CELL: THE UNIT OF LIFE

INTRODUCTION

Cell, basic unit of life, makes an organism living. All organisms are composed of cells.

CELL

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

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 that **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.

AN OVERVIEW OF CELL

- Cells differ greatly in size, shape and activities for example, Mycoplasma is smallest cell (0.3 μm), Egg of an ostrich is the largest isolated single cell. Nerve cells are some of the longest

cells. (RBCs- 7µm in diameter, Bacteria – 3-5µm, Virus - 0.02 – 0.2µm).

- **Cytoplasm** is main arena of cellular activities in both plant and animal cells.

PROKARYOTIC CELLS

- Lack membrane bound nucleus and cell organelles.
- Represented by bacteria, blue green algae, mycoplasma or PPLO (0.1µm).
- 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 → Cell wall → 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.
- **Mesosomes:** Extension of plasma membrane into the cell in the form of vesicles, tubules and lamellae.

  Functions of 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 (longest portion), hook and basal body.
- Pili and fimbriae do not play role in motility.
- Bacteria, **on the basis of the staining**, can be Gram positive or Gram negative.

Ribosomes and Inclusion Bodies

- Ribosomes are non-membrane bound organelles.
- Found in both eukaryotic and prokaryotic cells.
- Also found in cytoplasm, mitochondria & RER.
- 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.

EUKARYOTIC CELLS (10-20µm)

- 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.
- Cytoplasmic ribosomes are of 80S. 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.
- **Passive transport:** Many molecules can move across the membrane without any requirement of energy.
- **Osmosis:** Movement of water by diffusion.
- **Active transport:** Many molecules require energy/ATP for their 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.

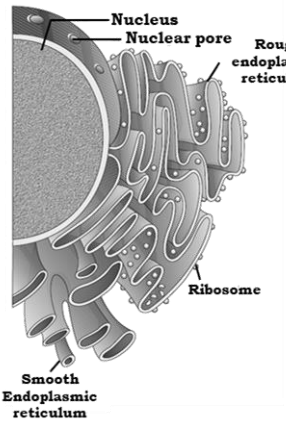
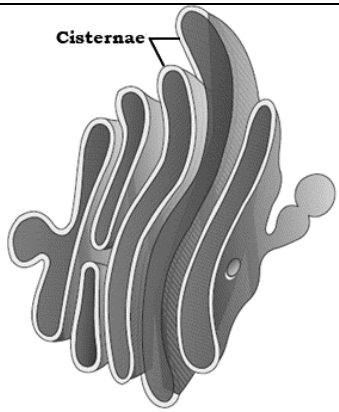
- **FUNCTIONS**
- Cell growth
- Formation of intercellular junctions
- Secretion, endocytosis, cell division etc.

- **CELL WALL**
- Non-living rigid structure forms an outer covering of the plasma membrane in fungi and plants.
- **Primary wall:** Cell wall of a young plant cell is capable of growth which gradually diminishes as the cell matures.
- **Secondary wall:** is formed on inner side (towards membrane) of the cell.

- **Middle lamella:** is a layer mainly of calcium pectate.
- **Cell wall of Algae:** Cellulose, galactans, mannans and calcium carbonate.
- **Cell wall of plants:** Cellulose, hemicellulose, pectin and proteins.

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**.

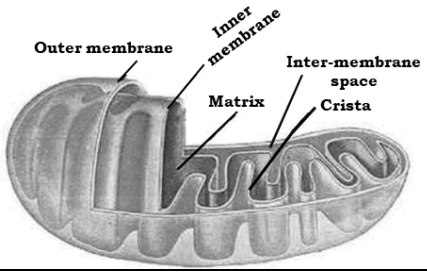
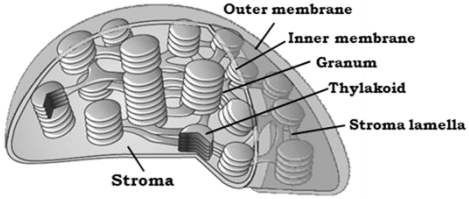
Endoplasmic reticulum	**Golgi apparatus**
	

Endoplasmic reticulum (ER)	**Golgi apparatus**	**Lysosome**	**Vacuole**
Reticulum of tiny tubular structures scattered in the cytoplasm.	These were named Golgi bodies after discoverer name **Camillo Golgi.**	These are membrane bound vesicular structures formed by the process of packaging m the Golgi apparatus.	The vacuole is the membrane bound space found in the cytoplasm, membrane is called **tonoplast**.

