8. Cell: The Unit of Life

POINTS TO REMEMBER :

CELL THEORY :

- **Schieiden and Schwann** together formulated the cell theory.
- They proposed that the body of animal and plant are composed of cells and product of cells.
- **Rudolf Virchow (1855)** he modified and gives the final shape to the**cell theory.**
    - **All living organisms are composed of cells and products of cells.**
    - **All cells arise from pre-existing cells.**

PROKARYOTIC CELLS :

- Represented by bacteria, blue-green algae, mycoplasma and PPLO.
- Smaller and multiply more rapidly than eukaryotic cells.
- Four basic shape of bacteria are
    - Bacillus (rod like)
    - Coccus (spherical)
    - Vibrio (comma shaped)
    - Sprillum (spiral)

- All prokaryotes have a cell wall surrounds the plasma membrane.
- There is no well defined nucleus.
- Chromosome is single and circular, not enveloped by nuclear membrane.
- Presence of many small, circular, extra chromosomal and self replicable DNA called **plasmid.**
- Plasmid provides unique characteristic to the bacteria.
- One of the characteristic is **antibiotic resistant**.
- No membrane bound cell organelles.
- A specialized differentiated form of cell membrane called **mesosome** is present.

Cell envelope and its Modifications :

- Most prokaryotic cell have characteristic complex cell envelope.
- The cell envelops consists of tightly bound three layer structure;
    - The outermost glycocalyx.
    - Middle cell wall
    - Inner plasma membrane.

- According to the nature of the cell wall and behavior towards the stain developed by Gram, bacteria are **Gram positive**or **Gram negative**.
- Glycocalyx may for a loose sheath called **slime layer.**
- Glycocalyx may be thick and tough called the **capsule.**
- The cell wall determines the shape of the cell, strong structural support to prevent the bacterium from bursting and collapsing.
- Plasma membrane is semi-permeable in nature and interacts with outside world.
- A special membranous structure is the mesosome which is formed by 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 the daughter cell.
- They also help in respiration and secretion.

- Some bacteria have filamentous extensions called flagella.
- Bacterial flagellum has three parts – **filament, hook** and **basal body.**
- **Pili** are elongated tubular structures made of a special protein.
- **Fimbriae** are small bristle like fibres sprouting out of the cell. Play role in adhesion.

Ribosome and inclusion bodies :

- Ribosomes are associated with the plasma membrane of the cell.
- Each ribosome (70 S) has two sub units; smaller (30 S) and large (50 S).
- Ribosomes are the site of protein synthesis.
- Several ribosomes attached to a single mRNA to form a chain called **polyribosome** or **polysome.**
- **Reserve materials are stored in the form of inclusion bodies.**
- Phosphate granules, cyanophycean granules and glycogen granules are the inclusion bodies.

EUKARYOTIC CELL :

- Eukaryotes include all the Protists, plants, animals and fungi.
- Extensive compartmentalization due to **membrane bound cell organelles.**
- Possess an organized **nucleus** with **nuclear envelope**.
- Have a variety of complex locomotory and **cytoskeletal structure**.
- Genetic materials are organized into **chromosomes.**
- The plant cell possess cell walls, plastids and a large central vacuole, which are absent in animal cell.
- Animal cells have **centrioles** which absent in plant cells.

Cell membrane :

- The cell membrane composed of lipids that arranged in bilayer.
- Lipids are arranged within the membrane with the **hydrophilic polar** head towards the outer sides and the**hydrophobic tails** towards the inner part.
- Non polar tail of **saturated hydrocarbons** is protected from the aqueous environment.
- The lipid component of the membrane mainly consists of **phophoglycerides.**
- Cell membrane also possesses protein and carbohydrates.
- Ratio of protein and lipids varies from cell to cell.
- Human erythrocyte plasma membrane contains 52 % protein and 40 % lipids.
- Membrane protein may be **integral** or **peripheral.**
- Peripheral protein lie on the surface and integral proteins are partially or totally buried in the membrane.
- The improved model of the structure of plasma membrane was proposed by singer and Nicolson (1972) widely accepted as **fluid mosaic model.**
- According to this the quasi fluid nature of lipid enables the lateral movement of proteins within the overall bilayer.

Function :

- Passive transport.
  - Simple diffusion

- Facilitated diffusion.

