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# CELL: THE UNIT OF LIFE

## WHAT IS A CELL?

**cell is the fundamental structural and functional unit of all living organisms.**

**All organisms are composed of cells. Some are composed of a single cell and are called unicellular organisms while others, like us, composed of many cells, are called multicellular organisms.**

## Unicellular organisms

**1. The cell is large and has various organelles performing all vital functions.**

**2. A single cell performs all functions necessary for life and is an independent unit.**

**3. The cell may not exhibit elaborate activities and response to stimuli is very limited.**

**Examples: Amoeba, Paramecium, Chlamydomonas, bacteria, yeast etc.**



## Multicellular organisms

**1. The cells of a multicellular organism are comparatively smaller.**

**2. The cells are differentiated to do specific functions.**

**3. The cells show division of labour and number of cells work together in a coordinated manner in a very efficient way.**

## 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.**

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'.

On the basis of this, 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.

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.



## AN OVERVIEW OF CELL

### Plant Cell

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.

### Human Cheek Cell

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.

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 and vacuoles. The prokaryotic cells lack such membrane bound organelles.

Within the cell, ribosomes are found not only in the cytoplasm but also within the two organelles – chloroplasts (in plants) and mitochondria and on rough ER. Animal cells contain another non-membrane bound organelle called centrosome which helps in cell division.

## PROKARYOTIC CELLS

All prokaryotes have a cell wall surrounding the cell membrane except in mycoplasma.

The fluid matrix filling the cell is the cytoplasm. There is no well-defined nucleus.

The genetic material is basically naked, not enveloped by a nuclear membrane.

The genomic smaller DNA are called plasmids.

The plasmid DNA confers certain unique phenotypic characters to such bacteria. One such character is resistance to antibiotics.



### Cell Envelope and its Modifications

The cell envelope consists of a tightly bound three layered structures i.e., the outermost glycocalyx followed by the cell wall and then the plasma membrane.

Bacteria can be classified into two groups on the basis of the differences in the cell envelopes and the manner in which .those that take up the gram stain are Gram positive and the others that do not are called Gram negative bacteria.

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 similar structurally to that of the eukaryotes.

A special membranous structure is the mesosome 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.

Bacterial cells may be motile or non-motile. If motile, they have thin filamentous extensions from their cell wall called 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.



## Ribosomes and Inclusion Bodies

Ribosomes are the site of protein synthesis. Several ribosomes may attach to a single mRNA and form a chain called polyribosomes or polysome.

The ribosomes of a polysome translate the mRNA into proteins. Inclusion bodies:

Reserve material in prokaryotic cells are stored in the cytoplasm in the form of inclusion bodies.

These are not bound by any membrane system and lie free in the cytoplasm, e.g., phosphate granules, cyanophycean granules and glycogen granules.

