

Biochemistry and Medicine

Biochemistry

- It is the application of chemistry to the study of biological processes (structure, composition and chemical reactions of substances in living systems) at the cellular and molecular level.
- The combination between chemistry, physiology and biology allows investigating the chemistry of living systems by:
 - A. Studying the structure and behavior of the complex molecules found in biological material
 - B. The ways these molecules interact to form cells, tissues and whole organism.

- Biochemistry involves and incorporates with large areas of:

1- Cell biology 2- Molecular biology 3- Molecular genetics

- It describes:

- > Origin
- > Formation
- > Function
- > Deficiency
- > Symptoms

Types of biomolecules

Small molecules:

- Lipid, phospholipids, glycolipid, sterol, - Vitamin
- Hormones, neurotransmitters - Carbohydrate, sugar

Monomers:

- Amino acids - Nucleotides - Monosaccharides

Polymers:

- Peptides, oligopeptides, polypeptides, proteins
- Nucleic acids (DNA, RNA)
- Disaccharides, oligosaccharides, polysaccharides (including cellulose)

Roles Of Important Biomolecules

- **Carbohydrates** serve as primary source of energy.
- **Lipids** serve as secondary source of energy.
- **Proteins** are structural and functional units of human body.

- Fat soluble and water soluble vitamins serve as accessory growth factors.
- Major and minor minerals having role in building human bodies.

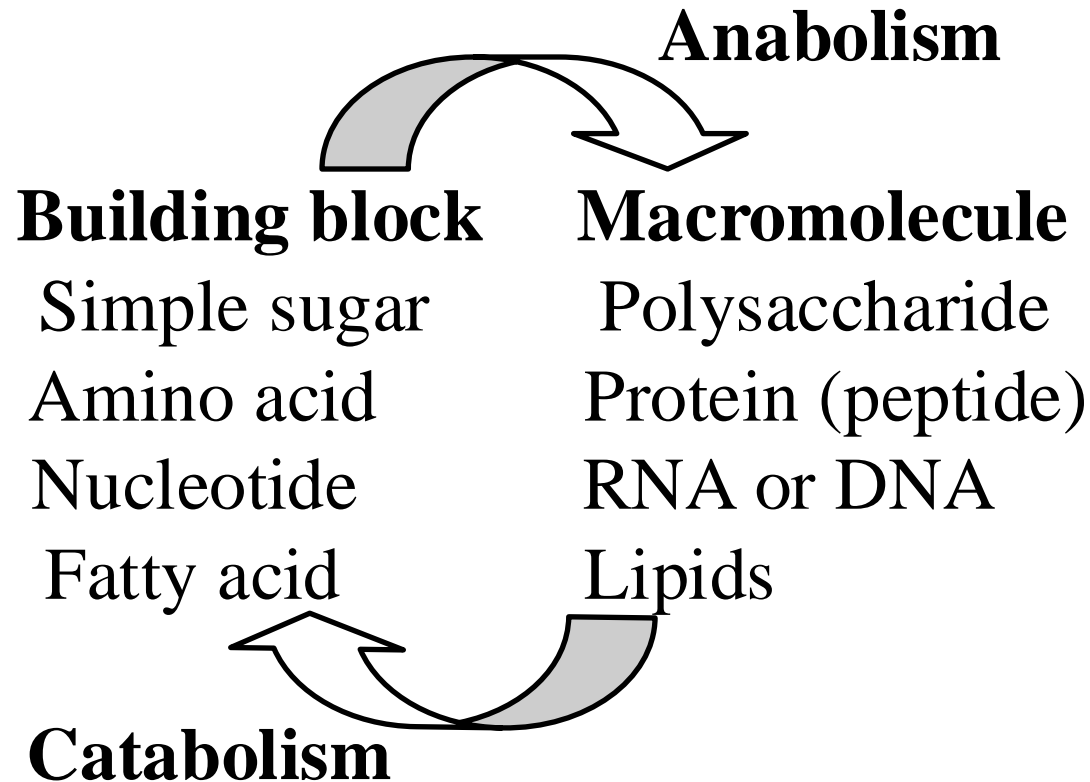
- **Enzymes** are biocatalysts catalyze specific biochemical reactions of metabolic pathways and considered as functional units of metabolism.