- Active transport.
- Phagocytosis
- Exocytosis.
- Pinocytosis.

Cell wall :

- A non-living rigid structure called cell wall present outside the plasma membrane of plant and fungal cell.
- Algae have a cell wall made of cellulose, galactans, mannans and minerals like calcium carbonate.
- Plant cell wall consists of cellulose, hemicelluloses, pectins and proteins.
- The cell wall of young plant is called **primary cell wall.**
- On maturity secondary cell wall formed inner to it.
- The middle lamella is a layer of calcium pectate which holds or glues the neighboring cells.
- The cell wall and middle lamella may traversed by **plasmodesmata**; the cytoplasmic connection between two adjacent cell.

The endomembrane system :

Endoplasmic reticulum :

- Network or reticulum of tiny tubular structures scattered in the cytoplasm, called **endoplasmic reticulum.**
- It divides the intracellular space into two distinct compartments:
  - **Luminal (inside the ER)**
  - **Extra luminal (cytoplasm).**

- The ER shows ribosomes attached to their outer surface called **Rough Endoplasmic reticulum (RER).**
- Endoplasmic reticulum without ribosome called **SER (smooth endoplasmic reticulum)**

Function:

- RER present in the cell actively involved in protein synthesis.
- SER is the site for synthesis of lipid, glycogen and steroid hormones.

Golgi apparatus:

- Camillo Golgi (1898) first observed this organelle, and named after him.
- It consists of many flat, disc shaped sacs or cisternae.
- These are staked parallel to each other.
- The Golgi cisternae are concentrically arranged near the nucleus with distinct convex ***cis***or the forming face and concave ***trans***or the maturing face.

Function:

- Principally responsible for packing of materials to be delivered intra-cellular target or intercellular target.

- Materials are packed in the form of vesicles, from the ER fuse with the cis face of the Golgi apparatus and move towards the trans face.
- Important site for the formation of glycoprotein and glycolipids.

Lysosomes:

- Membrane bound vesicular structure.
- Formed by Golgi body.
- Rich in all type **hydrolytic enzymes**, optimally active in acidic pH.
- These enzymes are capable to digesting carbohydrates, proteins, lipids and nucleic acids.

Vacuoles:

- The vacuole is the membrane-bound space found in the cytoplasm.
- It contains water, sap, excretory product.
- Vacuole is bounded by a single membrane called **tonoplast.**
- In plant cells the vacuole can occupy 90% of the volume.
- Tonoplast facilitates active transport of material from cytoplasm into the vacuole.
- In *Amoeba* the **contractile vacuole** is important for excretion and osmoregulation.
- In many protists, **food vacuoles** are formed by engulfing the food particles.

Mitochondria:

- The number of mitochondria varies according to the physiological activity of the cell.
- Each mitochondrion is a double membrane bound structure with outer and inner membrane, dividing its lumen into two aqueous compartments
    - Outer compartment.
    - Inner compartment.

- The inner compartment is called the matrix.
- The inner membrane forms a number of infoldings called the cristae towards the matrix.
- The cristae increase the surface area.
- Two membranes have their own specific enzymes associated with the mitochondrial function.
- Mitochondria are the site of aerobic respiration.
- They produce cellular energy in the form of ATP, hence called '**power house'** of the cell.
- The matrix also possess single circular DNA molecule and a few RNA molecules, ribosomes (70S), they synthesize their own protein.
- Mitochondria divide by fission.

Plastids :

- Plastids are found in all plant cells and in Euglenoids.
- They bear some specific pigment, impart specific colour to the plants.
- Based on the type of pigments plastids can be classified into
    - **Chloroplast**.
    - **Chromoplast**
    - **Leucoplast**.

- The chloroplasts contain **chlorophyll** and **carotenoid** pigments, traps solar energy for photosynthesis.
- In the chromoplasts fat soluble carotenoid pigments like carotene, xanthophylls are present.
- The leucoplasts are colourless plastids of varied shapes and size with stored nutrients.
    - **Amyloplast** - store carbohydrates.
    - **Elaioplasts** – store oils and fats.
    - **Aleuroplast** – store proteins and minerals.

