **chloroplasts, chromoplasts** and **leucoplasts**.

Types of Plastids :

(i) Leucoplasts :-

The leucoplasts are the **colourless plastids** of varied shapes and sizes with stored nutrients:

- **Amyloplasts** store carbohydrates **(starch)**, e.g., potato;
- **Elaioplasts** store **oils and fats,** e.g., castor seeds;
- **Aleuroplasts** store **proteins**.

(ii) Chromoplasts :- In chromoplasts **fat soluble carotenoid pigments** like **carotene, xanthophylls** and others are present. This gives yellow, orange or red colour to the part of the plant. Chlorophylls either absent or occur in very less amount.

Chromoplasts occurs mainly in **pericarp** and **petals**. Red colour of tomatoes is due to the red pigment **"Lycopene"** of chromoplasts.

(iii) Chloroplasts :- The chloroplasts contain **chlorophyll** and **carotenoid pigments** which are responsible for trapping light energy essential for photosynthesis.

Chloroplast :

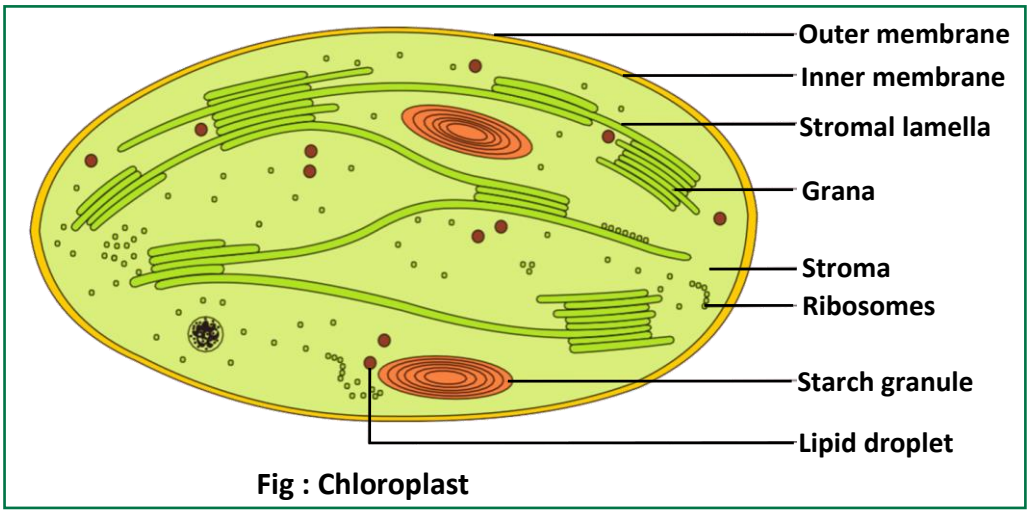


Fig : Chloroplast

- Majority of the chloroplasts of the green plants are found in the **mesophyll cells** of the leaves.
- Number varies from **1 per cell** of the ***Chlamydomonas*** (a green alga) to **20-40 per cell** in the **mesophyll**.
- These are lens-shaped, oval, spherical, discoid, or even ribbon-like organelles, having variable **length** (5–10 μm) and **width** (2–4 μm).
- Like mitochondria the chloroplast are also double membrane bound. Out of the two, the **inner membrane** is relative **less permeable**. **(Outer membrane contains porins)**
- The space limited by the inner membrane is called the **stroma**.
- In the stroma, a number of organized **flatted membranous sacs** are present called **thylakoids**. The membrane of the thylakoids enclose a space called **lumen**. Thylakoids are arranged in stacks like the piles of coins called **grana** (singular : **granum**) or the **intragranal thylakoids**. Each chloroplast contains about 40-60 grana.
- Stroma lamellae or Frets channel or Stroma thylakoids are flat membranous tubules connecting the thylakoids of the different grana.

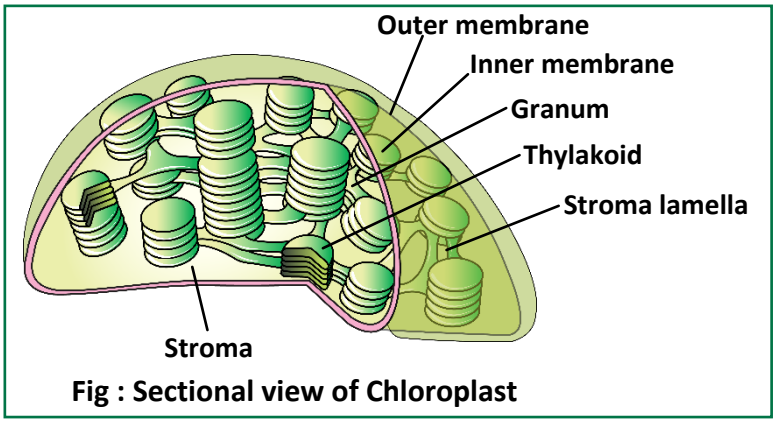


Fig : Sectional view of Chloroplast

- A photosynthetic functional unit (Located in thylakoid membrane) containing of about 250 to 400 molecules of various pigments (Chl-a, Chl-b, Carotenes, Xanthophyll etc.) is called as ***Quantasome***.

- The stroma of the chloroplast contains enzymes required for the synthesis of carbohydrate (i.e. enzymes of Calvin cycle or Dark reaction) and proteins.
- Stroma also contains small, **double stranded circular DNA molecules** and ribosomes. Chlorophyll pigments are present in the thylakoids.
- The ribosomes of the chloroplasts are smaller (70S) than the cytoplasmic ribosomes (80S).
- Chloroplasts are semiautonomous organelles of the cell.

