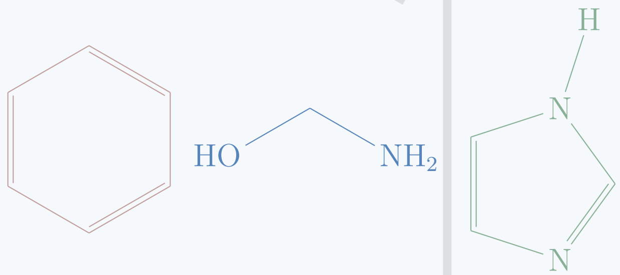
BIOCHEMISTRY
SUMMARY BOOK

Comprehensive Study Guide

Molecules • Pathways • Mechanisms



Proteins **Enzymes** **Metabolism**

DNA/RNA **Lipids**

Made by mResource

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Comprehensive Review & Study Material

Contents

1. Biomolecules

LECTURE 1: CARBOHYDRATES

KEY CONCEPT - Sources of Carbohydrates

Milk is the ONLY source of carbohydrates NOT derived from plants

Plant Storage:

- **Starch** - primary storage form
- Found in seeds, tubers, roots
- Energy reserve for plants

Animal Storage:

- **Glycogen** - animal starch
- Stored in muscles and liver
- Quick energy release

MONOSACCHARIDES - Simple Sugars

The building blocks of all carbohydrates

- **Glucose**
  - Most important monosaccharide
  - Present in ALL disaccharides
  - Blood sugar
- **Galactose**
  - Component of lactose
  - Found in milk products
- **Fructose**
  - Sweetest natural sugar
  - Found in fruits and honey
  - Component of sucrose
- **Ribose**
  - Nucleic acid sugar
  - Component of RNA
  - 5-carbon sugar (pentose)

DISACCHARIDES - Double Sugars

Two monosaccharides connected by glycosidic linkage

Glycosidic Linkage

Covalent bond between two monosaccharide units

Forms through dehydration synthesis (removal of water)

Sucrose
Glucose + Fructose
Sugar beets, Sugar cane
Table sugar

Lactose
Glucose + Galactose
Found in milk
Dairy products

Maltose
Glucose + Glucose
Germinating seeds
Malt sugar

POLYSACCHARIDES - Complex Carbohydrates

ALL polysaccharides are INSOLUBLE in water

Glycogen
Animal Storage
Stored in muscles and liver

Starch
Plant Storage
Potatoes, rice,Branched structure

Cellulose
Structural Support
Plant cell walls,Linear structure

LECTURE 2: CELL BIOLOGY

BIOLOGICAL ORGANIZATION HIERARCHY

Cells → Tissues → Organs → Organ Systems → Organism

Each level is more complex than the previous, with emergent properties

HISTORICAL TIMELINE - Discovery of Cells

Key scientists and their contributions to cell biology

Early Microscopy:

- **Hans Janssen** (1590s)
  - Invented compound microscope
  - Combined multiple lenses
- **Robert Hooke** (1665)
  - First used term "cell"
  - Observed cork plant tissue
- **Antonie van Leeuwenhoek** (1670s)
  - 200× magnification achieved
  - First to see living cells
  - Observed bacteria, sperm cells

Cell Theory Development:

- **Robert Brown** (1831)
  - Studied orchid plants
  - Discovered cell nucleus
  - Named the "nucleus"
- **Matthias Schleiden** (1838)
  - Plant tissues made of cells
  - All plants are cellular
- **Theodor Schwann** (1839)
  - Animal tissues are cellular
  - Started cell theory
- **Rudolf Virchow** (1855)
  - Cells come from existing cells
  - Completed cell theory

PROKARYOTES vs EUKARYOTES - Fundamental Cell Types

PROKARYOTES	EUKARYOTES
Nuclear Organization: No true nucleus DNA freely floating Circular DNA	**Nuclear Organization:** True membrane-bound nucleus DNA enclosed in nucleus Linear DNA
Cell Types: Bacteria Blue-green algae (cyanobacteria) Always unicellular	**Cell Types:** Humans Fungi Animals
Cell Structure: Smaller cells Cell wall present No membrane-bound organelles Simple internal structure	**Cell Structure:** Larger, more complex No cell wall (animals) Membrane-bound organelles Complex internal organization

STUDY SUMMARY & KEY POINTS

Carbohydrates Essentials:

- Milk = only non-plant carb source
- Glucose in all disaccharides
- Three main disaccharides & composition
- Polysaccharides = water insoluble
- Glycogen (animals) vs Starch (plants)
- Cellulose = structural, indigestible

Cell Biology Essentials:

- Organization: Cells → Tissues → Organs
- Historical timeline of discoveries
- Cell theory: All life is cellular
- Prokaryotes vs Eukaryotes differences
- Nuclear organization differences
- Size and complexity differences

Must Remember Examples:

- Sucrose = Glucose + Fructose
- Lactose = Glucose + Galactose
- Maltose = Glucose + Glucose
- Glycogen in muscles/liver
- Starch in plants (branched)
- Cellulose (linear, structural)

Key Scientists to Remember:

- Hooke → "cell" term
- Leeuwenhoek → living cells
- Brown → nucleus discovery
- Schleiden → plant cells
- Schwann → animal cells, cell theory
- Virchow → completed cell theory

Lecture 3: Cell - Building Block of Organism:

- **Unicellular organisms are independent**
- Each cell can carry out all life processes

Cell Membrane:

- **Composition**:
  - Phospholipids (2 layers - bilayer)
    * Glycoproteins = Carbohydrate + Protein clusters

Phospholipid Structure:

- **Polar head (hydrophilic)** - loves water
- **Non-polar tails (hydrophobic)** - repels water
- Forms selective permeability with integral proteins

Functions of Cell Membrane:

- **Key Functions**:
  - Protection of cell contents
  - Transport of materials in and out
  - Cell-to-cell communication
  - Maintains cell shape and structure

Mitochondria:

- **Oval-shaped organelles with double membrane**
  - Inner membrane is highly folded (cristae)
  - Called "Powerhouse of the cell" (energy production)
  - Site of cellular respiration and ATP synthesis
  - Contains its own DNA and ribosomes

Cytoplasm Components:

- **Cytosol**: Gel-like substance
  - **Cytoplasm**: Consists of organelles suspended in cytosol
    - Site of metabolic processes for proteins and carbohydrates
  - **Cytoskeleton**: Network of protein filaments in cytoplasm
    - Provides structural support and maintains cell shape
    - Helps organize organelles and cellular movement

Endoplasmic Reticulum (ER):

Rough ER (RER)	Smooth ER (SER)
• Ribosomes attached to surface • Involved in protein synthesis	• No ribosomes on surface • Major site for lipid synthesis

Nucleus:

- **Contains DNA and controls cellular processes**
  - **Nucleolus**: Spherical structure within nucleus
    - Site of ribosome synthesis and assembly
    - Contains ribosomal RNA (rRNA)

Ribosomes:

- **Found floating in cytoplasm or attached to RER**
  - Small spherical organelles
  - Called "Protein factories" of the cell
  - Site of protein synthesis (translation)
  - Composed of ribosomal RNA and proteins

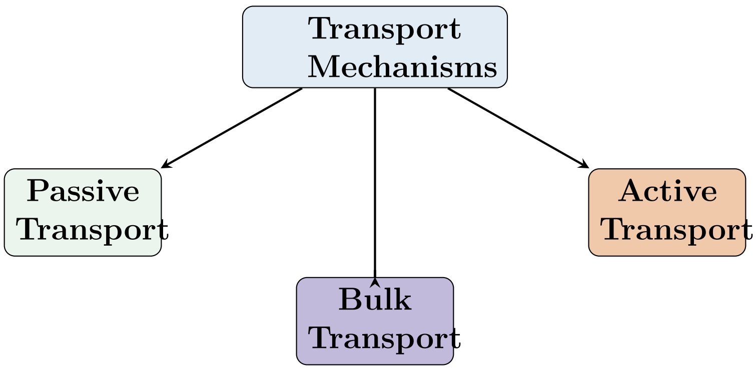
Lecture 4: Transport

Key Concept: Plasma Membrane

Selectivity: The plasma membrane is selectively permeable. Molecules pass easily when they are:

- **Small** (e.g., O_2, CO_2)
- **Non-polar/Non-charged** (e.g., lipids)
- **Lipid-soluble** (hydrophobic molecules)

