

BIOCHEMISTRY

Biochemistry Overview

by

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Chapter Description

- Overview

This chapter is to introduce the biochemistry fundamentals.

- Expected Outcomes

You should be able to have a general understanding of biochemistry and some basic know how in learning the subject.


- Other related Information

Some relevant questions been provided for improving your understanding of the topic. You are expected to search for external sources for information to adequately answer the questions. All pictures and figures within this chapter categorized as creative commons for the purpose of education only.



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<http://ocw.ump.edu.my/course/view.php?id=485>

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- **What is biomolecule?**
 - **What is biochemistry?**

How to study Biochemistry?

Do's:

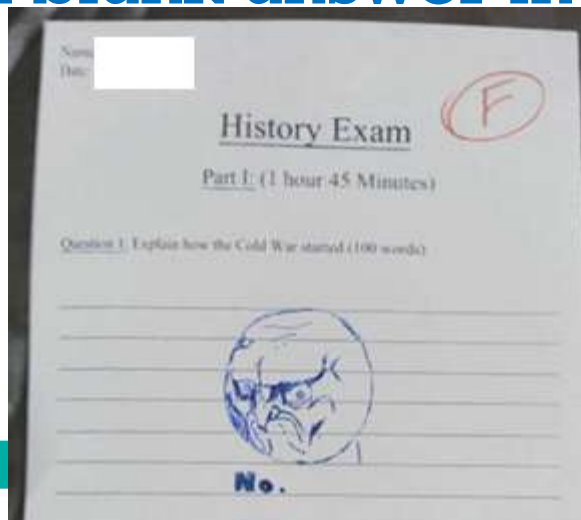
- Get to know important structures, terms, intermediates, steps, key regulatory enzymes and their regulations, overview on metabolic pathways and their connections with other pathways
- Attempt as many questions as possible

Don'ts

- Do not memorize facts such as whole pathway i.e step by step, each enzyme, structures and their stepwise changes etc.
- Do not read chapters in text book chapter to chapter rather refer to it when you do not understand certain facts in your lecture slides.

Don'ts

- Do not worry if you do not understand the integration of one pathway to the other as there will be reinforcement on this area in an integration of metabolism lecture.
- Do not leave a blank answer in exam papers!!!



Key Concepts in Biochemistry

- Cells -- important structural features; compartments (plasma membrane, nucleus or nucleoid, cytoplasm, ribosomes, organelles like mitochondria, chloroplasts, endoplasmic reticulum and Golgi apparatus)
- Chemical unity of living systems
- Transformation of energy and matter from surroundings - -> complex, orderly structures
- Biomolecules -- functional groups; condensation reactions
- Proteins -- molecular workhorses of living systems
- Enzymes increase rates of biological reactions to permit life on a biological timescale.
- Rates of processes exquisitely regulated to maintain dynamic steady state.
- 3-D structures of biomolecules determine their functions -- role of noncovalent interactions in structure and function.

Key Concepts, continued

- **Non-covalent interactions:** ionic interactions, hydrogen bonds, van der Waals interactions, hydrophobic “interactions”
 - individually much weaker than covalent bonds
 - collectively very strong
 - *crucial to structures and functions of biomolecules*
- **Properties of water -- “solvent”/milieu for living systems**
 - Most biomolecules have functional groups that are weak acids or bases, whose ionization properties are crucial to structures and functions of the molecules; pH determines state of ionization of biomolecular weak acids and bases.

Functional Groups to Know

Functional Group	Structural Formula	Example	Found In
Hydroxyl	—OH	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ \quad \\ \text{H} \quad \text{H} \\ \text{Ethanol} \end{array} $	carbo- hydrates, proteins, nucleic acids, lipids
Carbonyl	$ \begin{array}{c} \text{O} \\ \\ -\text{C}- \end{array} $	$ \begin{array}{c} \text{H} \quad \text{O} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \\ \text{H} \\ \text{Acetaldehyde} \end{array} $	carbo- hydrates, nucleic acids
Carboxyl	$ \begin{array}{c} \text{O} \\ // \\ -\text{C} \\ \backslash \\ \text{OH} \end{array} $	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{C} \begin{array}{l} // \text{O} \\ \backslash \text{OH} \end{array} \\ \\ \text{H} \\ \text{Acetic acid} \end{array} $	proteins, lipids
Amino	$ \begin{array}{c} \text{H} \\ / \\ -\text{N} \\ \backslash \\ \text{H} \end{array} $	$ \begin{array}{c} \text{O} \quad \text{H} \\ \quad \\ \text{HO}-\text{C}-\text{C}-\text{N} \begin{array}{l} / \text{H} \\ \backslash \text{H} \end{array} \\ \quad \\ \quad \text{CH}_3 \\ \text{Alanine} \end{array} $	proteins, nucleic acids

Functional Group	Structural Formula	Example	Found In
Sulfhydryl	— S — H	$\begin{array}{c} \text{COOH} \\ \\ \text{H—C—CH}_2\text{—S—H} \\ \\ \text{NH}_2 \end{array}$ <p>Cysteine</p>	proteins
Phosphate	$\begin{array}{c} \text{O}^- \\ \\ \text{— O — P — O —} \\ \\ \text{O} \end{array}$	$\begin{array}{c} \text{OH OH H} \\ \\ \text{H—C—C—C—O—P—O—} \\ \quad \\ \text{H H H} \quad \text{O}^- \end{array}$ <p>Glycerol phosphate</p>	nucleic acids
Methyl	$\begin{array}{c} \text{H} \\ \\ \text{— C — H} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \text{O H} \\ \\ \text{HO—C—C—NH}_2 \\ \\ \text{H—C—H} \\ \\ \text{H} \end{array}$ <p>Alanine</p>	proteins

Biochemical Processes

- Metabolism is the sum of all biochemical reactions.
- Functions of metabolism are:
 1. Synthesis of biomolecules.
 2. Transport of ions and molecules across cell membranes.
 3. Production of force and movement.
 4. Removal of metabolic waste and other toxic substances.

