# Cell : The Unit of Life

## 1 INTRODUCTION

- What makes an organism living? The answer to this is the presence of the basic unit of life the cell in all living organisms. All organisms are composed of cells.

## 2 WHAT IS A CELL?

- Cell is the fundamental structural and functional unit of all living organisms. Anything less than a complete structure of a cell does not ensure independent living.
- Anton Von Leeuwenhoek first saw and described a live cell.

## 3 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 the same time, Schwann (1839) a British Zoologist, reported that animal cells had a thin layer called plasma membrane. He concluded that plant cells have cell walls. Schleiden and Schwann together formulated the **cell theory** but this theory did not explain as to how-new cells are formed.
- Rudolf Virchow explained that new cells arise from pre-existing cells (*Omnis cellula-e cellula*) and finally modified the cell theory as:
  (i) All living organisms are composed of cells and products of cells
  (ii) All cells arise from pre-existing cells.

## 4 AN OVERVIEW OF CELL

- Cells differ greatly in size, shape and activities for example, Mycoplasma is smallest cell while egg of an ostrich is the largest isolated single cell. Nerve cells are some of the longest cells.
- The cytoplasm is main arena of cellular activities in both plant and animal cells.
- Ribosomes are non-membrane bound organelles found in both eukaryotic and prokaryotic cells. Apart from cytoplasm, they are also found in mitochondria, chloroplast and on rough ER.
- Animal cells contain another non-membrane bound organelle called centrosome which helps in cell division.
- Cells that have membrane bound nuclei are called eukaryotic cells that lack a membrane bound nucleus called prokaryotic cells.

## 5 PROKARYOTIC CELLS

- Lack membrane bound cell organelles.
- Are represented by bacteria, blue green algae, Mycoplasma or PPLO.
- In addition to genomic DNA, many bacteria have small circular DNA outside the genomic DNA called plasmids. Plasmid DNA confers certain unique phenotypic characters to such bacteria. One such character is resistance to antibiotics. Plasmid DNA is used to monitor bacterial transformation with foreign DNA.
- All prokaryotes have a cell wall surrounding the cell membrane (except Mycoplasma).

### Cell envelope and its modifications

- Most prokaryotic cells have cell envelope, which is tightly bound three layered structure.
- The outermost glycocalyx followed by cell wall and then the plasma membrane.
- Glycocalyx may be a loose sheath called slime layer or thick and tough called capsule.
- The cell wall prevents bacteria from bursting or collapsing.
- Extension of plasma membrane into the cell in the form of vesicles, tubules and lamellae are mesosomes. It helps in cell wall formation, DNA replication, distribution of daughter cells, respiration, secretion process and increase the surface area of plasma membrane.
- In cyanobacteria, chromatophores contain pigments.
- Each layer of the cell envelope performs distinct function, they act together as a single protective unit. The plasma membrane is selectively permeable in nature and interacts with the outside world. It is structurally similar to that of eukaryotes.
- Bacteria may be motile or non-motile. If motile they have flagella, composed of three parts filament, hook and basal body.
- Pili and fimbriae do not play role in motility.
- Bacteria on the basis of the differences in the cell envelope can be Gram positive or Gram negative.

### Ribosomes and inclusion bodies

- Ribosomes are 70S, has subunits 50S and 30S. Several ribosomes may attach to a single mRNA and form a chain called **polyribosome** or **polysome**.
- Ribosomes are associated with plasma membrane.
- The ribosomes of a polysome translate the mRNA into proteins.

**Inclusion bodies**

- Reserve material is stored in the form of inclusion bodies in prokaryotic cytoplasm. Eg. phosphate granules, cyanophycean granules and glycogen granules.
- Gas vacuoles are found in blue green and purple and green photosynthetic bacteria.

## 6 EUKARYOTIC CELLS

- Besides the nucleus eukaryotic cells have other membrane bound structure called organelles like ER, Golgi complex etc.
- The eukaryotes include all the protists, plants, animals and fungi. Plant cells have large vacuole. Animals cells have centrioles which are almost absent in plant cells.
- Ribosomes are of 80S (in cytoplasm). Small subunit is 40S and large 80S.

