

The Dynamic Cell

Cell and macromolecules

Cellular classification

Introduction to the Cell

- The **cell** is the basic **structural and functional unit** of life.
- It is the smallest unit capable of performing all the essential processes of life — such as metabolism, growth, reproduction, and response to stimuli.
- Cells are enclosed by a membrane and contain internal structures (organelles) and macromolecules that perform specialized functions.

Cellular Classification

Cells are broadly classified into **two types** based on structural organization:

A. Prokaryotic Cells

- Simpler in structure.
- Do not contain a **membrane-bound nucleus**.
- Lack membrane-bound organelles.
- DNA is found in a **nucleoid** region.
- Typical examples: **Bacteria** and **Archaea**.

Key Features:

- Small in size (0.1 – 5 μm).
- Single circular DNA molecule.
- Cell wall made of **peptidoglycan** (in bacteria).
- Ribosomes (70S) for protein synthesis.
- Divide by **binary fission**.

B. Eukaryotic Cells

- Structurally complex.
- Have a **true nucleus** enclosed by a nuclear membrane.
- Contain **membrane-bound organelles**.
- Found in: **Animals, plants, fungi, and protists**.

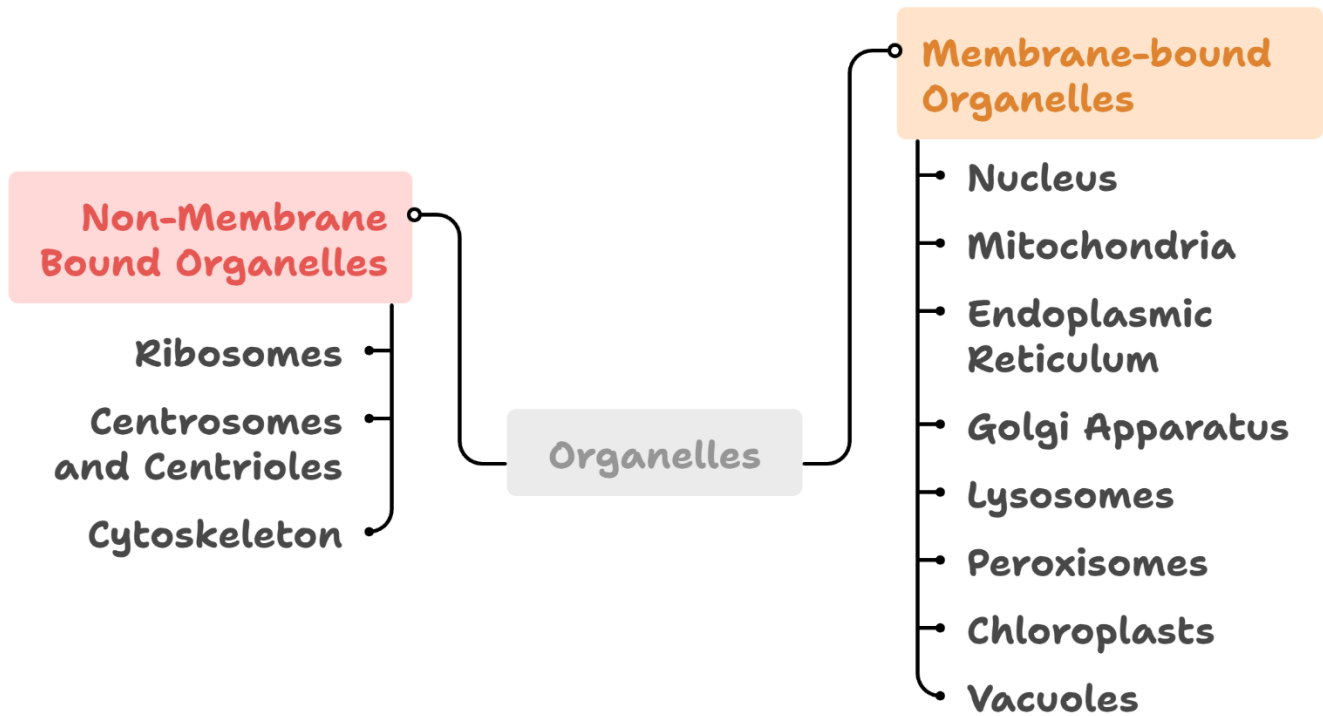
Key Features:

- Larger in size (10 – 100 μm).