- **Hormones, chemical messengers** of human body. They bring good coordination and regulate enzyme activities of metabolism.

Biochemical reactions

- Metabolism: total sum of the chemical reactions happening in a living organism, includes:
 - A- Anabolism: energy requiring biosynthetic pathways
 - B- Catabolism: degradation of fuel molecules and energy production for cellular function
- Most of the reactions are catalyzed by enzymes
- The primary functions of metabolism are:
 - a. Membrane transport mechanisms and signal transduction
 - b. Biochemical mechanisms of hormone action-cellular homeostasis
 - c. Synthesis of molecules needed for cell structure and functioning (as proteins, nucleic acids, lipids, & CHO)
 - d. Functions of Neurotransmitters
 - e. Oxygen transport, bioenergetics, electron transport chain
 - f. The Immune response
 - g. Removal of waste products.

Biomolecules – Structure



Frequent reactions encountered in biochemical processes

1. Nucleophilic substitution

- One atom or group is substituted by another

2. Elimination reactions

- Double bond is formed when atoms in a molecule are removed

3. Addition reactions:

- Two molecules combine to form a single product.

4. Isomerization Reactions.

- Involve intramolecular shift of atoms or groups

5. Oxidation-Reduction (redox) Reactions

- Occur when there is a transfer of e^- from a donor to an electron acceptor

6. Hydrolysis (hydration) reactions

- Cleavage of double bond by water.