RER: ER which has ribosomes on surface **SER:** In absence of ribosomes, they appear smooth.	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 (5.5).	Contain water, sap, excretory product and other materials not useful for the cell. In Amoeba, contractile vacuole is important for excretion.
RER is involved m protein synthesis **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 m protists, food vacuoles are formed by engulfing the food particles.

MITOCHONDRIA

- Mitochondria are visible under microscope only after staining.
- Each mitochondria is a **double membrane** bound structure with inner compartment called matrix. The two membranes have their own specific enzymes.
- **Outer membrane:** Forms the continuous limiting boundary of the organelle.
- **Inner membrane:** Forms cristae.
- Sites of aerobic respiration. They produce cellular energy in the form of **ATP**, hence called 'power house of the cell'.
- **Matrix** has single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins.
- **'S' (Svedberg's unit)** stands for sedimentation coefficient. It is an indirect measure of density and size.

Structure of mitochondria (Longitudinal section)	Sectional view of chloroplast
	

PLASTIDS

- Plastids are found in all plant cells and in euglenoids. Based on the pigments, plastids can be classified into chloroplasts, chromoplasts and leucoplasts.
- Chloroplast contain chlorophyll and carotenoid pigments.
- 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 e.g., Carotene, xanthophyll etc.
- The ribosomes of the chloroplasts (70S) are smaller than cytoplasmic ribosomes (80S).
- 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.

CYTOSKELETON

- An elaborate network of filamentous proteinaceous structures present in the cytoplasm.

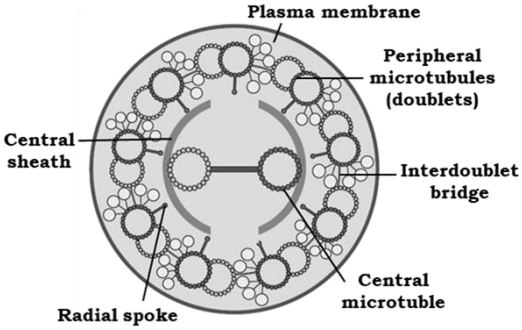
FUNCTIONS

- Mechanical support, motility, maintenance of the shape of the cell.

CILIA AND FLAGELLA

- 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- Axoneme.
- 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.

Structure of cilia/flagella



CENTROSOME AND CENTRIOLES

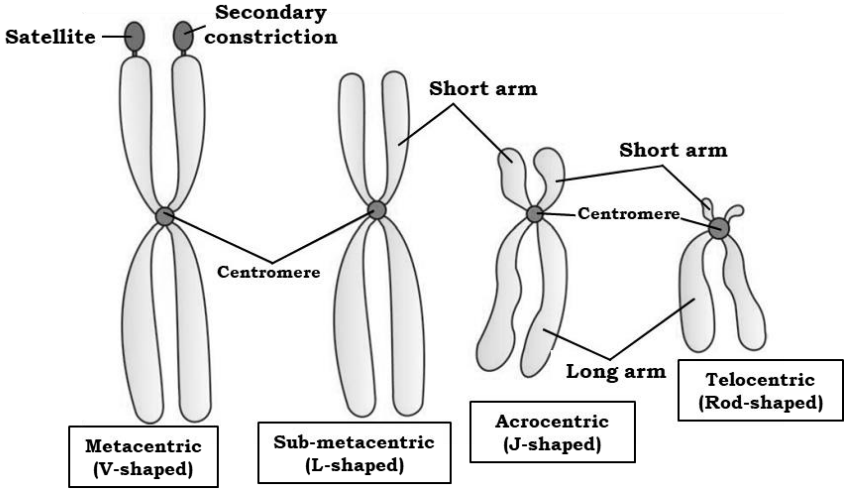
- A non-membrane bound organelle usually containing two cylindrical structures called centrioles. They are surrounded

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.
- Helps in cell division.

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.



- **Satellite:** Sometimes, a few chromosomes have non staining secondary constrictions at a constant location. This gives the appearance of a small fragment.
- **Nucleolus:** Not a membrane bound structure and site for active ribosomal RNA synthesis.

- **MICROBODIES**
- Membrane bound minute vesicles.
- Enzymes are present in both plant and animal cells.