Biogenesis of Chloroplast :

(1) From Proplastid

(2) From fission of pre-existing plastids.

ORIGIN : Endosymbiotic origin by a cyanobacterium.

BEGINNER'S BOX-3 EUKARYOTIC CELL (MITOCHONDRIA, PLASTIDS)

1. Cells which are metabolically more active, have –

(1) less number of mitochondria

(2) more number of mitochondria

(3) no relation between metabolic activities and number of mitochondria

(4) no mitochondria, to provide more space in cytoplasm for metabolic activities

BCL244

2. Mitochondria and Chloroplasts are similar in having –

(a) two membranes (b) Cristae (c) DNA (d) Ribosomes

(e) Thylakoids

(1) a, c and d (2) a, b and d (3) a and d (4) a, c, d and e

BCL245

3. Which of the following plastids store fat?

(1) Chromoplast (2) Elaioplast (3) Leucoplast (4) Amyloplast

BCL246

4. The ribosomes of the chloroplasts–

(1) are smaller than the cytoplasmic ribosomes

(2) are bigger than the cytoplasmic ribosomes

(3) are of similar size to that of cytoplasmic ribosomes

(4) may be bigger or smaller than the cytoplasmic ribosomes

BCL247

5. The inner membrane of mitochondria bears folding/finger like projections, these –

(1) increase surface area

(2) increase thickness of mitochondria

(3) keep all the substances away

(4) increase protein oxidation

BCL248

6. Space between the two mitochondrial membrane is -

(1) Matrix (2) Peri-mitochondrial space

(3) Lumen (4) Oxysomes

BCL249

7. Which of the following is found in mitochondrial matrix-

(1) DNA (2) Ribosomes (3) RNA (4) All of the above

BCL250

8. Yellow, orange or red colored pigments are stored in :-

(1) Chloroplast (2) Chromoplast (3) Tonoplast (4) Leucoplast

BCL251

9. Thylakoids are arranged in stacks like the piles of coins called :-

(1) Stroma (2) Matrix (3) Granum (4) Quantasome

BCL252

10. Membrane of the thylakoids enclose a space called :-

(1) Lumen (2) Stroma (3) Matrix (4) Cristae

BCL253

(6) RIBOSOMES (ENGINE OF CELL) :

- Ribosomes are the **granular structures** first observed under the electron microscope as dense particles by **George Palade** (1953).
- They are composed of ribonucleic acid (RNA) and proteins.
- They are **not surrounded by any membrane**.
- The eukaryotic ribosomes are 80S while the prokaryotic ribosomes are 70S. Here 'S' (Svedberg's unit) stands for the sedimentation coefficient; it is indirectly a measure of density and size.
- Each ribosome composed of **two subunits** i.e. **larger** and **smaller** subunits.
- The two subunits of **80S** ribosomes are 60S and 40S while that of **70S** ribosomes are 50S and 30S.

- Minimum 0.001 M Mg^{+2} concentration is required for structural formation of ribosomes.
- Several ribosomes may attach to a single mRNA and form a chain called **polyribosome** or **polysome** or **ergosome**.

Fig : Ribosome

(7) CYTOSKELETON :

- An elaborate network of **filamentous proteinaceous structures** present in the cytoplasm is collectively referred to as the cytoskeleton.
- It includes –

  (A) Microfilaments

  (B) Microtubules

  (C) Intermediate filaments

Property	Microtubules (Tubulin Polymers)	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes	Two intertwined strands of actin	Fibrous proteins coiled into cables
Diameter	25 nm with 15 nm lumen	7 nm	8-12 nm
Protein subunits	Tubulin, a dimer consisting of an α-tubulin and a β-tubulin	Actin	One of several different proteins (including keratins)
Main functions	Maintenance of cell shape, cell motility, chromosome movements in cell division, organelle movements	Maintenance of cell shape, changes in cell shape, muscle contraction, cytoplasmic streaming (plant cells), cell motility, cell division (animal cells)	Maintenance of cell shape, anchorage of nucleus and certain other organelles, formation of nucleus lamina

(8) CILIA & FLAGELLA :

- **Cilia** (sing.: cilium) and **flagella** (sing.: flagellum) are **hair-like outgrowths of the cell membrane**.
- **Cilia** are small structures which **work like oars**, causing the movement of either the cell or the surrounding fluid.
- **Flagella** are comparatively longer and responsible for cell movement.
- The prokaryotic bacteria also possess flagella but these are structurally different from that of the eukaryotic flagella.
- The electron microscopic study of a cilium or the flagellum show that they are covered with plasma membrane.
- Their **core** called the **axoneme**, possesses a number of microtubules running parallel to the long axis.
- The axoneme usually has pairs of nine doublets of radially arranged peripheral microtubules, and a pair of centrally located microtubules.
- Such an arrangement of axonemal microtubules is referred to as the **9+2 array**.
- The **central tubules** are connected by bridges and is also enclosed by a central sheath, which is connected to one of the tubules of each **peripheral doublets** by a **radial spoke**. Thus, there are nine radial spokes. The peripheral doublets are also interconnected by **linkers**.
- Both the cilium and flagellum emerge from **centriole-like structure** called the **basal bodies**.

