Chapter 8: Cell - The Unit of Life

Comprehensive Study Notes
Class 11 Biology - NCERT Based
EXAM SPRINT - Complete Coverage for NEET and Board Examinations

Introduction

Cell is the fundamental structural and functional unit of all living organisms. All organisms are composed of cells - some unicellular, others multicellular. The cell is the basic unit that distinguishes living from non-living things.

Historical Development

- **Antonie van Leeuwenhoek**: First observed live cells
- **Robert Brown**: Discovered the nucleus
- **Matthias Schleiden (1838)**: German botanist who observed that all plants are composed of cells
- **Theodore Schwann (1839)**: German zoologist who studied animal cells and discovered plasma membrane
- **Rudolf Virchow (1855)**: Proposed "Omnis cellula-e cellula" (all cells arise from pre-existing cells)

8.1 CELL THEORY

Modern Cell Theory States:

1. All living organisms are composed of cells and products of cells
2. All cells arise from pre-existing cells

8.2 OVERVIEW OF CELL TYPES

Based on Nuclear Organization:

Prokaryotic Cells:

- Lack membrane-bound nucleus
- Genetic material lies freely in cytoplasm
- Examples: Bacteria, blue-green algae, mycoplasma, PPLO

Eukaryotic Cells:

- Have membrane-bound nucleus
- Well-organized internal structures
- Examples: Plants, animals, fungi, protists

Cell Size and Shape:

- **Size range**: 0.3 µm (Mycoplasma) to several meters (ostrich egg)
- **Human RBC**: ~7.0 µm diameter
- **Shapes**: Disc-like, polygonal, columnar, cuboid, thread-like, irregular

8.3 PROKARYOTIC CELLS

General Characteristics:

- Smaller than eukaryotic cells
- Multiply rapidly
- Four basic bacterial shapes:
  - **Bacillus**: Rod-like
  - **Coccus**: Spherical

- **Vibrio**: Comma-shaped
- **Spirillum**: Spiral

Cell Structure:

- **Cell wall**: Present (except in Mycoplasma)
- **Cell membrane**: Semi-permeable barrier
- **Cytoplasm**: Semi-fluid matrix
- **Genetic material**: Naked DNA (nucleoid)
- **Plasmids**: Small circular DNA molecules
- **Ribosomes**: 70S type (50S + 30S subunits)

8.3.1 Cell Envelope

Three-layered structure:

1. **Glycocalyx** (outermost)
   - Loose sheath (slime layer) or thick capsule
2. **Cell Wall** (middle)
   - Determines cell shape
   - Provides structural support
3. **Plasma Membrane** (innermost)
   - Selectively permeable
   - Similar to eukaryotic membrane

Gram Staining:

- **Gram Positive**: Take up gram stain
- **Gram Negative**: Do not take up gram stain

8.3.2 Special Structures

Mesosomes:

- Infoldings of plasma membrane
- Functions:
  - Cell wall formation
  - DNA replication and distribution
  - Respiration
  - Increase surface area

Motility Structures:

- **Flagella**: Thin filamentous extensions for movement
  - Parts: Filament, hook, basal body
- **Pili**: Tubular structures (protein)
- **Fimbriae**: Small bristle-like fibers for attachment

Inclusion Bodies:

- Reserve materials stored in cytoplasm
- Not membrane-bound
- Examples: Phosphate granules, cyanophycean granules, glycogen granules
- **Gas vacuoles**: Found in photosynthetic bacteria

8.4 EUKARYOTIC CELLS

General Features:

- Extensive compartmentalization

- Organized nucleus with nuclear envelope
- Complex locomotory structures
- Organized chromosomes

Differences Between Plant and Animal Cells:

Feature	Plant Cells	Animal Cells
Cell Wall	Present	Absent
Plastids	Present	Absent
Large Vacuole	Present	Absent
Centrioles	Absent (mostly)	Present

8.5 CELL ORGANELLES

8.5.1 Cell Membrane (Plasma Membrane)

Composition:

- **Lipids**: Mainly phospholipids in bilayer arrangement
- **Proteins**: Integral and peripheral
- **Cholesterol**: In animal cells
- **Carbohydrates**: Glycoproteins and glycolipids

Structure - Fluid Mosaic Model (Singer & Nicolson, 1972):

- Phospholipid bilayer with embedded proteins
- Quasi-fluid nature allows lateral movement
- Polar heads outward, hydrophobic tails inward

Functions:

- **Transport mechanisms**:
  - **Passive Transport**: No energy required
    - Simple diffusion
    - Osmosis (water movement)
    - Facilitated diffusion (carrier proteins)
  - **Active Transport**: Energy required (ATP)
    - Against concentration gradient
    - Example: Na^+/K^+ pump

8.5.2 Cell Wall

Composition by Organism Type:

- **Plants**: Cellulose, hemicellulose, pectins, proteins
- **Algae**: Cellulose, galactans, mannans, calcium carbonate
- **Fungi**: Chitin

