CELL: THE UNIT OF LIFE

- Cell: Basic unit of life.
  - Fundamental structural and functional unit of all living organisms.

- Cytology – study of cell and cellular structures.

- Types of organisms –
  - All unicellular organisms are capable of:
    - Independent existence.
    - 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.

- Some important scientists –
  - Robert Hooke: Discovered cell.
  - Anton von Leeuwenhoek: First saw and described a live cell.
  - Schleiden (German botanist), Schwann (British Zoologist): Formulated Cell Theory.

- Robert Hooke first time describe about cell in his book ‘Micrographia’. He actually saw cell wall of dead cells not cell itself.

- CELL THEORY
  - Formulated by Schleiden and Schwann.
  - Modified by Rudolf Virchow – he explained that new cells develop from pre-existing cells by cell division (*Omnis cellula-e cellula*).
  - Exception of cell theory - virus, viroids,
  - i) All living organisms are composed of cells and products of cells.
  - ii) Cell is structural unit of life.
  - iii) All cells arise from pre-existing cells.
CHAPTER 8: CELL: THE BASIC UNIT OF LIFE

- **CELL SIZE AND SHAPE**
  - Smallest cell – mycoplasmas (PPLO – Pleuro Pneumonia Like Organisms)
  - Largest cell – egg of an ostrich.
  - Largest cell in human body – Ovum.
  - Longest cell in human body – Nerve Cell.
  Even shape of cells may vary with the functions they perform.

- **TYPES OF CELLS**

  ![Diagram of cell types]

  - **PROKARYOTIC CELLS**
    - Lack a membrane bound nucleus.
    - Membrane bound organelles are absent.

  - **EUKARYOTIC CELLS**
    - Have membrane bound nucleus.
    - Membrane bound organelles are present like ER, Mitochondria, Golgibodies, Plastids, Lysosomes.

**PROKARYOTIC CELL**

- Represented by Blue Green Algae, mycoplasmas, bacteria etc.

  ![Diagram of prokaryotic cell]

  - **Bacteria**
    - Bacillus (Rod shape)
    - coccus (spherical)
    - vibrio (comma shape)
    - spirillum (spiral shape)
CHAPTER 8: CELL: THE BASIC UNIT OF LIFE

Basic structure of prokaryotes

- Cell envelope and its modifications
  - Glycocalyx
  - Cell wall
  - Plasma membrane

- Cytoplasm, cell organelles and inclusion bodies

- Naked genetic material = genomic DNA (Single chromosome)

- Cell wall
  - Determine shape of cell.
  - Provide strong, structural support
  - Prevent bacteria from bursting or collapsing

- Plasma membrane
  - Semipermeable
  - Structurally similar to that of eukaryotes.

- Mesosomes
  - Formed by extension of plasma membrane into cell.
  - In the form of vesicles, tubules and lamella.
  - Help in cell wall formation, DNA replication and distribution to daughter cells.
  - Also help in respiration, secretion processes, to increase the surface area of the plasma membrane and enzymatic content.

On the basis of difference in cell envelope/cell wall and Gram staining

- Gram +ve (take up Gram stain)
- Gram -ve (don't take up Gram stain)

Prepared by –
Dr. Anurag mittal
- **Chromatophores**
  - Membranous extensions into cytoplasm.
  - Contain pigments.
  - In cyanobacteria.

- **Flagella**
  - Present in motile cells.
  - Thin filamentous extensions from their cell wall.
  - Composed of three parts – filament, hook and basal body.

- **Pili and Fimbriae**
  - Pili are elongated tubular structure while fimbriae are small bristle like fibres.
  - Help in attachment of bacteria.

- **Ribosomes**
  - Associated with the plasma membrane of the cell.
  - Made of two subunits - 50S and 30S units which when present together form 70S.
  - Site of protein synthesis.
  - Ribosome of a polysome translate the mRNA into protein.

- **Inclusion bodies**
  - For storage of reserve material in prokaryotic cells.
  - These are not bounded by any membrane system and lie free in the cytoplasm.
  - E.g., phosphate granules, cyanophyceae granules and glycogen granules.
  - Gas vacuoles are found in blue green and purple and green photosynthetic bacteria.