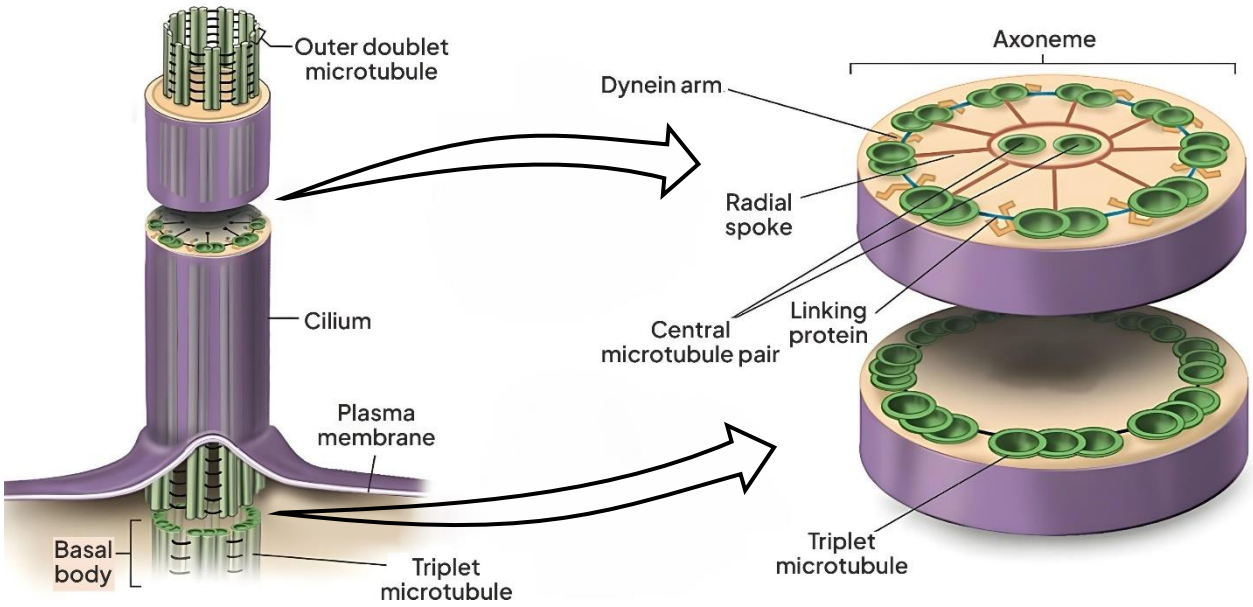


Fig : Transverse section of cilia and flagella

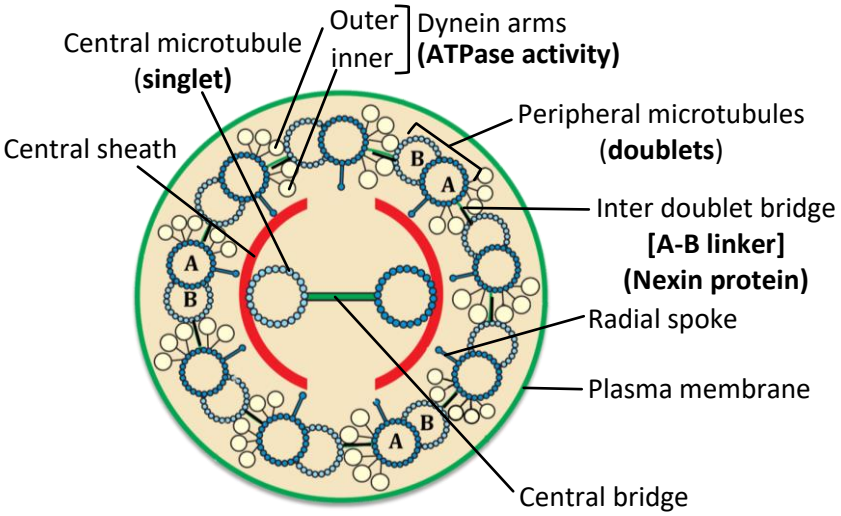


Fig : Internal structure of Cilia/Flagella

	CILIA	FLAGELLA
Size	small (5-10 µm)	long (up to 150 µm)
Number	more	less
Beating	pendulating (work like oars)	undulating (independent)
Function	locomotion, attachment, feeding and sensation	involved only in locomotion

(9) CENTROSOME & CENTRIOLES :

NCERT Question :

Describe the structure of the following with the help of labelled diagrams.

Centrosome

- **Centrosome** is an organelle usually containing two **cylindrical structures** called **centrioles**. They are surrounded by amorphous **pericentriolar materials**.
- Both the centrioles in a centrosome lie **perpendicular** to each other in which each has an organisation like the **cartwheel**.
- They are made up of **nine** evenly spaced peripheral fibrils of **tubulin protein**. Each of the peripheral fibril is a **triplet (9 + 0)**.
- The adjacent triplets are also linked.
- The central part of the **proximal region** of the centriole is also **proteinaceous** and called the **hub**, which is connected with tubules of the peripheral triplets by **radial spokes** made of protein.
- The centrioles form the basal body of cilia or flagella, and spindle fibres that give rise to spindle apparatus during cell division in animal cells.

- In **animal cells**, centrioles play important **role in cell division** by arranging spindle fibers between two poles of cell. The location of centrioles during cell division decides the plane of division. The plane of division is always at right angle to the spindle.