- DNA organized into linear chromosomes.
- Ribosomes (80S) in cytoplasm, 70S in mitochondria/chloroplasts.
- Undergo **mitosis or meiosis** for division.

Subcellular Organelles

- Organelles are specialized structures within eukaryotic cells that perform distinct functions.
- They can be membrane-bound or non-membrane-bound.



A. Membrane-bound Organelles

1. Nucleus

- **Function:** Stores genetic information, site of transcription (DNA → RNA)
- **Structure:** Nuclear envelope (double membrane), nuclear pores, nucleolus (ribosomal RNA synthesis), chromatin (DNA + proteins)

2. Mitochondria

- **Function:** ATP production through aerobic respiration (oxidative phosphorylation)
- **Structure:** Double membrane, inner membrane folds (cristae), matrix with mitochondrial DNA and ribosomes

3. Endoplasmic Reticulum (ER)

A. Rough ER:

- Studded with ribosomes
- Synthesizes proteins for secretion/membranes

B. Smooth ER:

- Lipid synthesis, detoxification, calcium storage

4. Golgi Apparatus

- **Function:** Modifies, sorts, and packages proteins and lipids
- **Structure:** Series of flattened cisternae (membranous sacs)

5. Lysosomes

- **Function:** Intracellular digestion (autophagy, phagocytosis)
- **Enzymes:** Acid hydrolases active at low pH

6. Peroxisomes

- **Function:** Break down fatty acids and detoxify harmful substances (e.g., hydrogen peroxide breakdown by catalase)

7. Chloroplasts (in plants and algae)

- **Function:** Photosynthesis
- **Structure:** Double membrane, internal thylakoid membranes (grana), stroma, chlorophyll, own DNA

8. Vacuoles

- **Function:** Storage of nutrients, waste products, structural support (especially in plant cells)
- **Types:**
 - Central vacuole (plants)
 - Contractile vacuole (protists)

B. Non-Membrane Bound Organelles

1. Ribosomes

- **Function:** Protein synthesis
- **Structure:** rRNA and protein complex, two subunits (small and large)
- **Types:**
 - Free ribosomes (cytoplasm) – synthesize cytosolic proteins
 - Bound ribosomes (RER) – synthesize membrane-bound or secretory proteins

2. Centrosomes and Centrioles

- **Function:** Organize microtubules during cell division (mitotic spindle formation)
- **Structure:** In animals, centrosome contains a pair of centrioles