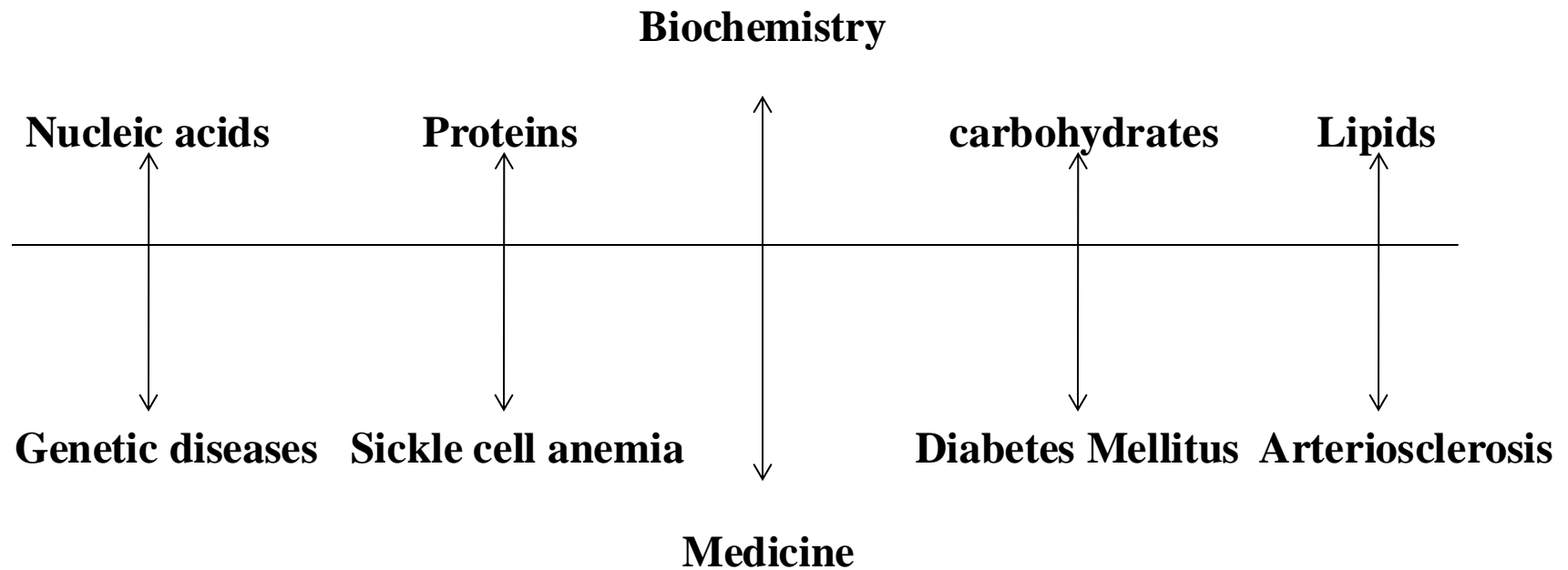
The aim of biochemistry

- Is the complete understanding, at molecular level all biomolecules composed in the living organisms (their chemical structures, occurrence, location and their functions), also, the chemical processes associated with living cells.
- Identification of mechanisms of diseases
- Study of Inborn metabolic errors
- Study of oncogenes in cancer cells
- Also, structures and functions, metabolism and its regulation, gene expression modulation and how the life has begun (DNA ——— RNA Proteins)
- To realize these targets, biochemists have to isolate numerous molecules found in cells, determine their structures, and analyze how they function.
- Many techniques have been used for these purposes as chromatography, electrophoresis, elemental analysis, ultracentrifugation, mass spectrometry and X-ray crystallography.

Biochemistry and Medicine are Intimately related

- In a specific diseased condition there occurs derangements in the hormonal actions, which affects, homeostatic mechanisms and metabolic processes, which in turn alters the normal concentrations of biochemical constituents in body cells and their fluids.
- Metabolic changes associated with specific disorders may give rise to a changes in the body fluids.
- Biochemical profile of a particular body fluid is analyzed for example:
 - Blood glucose in Diabetes mellitus;
 - Glucose levels in the cerebrospinal fluid in bacterial meningitis (which are greatly reduced).
- So, specific parameters are looked for in a specific body fluid when a disease is suspected to be investigated for the levels of biochemical parameters
- In various collected biological specimens
- Blood/plasma/serum/urine/CSF/other body fluids

- The collected specimens are analyzed in Clinical Biochemistry
- Laboratory using various analytical methods to obtain the results
- The obtained results are compared with the values with respective normal/reference range.
- The reported results help for confirming the diagnosis and treatment of the patient.
- The interrelationship of biochemistry and medicine is a wide two-way street.



Biochemical research, nutrition and preventive medicine

- One major item for the **maintenance of health** is that there be optimal dietary intake of a number of chemicals; the chief of these are vitamins, certain amino acids, certain fatty acids, various minerals, and water. The nutrition is concerned with the study of various aspects of these chemicals depending upon the knowledge of biochemistry.

Branches of Biochemistry

- **Medical Biochemistry:** it deals with chemical basis of human body, biochemical constituents of human body, their interactions intracellularly to maintain normal health, growth and reproduction and related diseases.
- Study of various Biochemical constituents of cell:
(Chemistry, properties, functions, metabolism and related disorders).
 - Carbohydrates
 - Lipids
 - Proteins
 - Vitamins
 - Minerals
 - Water

Metabolism of Biomolecules

Ingestion → digestion → absorption → transport → uptake, finally assimilation of food constituents in human body.

- **Clinical Biochemistry:** it deals with clinical diseases/pathological conditions of human body to support the diagnosis, therapy and research of Medical field

- Clinical Biochemistry includes two main components:
Methodological and Interpretative.
- Which is driven by the discovery of biomarkers, and the availability of appropriate measurement methods.

Diagnostic Investigations of Clinical Biochemistry

Types:

Routine biochemical investigations

- Blood glucose {fasting, postprandial and random}
- Kidney function tests: Non-protein nitrogenous substances -blood urea ,uric Acid, creatinine.
- Serum and urinary proteins
- Lipids: triacylglycerols, cholesterol, lipoproteins.
- Liver function tests: enzymes (AST, ALT, GGT, ALP), bilirubin (total, direct, indirect), total Proteins, albumin
- Electrolytes: (Na, K)
- Minerals: (Ca, P)
- Blood: pH, anion gap, pO₂, pCO₂, bicarbonate.

Special investigations

- Glucose Tolerance Test
- Vitamins
- Hormones
- Minerals (Mg, Zn, Cu, Fe, I)
- Drugs
- Bence Jones Proteins
- Electrophoresis
- Chromatography

Biochemical test profiles and biomarkers

- Lipid Profile
- Cardiac Profile
- Diabetic Profile
- Bone Markers
- Anemia Markers
- Tumor Markers