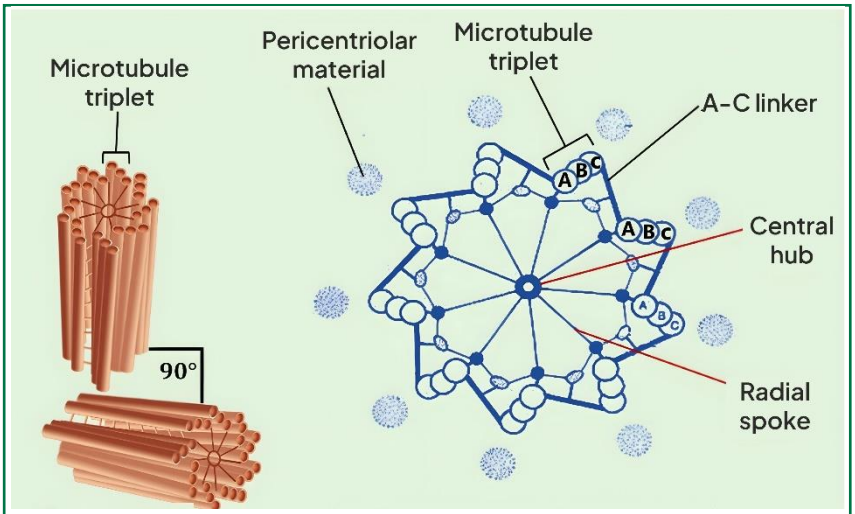


Fig : (A) Centrosome Fig : (B) Transverse section of centriole

(10) MICROBODIES :

- Many membrane bound minute vesicles called microbodies that contain various enzymes are present in both plant and animal cells.

(i) Peroxisomes or Uricosomes :

- These are found in both plant and animal cells. Peroxisomes contain catalase enzyme which is concerned with peroxide (H_2O_2) metabolism. Catalase degrade the H_2O_2 into water and oxygen.
- In plants, peroxisomes are found in cells of green tissues and concerned with photorespiration (glycolate pathway).
- Peroxisomes are also involved in β-oxidation of fatty acids.
- Peroxisome associated with chloroplast and mitochondria perform photorespiration or glycolate cycle.

(ii) Glyoxysomes :

- Glyoxysomes occurs only in plants especially in fatty seeds (castor seed, ground nut seed etc.).
- Glyoxysomes are considered as a highly specialised peroxisomes. Glyoxylate cycle takes place in glyoxysomes. This cycle convert fats into carbohydrates.
- In germinating seeds, fatty acids are degraded exclusively in the glyoxysome.

BEGINNER'S BOX-4 EUKARYOTIC CELL (RIBOSOME, CYTOSKELETON, CILIA, FLAGELLA, CENTROSOME AND CENTRIOLE, MICROBODIES)

1. Conversion of H_2O_2 into H_2O and O_2 occurs in ..... by the enzyme .....
(1) Glyoxysome, Catalase (2) Peroxisome, Urease
(3) Golgi body, Lipase (4) Uricosome, Catalase
BCL254

2. Which of the following cellular structure is found only in plant cells?
(1) Peroxisome (2) Glyoxysome (3) Mitochondria (4) Plasma membrane
BCL255

3. Which of the following arrangements of microtubules is correct for flagellum ?
(1) 9 peripheral singlets + 2 central doublets
(2) 9 peripheral triplets + 2 central singlets
(3) 9 peripheral doublets + 2 central singlets
(4) 9 peripheral doublets + 2 central triplets
BCL256

4. Cell organelle which exhibit cart wheel structure in transverse section, :-
(A) is helpful in cell division in almost all plant cells
(B) is not covered by any membrane
(C) is a self duplicating unit
(D) contain microtubules composed of Dynein protein
(1) A and C are incorrect (2) B and C are correct
(3) Only A is incorrect (4) Only B is correct
BCL257

5. The eukaryotic ribosomes are 80 S, while the prokaryotic ribosomes are 70 S. Here 'S' stands for ....., it indirectly is a measure of ..... :-
(1) Svedberg unit, number of r-RNA in ribosome
(2) Smooth surface, surface area of ribosome
(3) Shortest organelle, size
(4) Sedimentation coefficient, size and density
BCL258

6. Which organelle is not surrounded by any membrane?
(1) Mitochondria (2) Lysosome (3) Chloroplast (4) Ribosome
BCL259

7. Spindle fibres are formed by :-
(1) Microfilaments (2) Lysosome (3) Microtubules (4) Golgi complex
BCL260

8. ATPase activity is shown by :-
(1) A-B linker (2) Central hub (3) Radial spoke (4) Dynein arms
BCL261

9. Two centrioles in a centrosome lie at an angle of-
(1) 60° (2) 180° (3) 90° (4) 120°
BCL262

(11) NUCLEUS :

- Nucleus **as a cell organelle** was first described by **Robert Brown** as early as **1831.**
- Later the material of the nucleus stained by the **basic dyes (Acetocarmine)** was given the name **chromatin** by **Flemming**.
- *Nucleus is a double membrane bound dense protoplasmic body, which controls all cellular metabolism and encloses the genetic information of cell.*
- Generally eukaryotic cell contains at least one nucleus but nucleus is absents in mature phloem **sieve tube elements** and **erythrocytes (mature RBCs) of mammals**.
- **Dikaryotic** (*Paramoecium*) and **multikaryotic cells** (few Fungi) are also known.