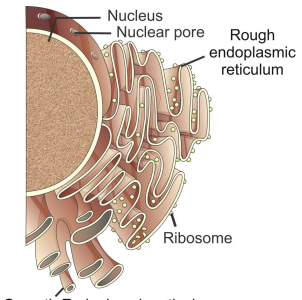
### Cell Membrane

- Chemical studies on the cell membrane, especially in human RBC enabled scientists to deduce the possible structure of plasma membrane.
- Cell membrane is mainly composed of proteins and lipids (mainly phospholipids).
- Phospholipids consist of polar head (outward) and non-polar tail (hydrophobic) inner side. In human RBC 52% is proteins and 40% lipids.
- Membrane proteins can be integral or peripheral.
- Most accepted model for structure of cell membrane is **fluid mosaic model** given by **Singer and Nicolson** (1972).
- Membrane is selectively permeable. Many molecules can move across the membrane without any requirement of energy is called passive transport. Movement of water by diffusion is called osmosis. Many molecules require energy/ATP for their transport called active transport, e.g. $Na^+/K^+$ pump.
- 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.
- Polar molecules cannot move through the non-polar lipid bilayer.
- The fluid nature of membrane is important for functions like cell growth, formation of intercellular junctions, secretion, endocytosis, cell division etc.

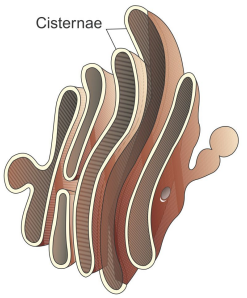
## 7 CELL WALL

- Non-living rigid structure called the cell wall forms an outer covering of the plasma membrane in fungi and plants. 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 inner side (towards membrane) of the cell. The middle lamella is a layer mainly of calcium pectate.
- Algae have cell wall made up of cellulose, galactans, mannans and calcium carbonate. In plants it consists of cellulose, hemicellulose, pectin and proteins.

## 8 ENDOMEMBRANE SYSTEM



**Endoplasmic reticulum**



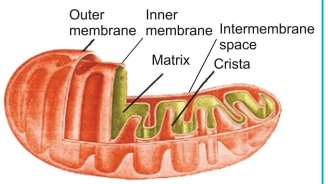
**Golgi apparatus**

- 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.

| Endoplasmic reticulum (ER) | Golgi apparatus | Lysosome | Vacuole |
|---|---|---|---|
| Reticulum of tiny tubular structures scattered in the cytoplasm is called ER. | These were named Golgi bodies after discoverer name Camillo Golgi. | These are membrane bound vesicular structures formed by the process of packaging in the Golgi apparatus. | The vacuole is the membrane bound space found in the cytoplasm, membrane is called tonoplast. |
| The ER which has ribosomes on surface are called RER, in absence of ribosomes they appear smooth called SER. | They consist of cisternae, which are concentrically arranged near the nucleus with distinct convex cis or the forming face and concave trans or the maturing face. | They are rich in hydrolytic enzymes (lipases, proteases carbohydrases), optimally active at acidic pH. | Contain water, sap, excretory product and other materials not useful for the cell. In *Amoeba*, contractile vacuole is important for excretion. |
| RER is involved in protein synthesis whereas SER is involved in lipid synthesis. | Principally performs the function of packaging of materials. It is the important site for formation of glycoproteins and glycolipids. | These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids. | In many cells, as in protists, food vacuoles are formed by engulfing the food particles. |

## 9 MITOCHONDRIA

- Mitochondria unless specifically stained are not easily visible under microscope.
- Each mitochondria is a double membrane bound structure with inner compartment called matrix. The two membranes have their own specific enzymes.
- The outer membrane forms the continuous limiting boundary of the organelle and inner membrane forms cristae.
- Mitochondria are the sites of aerobic respiration. They produce cellular energy in the form of ATP, hence called 'power house of the cell'. The matrix has single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins. Here 'S' (Svedberg's unit) stands for sedimentation coefficient. It is an indirect measure of density and size.

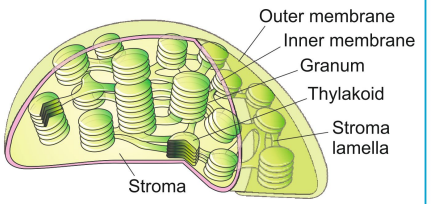


Structure of mitochondrion (Longitudinal section)

Mitochondria divide by fission.

## 10 PLASTIDS

- Plastids are found in all plant cells and in euglenoids. Based on the pigments plastids can be classified into chloroplasts, chromoplasts and leucoplasts.
- The chloroplast contain chlorophyll and carotenoid pigments. The leucoplast are colourless plastids. Amyloplasts store carbohydrates e.g. Potato, Elaioplasts store oils and fats whereas the aleuroplast store proteins.
- Chloroplast are also double membrane bound structure which has membranous sac like structure called thylakoids and the matrix is called stroma. It also contains small, ds circular DNA and ribosomes. Carotenoid is fat soluble pigment eg., carotene, xanthophyll etc.
- The ribosomes of the chloroplasts (70S) are smaller than cytoplasmic ribosomes.
- Thylakoids are arranged in stacks called grana (singular-granum). Flat membranous tubules called the stroma lamellae connecting the thylakoids of the different grana.
- Stroma contain required enzymes for carbohydrate and protein synthesis.
- Chlorophyll pigments are present in the thylakoids.