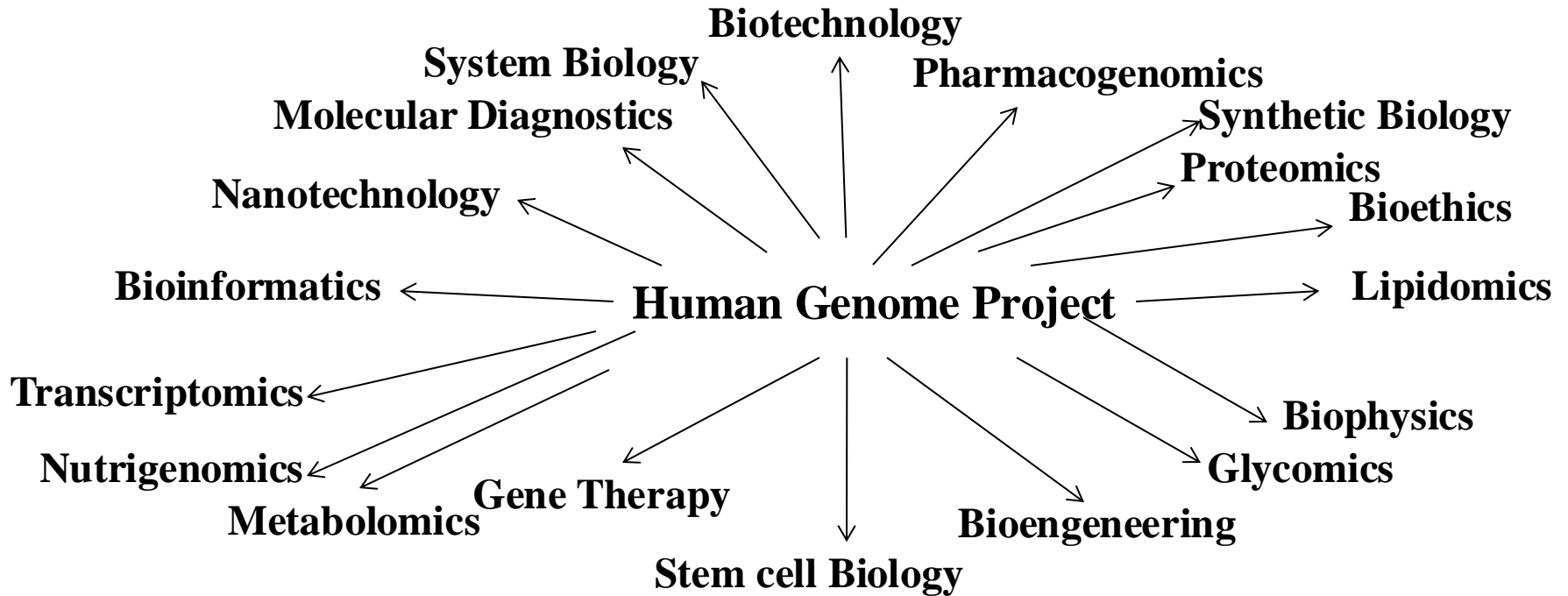
Some uses of biochemical laboratory tests in relation to diseases

Use

- To reveal the fundamental causes and mechanisms of diseases
- To suggest rational treatments of diseases based on 1 above
- To assist in the diagnosis of specific diseases
- To act as screening tests for the early diagnosis of certain diseases
- To assist in monitoring the progress (e.g, recovery, worsening, remission, or relapse) of certain diseases
- To assist in assessing the response of diseases to therapy

Example

- Demonstration of the causes of genetic defect as in **cystic fibrosis**
- A diet low in **phenylalanine** for treatment of **Phenylketonuria**
- Use of the plasma enzyme **creatine kinase MB (CK-MB)** in the diagnosis of **myocardial infarction**
- Use of measurement of blood **thyroxine or (TSH)** in the diagnosis **congenital hypothyroidism.**
- Use of the plasma enzyme **ALT** in monitoring the progress of **infectious hepatitis**
- Use of measurement of blood **CEA** in patients who have been treated for **cancer colon.**



- The Human Genome Project (HGP) has influenced many disciplines and areas

of research. Biochemistry was underway long before the HGP commenced.

- However, a number of the disciplines shown (e.g., bioinformatics, genomics, glycomics, lipidomics, metabolomics, molecular diagnostics, proteomics, and transcriptomics) are very active areas of research by biochemists.

References

- 1- Harper's Illustrated Biochemistry, 29th edition**
- 2- Lippincott illustrated biochemistry, 5th edition**
- 3- Biochemistry, Stryer, 8th edition**

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