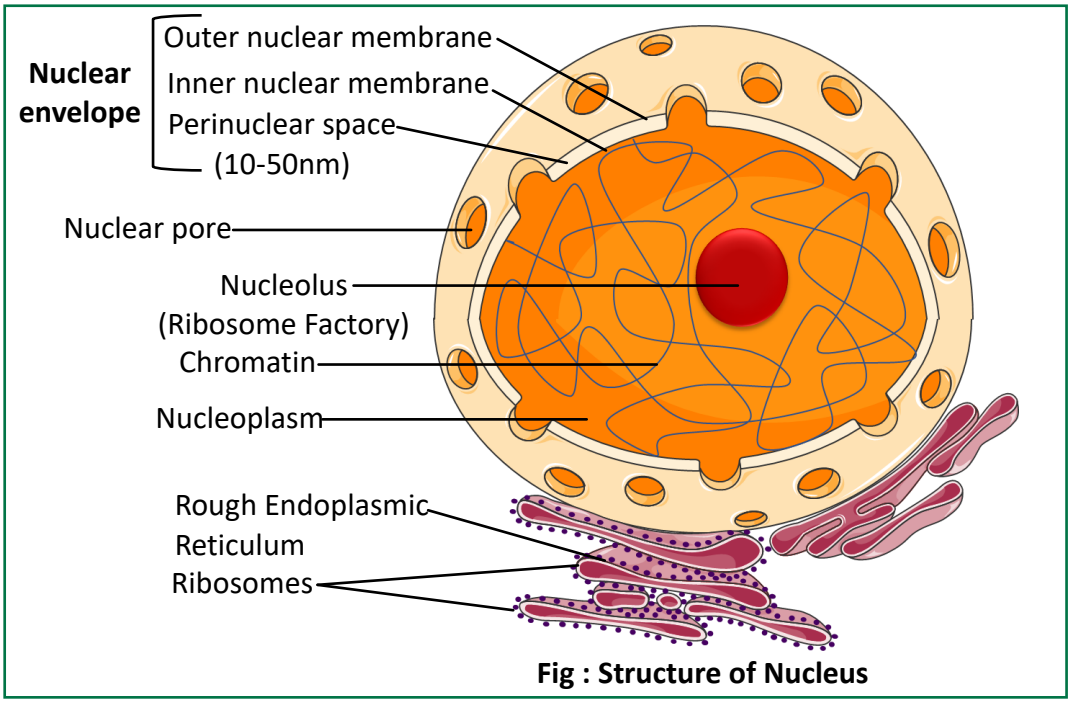


Fig : Structure of Nucleus

➢ The **interphase nucleus** (nucleus of a cell when it is not dividing) has highly extended and elaborate nucleoprotein fibres called **chromatin**, **nuclear matrix** and one or more spherical bodies called **nucleoli** (sing.: nucleolus).

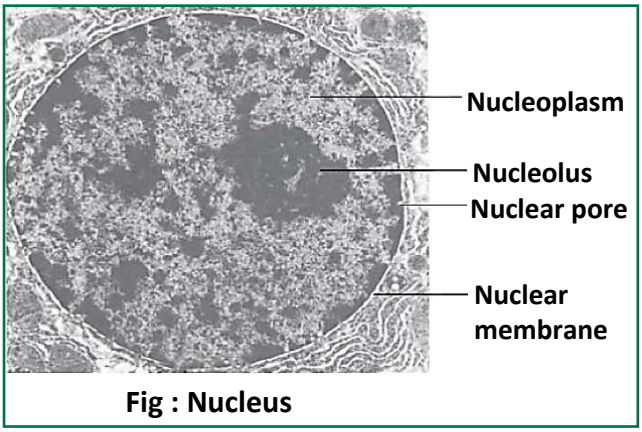


Fig : Nucleus

➢ Electron microscopy has revealed that the **nuclear envelope,** which consists of two parallel membranes with a space between (10 to 50 nm) called the "perinuclear space", **forms a barrier between the materials present inside the nucleus and that of the cytoplasm.**

- The outer membrane usually remains continuous with the endoplasmic reticulum and also bears ribosomes on it.

NCERT Question :
What are nuclear pores? State their function.

- At a number of places the nuclear envelope is interrupted by **minute pores**, which are formed by the fusion of its two membranes. These **nuclear pores** are the passages through which movement of RNA and protein molecules takes place in both directions between the nucleus and the cytoplasm.
- The **nuclear matrix** or the **nucleoplasm** contains nucleolus and chromatin.
- **Chromatin** fibers contain genetic information and condense to form chromosomes during cell division. Chromatin contains DNA, Histone proteins (basic protein), non-histone proteins and RNA.
- The **nucleoli** are spherical structures present in the nucleoplasm. The content of nucleolus is continuous with the rest of the nucleoplasm as it is not a membrane bound structure. It is a site for active ribosomal RNA (r-RNA) synthesis hence also known as "ribosome factory".
- **Larger and more numerous nucleoli** are present in cells **actively carrying out protein synthesis.**
- Nucleolus is usually attached to chromatin (or chromosomes) at specific site called **Nucleolar organizer region (NOR)**.

(12) CHROMOSOME :

- **Interphase nucleus** has a loose and indistinct **network of nucleoprotein fibres** called **chromatin**.
- But **during different stages of cell division**, cells show structured chromosomes, **in place of the nucleus.** Thus, chromosome is highly condensed form of the chromatin
- Chromatin contains DNA and some **basic proteins** called **histones**, some **non-histone proteins** and also **RNA**.
- Chromosomes can be best studied at metaphase stage because size of chromosomes is the shortest during metaphase (*Shape of chromosome is studied at Anaphase stage*)