Transport Mechanisms Overview

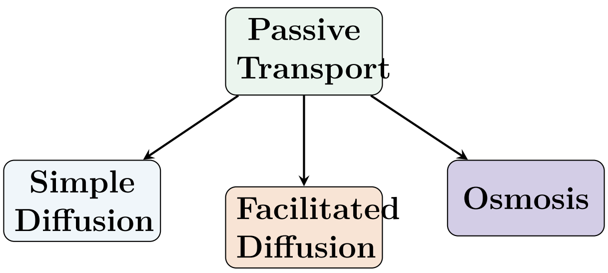


Passive Transport

Definition & Characteristics

- **Energy Requirement:** No cellular energy (ATP) required
- **Direction:** High concentration → Low concentration
- **Gradient:** Down the concentration gradient
- **Types:** Simple diffusion, facilitated diffusion, osmosis

Types of Passive Transport



A. Simple Diffusion

- **Molecules:** Small, non-polar molecules (O_2, CO_2, lipids)
- **Process:** Direct movement through lipid bilayer
- **Equilibrium:** Net movement stops when concentrations equalize

$$C_{\text{intracellular}} = C_{\text{extracellular}}$$

B. Facilitated Diffusion

- **Requirement:** Transport proteins needed
- **Molecules:** Larger or polar molecules (glucose, ions)
- **Characteristics:**
  - Specificity - proteins select particular molecules
  - Saturation - limited by number of transport proteins

Transport Proteins Comparison

Channel Proteins	Carrier Proteins
Form hydrophilic passages	Bind specifically to molecules
Allow rapid movement (e.g., ion channels)	Undergo conformational changes
Less selective (size-based)	Highly selective

Table 1: Comparison of Transport Proteins in Facilitated Diffusion

C. Osmosis

Osmosis Definition

Movement of water molecules across a semipermeable membrane from:

- High water concentration (low solute) → Low water concentration (high solute)
- Or: Low solute concentration → High solute concentration

Tonicity and Cell Response

Summary

Key Points Summary

- Passive transport moves substances **down** their concentration gradient **without energy**
- **Simple diffusion** for small/nonpolar molecules through bilayer
- **Facilitated diffusion** uses proteins for larger/polar molecules
- **Osmosis** is water movement across membranes
- Tonicity (iso-, hypo-, hypertonic) determines water movement direction

Solution Type	Cellular Effect
Isotonic	• Equal solute concentration inside/outside cell • No net water movement • Cell maintains normal shape
Hypotonic	• Lower solute concentration outside cell • Water enters cell • Animal cells may lyse; plant cells become turgid
Hypertonic	• Higher solute concentration outside cell • Water leaves cell • Animal cells shrivel; plant cells plasmolyze

Table 2: Effects of Tonicity on Cells

Lec 5:Active Transport and Bulk

Active Transport

ACTIVE TRANSPORT - Key Concept

REQUIRES ENERGY (ATP)
Movement against concentration gradient
Low concentration → High concentration

ATP (3 phosphates) → ADP (2 phosphates) + Pi + ENERGY

PRIMARY ACTIVE TRANSPORT

Direct Energy Use:

- Energy directly from ATP hydrolysis
- Common ions: Na^+, K^+, Ca^{2+}, Mg^{2+}
- Uses specific ion pumps

SECONDARY ACTIVE TRANSPORT

Indirect Energy Use:

- Uses existing gradients
- Couples to primary transport
- No direct ATP use

WHY ACTIVE TRANSPORT MATTERS

- **Maintain concentrations**
- **Control cell volume**
- **Create membrane potential**
- **Drive other processes**

TRANSPORT PROTEIN TYPES

UNIPORTER

1 molecule
1 direction
integral protien,sugar and amino acids
A $\rightarrow$

SYMPORTER

2 molecules
SAME direction
Glucose and Na^+
A $\rightarrow$ B $\rightarrow$

ANTIPORTER

2 molecules
OPPOSITE directions
sodium potassium pump
A $\rightarrow \leftarrow$ B

Bulk

BULK TRANSPORT - For Large Molecules

EXOCYTOSIS

OUT of cell

- Vesicle fuses with membrane
- Waste removal
- Secretion

ENDOCYTOSIS

INTO cell

- Membrane invaginates
- Forms vesicle
- Material uptake

SPOTLIGHT: Na^+/K^+ PUMP

3 Na^+ $\rightarrow$ Out the cell
2 K^+ $\rightarrow$ Into the cell
1 ATP per cycle

Functions:

- Creates membrane potential
- Nerve impulse transmission
- Cell volume regulation
- Drives secondary transport

QUICK REVIEW

Remember:

- Active = Needs ATP
- Against gradient
- Requires proteins
- Maintains cell balance

