

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 study of the chemical and physical properties of the

:Biochemistry involves and incorporates with large areas of-
Cell biology 2- Molecular biology 3- Molecular genetics- 1

:It describes-

Origin →

Formation →

Function →

Deficiency →

Symptoms →

Types of biomolecules

:Small molecules

Lipid, phospholipids, glycolipid, sterol, - Vitamin-
Hormone, neurotransmitter - Carbohydrate, sugar-

:Monomers

Amino acids - Nucleotides - Monosaccharides-

:Polymers

Peptides, oligopeptides, polypeptides, proteins-

Nucleic acids, i.e. DNA, RNA-

Oligosaccharides, polysaccharides (including cellulose)-

Roles Of Important Biomolecules

.Carbohydrates serves as primary source of energy-

.Lipids serves as secondary source of energy-

Proteins are structural and functional units of human body-

.which are of prime importance and survival of human beings

Vitamins: Fat soluble and water soluble vitamins have specific-

.functions which serve as accessory growth factors

Minerals: Inorganic elements major and minor type has-

.important role in building and functioning of human bodies

Enzymes are biomolecules which are biocatalysts catalyzes-

specific biochemical reactions of metabolic pathways and

.considered as functional units of metabolism

Hormones the endocrine substances, 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, Mitochondrial Respiratory chain
- f. The Immune response

Biomolecules – Structure

Anabolism



Building block

Macromolecule

Simple sugar

Polysaccharide

Amino acid

Protein (peptide)

Nucleotide

RNA or DNA

Fatty acid

Lipids

Catabolism

Frequent reaction encountered in biochemical processes

Nucleophilic Substitution. 1

One atom or group substituted for another -

Elimination Reactions. 2

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

Addition Reactions. 3

Two molecules combine to form a single product -

A. Hydration Reactions -

Water added to alkene > alcohol (common addition reaction) -

Isomerization Reactions. 4

Involve intramolecular shift of atoms or groups -

Oxidation-Reduction (redox) Reactions. 5

Occur when there is a transfer of e⁻ from a donor to an electron

acceptor

Hydrolysis reactions. 6

Principles of Biochemistry

Cells (basic structural units of living organisms) are highly

organized and constant source of energy is required to

- .maintain the ordered state

Living processes contain thousands of chemical-

- .pathways

The regulation and integration of these pathways are required to maintain life

Certain important pathways e.g. glycolysis is found in-

- .almost all organisms

All organisms use the same type of molecules:-

- .carbohydrates, proteins, lipids and nucleic acids

Instructions for growth and reproduction for each-

- organism is encoded in their DNA

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 disease mechanisms-

.Study of Inborn Errors of metabolism-

.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 suspect

Suspected diseased cases by a physician are investigated for-
the levels of biochemical parameters

In various collected biological specimens-

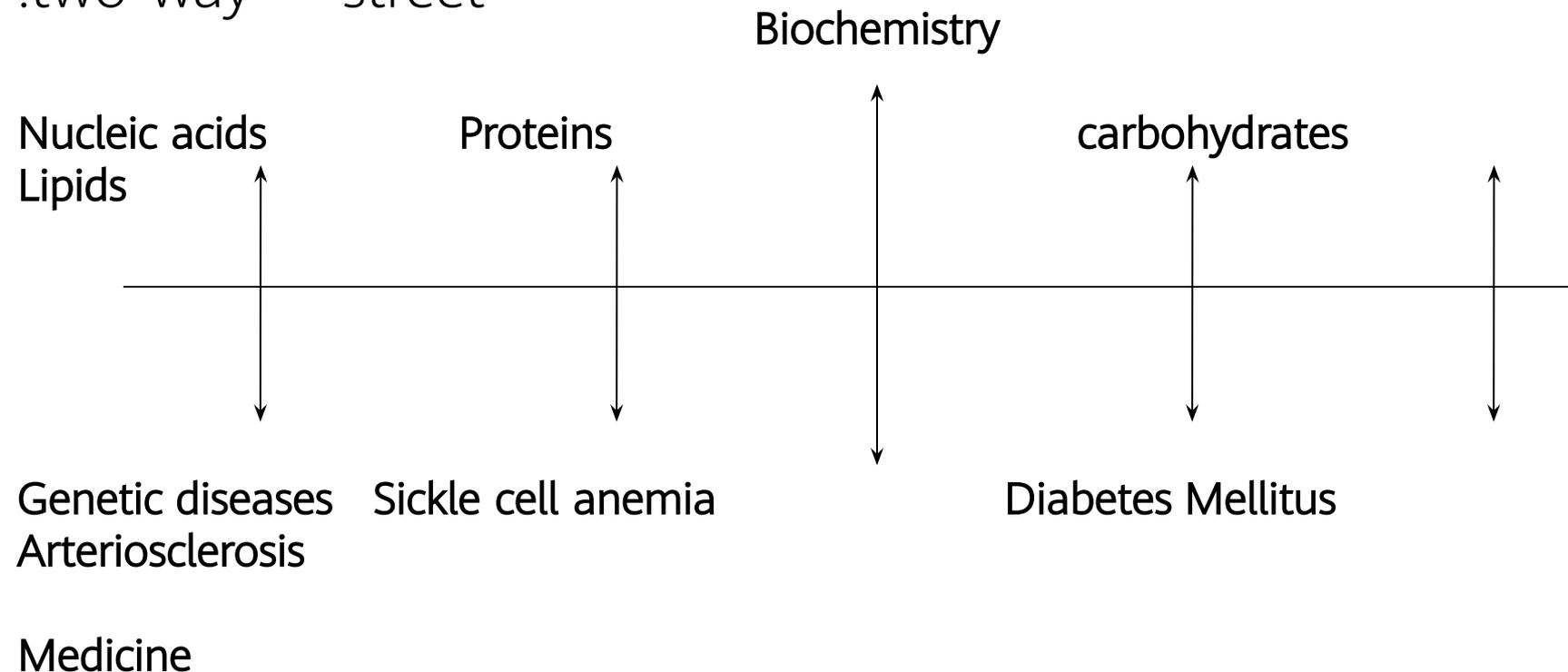
Blood/plasma/serum/urine/CSF/other body fluids-