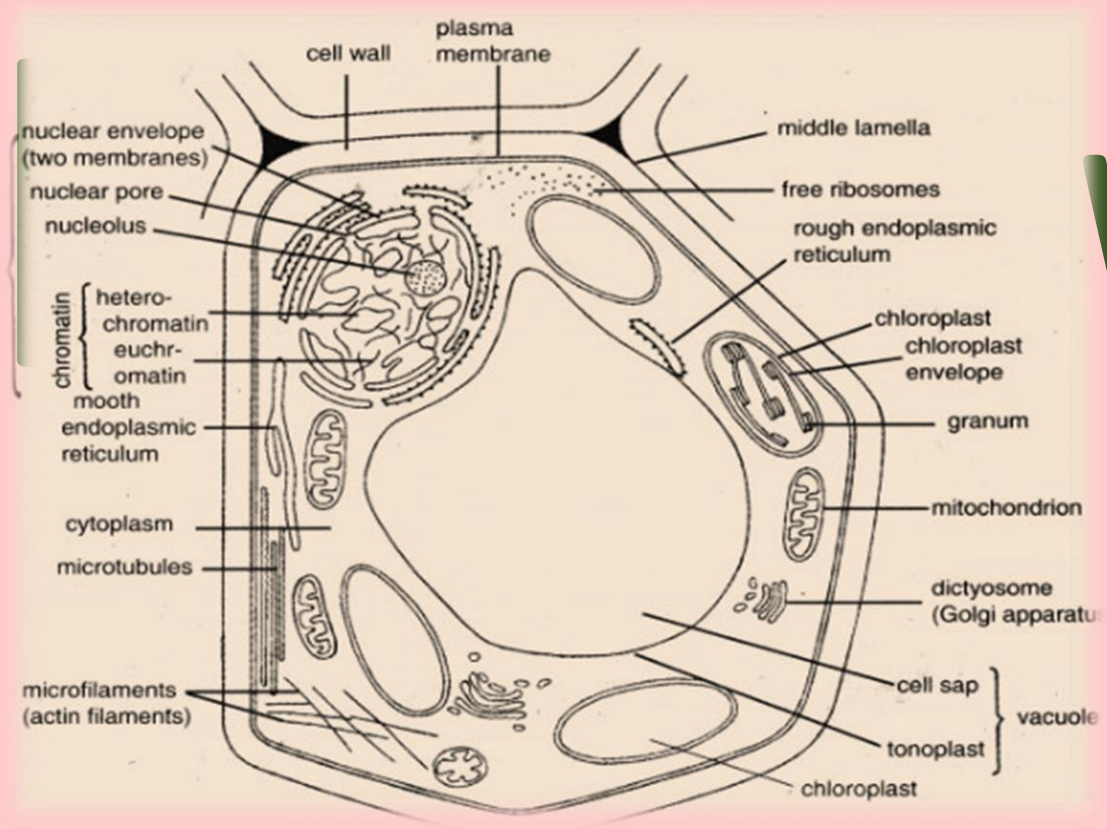
# EUKARYOTIC CELLS

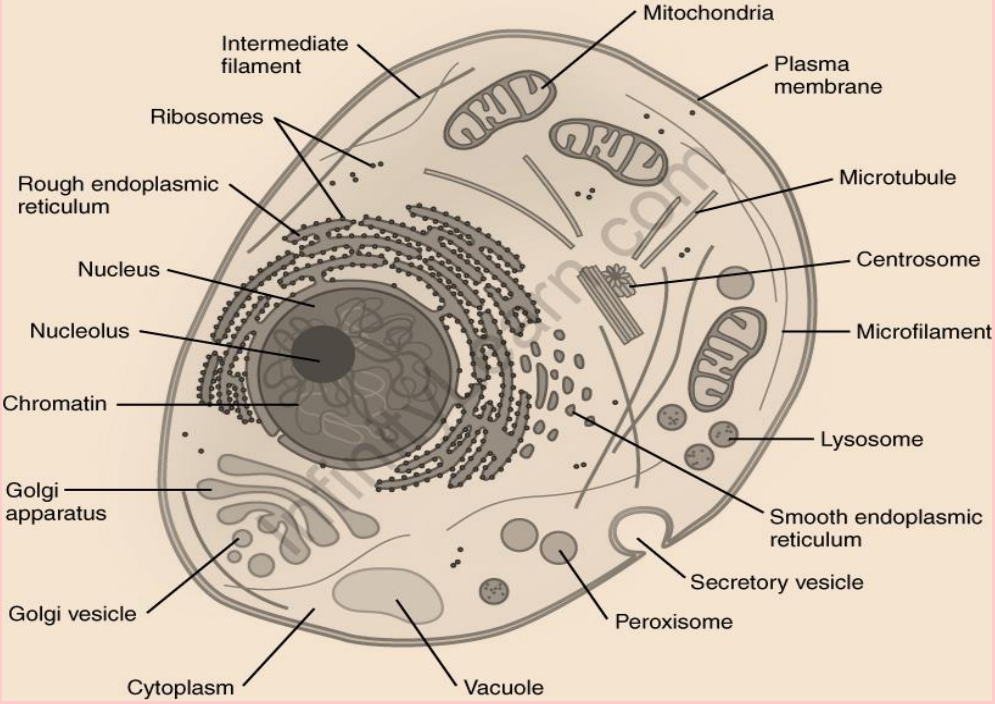
**Eukaryotic cells possess an organised nucleus with a nuclear envelope.**