Structure:

- **Primary wall**: Young, growing cells
- **Secondary wall**: Mature cells (inner side)
- **Middle lamella**: Calcium pectate, holds adjacent cells
- **Plasmodesmata**: Connect cytoplasm of neighboring cells

Functions:

- Provides shape and protection
- Cell-to-cell interaction
- Barrier to undesirable molecules

8.5.3 Endomembrane System

Components: ER, Golgi complex, lysosomes, vacuoles
(Mitochondria, chloroplasts, peroxisomes excluded due to independent functions)

8.5.3.1 Endoplasmic Reticulum (ER)

Types:

- **Rough ER (RER)**:
  - Bears ribosomes
  - Protein synthesis and secretion
  - Continuous with nuclear membrane
- **Smooth ER (SER)**:
  - No ribosomes
  - Lipid synthesis
  - Steroid hormone synthesis (animals)

Functions:

- Divides cell into luminal and extra-luminal compartments
- Transport of materials
- Synthesis of proteins and lipids

8.5.3.2 Golgi Apparatus

Structure:

- Flattened, disc-shaped sacs (cisternae)
- Diameter: 0.5-1.0 µm

- **Cis face**: Forming face (convex)
- **Trans face**: Maturing face (concave)

Functions:

- Packaging of materials
- Modification of proteins from ER
- Formation of glycoproteins and glycolipids
- Secretion

8.5.3.3 Lysosomes

Characteristics:

- Membrane-bound vesicles from Golgi
- Rich in hydrolytic enzymes (hydrolases)
- Optimally active at acidic pH

Enzymes present:

- Lipases, proteases, carbohydrases
- Digest carbohydrates, proteins, lipids, nucleic acids

8.5.3.4 Vacuoles

Plant Cell Vacuoles:

- Can occupy up to 90% cell volume
- Bounded by tonoplast (single membrane)
- Transport ions against concentration gradient

Functions in different organisms:

- **Amoeba**: Contractile vacuole for osmoregulation
- **Protists**: Food vacuoles for digestion

8.5.4 Mitochondria

Structure:

- Double membrane-bound
- Size: 0.2-1.0 µm diameter, 1.0-4.1 µm length
- **Outer membrane**: Smooth, continuous boundary
- **Inner membrane**: Forms cristae (infoldings)
- **Matrix**: Dense substance in inner compartment

Functions:

- Aerobic respiration
- ATP production ("Powerhouse of cell")
- Contains own DNA, RNA, ribosomes (70S)
- Divide by fission

8.5.5 Plastids

Types based on pigments:

Chloroplasts (Green plastids)

Structure:

- Double membrane-bound
- Size: 5-10 µm length, 2-4 µm width

- **Stroma**: Inner space with enzymes
- **Thylakoids**: Flattened sacs containing chlorophyll
- **Grana**: Stacks of thylakoids
- **Stroma lamellae**: Connect different grana

Functions:

- Photosynthesis
- Contains own DNA, RNA, ribosomes (70S)

Chromoplasts (Colored plastids)

- Contain carotenoids (carotene, xanthophylls)
- Give yellow, orange, red colors

Leucoplasts (Colorless plastids)

- **Amyloplasts**: Store starch
- **Elaioplasts**: Store oils and fats
- **Aleuroplasts**: Store proteins

8.5.6 Ribosomes

Types:

- **Eukaryotic**: 80S (60S + 40S subunits)
- **Prokaryotic**: 70S (50S + 30S subunits)

Composition:

- RNA and proteins
- Not membrane-bound

Location:

- Free in cytoplasm
- Attached to ER (rough ER)
- Inside chloroplasts and mitochondria

Function:

- Protein synthesis
- Form polyribosomes (polysomes) on single mRNA

8.5.7 Cytoskeleton

Components:

- **Microtubules**: Largest filaments
- **Microfilaments**: Smallest filaments
- **Intermediate filaments**: Medium-sized

Functions:

- Mechanical support
- Cell motility
- Maintain cell shape

8.5.8 Cilia and Flagella

Structure:

- Covered by plasma membrane
- **Axoneme**: Core with microtubules

- **9+2 arrangement**: 9 peripheral doublets + 2 central microtubules
- Connected by radial spokes and linkers

Differences:

- **Cilia**: Short, numerous, oar-like movement
- **Flagella**: Long, few, whip-like movement

Origin:

- Emerge from basal bodies (centriole-like structures)

8.5.9 Centrosome and Centrioles

Structure:

- Two cylindrical centrioles perpendicular to each other
- **9+0 arrangement**: 9 peripheral triplets, no central microtubules
- Surrounded by pericentriolar material

Functions:

- Form basal bodies of cilia/flagella
- Form spindle apparatus during cell division

8.5.10 Nucleus

Structure:

- **Nuclear envelope**: Double membrane with nuclear pores
- **Perinuclear space**: 10-50 nm gap between membranes
- **Nucleoplasm**: Nuclear matrix

