Overview of Cells :

Definition: Cells are the basic structural, functional, and biological units of all living organisms. They are often referred to as the building blocks of lifebecause they are the smallest units capable of performing all life processes.

- **Discovery**: The term "cell" was coined by Robert Hooke in 1665 when heobserved cork cells under a microscope and noted their resemblance to small rooms or "cells."
- **Study**: The study of cells is known as Cytology, a branch of biology thatexamines cell structure, function, and behavior.

- **Contributors**:
  - **Robert Hooke**: Introduced the term "cell" in his work "Micrographia,"which described the microscopic structures he observed.
  - **Robert Brown**: Discovered the cell nucleus in 1831, noting its centralrole in the cell's structure.

Cell Theory :

- **Founders**: The Cell Theory was developed by Theodor Schwann, MatthiasSchleiden, and Rudolf Virchow in the 19th century.

- **Principles**:
  - **All living organisms are composed of cells**: This principle asserts that cells are the fundamental building blocks of all life forms, from single-celled organisms to complex multicellular entities.
  - **A cell is the basic unit of life**: Cells are the smallest units that exhibit all characteristics of life, including metabolism, growth, and reproduction.
  - **All cells arise from pre-existing cells**: This principle emphasizes that new cells are produced by the division of existing cells, highlighting the continuity of life.

- **Modern Version**:
  - **Energy flows within cells**: Cells are dynamic environments whereenergy is transferred and utilized through metabolic processes andcellular activities.
  - **Genetic information is passed from one cell to another**: Hereditary information is transmitted through DNA during cell division, ensuring the continuity of genetic traits.
  - **All cells have a similar chemical composition**: Despite diversity in cell types, all cells share a common set of biochemical components, including proteins, lipids, carbohydrates, and nucleic acids.

Types of Cells :

1. **Prokaryotic Cells**

- **Characteristics**:
  - **Primitive, underdeveloped cells**: These cells lack a well-defined nucleus and membrane-bound organelles, making them simpler in structure compared to eukaryotic cells.
  - **Found in unicellular organisms**: Examples include bacteria, blue-green algae (cyanobacteria), and mycoplasma.
  - **Generally small (0.1-5 µm)**: Prokaryotic cells are typicallysmaller than eukaryotic cells, reflecting their simpler organization.
  - **Lack a well-defined nucleus**: The genetic material is located ina nucleoid region rather than a membrane-bound nucleus.
  - **Absence of membrane-bound organelles**: Prokaryotic cells donot have organelles such as mitochondria or chloroplasts.
  - **Contains a single chromosome**: Prokaryotic cells have a singlecircular chromosome.
  - **Cell division by fission or budding**: Reproduction occurs through binary fission or budding, processes that do not involvemitosis.
  - **Mitochondria are absent**: Prokaryotic cells lack mitochondria, and energy production occurs across the cell membrane.

2. **Eukaryotic Cells**

- **Characteristics**:
  - **Complete, developed cells**: Eukaryotic cells have a complexstructure with a well-defined nucleus and membrane-boundorganelles.
  - **Found in unicellular and multicellular organisms**: Examplesinclude plants, animals, fungi, and protists.
  - **Generally large (>5 µm)**: Eukaryotic cells are usually larger than prokaryotic cells, reflecting their more complex internal organization.
  - **Presence of a well-defined nucleus**: The nucleus, enclosed by a nuclear membrane, contains the cell's genetic material.
  - **Presence of membrane-bound organelles**: Eukaryotic cells have organelles such as mitochondria, endoplasmic reticulum,Golgi apparatus, and lysosomes.
  - **Multiple chromosomes**: Eukaryotic cells have multiple linearchromosomes organized within the nucleus.
  - **Cell division by mitosis or meiosis**: Eukaryotic cells divide through mitosis for growth and repair or meiosis for sexualreproduction.

- **Mitochondria are present**: Mitochondria, the energy-producing organelles, are found in eukaryotic cells.

Prokaryotic Cells	Eukaryotic Cells
These are primitive cells (under developed).	These are complete cells (developed).
Found only in Unicellular organisms	Found in both - Unicellular A Multicellular
Size of the cell is generally small. (0.1-5 um).	Size of cell is generally large (> 5 um).
Lack a well-defined nucleus.	Nucleus is present
Membrane bound cell organelles areabsent.	Membrane bound cell organelles are present.
It contains only one chromosome.	It contains more than one chromosome.
Cell division takes place by fission orbudding.	Cell division by mitosis or meiosis.
Mitochondria is absent.	Mitochondria is present.
Bacteria, blue-green algae, mycoplasma, etc.	plants, animals, fungi, etc.