**eukaryotic cells have a variety of complex locomotory and cytoskeletal structures. Their genetic material is organised into chromosomes.**

**Plant and animal cells are different as the former possess cell walls, plastids and a large central vacuole which are absent in animal cells.**

**On the other hand, animal cells have centrioles which are absent in almost all plant cells**








## Cell Membrane

**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.**

**It also possess protein and carbohydrate. The ratio of protein and lipid varies considerably in different cell types**

**An improved model of the structure of cell membrane was proposed by Singer and Nicolson (1972) widely accepted as fluid mosaic model . According to this, the quasi-fluid nature of lipid enables lateral movement of proteins within the overall bilayer.**

**This ability to move within the membrane is measured as its fluidity. The fluid nature of the membrane is also important from the point of view of functions like cell growth, formation of intercellular junctions, secretion, endocytosis, cell division etc.**

## Passive transport

**The plasma 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.**

**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.**

## Active transport

**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. 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.**



## Cell Wall

**Cell wall not only gives shape to the cell and protects the cell from mechanical damage and infection, it also helps in cell-to-cell interaction and provides barrier to undesirable macromolecules.**

**The cell wall of a young plant cell, the primary wall is capable of growth, which gradually diminishes as the cell matures and the secondary wall is formed on the inner (towards membrane) side of the cell.**

**The middle lamella is a layer mainly of calcium pectate which holds or glues the different neighbouring cells together. The cell wall and middle lamellae may be traversed by plasmodesmata which connect the cytoplasm of neighbouring cells**

# Endomembrane System

**The endomembrane system include endoplasmic reticulum (ER), golgi complex, lysosomes and vacuoles.**

## The Endoplasmic Reticulum (ER)

**ER divides the intracellular space into two distinct compartments, i.e., luminal (inside ER) and extra luminal (cytoplasm) compartments.**

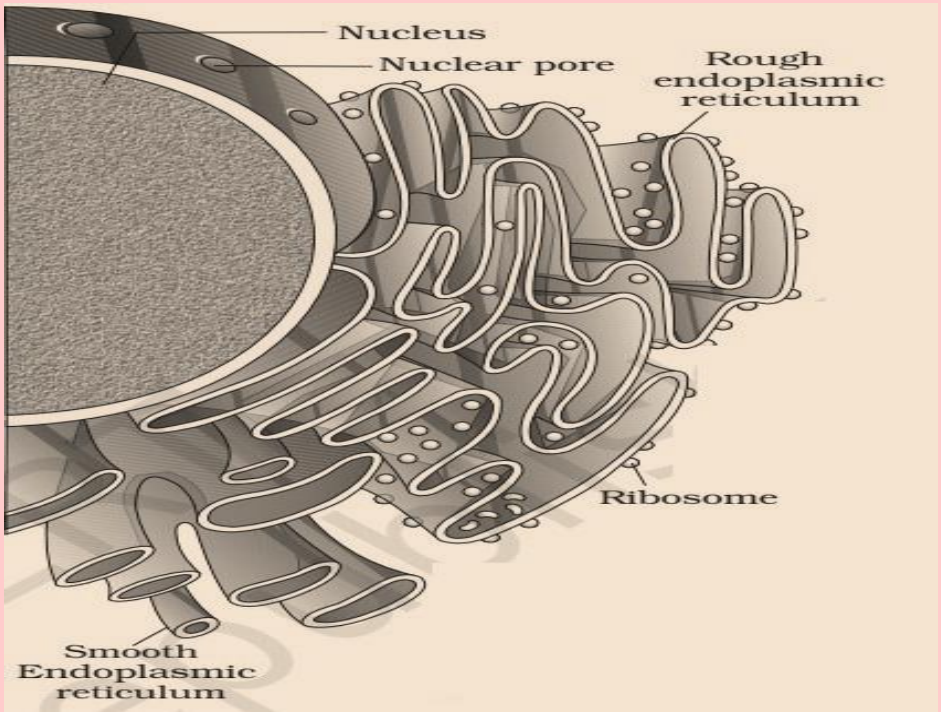
**The ER often shows ribosomes attached to their outer surface.**