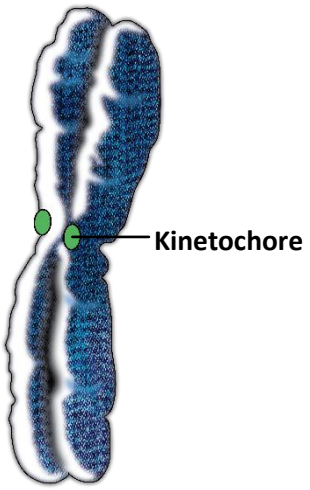
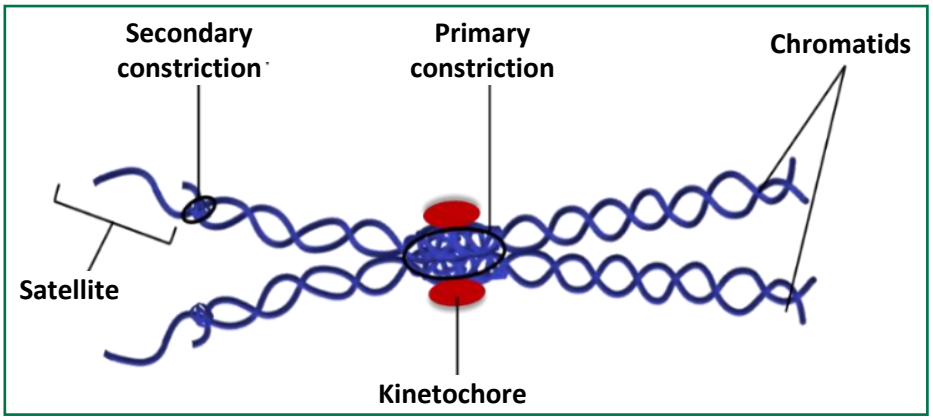


Fig : Chromosome

- The number of chromosomes in a gamete is called "Genome" or “A complete set (**n**) of chromosomes” inherited as a unit from one parent is known as genome.
- A **single human cell** has approximately **two-meter-long** thread of **DNA** distributed among its 46 (**23 pairs**) chromosomes.
- Every chromosome (visible only in dividing cells) essentially has a **primary constriction** or the **centromere** on the sides of which disc shaped structures called **kinetochores** are present.
- Centromere holds two chromatids of a chromosome.
- Sometimes a few chromosomes have **non-staining** secondary constrictions at a constant location. This gives the appearance of a small fragment called the **satellite**.
- SAT chromosomes have a secondary constriction and the part of chromosome beyond that is known as satellite.



- **Secondary constriction** is non-staining and found at a constant location. It is also known as **NOR** (Nucleolar organizer region) **[13,14,15,21,22 chromosomes in human]**
- Based on the position of the centromere, the chromosomes can be classified into four types.
  - The **metacentric** chromosome (V shaped) has middle centromere forming two equal arms of the chromosome.
  - The **sub-metacentric** chromosome (L shaped) has centromere nearer to one end of the chromosome resulting into one shorter arm and one longer arm.
  - In case of **acrocentric** chromosome (J shaped) the centromere is situated close to its end forming one extremely short and one very long arm.
  - The **telocentric** chromosome (I shaped) has a terminal centromere.

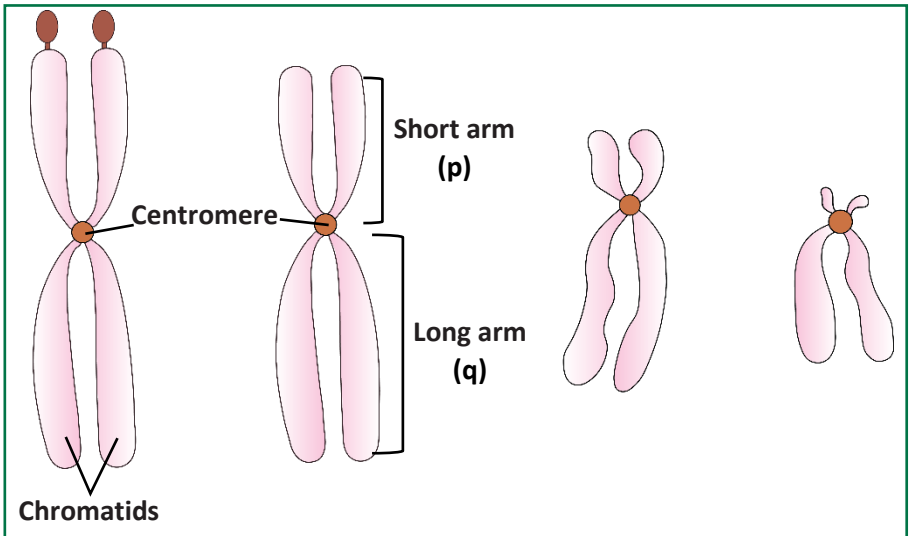


Fig : Types of chromosome based on the position of centromere

NCERT Question :

What is a centromere? How does the position of centromere form the basis of classification of chromosomes. Support your answer with a diagram showing the position of centromere on different types of chromosomes.

NCERT Question :

Describe the structure of the following with the help of labelled diagrams.

Nucleus

NOTE : Chromatin net has two type of chromatins :-

(i) Euchromatin : This is lightly stained and diffused part of chromatin. Which is transcriptionally or **genetically more active.**

(ii) Heterochromatin : This is dark stained, thick and condensed part of chromatin. Heterochromatin is **genetically less active or inactive chromatin.**

Telomere : Chromosomes have polarity and polar ends of chromosomes are known as Telomeres.

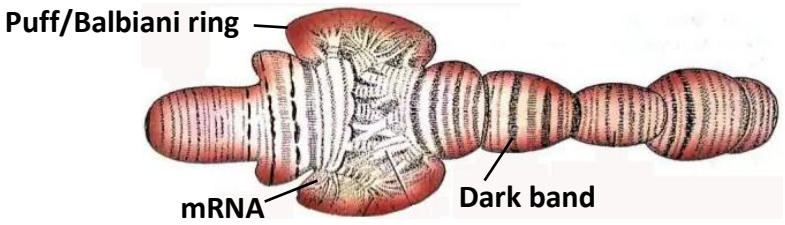
- Telomere prevents fusion or sticking of one chromosome to other chromosome. Telomeres are rich in **Guanine base.** (5' -TTAGGG-3')
- **Enzyme Telomerase** which is a **Ribonucleoprotein** synthesize telomere part of chromosome.