Cell Structures :

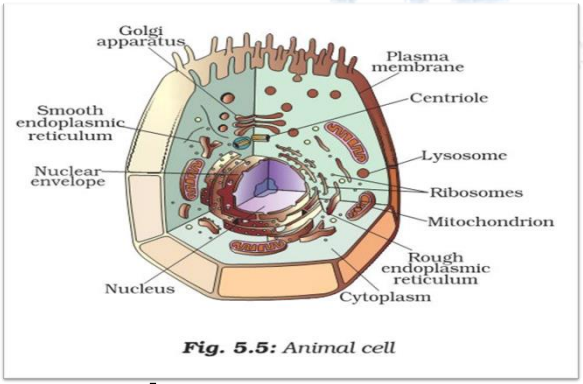


Fig. 5.5: Animal cell

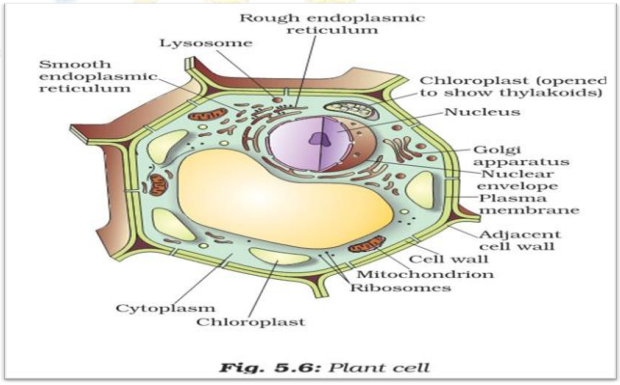


Fig. 5.6: Plant cell

1. **Cell Wall**
   - **Location**: Present only in plant cells, some fungi, and bacteria.
   - **Composition**: Composed primarily of cellulose in plants, chitin in fungi, and peptidoglycan in bacteria.
   - **Function**: Provides structural support, shape, and rigidity to the cell; freely permeable to water and nutrients.

2. **Cell Membrane**
   - **Also Called**: Plasma membrane.
   - **Location**: Present in both animal and plant cells.
   - **Composition**: Composed of a phospholipid bilayer with embedded proteins; thin, elastic, and double-layered.
   - **Function**: Acts as a selectively permeable barrier that regulates the movement of substances into and out of the cell.

3. **Protoplasm**
   - **Definition**: The living substance within the cell, excluding the cell wall.

   Types
   - **Cytoplasm**: The gel-like fluid outside the nucleus that contains organelles and other cellular components.
   - **Nucleoplasm**: The semi-fluid substance within the nucleus that contains the genetic material and nucleolus.

4. **Mitochondria**
   - **Also Called**: Powerhouse of the cell.
   - **Characteristics**: Surrounded by a double-membrane structure; the inner membrane folds into cristae; contains its own DNA.
   - **Function**: Produces ATP (adenosine triphosphate), the primary energy carrier in cells; involved in cellular respiration.

5. **Golgi Bodies**
   - **Function**: Acts as the cell's packaging and distribution center; processes and modifies proteins and lipids from the ER; synthesizes lysosomes.
   - **Location in Plants**: More numerous and known as dictyosomes; involved in the transport and modification of cellular materials.

6. **Lysosomes :**
   - **Characteristics**: Membrane-bound sac-like structures containing digestive enzymes.
   - **Function**: Facilitates intracellular digestion by breaking down waste materials and cellular debris; also referred to as "suicidal bags" due to their role in apoptosis (programmed cell death).
   - **Note**: Lysosomes are absent in mammalian red blood cells.

7. **Plastids**
   - **Location**: Found exclusively in plant cells and some algae.
   - **Types**:
   - **Chloroplasts**: Known as the "kitchen of the cell," responsible forphotosynthesis; contain chlorophyll and other pigments.
   - **Chromoplasts**: Contain pigments like carotene (orange) andlycopene (red); responsible for color in fruits and flowers.
   - **Leucoplasts**: Colorless plastids found in roots; specialized instoring starch, oils, and proteins.

8. **Vacuoles**
   - **Characteristics**: Fluid-filled organelles bounded by a single membrane; can vary in size.
   - **Function**: Stores nutrients, waste products, and toxic substances; plays a role in maintaining turgor pressure and osmoregulation.
   - **Size**: Typically larger in plant cells; smaller in animal cells.

9. **Endoplasmic Reticulum (ER)**
   - **Structure**: A complex network of membranous tubules and sacs extending throughout the cytoplasm; continuous with the nuclearenvelope.
   - **Function**: Facilitates the synthesis, folding, modification, andtransport of proteins and lipids.

   Types:
   - **Smooth ER**: Lacks ribosomes; involved in lipid synthesis, metabolism, and detoxification.
   - **Rough ER**: Studded with ribosomes; primarily involved in protein synthesis and processing.

10. **Ribosomes**
    - **Characteristics**: Composed of ribonucleic acid (RNA) and proteins; can be found as free ribosomes or attached to the rough ER.
    - **Function**: Synthesizes proteins by translating mRNA into polypeptides; ofien referred to as the "factory of proteins."
    - **Types**:
    - **80S Ribosomes**: Found in eukaryotic cells; larger and morecomplex.
    - **70S Ribosomes**: Found in prokaryotic cells; smaller andsimpler.