Key Examples:

- Na^+/K^+ pump
- Ca^{2+} pump
- Glucose cotransporter
- Bulk transport

Lecture 6: Proteins

PROTEINS - Building Blocks of Life

Composed of Amino Acids (monomers)
Elements: C, H, N, O in all proteins

Amino Acid → Peptide → Protein

Connected by **peptide bonds**

Protein Importance

WHY PROTEINS ARE ESSENTIAL

- **Catalysis** (Enzymes)
- **Transport oxygen** (Hemoglobin)
- **Disease protection** (Antibodies)
- **Hormones** (Insulin)
- **Folding DNA** (Histones)
- **Structural support** (Collagen)
- **Mechanical support** (Muscle proteins)

PROTEIN SIZE CLASSIFICATION

2 amino acids	3 amino acids	10+ amino acids
↓	↓	↓
Dipeptide	**Tripeptide**	**Polypeptide**

AMINO ACID STRUCTURE

$$NH_2 \text{ - } CHR \text{ - } COOH$$

Amino Group	**R Group**	**Carboxyl Group**
(NH_2, $NH_3{}^{+}$)	(Side Chain)	($COOH$,COO^{-})
Basic	Variable part	Acidic

Note: R group is unique to each amino acid

Nutritional classification

NUTRITIONAL CLASSIFICATION

ESSENTIAL (9 amino acids)

Cannot be synthesized by body

- Lysine
- Histidine
- Methionine
- Valine
- Leucine
- Isoleucine
- Phenylalanine
- Threonine
- Tryptophan

Memory aid: L-H-M-V-I

NON-ESSENTIAL (11 amino acids)

Can be synthesized by body

- Alanine
- Arginine
- Asparagine
- Aspartic acid
- Cysteine
- Glutamic acid
- Glutamine
- Glycine
- Proline
- Serine
- Tyrosine

Key ones: A-C-S-G

CLASSIFICATION BY SIDE CHAIN (R GROUP)

CLASSIFICATION BY SIDE CHAIN (R GROUP)

NON-POLAR

Properties:

- Less soluble in water (hydrophobic)
- Contains C and H mainly
- Examples: CH_3, CH_2, CSH

POLAR

Properties:

- Water soluble (hydrophilic)
- **Uncharged:** NH_2, OH
- **Positive:** NH_3^+
- **Negative:** COO^-

AROMATIC

Contains ring structures
(e.g., benzene rings)

ALIPHATIC

Straight or branched chains
(no ring structures)

QUICK REVIEW

Key Points:

- Proteins = Amino acid chains
- Connected by peptide bonds
- 9 essential amino acids
- R group determines properties

Remember:

- Polar = Water-loving
- Non-polar = Water-fearing
- Charged = Ionic interactions
- Structure determines function

Lecture 7: proteins

FUNDAMENTAL PROTEIN CHEMISTRY

Peptide Bond Formula: Number of bonds = n - 1

Peptide bond : the C_N bond link amino acids together (where n = number of amino acids)

Examples:

- 5 amino acids → 4 peptide bonds
- 50 amino acids → 49 peptide bonds
- 100 amino acids → 99 peptide bonds
- 500 amino acids → 499 peptide bonds

The Four Levels Of Protein Structure

THE FOUR LEVELS OF PROTEIN STRUCTURE

PRIMARY STRUCTURE - The Foundation

Linear sequence of amino acids connected by peptide bonds

Characteristics:
- Specific amino acid order
- Covalent peptide bonds
- Affects all higher levels

Abnormal Sequence causes:
- Sickle cell anemia
- Single amino acid change
- Causes protein dysfunction

SECONDARY STRUCTURE - Local Patterns

Regular, repeating structural motifs stabilized by hydrogen bonds

αHelix (Alpha Helix):
- found in skin and hair .
- they are rigiditly determined by disulfide bond.
- Common in structural proteins

β Sheet (Beta Sheet):
- Extended, stretched chains
- Forms pleated sheets called β pleated sheet.

TERTIARY STRUCTURE - 3D Architecture

Complete three-dimensional folding of a single polypeptide chain
Stabilizing Forces:

- **Disulfide bonds** (covalent)
- Hydrogen bonds s

Disulfide Bonds - Key Feature:
- Between cysteine residues
- Strongest stabilizing force

Fibrous Proteins:
- **Collagen:** Skin, bones, tendons
- **actin**
- **myosin** muscle contraction
- Long, rope-like structures

Globular Proteins:
- **Myoglobin:** Oxygen storage
- **Casein, whey:** Milk protein
- Compact, spherical shape

QUATERNARY STRUCTURE - Multi-Subunit Assembly

Association of multiple polypeptide chains (subunits)

Characteristics:
- when the subnits come together
- subnits : multible folded peptide chain.

