

Introduction to biochemistry

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What is Biochemistry?

- Biochemistry is the branch of science that explores the chemical processes and substances occurring within living organisms.
- It serves as a bridge between biology and chemistry, aiming to understand life at the molecular level.

Scope and Importance

- Biochemistry helps explain how biological molecules give rise to the processes that occur within and between living cells.
- It plays a critical role in fields such as medicine, genetics, agriculture, and biotechnology.

Key Areas of Study in Biochemistry:



Structure and
Function



Metabolism



Enzymology



Genetics and
Molecular
Biology



Signal
Transduction

A. Structure and Function of Biomolecules

- Study of essential biological molecules including:
 - **Proteins** – enzymes, structural components, signaling molecules.
 - **Carbohydrates** – energy storage and structural functions.
 - **Lipids** – membrane components and energy storage.
 - **Nucleic Acids (DNA & RNA)** – genetic material and information transfer.

B. Metabolism

- Investigation of chemical reactions that sustain life, including:
 - Energy production (catabolism)
 - Synthesis of biomolecules (anabolism)

C. Enzymology

- Study of enzymes, their mechanisms, structure, kinetics, and regulation in catalyzing biochemical reactions.

D. Genetics and Molecular Biology

- Examination of:
 - DNA and RNA structures
 - Gene expression and regulation
 - Molecular mechanisms of inheritance

E. Signal Transduction and Cellular Communication

- Understanding how cells detect, process, and respond to signals, enabling regulation and coordination of cellular activities.

Scope of Biochemistry in Pharmacy

Biochemistry plays a crucial role in pharmacy and pharmaceutical sciences.

A. Drug Design and Development:

- Biochemistry helps in understanding how drugs interact with biological molecules (like enzymes, receptors, DNA).
- Structure-activity relationships (SAR) are derived using biochemical knowledge.

B. Pharmacodynamics and Pharmacokinetics:

- **Pharmacodynamics:** What the drug does to the body — involves understanding biochemical pathways.
- **Pharmacokinetics:** What the body does to the drug — involves metabolism, which is deeply rooted in biochemical processes (e.g., liver enzyme activity).

C. Enzyme Inhibition:

- Many drugs act by **inhibiting specific enzymes** (e.g., ACE inhibitors for hypertension).
- Understanding enzyme kinetics is essential in drug development.

D. Disease Mechanisms:

- Biochemistry helps understand **pathophysiology** — how diseases alter biochemical pathways (e.g., diabetes, cancer).
- This knowledge aids in designing targeted therapies.

E. Clinical Biochemistry:

- Laboratory tests based on biochemical markers are used for **diagnosis, monitoring, and prognosis** of diseases.
- Example: Blood glucose, cholesterol levels, liver and kidney function tests.

F. Biotechnology and Molecular Pharmacology:

- Involves genetic engineering, recombinant DNA technology, and biopharmaceuticals.
- Biochemistry is the foundation for understanding and applying these techniques.

Cell and Its Biochemical Organization

- The **cell** is the **basic structural and functional unit** of life. A clear understanding of cellular organization is essential to appreciate how biochemical reactions occur in different compartments.

Types of Cells:



- Prokaryotic cells:** Simple structure, no nucleus (e.g., bacteria).
- Eukaryotic cells:** Complex structure, with nucleus and membrane-bound organelles (e.g., human cells).

Major Components of a Eukaryotic Cell:

Organelle	Structure & Function	Biochemical Significance
Plasma Membrane	Phospholipid bilayer with embedded proteins	Regulates transport, signal transduction
Nucleus	Contains DNA	Site of transcription (DNA → RNA)
Mitochondria	Double membrane, has its own DNA	Site of ATP production (aerobic respiration)
Endoplasmic Reticulum (ER)	Smooth & rough (with ribosomes)	Protein and lipid synthesis
Golgi Apparatus	Stacked membranous sacs	Modifies, sorts, packages proteins
Lysosomes	Membrane-bound vesicles	Contains digestive enzymes (autophagy, apoptosis)
Ribosomes	RNA and protein	Site of protein synthesis
Cytoplasm	Gel-like fluid	Contains enzymes for metabolic reactions

Biochemical Processes in the Cell:

- Glycolysis** in cytoplasm.
- Krebs cycle** and **oxidative phosphorylation** in mitochondria.