- **Nucleolus**: Site of rRNA synthesis
- **Chromatin**: DNA + histone proteins

Nuclear Pores:

- Allow movement of RNA and proteins
- Bidirectional transport between nucleus and cytoplasm

Chromosome Types (based on centromere position):

- **Metacentric**: Middle centromere, equal arms
- **Sub-metacentric**: Slightly off-center, unequal arms
- **Acrocentric**: Near one end, very unequal arms
- **Telocentric**: Terminal centromere

Chromosome Parts:

- **Centromere**: Primary constriction
- **Kinetochore**: Disc-shaped structures at centromere
- **Satellite**: Small fragment from secondary constriction

8.5.11 Microbodies

Characteristics:

- Membrane-bound vesicles
- Contain various enzymes
- Present in both plant and animal cells

NEET-Specific Important Points

High-Yield Topics for NEET:

1. **Cell Theory and History**
2. **Prokaryotic vs Eukaryotic differences**
3. **Cell membrane structure and transport**
4. **Organelle functions and characteristics**
5. **Ribosome types and sizes**
6. **Chromosome classification**

Common NEET Question Patterns:

1. **Identification Questions**:
   - Organelle functions
   - Cell types based on features
   - Ribosome sizes
2. **Comparison Questions**:
   - Prokaryotic vs Eukaryotic
   - Plant vs Animal cells
   - Different organelles
3. **Structure-Function Correlation**:
   - Membrane transport mechanisms
   - Organelle specializations

Memory Aids and Mnemonics

Cell Theory Scientists: "**S**chleiden **S**tudied **V**egetation"

- **S**chleiden (plants)
- **S**chwann (animals)
- **V**irchow (cell division)

Ribosome Sizes: "**P**rokaryotes **S**eventy, **E**ukaryotes **E**ighty"

- **P**rokaryotic: **70S**
- **E**ukaryotic: **80S**

Chromosome Types: "**M**y **S**ister **A**lways **T**eases"

- **M**etacentric
- **S**ub-metacentric
- **A**crocentric
- **T**elocentric

Endomembrane System: "**E**very **G**irl **L**oves **V**acations"

- **E**R (Endoplasmic Reticulum)
- **G**olgi apparatus
- **L**ysosomes
- **V**acuoles

Practice Questions for NEET

Multiple Choice Questions:

1. Which of the following is NOT correct about cell theory? a) All cells arise from pre-existing cells b) All living organisms are made of cells c) Robert Brown formulated the cell theory d) Cell is the basic unit of life

2. 70S ribosomes are found in: a) Eukaryotic cells only b) Prokaryotic cells only c) Both prokaryotic and eukaryotic cells d) Neither prokaryotic nor eukaryotic cells
3. The fluid mosaic model was proposed by: a) Schleiden and Schwann b) Singer and Nicolson c) Watson and Crick d) Brown and Virchow

Short Answer Questions:

1. Differentiate between rough and smooth endoplasmic reticulum.
2. What is the significance of 9+2 arrangement in cilia and flagella?
3. Why are mitochondria called the powerhouse of the cell?

Long Answer Questions:

1. Describe the structure and function of the nucleus.
2. Compare prokaryotic and eukaryotic cells with suitable examples.
3. Explain the fluid mosaic model of plasma membrane.

Summary Table: Prokaryotic vs Eukaryotic Cells

Feature	Prokaryotic	Eukaryotic
Nuclear membrane	Absent	Present
Nucleus	Not well defined	Well defined
Genetic material	Naked DNA	DNA with histones
Ribosomes	70S	80S
Organelles	Few, non-membrane bound	Many, membrane bound
Cell wall	Usually present	Present in plants/fungi
Size	Generally smaller	Generally larger
Example	Bacteria, Archaea	Plants, Animals, Fungi

Comparative Organelle Functions

Organelle	Primary Function	Key Feature
Nucleus	Control center, heredity	Contains DNA
Mitochondria	Energy production	Double membrane, cristae
Chloroplast	Photosynthesis	Thylakoids, grana
ER	Transport, synthesis	Rough (proteins), Smooth (lipids)
Golgi	Packaging, modification	Cis and trans faces
Ribosomes	Protein synthesis	70S (prokaryotes), 80S (eukaryotes)
Lysosomes	Digestion	Hydrolytic enzymes
Vacuoles	Storage, support	Large in plants

Key Transport Mechanisms

Type	Energy Required	Direction	Examples
Simple Diffusion	No	High → Low concentration	O_2, CO_2
Facilitated Diffusion	No	High → Low concentration	Glucose via carriers
Osmosis	No	High → Low water potential	Water movement
Active Transport	Yes (ATP)	Low → High concentration	Na^+/K^+ pump

EXAM SPRINT - Master Cell Biology with focused study on organelle functions, transport mechanisms, and comparative features. Practice identifying structures and understanding their functional significance for NEET success.