Classic Example - Hemoglobin:
- 4 subunits (2α, 2β)

Conjugated Proteins

CONJUGATED PROTEINS - Beyond Pure Protein

Proteins combined with non-protein prosthetic groups for specialized functions

Types & Examples:

- **Nucleoproteins:** Histones + DNA
- **Glycoproteins:** Antibodies, hormones
- **Phosphoproteins:** Casein, egg proteins
- **Lipoproteins:** HDL, LDL cholesterol carriers

Protein Denaturation

PROTEIN DENATURATION - Structure Loss

Disruption of protein's native structure leading to loss of biological activity

Native vs Denatured:

Native State:

- Properly folded
- Biologically active
- Functional conformation

Denatured State:

- Unfolded/misfolded
- Loss of activity
- Random structure

Denaturing Agents:

Temperature	pH Extremes	Chemical Agents
Heat breaks H-bonds	Acid/Base disruption	Urea, detergents
Example: Cooking eggs	Changes ionization	Disrupt interactions

STUDY CHECKLIST & KEY TAKEAWAYS

Essential Concepts:

- Four levels of protein structure
- Peptide bond calculation (n-1)
- Denaturation causes & effects
- Disulfide bonds
- Structure determines function
- Conjugated protein types

Important Examples to Remember:

- Hemoglobin (quaternary structure)
- Collagen ,actin (fibrous)
- Myoglobin (globular, oxygen storage)
- Casein, whey (Globular, phosphoprotein in milk)
- myosin(fibrous, muscles conteraction)
- Egg whites (denaturation example by heat)

Lecture 8: Enzymes (Part1)

ENZYMES: PROTEIN CATALYSTS

Biological molecules that speed up chemical reactions in living organisms

Enzyme properties

Key Properties:

- **Increase reaction velocity**
- **Not consumed** during reaction
- **Lower activation energy**
- **Highly specific** for substrates
- **Reusable** - can catalyze multiple reactions

Activation Energy Concept:

- **Without enzyme:** High activation energy
- **With enzyme:** Lower activation energy
- **Result:** Faster reaction rates
- **Same end result** achieved more efficiently

Substrate: The molecule that reacts with the enzyme

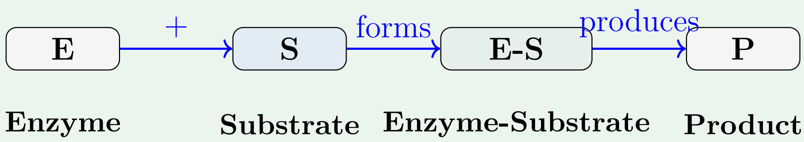
ENZYME ACTION MECHANISM

Step-by-step process of how enzymes work

Active Site

Specific location on enzyme where substrate binds
Like a lock that only fits a specific key

Enzyme Reaction Sequence:



$$E + S \rightarrow ES \rightarrow P$$

Key Points:

- Enzyme binds to substrate at active site
- Forms temporary enzyme-substrate complex (ES)
- Highly specific binding - enzyme recognizes specific substrate

ENZYME EXAMPLES & FUNCTIONS

Amylase
Carbohydrate Digestion
Breaks down starch
Polysaccharide →
Disaccharide
Begins starch digestion

sucrase
Acts on sucrose
Disaccharide →
Monosaccharide
sucrose→Glucose+fructose

Lactase
Acts on lactose
lactose→glucose+galactose

Detailed Example - Amylase:

$$\text{Starch (polysaccharide)} \xrightarrow{\text{Amylase}} \text{Maltose (disaccharide)}$$

Enzyme Classification

ENZYME CLASSIFICATION - The Six Classes

OXIDOREDUCTASES

Catalyze oxidation-reduction reactions

$$A^{red} + B^{ox} \rightarrow A^{ox} + B^{red}$$

- **Function:** One compound oxidized, another reduced
- **Key feature:** Transfer of electrons/hydrogen atoms

TRANSFERASES

Catalyze transfer of functional groups

$$X - R + Y \rightarrow X + Y - R$$

- **Function:** Move functional groups between molecules
- **Key feature:** R = donor group, Y = acceptor molecule

