

Chapter 4: Cells and Tissues

Comprehensive Master Presentation Notes for Secondary Education
Excellence

 Microscopy & Theory  Organellar Dynamics  Membrane Transport  Plant & Animal Histology

Milestone History of Microscopy

1590

Compound Lens

Zacharias Janssen invented the initial compound microscope with $3\times$ to $9\times$ power.

1665

Robert Hooke

Examined cork slices, observed honey-comb dead walls, and coined the term "**cell**".

1670–1683

Leeuwenhoek

Built advanced single-lens microscopes, discovering live cells "**animalcules**".

Light (LM) vs. Electron Microscope (EM)

💡 Light Microscope (LM)

- ✓ **Illumination:** Visible light waves ($\lambda \approx 400\text{--}700\text{ nm}$).
- ✓ **Magnification:** Up to $\sim 1500\times$ ceiling.
- ✓ **Resolution:** Resolves down to $\sim 200\text{ nm}$.
- ✓ **Specimens:** Capable of viewing live, unstained cells.

⚡ Electron Microscope (EM)

- ✓ **Illumination:** High-velocity electron beam ($\lambda < 1\text{ nm}$).
- ✓ **Magnification:** Ultra-high exceeding $250,000\times$.
- ✓ **Resolution:** Resolves down to $\sim 0.2\text{ nm}$ ($2\text{ \AA}$).
- ✓ **Specialized Types:** SEM (3D surface) & TEM (internal ultrastructure).

Note: TEM requires rigorous vacuum–dehydrated and metal–coated ultrathin section specimens.

The Cell Theory & Exceptions

Core Postulates (Schleiden, Schwann, Virchow)

1. All living organisms consist of one or more cells.
2. The cell is the basic structural and functional unit of life.
3. All cells originate from pre-existing cells (*Omnis cellula e cellula*).
4. Hereditary information (DNA) is passed down across divisions.

⚠ Acellular Exceptions

Viruses, Prions, and Viroids lack true cellular organization, metabolism, and membranes outside a host.

They are classified as biological entities due to genetic replication and mutation capabilities.

Formulated initially in 1838–1839 and expanded in 1855.

Prokaryotes vs. Eukaryotes

Prokaryotes

Size: Tiny ($1\text{--}10\ \mu\text{m}$).

Nucleus: Nucleoid region, no true envelope; single circular DNA without histones.

Organelles: Completely devoid of membrane-bound compartments.

Ribosomes: Smaller sedimentation rate (70S).

Wall: Rigid peptidoglycan murein layer.

Eukaryotes

Size: Larger ($10\text{--}1000\ \mu\text{m}$).

Nucleus: True membrane-bound nucleus with linear chromosomes & histones.

Organelles: Abundant compartments (mitochondria, ER, Golgi, chloroplasts).

Ribosomes: Larger (80S) in cytoplasm/RER.

Wall: Cellulose in plants, chitin in fungi, absent in animals.

Example organisms: Bacteria and Cyanobacteria (Prokaryotes); Fungi, Plants, and Animals (Eukaryotes).

Subcellular Organelles & Functions

Mitochondria

Powerhouse of the cell; inner folds called **cristae** drive aerobic respiration and ATP synthesis.

Endoplasmic Reticulum

Rough ER (RER) synthesizes proteins; **Smooth ER (SER)** handles lipid synthesis and detoxification.

Golgi Apparatus

Stack of cisternae modifying, sorting, and packaging proteins/lipids for internal delivery or export.

Lysosomes & Plastids

Vesicles containing acidic hydrolytic enzymes; plant plastids drive photosynthesis and storage.

Organelles operate in integrated harmony to sustain cellular homeostasis.

The Fluid Mosaic Model (1972)

Phospholipid Bilayer

Amphipathic structure featuring polar, hydrophilic heads facing aqueous environments and nonpolar, hydrophobic fatty acid tails sandwiched in the core.

Membrane Proteins & Lipids

Integral Proteins: Span membrane for polar solute transport.

Peripheral Proteins: Bound to surfaces for structural/enzymatic roles.

Cholesterol: Modulates animal membrane fluidity across temperatures.

Proposed by S.J. Singer and G.L. Nicolson, incorporating glycolipids and glycoproteins for recognition.

Passive Transport Mechanisms

Simple Diffusion

Random thermal movement of small, nonpolar molecules (O_2 , CO_2) directly across the lipid bilayer down concentration gradient.

Facilitated Diffusion

Passive transport of polar or ionic molecules aided by specific transmembrane carrier or channel proteins.

Osmosis

Net passive movement of water from higher water potential (hypotonic) to lower water potential (hypertonic).

Key Characteristic: Downhill transport requiring zero metabolic energy (ATP).

Active & Bulk Transport Mechanics

Active Transport

Movement of solutes **against** their electrochemical gradient (low to high).

Requires ATP and specialized transport pumps (e.g., Na^+/K^+ pump).

Bulk Transport (Vesicular)

Endocytosis: Infolding for ingestion (Phagocytosis & Pinocytosis).

Exocytosis: Fusion of vesicles to expel waste or hormones.

Essential for maintaining ion gradients and exporting macromolecular secretions.

Why Are Cells So Small?

High SA:V

Small cell size maximizes effective nutrient exchange and waste elimination.

Cubic Volume Increase ($V \propto r^3$)

As a cell grows, internal metabolic volume expands exponentially faster than its surface area.

Quadratic Area Increase ($\text{SA} \propto r^2$)

Low $\text{SA}:V$ ratios restrict rapid diffusion into the center, forcing cells to remain microscopic.

Organization of Plant Tissues

Meristematic Tissues

Actively dividing undifferentiated cells driving growth:

Apical Meristems: Root and shoot tips (primary growth/length).

Lateral Meristems: Vascular & cork cambium (secondary growth/girth).

Permanent Tissues

Differentiated cells performing specialized tasks:

Simple: Parenchyma, Collenchyma, Sclerenchyma.

Complex: Xylem (water transport) & Phloem (food transport).

Primary Animal Tissue Categories

Epithelial

Covers surfaces and lines internal cavities (squamous, cuboidal, columnar).

Connective

Binds and supports tissues with extracellular matrix (bone, cartilage, blood).

Muscular

Specialized for movement (skeletal, smooth, and cardiac muscle fibers).

Nervous

Composed of neurons and neuroglia for rapid electrochemical signaling.