**Eukaryotic Cells**
- Include all the protists, plants, animals and fungi.
- Extensive compartmentalisation of cytoplasm through the presence of membrane bound organelles present.
- Possess an organised nucleus with a nuclear envelope.
- Genetic material is organised into chromosomes.
Cell wall
- non-living, rigid structure
- forms an outer covering for the plasma membrane of fungi and plants.
- 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.

Layers of cell wall
- Middle lamella
  - Outermost
  - Made up of mainly calcium pectate.
  - Holds or glues the different neighbouring cell together.
- Primary wall
  - Capable of growth.
  - Present in young cell.
  - Gradually diminishes as cell matures.
  - Madeup of cellulose, hemicelluloses.
  - Present in meristem, pith, cortex etc.
- Secondary wall
  - Innermost layer.
  - Hard.
  - Lignified (in sclerenchyma, vesels, tracheids), suberinised (casparian strips, endodermis)
  - Suberin, lignin make cell wall impermeable.
  - Present in sclerenchyma, collenchyma, and vessels, tracheids.

Cell wall and middle lamella maybe traversed by plasmodesmata which connects the cytoplasm of neighbouring cells.
Cell membrane
- Mainly composed of bilayer phospholipids, also possess protein and carbohydrate.
- Lipids are arranged within the membrane with the polar head (hydrophilic) towards the outer sides and the nonpolar tails (hydrophobic) towards the inner part. This ensures that the nonpolar tail of saturated hydrocarbons is protected from the aqueous environment.
- The ratio of protein and lipid varies in different cell types. (In human RBC membrane has 52% protein and 40% lipids.)
- Structure of cell membrane is explained by Fluid Mosaic Model which was given by Singer and Nicolsan.
- According to this model the quasi-fluid nature of lipid enables lateral movement of proteins within the overall bilayer.
- The fluid nature of the membrane is important for functions like cell growth, formation of intercellular junctions, secretion, endocytosis, cell division etc.

Transport across cell membrane
- Passive transport
  - Energy is not utilised. (energy independent)
  - Movement of substances according to concentration gradient (from low conc. to high conc.)
- Active transport
  - Energy/ATP is utilised. (energy dependent)
  - Movement of substances against the concentration gradient (from low conc. to high conc.)
Mitochondria
- Double membrane bound cell organelle.
  - Outer membrane
    - Forms continuous limiting boundary of the organelle.
  - Inner membrane
    - Forms a number of infoldings called Cristae
      - Divide mitochondrial lumen into 2 aqueous compartments.
  - Outer compartment
  - Inner compartment
  - Peri Mitochondrial Space/Inter membranous space
  - Matrix

- Mitochondria are site of aerobic respiration. They produce ATP, hence called ‘Power House of Cell’.
- The matrix also possesses single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins. So, mitochondria also known as ‘semi autonomous organelle’.
- The mitochondria divide by fission and produce new mitochondria.
A cell is the basic unit of life. Cells are divided into two main types: prokaryotic and eukaryotic. Prokaryotic cells contain only DNA, whereas eukaryotic cells contain DNA and organelles. The organelles are responsible for various functions such as energy production, waste removal, and protein synthesis. The plasma membrane surrounds the cell and controls the movement of substances in and out of the cell. The cytoskeleton provides structural support and helps in cell movement. The Golgi apparatus modifies, packages, and sends cell products to various locations within the cell or for secretion. The endoplasmic reticulum is a network of membranes that helps in protein synthesis and lipid production. The nucleus is the control center of the cell and contains the cell’s DNA. The ribosomes are the sites of protein synthesis. The mitochrondria are the powerhouses of the cell, producing energy in the form of ATP. The chloroplasts are the sites of photosynthesis, where energy is captured from sunlight and converted into chemical energy. The endoplasmic reticulum and Golgi apparatus are involved in the synthesis and modification of lipids and proteins. The lysosomes are responsible for breaking down waste materials and debris.
- There are also stroma lamellae connecting the thylakoids of the different grana.
- Stroma also contains small, double-stranded circular DNA molecules and ribosomes (70S). So, it is also known ‘semi autonomous organelle’.

**Endoplasmic Reticulum**
- A network or reticulum of tiny tubular structures scattered in the cytoplasm that is called the endoplasmic reticulum (ER).
- Hence, ER divides the intracellular space into two distinct compartments, i.e., luminal (inside ER) and extra luminal (cytoplasm).