HYDROLASES

Catalyze bond cleavage using water

$$A - B + H_2O \rightarrow A - OH + B - H$$

- **Function:** Break bonds by adding water

LYASES

Catalyze bond breaking without water

- **Function:** Break bonds without using water

ISOMERASES

Catalyze molecular rearrangements

$$A - B \rightarrow B - A$$

- **Function:** Rearrange atoms within molecules
- **Key feature:** Same molecular formula, different arrangement

LIGASES

Catalyze bond formation using ATP energy

$$A + B + ATP \rightarrow A - B + ADP + P_i$$

- **Function:** Form bonds between two molecules
- **Key feature:** Requires ATP energy input (energy-coupling)

Enzyme Specificity

ENZYME SPECIFICITY - Lock and Key Model

Enzymes are highly specific for their substrates

Key-Lock Model:

- **Substrate = Key**
- **Active site = Lock**
- **Perfect fit required**
- **Specific shape recognition**

Specificity Features:

- **Shape complementarity**
- **Chemical compatibility**
- **Binding affinity**
- **Right-sized active site**

Induced Fit Model (Advanced)

Modern understanding: Enzyme shape changes slightly upon substrate binding

More flexible than rigid lock-and-key model

Process:

1. Substrate approaches active site
2. Initial binding occurs
3. Enzyme-substrate complex forms
4. Product released, enzyme regenerated

ENZYME STUDY SUMMARY

Core Concepts:

- Enzymes are protein catalysts
- Lower activation energy
- Not consumed in reactions
- Highly specific for substrates
- Form enzyme-substrate complexes
- Active site is binding location

Six Enzyme Classes:

- Oxidoreductases (redox)
- Transferases (group transfer)
- Hydrolases (water-dependent)
- Lyases (non-water bond breaking)
- Isomerases (rearrangement)
- Ligases (ATP-dependent bonding)

Key Examples:

- Amylase: starch $\rightarrow$ maltose
- Fructokinase: fructose metabolism
- Galactokinase: galactose processing
- Hydrolases: digestion enzymes
- Dehydrogenases: energy metabolism

Specificity Models:

- Lock-and-Key: rigid fit
- Induced-fit: flexible binding
- Shape + chemical compatibility
- Substrate clearance after reaction

Remember: $E + S \rightarrow ES \rightarrow P$

(Enzyme regenerated and can work again!)

Lecture 9: Enzymes (Part2)

Apoenzyme & Cofactor

Component	Nature	Activity
Apoenzyme	Protein part	Inactive
Cofactor	Non-protein helper	Required
Holoenzyme	Apoenzyme + Cofactor	**Active**

Types of Cofactors:

- after activation conjugated enzyme (Holoenzyme)

Proenzymes (Zymogens)

Proenzyme	Active Enzyme	Activator
Trypsinogen	Trypsin	Enteropeptidase
Pepsinogen	Pepsin	HCl (low pH)

Key Points:

- **Inactive** trypsinogen → (avtive)trypsin
- Activated after partial cleavage
- Common in: digestive system

Isoenzymes - LDH Distribution

Isoenzyme	Primary Location	Subnits
LDH1	Heart, RBCs	4 subnit A
LDH2	WBCs	3 subnit A , 1 subnit B
LDH3	Lungs	2 subnit A, 2 subnit B
LDH4	Kidneys, pancreas	3 subnit B, 1 subnit A
LDH5	Liver, skeletal muscle	4 subnit B

Definition: LHD : Lactase Dehydrogenase Isoenzymes

Factors Affecting Enzyme Activity

1. Temperature Effects:

Temperature	Effect
Optimal (37°C)	**Maximum activity**
High (>50°C)	Denaturation → Inactive
Low (<20°C)	Slow kinetics → Low activity

2. pH Effects:

Enzyme	Optimal pH
Most enzymes	6.0 - 8.0
Trypsin	8.0 - 8.5

3. Concentration Effects:

- ↑ [concentration] → ↑ [Reaction rate]
- there is a direct propstion between velocity and concentration

Lecture 10: Inhibtion

Quick Review

Concept	Key Point
Holoenzyme	**Complete active enzyme** = Apoenzyme + Cofactor
Zymogens	**Inactive precursors** activated by cleavage
Isoenzymes	**Tissue-specific** forms for diagnosis
Enzyme Activity	Depends on temp, pH, concentration