Telomeres of chromosomes become shorter during ageing process.

★ Golden Key Points ★

Special Type of Chromosomes :

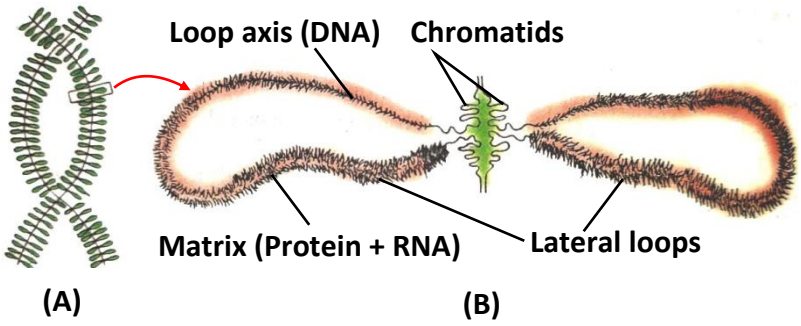
(i) Salivary gland chromosome : This type of chromosome was discovered by E.G. Balbiani, in Chironomus larva.



- This chromosome is called **Polytene chromosome**, because number of chromatids are very high.
- Swollen areas present at some places in polytene chromosome, which are called as **Balbiani rings** or **puffs**. These puffs helps in synthesis of RNA and proteins.
- Salivary gland chromosome concerns with **metamorphosis** and **moulting** process of insect larva.

(ii) Lamp brush chromosome : Discovered by **Flemming and Ruckert** from oocytes of vertebrates (Amphibia) during diplotene stage of cell division. These chromosomes look like lamp - brush, thus called as **lamp brush chromosomes**.

- Axis of lamp-brush chromosome is consist of DNA, while matrix is consist of RNA & proteins.
- Lamp brush chromosome is concerned with **"Vitellogenesis"** (Yolk formation)



BEGINNER'S BOX-5 EUKARYOTIC CELL (NUCLEUS, CHROMOSOME)

1. The nucleus is separated from surrounding cytoplasm by a nuclear envelope, which is :-
(1) Double layered without pores (2) Single layered with pores
(3) Double layered with pores (4) Single layered without pores
BCL263

2. The interphase nucleus (nucleus of cell when it is not dividing) has highly extended and elaborate nucleoprotein fibres called :-
(1) Chromatin (2) Nuclear matrix (3) Chromosomes (4) Nucleoli
BCL264

3. Nucleolus is the site for :-
(1) Protein synthesis (2) Ribosomal RNA synthesis
(3) Messenger RNA synthesis (4) Chromatin synthesis
BCL265

4. Which of the following cells lack the structure discovered by Robert Brown in orchid plants?
(1) Erythrocyte of mammals (2) Sieve tube cells
(3) Both (1) and (2) (4) Liquid endosperm of coconut
BCL266

5. Match the following :-

Chromosome	**Position of centromere**
(A) Metacentric	(a) At the tip
(B) Acrocentric	(b) Slightly away from the middle
(C) Telocentric	(c) At the middle
(D) Submetacentric	(d) Almost near the tip

Choose the correct match :-
(1) A – a, B – b, C – c, D – d (2) A – c, B – d, C – a, D – b
(3) A – d, B – c, C – b, D – a (4) A – b, B – a, C – d, D – c
BCL267

6. The term chromatin was given by -
(1) Schwann (2) Camillo Golgi (3) Flemming (4) Robert Brown
BCL268

7. Nuclear envelope includes -
(1) Outer nuclear membrane (2) Perinuclear space
(3) Inner nuclear membrane (4) All of the above
BCL269

8. Chromatin is composed of -
(1) DNA (2) RNA (3) Proteins (4) All of the above
BCL270

9. Chromosome is highly condensed form of :-

(1) Chlorophyll (2) Chromatin (3) r-RNA (4) Microtubules

BCL271

10. Which of the following is correct for secondary constriction?

(1) Non-staining (2) Found at constant location

(3) NOR (4) All of the above

BCL272

11. Microbodies are found in :-

(1) Plants (2) Animals (3) Both (1) and (2) (4) Viruses

BCL273

BEGINNER'S BOX ANSWERS KEY

BEGINNER'S BOX-1	**Que.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Ans.	**2**	**2**	**3**	**3**	**4**	**4**	**1**	**3**	**1**	**4**
	Que.	**11**	**12**	**13**	**14**	**15**					
	Ans.	**2**	**3**	**3**	**4**	**1**					

BEGINNER'S BOX-2	**Que.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Ans.	**4**	**2**	**2**	**4**	**2**	**3**	**4**	**3**	**4**	**1**
	Que.	**11**	**12**								
	Ans.	**4**	**2**								

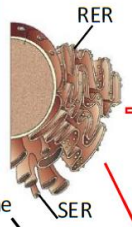
BEGINNER'S BOX-3	**Que.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Ans.	**2**	**1**	**2**	**1**	**1**	**2**	**4**	**2**	**3**	**1**

BEGINNER'S BOX-4	**Que.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	Ans.	**4**	**2**	**3**	**2**	**4**	**4**	**3**	**4**	**3**

BEGINNER'S BOX-5	**Que.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Ans.	**3**	**1**	**2**	**3**	**2**	**3**	**4**	**4**	**2**	**4**
	Que.	**11**									
	Ans.	**3**									

These are membrane bound vesicular structures formed by the process of packaging in the Golgi apparatus. The isolated lysosomal vesicles have been found to be very rich in almost all types of hydrolytic enzymes (hydrolases-lipases, proteases, carbohydrases) optimally active at the acidic pH. These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.