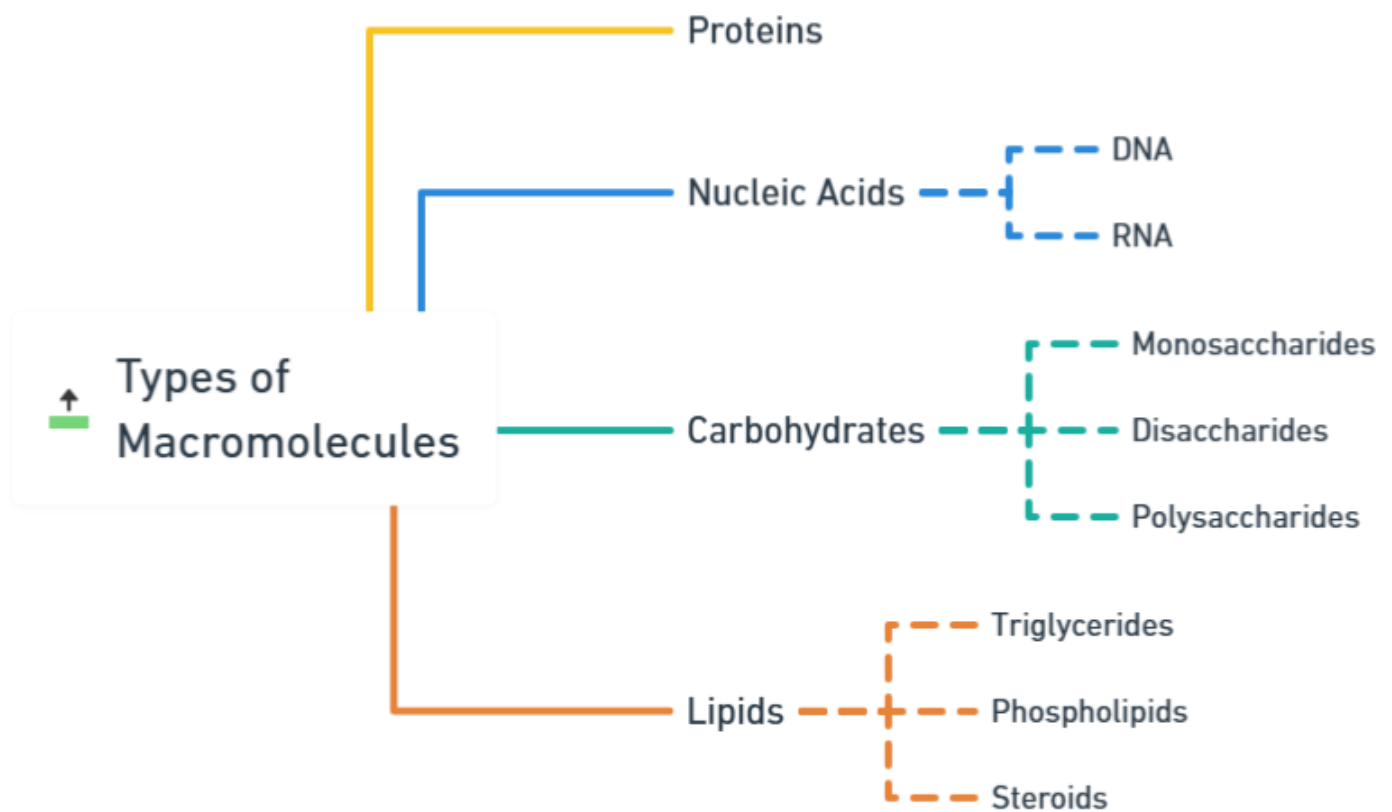
3. Cytoskeleton

- **Function:** Provides structural support, intracellular transport, cell motility
- **Components:**
 - Microfilaments (actin)
 - Intermediate filaments
 - Microtubules (tubulin)

Macromolecules

- Macromolecules are large, complex molecules made of smaller subunits (monomers).
- They are essential for structure and function in cells.

Types of Macromolecules



1. Proteins

- **Monomer:** Amino acids (20 standard types)
- **Bond:** Peptide bond
- **Structure:**
 - Primary (amino acid sequence)
 - Secondary (α -helices and β -sheets via H-bonding)
 - Tertiary (3D folding, disulfide bridges, hydrophobic interactions)
 - Quaternary (multiple polypeptide subunits)

➤ **Functions:**

- Enzymes (catalysts)
- Structural proteins (collagen, keratin)
- Transport (hemoglobin)
- Signaling (hormones, receptors)
- Immune defense (antibodies)

2. Nucleic Acids

➤ **Monomer:** Nucleotides (sugar + phosphate + nitrogenous base)

➤ **Types:**

- DNA: deoxyribonucleic acid (stores genetic information)
- RNA: ribonucleic acid (protein synthesis, regulation)

➤ **Bond:** Phosphodiester bond

➤ **Structure:**

- DNA: Double-stranded helix, antiparallel, complementary base pairing (A-T, G-C)
- RNA: Single-stranded, can fold into complex structures (tRNA, rRNA)

3. Carbohydrates

➤ **Monomer:** Monosaccharides (e.g., glucose, fructose)

➤ **Bond:** Glycosidic bond

➤ **Types:**

- Monosaccharides (glucose)
- Disaccharides (sucrose, lactose)
- Polysaccharides:
 - Storage: Starch (plants), Glycogen (animals)
 - Structural: Cellulose (plant cell wall), Chitin (fungi, arthropods)

○ **Functions:** Energy source, structural components, cell recognition

4. Lipids

➤ **Monomers:** Fatty acids and glycerol (not true polymers)

➤ **Types:**

- Triglycerides (fats and oils): Energy storage
- Phospholipids: Membrane structure (hydrophilic head, hydrophobic tails)
- Steroids: Hormones (e.g., cholesterol, testosterone)

➤ **Functions:**

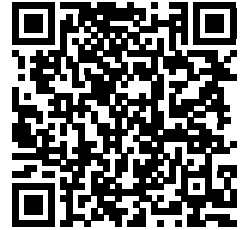


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