11. **Nucleus**
    - **Also Called**: Control room of the cell.
    - **Characteristics**: Enclosed by a double-membraned nuclear envelope; contains chromatin and nucleolus.
    - **Function**: Regulates all cellular activities, including growth, metabolism, and reproduction; houses genetic material (DNA andRNA).
    - **Parts**:
    - **Nuclear Membrane**: Double-layered membrane that separatesthe nucleus from the cytoplasm.
    - **Chromatin**: Complex of DNA and histone proteins; visible aschromosomes during cell division.
    - **Nucleolus**: Dense structure within the nucleus involved in ribosomal RNA (rRNA) synthesis and ribosome assembly.
    - **Nucleoplasm**: Semi-fluid substance within the nucleus.

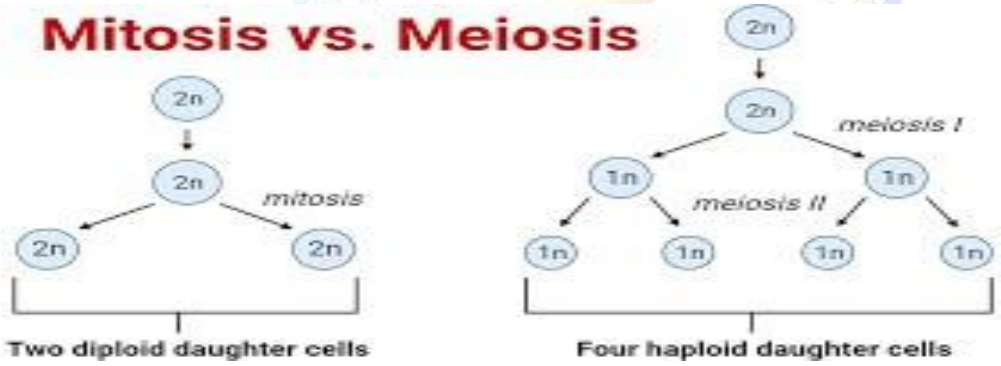
12. **Centrosome**
    - **Location**: Present only in animal cells.
    - **Characteristics**: Non-membrane-bound structure composed of a pairof centrioles.
    - **Function**: Organizes microtubules and facilitates cell division byforming the mitotic spindle.

13. **Chromosomes**
    - **Characteristics**: Thread-like structures composed of DNA and associated proteins; become visible as distinct rod-shaped structuresduring cell division.
    - **Function**: Carry genetic information necessary for inheritance;functional segments of DNA are called genes, which encode for specific traits.

Difference between Plant Cell and Animal Cell

Plant cell	Animal cell
Having fixed shape	Having irregular shape
Larger in size	Smaller in size
Cell wall is present	Absent
Plastids are present	Absent
Vacuoles are of larger size	Smaller size
Food stored in the form of starch	Glycogen
Centrosome is absent	Present

Cell Division



1. **Mitosis**
   - **Definition**: Mitosis is a type of cell division that produces two genetically identical daughter cells, each with the same number ofchromosomes as the parent cell.
   - **Purpose**: Facilitates growth, tissue repair, and asexual reproduction inorganisms.

Stages:

- **Prophase**: Chromatin condenses into visible chromosomes;spindle fibers form; nuclear envelope breaks down.
- **Metaphase**: Chromosomes align at the cell's equatorial plane;spindle fibers attach to centromeres.
- **Anaphase**: Chromatids are pulled apart toward opposite polesof the cell.

- **Telophase**: Chromatids reach the poles; nuclear envelopesreform around each set of chromosomes; chromosomes decondense.
- **Cytokinesis**: Division of the cytoplasm, resulting in two distinctdaughter cells.
  - **Outcome**: Two genetically identical diploid cells with the samechromosome number as the original cell.

2. **Meiosis**
   - **Definition**: Meiosis is a specialized type of cell division that reduces the chromosome number by half, resulting in four genetically diversehaploid daughter cells.
   - **Purpose**: Essential for sexual reproduction, producing gametes (spermand eggs) with genetic variation.
   - **Stages**:

Meiosis I:

- **Prophase I**: Homologous chromosomes pair up andexchange genetic material through crossing-over.
- **Metaphase I**: Homologous chromosome pairs align at thecell's equatorial plane.
- **Anaphase I**: Homologous chromosomes are separated and pulled toward opposite poles.
- **Telophase I**: Chromosomes reach the poles; nuclearenvelopes may reform; cell divides into two.

Meiosis II:

- **Prophase II**: Chromosomes condense; spindle fibersform in each of the two daughter cells.
- **Metaphase II**: Chromosomes align at the equatorial planeof each cell.
- **Anaphase II**: Sister chromatids are separated and movedto opposite poles.
- **Telophase II**: Chromatids reach the poles; nuclearenvelopes reform; cells divide into four.
  - **Outcome**: Four genetically diverse haploid cells, each with half the chromosome number of the original cell.