**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).**

**They are extensive and continuous with the outer membrane of the nucleus. The smooth endoplasmic reticulum is the major site for synthesis of lipid. In animal cells lipid-like steroidal hormones are synthesised in SER.**



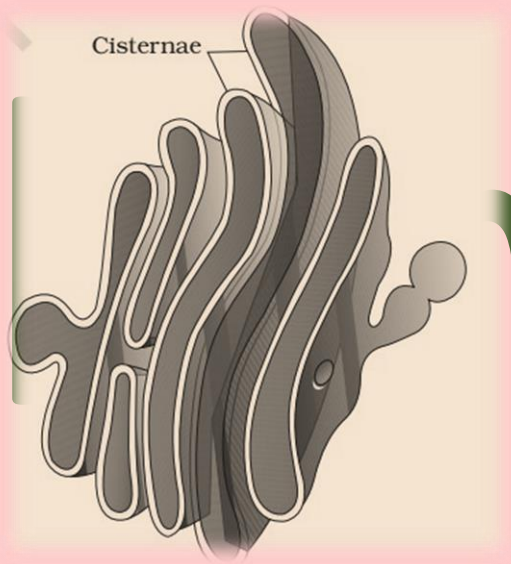


## Golgi apparatus

**The Golgi cisternae are concentrically arranged near the nucleus with distinct convex cis or the forming face and concave trans or the maturing face. The cis and the trans faces of the organelle are entirely different, but interconnected.**

**The Golgi apparatus 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.**




**Golgi apparatus is the important site of formation of glycoproteins and glycolipids.**

## Lysosomes

**They are bound by a single membrane and measure about 500 nm. They are involved in intracellular digestion and contain many digestive enzymes known as acid hydrolases. They are capable of hydrolysing all classes of macromolecules.**

## Vacuoles

**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. The vacuole is bound by a single membrane called tonoplast.**

**In plants, 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.**

## Mitochondria

**Each mitochondrion is a double membrane-bound structure with the outer membrane and the inner membrane dividing its lumen distinctly into two aqueous compartments.**



**The inner compartment is filled with a dense homogeneous substance called the matrix.**

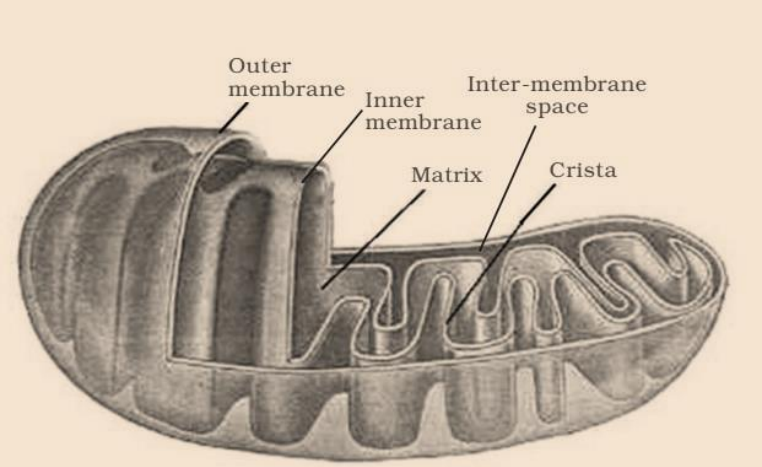
**The outer membrane forms the continuous limiting boundary of the organelle.**