Sectional view of chloroplast

## 11 CYTOSKELETON

- An elaborate network of filamentous proteinaceous structures present in the cytoplasm is collectively referred to as the cytoskeleton.
- It is involved in many functions such as mechanical support, motility, maintenance of the shape of the cell.

## 13 CENTROSOME AND CENTRIOLES

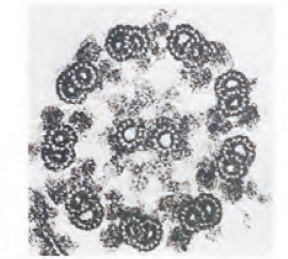
- Centrosome is an organelle usually containing two cylindrical structures called centrioles. They are surrounded by amorphous pericentriolar materials and lie perpendicular to each other.
- The central part of the proximal region of the centriole is proteinaceous called the hub, which is connected with tubules of the peripheral triplets (nine) by radial spokes made of protein.

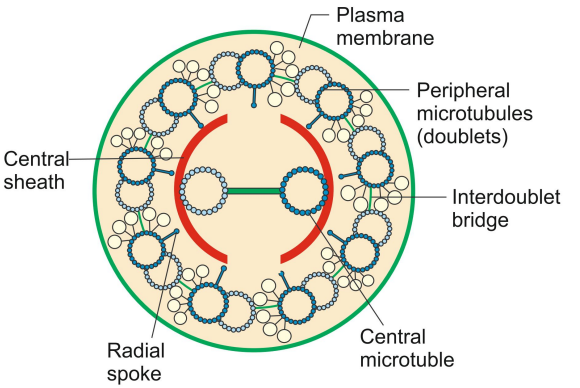
## 14 NUCLEUS

- Nucleus as a cell organelle was first described by Robert Brown as early as 1831. Later the material of nucleus was given the name chromatin by Flemming.
- Interphase nucleus has chromatin, nuclear matrix and nucleolus. Nucleus has the membranes and the space between two membranes is perinuclear space.
- Outer membrane usually remains continuous with the endoplasmic reticulum and also bears ribosomes on it.
- The nuclear matrix or the nucleoplasm contains nucleolus and chromatin.
- During different stages of cell division, cells show structured chromosomes. Chromatin contains DNA, some basic histones, some non-histones and some RNA.
- Every chromosome has primary constriction called centromere on the sides of which disc shaped structures called kinetochores are present.
- Based on the position of centromere, the chromosome can be classified into four types.
  - Metacentric – Centromere is in the middle
  - Sub metacentric – Centromere slightly away from the middle
  - Acrocentric – Centromere situated close to one end
  - Telocentric – Centromere at terminal position
- Sometimes a few chromosomes have non staining secondary constrictions at a constant location. This gives the appearance of a small fragment called the satellite.
- Nucleolus is not a membrane bound structure and it is a site for active ribosomal RNA synthesis.

## 12 CILIA AND FLAGELLA

- Cilia and flagella are hair like outgrowths of the cell membrane. Flagella are comparatively longer and responsible for cell movement.
- The prokaryotic bacteria also possess flagella but these are structurally different from eukaryotic flagella.
- The central core is called axoneme and the arrangement of axonemal microtubules is referred to as the 9 + 2 array.
- Both cilium and flagellum arise from centriole like structure called basal bodies. They are covered will plasma membrane.

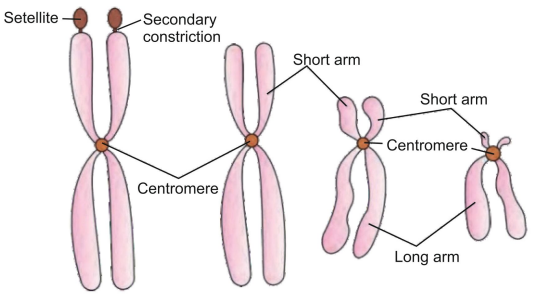





Section of cilia/flagella showing different parts (a) Electron micrograph (b) Diagrammatic representation of internal structure

## 15 MICROBODIES

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




Types of chromosomes based on the position of centromere