Enzyme Inhibition

Enzyme Inhibition

Definition: Reduction or stopping of enzyme activity
Inhibitor: Molecule that binds to enzyme to prevent normal function
Normal Reaction:

$$E + S \to ES \to P$$

With Inhibitor:

$$E + S + I \to ESI \text{ or } EI \to \text{No Product}$$

Types of Enzyme Inhibition

Type	Binding Site	Mechanism
Competitive	Active site	Structure similar to substrate; competes for active site
Uncompetitive	Enzyme-substrate complex	Binds only to ES complex, forms ESI
Non-competitive	Allosteric site	Binds to alternative site; changes enzyme shape

Key Characteristics:

- **Competitive:** Can be overcome by increasing substrate concentration
- **Uncompetitive:** Cannot bind to free enzyme
- **Non-competitive:** Cannot be overcome by substrate increase

Medical Applications of Enzymes

Medical Applications of Enzymes

1. Blood Clot Dissolution:

Enzyme	Function	Clinical Use
Serratiopeptidase	Dissolves blood clots	Heart attack, stroke

Importance: Blood clots can cause death; enzymes help dissolve dangerous clots.

Digestive Enzyme Supplementation

Problem: Elderly patients have low digestive enzyme secretion

Enzyme	Substrate	Product
Lipase	Lipids (fats)	Fatty acids + glycerol
Amylase	Starch	Maltose
Maltase	Maltose	Glucose
Trypsin	Proteins	Amino acids
Lactase	Lactose	Glucose + galactose

Benefits:

- Improved digestion in elderly
- Papain can be used easier for digestion
- Reduced digestive discomfort

Quick Review

Concept	Key Point
Inhibition	**Stopping enzyme activity** - competitive, uncompetitive, non-competitive
Medical Enzymes	**Clot dissolution** - streptokinase, urokinase prevent death
Digestive Aids	**Enzyme supplements** help elderly with poor digestion
Clinical Importance	Enzymes as **therapeutic agents** in medicine

Lecture 11: DNA,RNA Structures

DNA

DNA (Deoxyribonucleic Acid)

Function: Stores genetic information
Structure: Double-stranded helix, polymer of nucleotides
Nucleotide Components:

$$\text{Sugar (Deoxyribose)} + \text{Phosphate } (PO_4^{3-}) + \text{Nitrogenous Base}$$

Component	Type	Details
Sugar	Deoxyribose	Ribose minus one OH group at C-2'
Phosphate	PO_4^{3-}	Links nucleotides together
Bases	Purines	Adenine (A), Guanine (G)
	Pyrimidines	Thymine (T), Cytosine (C)

Base Pairing Rules:

- A pairs with T (2 hydrogen bonds)
- G pairs with C (3 hydrogen bonds)

RNA

RNA (Ribonucleic Acid)

Function: Protein synthesis and gene expression
Structure: Single-stranded, polymer of nucleotides
Nucleotide Components:

$$\text{Sugar (Ribose)} + \text{Phosphate } (PO_4^{3-}) + \text{Nitrogenous Base}$$

Component	Type	Details
Sugar	Ribose	Has OH groups at both C-2' and C-3'
Phosphate	PO_4^{3-}	Links nucleotides together
Bases	Purines	Adenine (A), Guanine (G)
	Pyrimidines	Uracil (U), Cytosine (C)

Base Pairing Rules (in RNA-RNA pairing):

- A pairs with U (2 hydrogen bonds)
- G pairs with C (3 hydrogen bonds)

DNA vs RNA Comparison

Feature	DNA	RNA
Structure	Double-stranded helix	Single-stranded
Sugar	Deoxyribose	Ribose
Bases	A, T, G, C	A, U, G, C
Function	Genetic storage	Protein synthesis
Location	Nucleus	Nucleus & cytoplasm
Size	Very large	Smaller

Nitrogenous Base Categories

Nitrogenous Base Categories

Category	Structure	DNA Bases	RNA Bases
Purines	Double ring	Adenine (A), Guanine (G)	Adenine (A), Guanine (G)
Pyrimidines	Single ring	Thymine (T), Cytosine (C)	Uracil (U), Cytosine (C)

Key Differences:

- DNA uses Thymine (T), RNA uses Uracil (U)
- Purine always pairs with pyrimidine for consistent helix width