**Smooth (SER)**
- Absence of ribosomes they appear smooth.
- Major site for synthesis of lipid.
- In animal cells lipid-like steroidal hormones are synthesised in SER.

**Rough (RER)**
- Bear ribosomes on their surface proteins.
- Involved in protein synthesis and secretion.
- Are extensive and continuous with the outer膜

**Endoplasmic Reticulum**
**Golgi apparatus**
Golgi apparatus
- Discovered by Camillo Golgi.
- They consist of many flat, disc-shaped sacs or cisternae stacked parallely.
- The Golgi cisternae are concentrically arranged near the nucleus with distinct convex 
  cis or the forming face and concave trans or the maturing face, which are 
  interconnected.
- The golgi apparatus principally performs the function of packaging materials.
- golgi apparatus remains in close association with the endoplasmic reticulum as 
  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.
- 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 forma
  tional glycoproteins and glycolipids

Lysosomes
- 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.

Vacuoles
- Membrane-bound space found in the cytoplasm. Membrane known as tonoplast.
- It contains water, sap, excretory product and other materials not useful for the cell.
- In plant cells the vacuoles are very large.
- In plants, the tonoplast facilitates the transport of a number of ions and other 
  materials against concentration gradients into the vacuole.
- In Amoeba the contractile vacuole is important for excretion.
- In many cells food vacuoles are formed by engulfing the food particles.

Ribosome
- first observed under the electron microscope by George Palade.
- They are composed of ribonucleic acid (RNA) and proteins.
- Not Bounded by any membrane.
- The eukaryotic ribosomes are 80S while the prokaryotic ribosomes are 70S. 
  (‘S’ stands for the sedimentation coefficient).
> Cytoskeleton
- An elaborate network of filamentous proteinaceous structures present in the cytoplasm
- Functions are mechanical support, motility, maintenance of the shape of the cell.

> Cilia and Flagella
- They are hair-like outgrowths of cell membrane responsible for locomotion and movement of cell.
- Cilia are small structures which work like oars, causing the movement of either the cell or the surrounding fluid. Flagella are comparatively longer.
- Eukaryotic cilium and flagellum 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 nine pairs of doublets of radially arranged peripheral microtubules, and a pair of centrally located microtubules \((9+2)\).
- Both the cilium and flagellum emerge from centriole-like structure called the basal bodies.

> Centrosome and centriole
- Centrosome is an organelle usually containing two perpendicularly lying centrioles surrounded by amorphous pericentriolar materials.
- Centriole has an organisation like the cartwheel. They are made up of nine evenly spaced triplet peripheral fibrils of tubulin.
- The central part of the centriole is also proteinaceous and called the hub, connected with peripheral tubules by radial spokes.
- 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.

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

- first described by Robert Brown.
- the material of the nucleus stained by the basic dyes was given the name **chromatin** by Flemming.
- The interphase nucleus has nucleoprotein fibres called chromatin, nuclear matrix and one or more spherical bodies called **nucleoli**.
- the nuclear envelope consists of two parallel membranes with a space inbetween called **perinuclear space**.
- The outer membrane usually remains continuous with the endoplasmic reticulum and also bears ribosomes on it.
- At a number of places the nuclear envelope is interrupted by minute pores. These nuclear pores provide passages for movement of RNA and protein molecules.
- Normally, there is only one nucleus per cell. Some mature cells even lack nucleus, e.g., erythrocytes of many mammals and sieve tube cells of vascular plants.
- The nuclear matrix or the **nucleoplasm** contains nucleolus and chromatin.
- The nucleoli are spherical structures present in the nucleoplasm. It is a site for active ribosomal RNA synthesis.
- During cell division, chromatin network condenses into **chromosomes**.
- 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.

<table>
<thead>
<tr>
<th>Position of Centromere</th>
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<tbody>
<tr>
<td>telocentric</td>
</tr>
<tr>
<td>acrocentric</td>
</tr>
<tr>
<td>Submetacentric</td>
</tr>
<tr>
<td>Metacentric</td>
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- Sometimes a few chromosomes have non-staining secondary constrictions at a constant location. This gives the appearance of a small fragment called the **satellite**.