**The inner membrane forms a number of infoldings called the cristae towards the matrix .**

**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 single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins.**

**The mitochondria divide by fission.**




## Plastids

**Plastids are found in all plant cells and in euglenoids. Based on the type of pigments plastids can be classified into chloroplasts, chromoplasts and leucoplasts.**

**The chloroplasts contain chlorophyll and carotenoid pigments which are responsible for trapping light energy essential for photosynthesis. In the chromoplasts fat soluble carotenoid pigments like carotene, xanthophylls and others are present. This gives the part of the plant a yellow, orange or red colour**



**The leucoplasts are the colourless plastids of varied shapes and sizes with stored nutrients: Amyloplasts store carbohydrates (starch), e.g., potato; alaioplasts store oils and fats whereas the aleuroplasts store proteins.**

**chloroplasts are double membrane bound. Of the two, the inner chloroplast membrane is relatively less permeable. The space limited by the inner membrane of the chloroplast is called the stroma. A number of organised flattened membranous sacs called the thylakoids.**

**Thylakoids are arranged in stacks like the piles of coins called grana or the intergranal thylakoids. In addition, there are flat membranous tubules called the stroma lamellae connecting the thylakoids of the different grana.**

The membrane of the thylakoids enclose a space called a lumen. The stroma of the chloroplast contains enzymes required for the synthesis of carbohydrates and proteins. It also contains small, doublestranded circular DNA molecules and ribosomes. Chlorophyll pigments are present in the thylakoids.

## Ribosomes

They are composed of ribonucleic acid (RNA) and proteins and are not surrounded by any membrane. The eukaryotic ribosomes are 80S while the prokaryotic ribosomes are 70S.

Each ribosome has two subunits, larger and smaller subunits. The two subunits of 80S ribosomes are 60S and 40S while that of 70S ribosomes are 50S and 30S.

Here 'S' (Svedberg's Unit) stands for the sedimentation coefficient; it is indirectly a measure of density and size.



## Cytoskeleton

An elaborate network of filamentous proteinaceous structures consisting of microtubules, microfilaments and intermediate filaments present in the cytoplasm is collectively referred to as the cytoskeleton.

The cytoskeleton in a cell are involved in many functions such as mechanical support, motility, maintenance of the shape of the cell.

## Cilia and Flagella

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.

cilia or the flagella covered with plasma membrane.

Their core called the axoneme, possesses a number of microtubules running parallel to the long axis.

The axoneme usually has nine doublets of radially arranged peripheral microtubules, and a pair of centrally located microtubules.

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.

The peripheral doublets are also interconnected by linkers. Both the cilium and flagellum emerge from centriole-like structure called the basal bodies

## Centrosome and Centrioles



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.

They are made up of nine evenly spaced peripheral fibrils of tubulin protein. Each of the peripheral fibril is a triplet.

The central part of the proximal region of the centriole is also proteinaceous and called the hub.

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.

## Nucleus

The nuclear envelope, which consists of two parallel membranes with a space between 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.**

**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. 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.**

**Chromatin contains DNA and some basic proteins called histones, some non-histone proteins and also RNA.**

**Every chromosome 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.**

**Based on the position of the centromere, the chromosomes can be classified into four types.**

**The metacentric chromosome has middle centromere forming two equal arms of the chromosome.**

**The sub-metacentric chromosome has centromere slightly away from the middle of the chromosome resulting into one shorter arm and one longer arm.**

**Acrocentric chromosome the centromere is situated close to its end forming one extremely short and one very long arm, whereas the telocentric chromosome has a terminal centromere.**

## Microbodies

**Many membranes bound minute vesicles called microbodies that contain various enzymes, are present in both plant and animal cells.**