Energy

- Energy is the capacity to do work.
- Cells generate most of their energy from redox reactions.
- When electrons are transferred to an electron deficient molecule, energy is lost. Several redox reactions provide enough energy for ATP synthesis.
- The ultimate source of energy used by most organisms on earth is the sun.

Metabolism

- Metabolism is the sum of all the enzyme- catalyzed reactions in a living organism.
- In anabolic (biosynthetic) pathways large complex molecules are synthesized from smaller molecules.
- In catabolic pathways large complex molecules are degraded into simpler products. A portion of the energy produced drive anabolic reactions.

Biological Order

Cellular processes can be classified into the following categories:

1. **Synthesis of biomolecules**
 - Many reactions are integrated into carefully regulated pathways. Energy is supplied either directly or indirectly by breaking phosphoanhydride bonds of ATP.



2. Transport across membranes.

- Cell membranes regulate the passage of ions and molecules from one compartment to another.
- Much of this is accomplished by membrane bound proteins.

3. Cell movement

- Examples include cell division, organelle movement and even movement of enzymes along a DNA strand.



4. Waste removal

- Excess CO_2 , H_2O , and NH_3 must be removed. CO_2 is exhaled, H_2O is excreted by the kidneys, and NH_3 is converted to urea.

- Hydrophobic molecules such as the steroid hormones are converted to water soluble derivatives.

Genetic Information

- “Central dogma” of molecular biology:
- The chemical information in a gene (DNA) directs the assembly of amino acids into polypeptides (proteins).

Information Flow

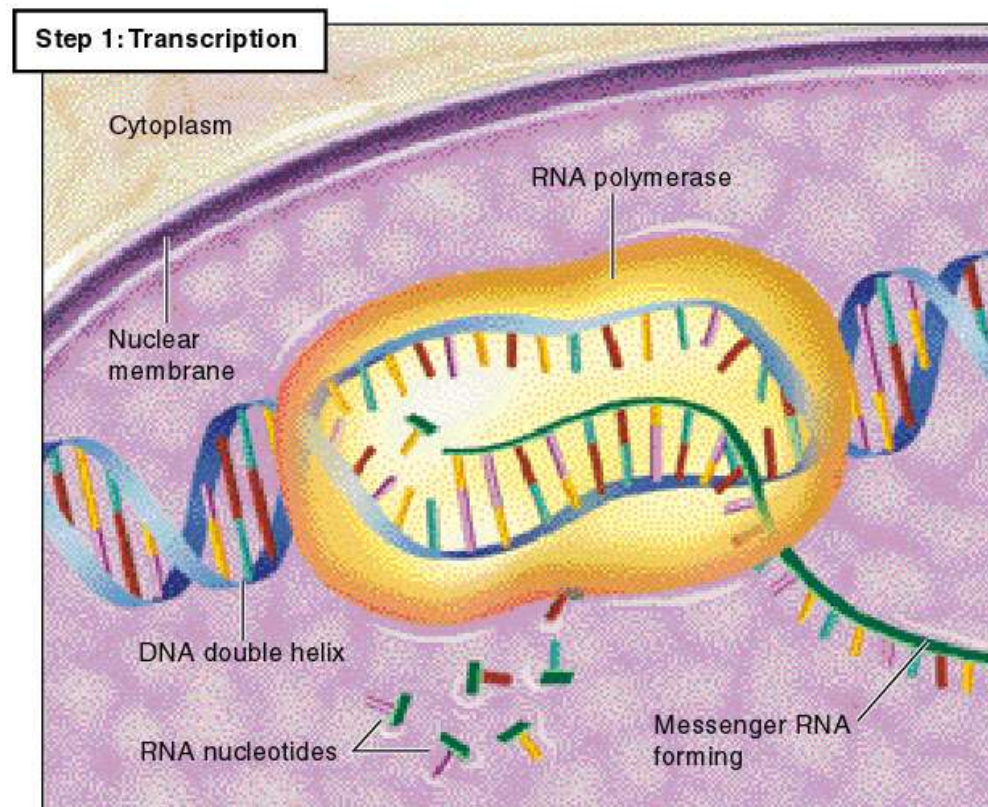


1. Transcription: RNA is made on a DNA template

2. Translation: Protein is synthesized from AAs and the three RNAs.

Transcription

- RNA polymerases and proteins copy the coded instructions in genes into RNA molecules.



Student's Activities

- Find out the importance in studying biochemistry for better understanding of other subjects in your course?
- What is the significance of learning biochemistry for your career?

References:

Title/URL	Author	Publisher	Year
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Biochemistry.2010	Garret, R.H., Grisham, C.	Thompson Brooks	2007
Biochemistry	Hames, D	USA: Taylor and Fran	-
Color Atlas of Biochemistry	Koolman, J., Roehm, K.H	Thieme Stuttgart	2005
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Biochemistry, 4th Edition	Donald Voet and Judith C	Wiley and Co	2011
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