- Chloroplasts are found in the **mesophyll cells** of the leaves.
- These are oval, spherical, discoid or even ribbon like organelles.
- Chloroplast is a double membrane organelle.
- The space limited by inner membrane is called **stroma.**
- A number of organized flattened membranous sacs called **thylakoid** are present in the stroma.
- Thylakoids are arranged like stakes of coins to form **grana.**
- There are flat membranous tubules called the **stroma lamellae** connecting the thylakoids of the different grana.
- They thylakoids enclose a space called **lumen.**
- **Chlorophyll** pigments are located in the thylakoids.
- Chloroplast contains enzymes required for the synthesis of carbohydrates and proteins.
- Stroma contains small circular **DNA** and **ribosomes.**

Ribosomes :

- Ribosomes are granular structure first observed by George Palade (1953).
- Composed of ribonucleic acid (RNA) and proteins.
- Non-membranous cell organelles.
- Eukaryotic ribosomes are 80S while the prokaryotic ribosomes are 70S.
- 'S' stands for sedimentation coefficient; measure of density and size.
- Both 70S and 80S ribosomes consists of two subunits.
- Primary function is protein synthesis hence called protein factory of the cell.

Cytoskeleton :

- An elaborate network of filamentous proteinaceous structures present in the cytoplasm is collectively known as**cytoskeleton.**
- Cytoskeleton involved in many function such as mechanical support, motility, maintenance of the shape of the cell.

Cilia and Flagella :

- Cilia and flagella are hair-like outgrowths of the cell membrane.
- Cilia are small help in the movement of cell or surrounding fluid.
- Flagella are longer and responsible for cell movement.
- Cilia and flagella covered by plasma membrane.
- Their core called **axoneme,** possess a number microtubules running parallel to the long axis.
- The axoneme usually has nine pairs of doublets of radially arranged peripheral microtubules and a pair of centrally located microtubules.
- The central tubules are connected by bridges and are also enclosed by a central sheath, which is connected to one of the tubules of each peripheral doublet by radial spoke.
- The peripheral doublets are also interconnected by linkers.

- Both cilia and flagella emerge from centrioles-like structure called basal bodies.

Centrosome and centrioles :

- Centrosome is an organelle usually containing two cylindrical structures called centrioles.
- They are surrounded by amorphous pericentriolar materials.
- Both centrioles in a Centrosome lie perpendicular to each other.
- Each centriole has an organization like the cartwheel.
- They are made of nine evenly spaced peripheral fibrils of tubulin.
- Each of the peripheral fibril is a triplet.
- The adjacent triplets are also linked to each others.
- The central part of the centriole is called **hub.**
- The hub connected to peripheral triplets by radial **spokes.**
- The centriole forms the **basal body** for cilia, flagella and form **spindle fibres** during cell division.

Nucleus :

- Nucleus as a cell organelle was first described by **Robert Brown** in 1831.
- Materials inside the nucleus was stained by **Flemming** and named as **chromatin.**
- The interphase nucleus has highly extended and elaborates nucleoprotein fibres called chromatin.
- The nucleus also contains nuclear matrix and one or two spherical bodies called **nucleoli.**
- Nuclear envelope consists of two membranes with perinuclear space (10- 50 nm).
- The outer membrane remains continuous with endoplasmic reticulum.
- Presence of nuclear pore due to fusion of two membranes.
- Nuclear pores allow the movement of RNA and protein in both directions.
- The nuclear matrix or **nucleoplasm** contains nucleolus and chromatin.
- Nucleolus is the site for active ribosomal RNA synthesis.
- During cell division the chromatins condensed to form **chromosomes.**
- Chromatin contains DNA and some basic proteins called **histones, non-histone proteins** and some **RNA.**
- A single human cell contains approximately two meter long thread of DNA in 46 chromosomes.
- Each chromosome essentially has a primary constriction or the **centromere.**
- On each side of centromere there is disc shaped structures called **kinetochores.**

- Based on the position of the centromere chromosomes are classified into four types:-
    - **Metacentric:** centromere at the middle with two equal arms.
    - **Sub-Metacentric:** one short arm and one long arm.
    - **Acrocentric:** with extremely short arm and a very long arm.
    - **Telocentric:** with terminal centromere.

- A few chromosomes have non-staining constrictions at a constant location. This gives the appearance of a small fragment called the **satellite.**