Quick Review

Concept	Key Point
Nucleotide	**Basic unit** = Sugar + Phosphate + Base
DNA Structure	**Double helix** with complementary base pairing
RNA Structure	**Single strand** with ribose sugar and uracil
Base Pairing	**A-T/U, G-C** maintain genetic code accuracy

Lecture 12:Central Dogma of Molecular Biology

Central Dogma of Molecular Biology

Definition: Process by which DNA is transcribed to mRNA, then translated to protein

$$\textbf{DNA} \xrightarrow{\text{Transcription}} \textbf{mRNA} \xrightarrow{\text{Translation}} \textbf{Protein}$$

Process	Location	Product
Transcription	Nucleus	mRNA from DNA
Translation	Ribosomes (cytoplasm)	Protein from mRNA

Types of RNA

RNA Type	Function	Structure
mRNA	Carries genetic info from DNA to ribosomes	Single-stranded
rRNA	Main component of ribosomes	Single-stranded, folded
tRNA	Transfers amino acids to ribosomes	Single-stranded, cloverleaf

mRNA (Messenger RNA)

Function: Carries genetic information from DNA (nucleus) to ribosomes (cytoplasm)
Characteristics:

- Single-stranded
- Made from DNA by transcription
- Template for protein synthesis
- Contains codons (triplet sequences)

rRNA (Ribosomal RNA)

Function: Main component of ribosomes, carries out protein synthesis

Ribosome Subunit	Function
Small subunit	mRNA binds here
Large subunit	tRNA with amino acids bind here

Role: Facilitates translation with help of mRNA and tRNA

tRNA (Transfer RNA)

Function: Transfers amino acids to ribosomes during translation
Structure Components:

- **Amino acid attachment site:** Specific for each amino acid
- **Anticodon:** Pairs with specific codon on mRNA
- **Cloverleaf structure:** Allows proper folding and function

Genetic Code

Definition: Sequence of three nucleotide bases (codon) in mRNA
Codon Language: Uses 4 bases (A, G, C, U)

Codon Type	Number/Function
Total possible codons	64 (4^3)
Amino acid coding codons	61
Stop codons	3

Special Codons:

- **AUG:** Start codon (codes for methionine)
- **UAA, UGA, UAG:** Stop codons (terminate translation)

Quick Review

Concept	Key Point
Central Dogma	**DNA → mRNA → Protein** (transcription then translation)
mRNA	**Messenger** carries genetic info to ribosomes
rRNA	**Ribosomal** component that facilitates translation
tRNA	**Transfer** brings amino acids to ribosomes
Genetic Code	**Triplet codons** specify amino acids (61) + stop signals (3)

Organelle Table:

Organelle	Function	Key Point
Nucleus	Controls cell activities	Contains DNA
Mitochondria	Energy production	"Powerhouse"
Rough ER	Protein synthesis	Has ribosomes
Smooth ER	Lipid synthesis	No ribosomes
Ribosomes	Make proteins	Protein factories

Cell Transport Mechanisms:

Transport Type	Description	Energy Required	Examples
Simple Diffusion	Movement down concentration gradient	No (Passive)	O_2, CO_2, H_2O
Facilitated Diffusion	Through protein channels/carriers	No (Passive)	Glucose, ions
Active Transport	Against concentration gradient	Yes (ATP)	Na^+/K^+ pump
Endocytosis	Cell engulfs materials	Yes (ATP)	Phagocytosis
Exocytosis	Cell expels materials	Yes (ATP)	Hormone secretion

Cell Types Overview:

Characteristic	Prokaryotic Cells	Eukaryotic Cells
Nucleus	No true nucleus (nucleoid)	Membrane-bound nucleus
Organelles	No membrane-bound organelles	Multiple organelles
DNA Organization	Circular, in cytoplasm	Linear, in nucleus
Cell Size	Smaller (1-10 μm)	Larger (10-100 μm)
Examples	Bacteria, Archaea	Plants, Animals, Fungi

Summary and Key Points:

Important Concepts to Remember

- **Cell Theory**: All living things are made of cells; cells are the basic unit of life
- **Membrane Importance**: Controls what enters and exits the cell
- **Energy Flow**: Mitochondria provide ATP for cellular processes
- **Protein Production**: Ribosomes $\rightarrow$ ER $\rightarrow$ Golgi $\rightarrow$ Final destination
- **Cellular Transport**: Multiple mechanisms for moving materials
- **Cell Types**: Prokaryotic vs Eukaryotic differences are fundamental