Lysosome



- SER - major site for synthesis of lipid.
- In animal cells steroidal hormones are synthesized in SER.
- RER - involved in protein synthesis and secretion.
- ER divides the intracellular space into two distinct compartments i.e. luminal (inside ER) and extra luminal (Cytoplasm) compartments)

Smooth endoplasmic reticulum

Rough endoplasmic reticulum

- First described by Robert Brown as early as 1831.
- Material of the nucleus - chromatin (termed by Flemming) stained by the basic dyes.
- Nucleus can be seen during interphase but during different stages of cell division cell show chromosomes in place of the nucleus.
- Perinuclear space -10 to 50 nm.
- Nucleolus is Membraneless structure and it is a site for r-RNA synthesis.

- First observed under the electron microscope by George Palade (1953) so ribosome is also called 'Palade Particle'.
- Composed of Ribonucleic Acid (RNA) and proteins.
- Membrane less (not surrounded by membrane)
- Organelle within organelle
- 'S' (Svedberg's Unit) stands for the sedimentation coefficient, it indirectly is a measure of density and size.

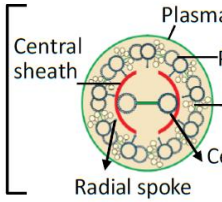
Ribosome

Plasmodesmata

Cisternae

- Important site of formation of glyoproteins and glycolipids.
- Principal function-Packaging materials.

T.S. of Cilia or Flagella (Made up Of microtubuies)



Nucleus

Nucleolus

Golgi apparatus

Nuclear envelope

Plasma membrane

- Bound by a single membrane called tonoplast.
- Tonoplast facilitates a number of ions against concentration gradient into the vacuole so their concentration is higher in the vacuole than in the cytoplasm.

•Contains water, excretory product and other materials not useful for the cell.
• Can occupy upto 90 percent of the volume of the cell.

Vacuole

Tonoplast
Cell sap
Central vacuole

Middle lamella

Microtubule

- Composed of two type of monomers-α-tubulin & β-tubulin protein.
- Size-25 nm

Microfilaments
- Composed of single type of monomers-Actin protein.
- Size-6 to 7 nm

Peroxisome

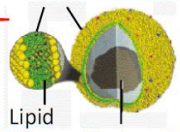
Cytoplasm

Mitochondrion

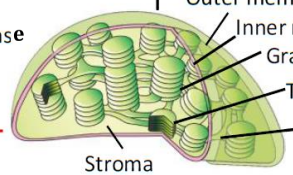
- Diameter 0.2 to 1.0 and length 1.0 to 4.1 μm,
- Number, shape & size of mitochondria is variable.
- Number of mitochondria depends on the physiological activity of the cell.
- Cristae increase the surface area of inner membrane so that more enzymes regarding respiration & ATP formation can be placed.
- Matrix possess circular DNA molecule, few RNA molecules, 70 s ribosomes and the components required for the synthesis of proteins.

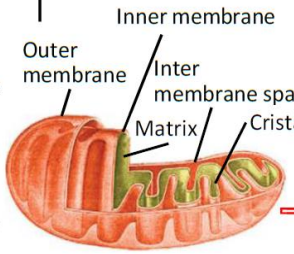
- Found in both plant and animal cells. Involved in photorespiration/Glycolate cycle in plants alongwith chloroplast and mitochondria.
- Breakdown of H_2O_2 by catalase enzyme.

Plasma membrane



Chloroplast





- Length - 5 to 10 μm, width - 2 to 4 μm
- Double membrane bound, inner membrane relatively less permeable.
- Contains enzyme require for the synthesis of carbohydrates and proteins.

NCERT SUMMARY

All organisms are made of cells or aggregates of cells. Cells vary in their shape, size and activities/ functions. Based on the presence or absence of a membrane bound nucleus and other organelles, cells and hence organisms can be named as eukaryotic or prokaryotic.

A typical eukaryotic cell consists of a cell membrane, nucleus and cytoplasm. Plant cells have a cell wall outside the cell membrane. The plasma membrane is selectively permeable and facilitates transport of several molecules. The endomembrane system includes ER, golgi complex, lysosomes and vacuoles. All the cell organelles perform different but specific functions. Centrosome and centriole form the basal body of cilia and flagella that facilitate locomotion. In animal cells, centrioles also form spindle apparatus during cell division. Nucleus contains nucleoli and chromatin network. It not only controls the activities of organelles but also plays a major role in heredity.

Endoplasmic reticulum contains tubules or cisternae. They are of two types: rough and smooth. ER helps in the transport of substances, synthesis of proteins, lipoproteins and glycogen. The golgi body is a membranous organelle composed of flattened sacs. The secretions of cells are packed in them and transported from the cell. Lysosomes are single membrane structures containing enzymes for digestion of all types of macromolecules. Ribosomes are involved in protein synthesis. These occur freely in the cytoplasm or are associated with ER. Mitochondria help in oxidative phosphorylation and generation of adenosine triphosphate. They are bound by double membrane; the outer membrane is smooth and inner one folds into several cristae. Plastids are pigment containing organelles found in plant cells only. In plant cells, chloroplasts are responsible for trapping light energy essential for photosynthesis. The grana, in the plastid, is the site of light reactions and the stroma of dark reactions. The green coloured plastids are chloroplasts, which contain chlorophyll, whereas the other coloured plastids are chromoplasts, which may contain pigments like carotene and xanthophyll. The nucleus is enclosed by nuclear envelope, a double membrane structure with nuclear pores. The inner membrane encloses the nucleoplasm and the chromatin material. Thus, cell is the structural and functional unit of life.