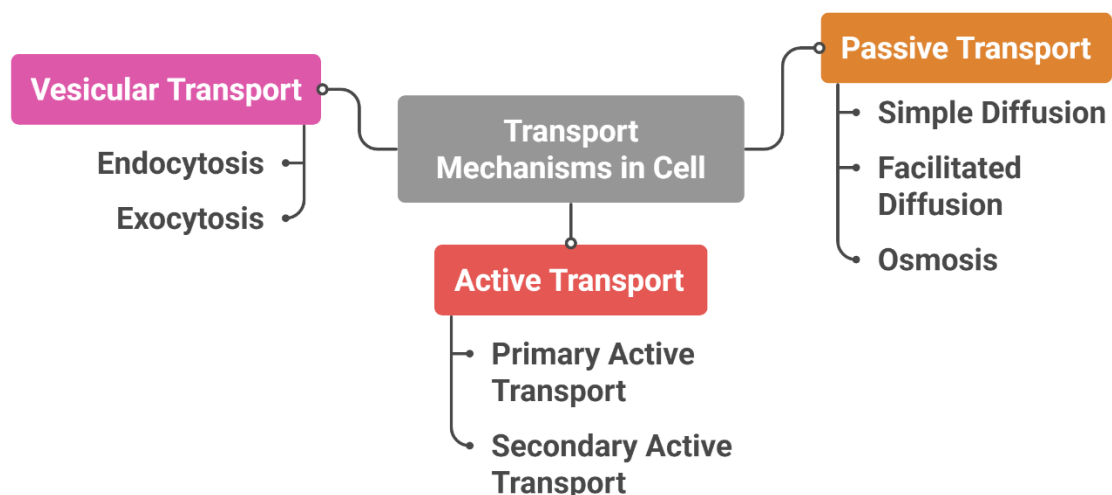
- **Protein synthesis** on ribosomes (cytoplasmic or attached to ER).
- **DNA replication** and **RNA transcription** in nucleus.
- **Detoxification** in smooth ER (especially in liver cells).

Transport Processes Across Cell Membranes

Importance of Membrane Transport

- Transport across the cell membrane is essential for:
 - Nutrient uptake
 - Waste removal
 - Ion balance and homeostasis
 - Signal transduction
 - Maintenance of electrochemical gradients

Types of Transport Mechanisms



A. Passive Transport (Does not require energy)

1. Simple Diffusion

- Movement of molecules from higher to lower concentration.
- Only small, non-polar molecules like O_2 , CO_2 , and N_2 can pass directly through the lipid bilayer.

2. Facilitated Diffusion

- Involves transmembrane proteins (channels or carriers).
- Still follows the concentration gradient.
- Examples: Glucose transporter (GLUT), ion channels for Na^+ , K^+ , Cl^- .

3. Osmosis

- Diffusion of water through a semipermeable membrane.
- Driven by solute concentration differences (osmotic pressure).

B. Active Transport (Requires energy, typically ATP)

1. Primary Active Transport

- Direct use of ATP to move ions or molecules against their concentration gradient.
- Example: Na^+/K^+ ATPase pump which maintains the electrochemical gradient across the plasma membrane.

2. Secondary Active Transport

- Indirect use of energy; uses the electrochemical gradient created by primary active transport.
- Examples:
 - **Symport:** Both molecules move in the same direction (e.g., Na^+ /glucose symporter).
 - **Antiport:** Molecules move in opposite directions (e.g., Na^+/H^+ exchanger).

C. Vesicular Transport (Bulk Transport)

1. Endocytosis

- Uptake of material by invagination of the plasma membrane.
- Types:
 - **Phagocytosis:** Engulfing large particles like pathogens.
 - **Pinocytosis:** Uptake of extracellular fluid.
 - **Receptor-mediated endocytosis:** Selective uptake via receptor-ligand interaction (e.g., LDL uptake).

2. Exocytosis

- Release of substances from the cell by fusion of vesicles with the plasma membrane.
- Involved in secretion of hormones, neurotransmitters, and enzymes.

Regulation of Membrane Transport

- **Membrane potential** and **electrochemical gradients** control ion transport.
- **Hormonal regulation**, such as insulin-mediated translocation of GLUT4 in muscle and adipose cells.
- **Phosphorylation states** of transport proteins can influence their activity.
- **Intracellular pH and calcium levels** modulate transporter functions.



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