The collected specimens are analyzed in a 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



Biochemistry; and life sciences

Genetics; nucleic acids, their structures, and functions-

.constitute the core of genetics

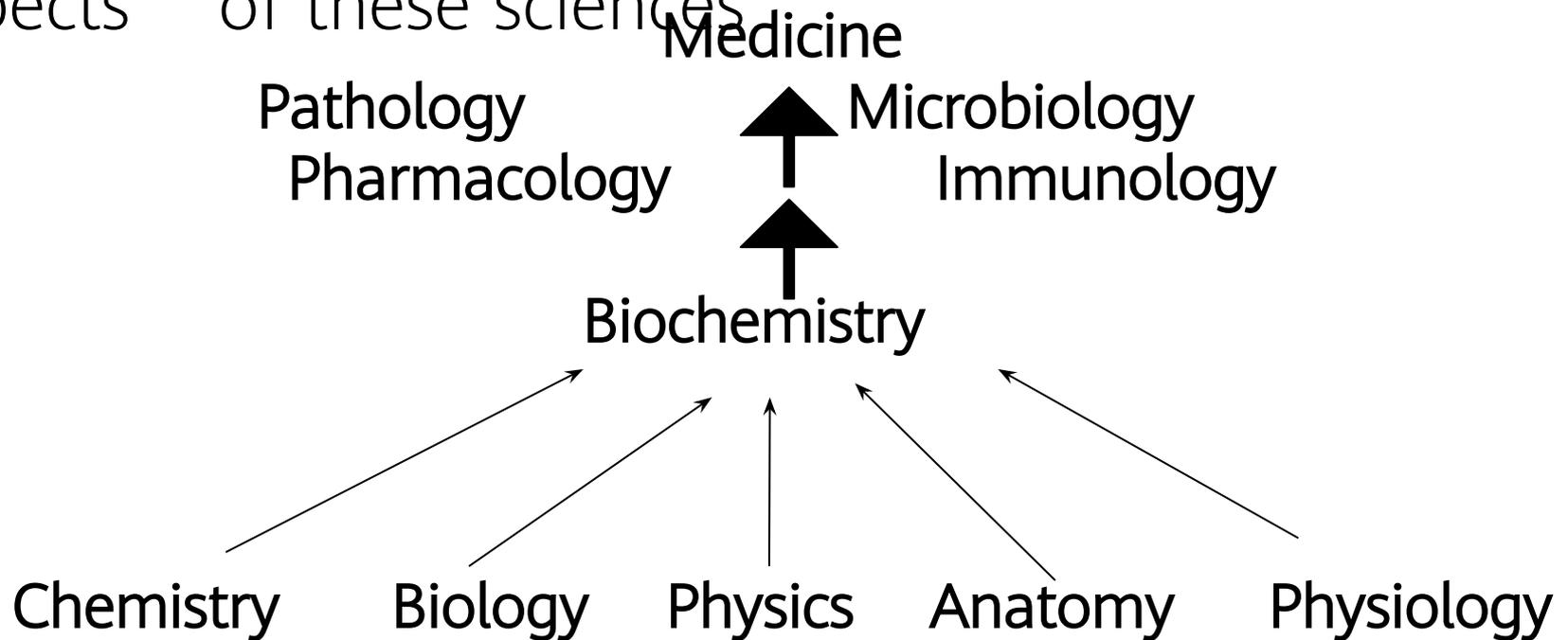
Physiology; biochemistry overlaps almost completely-
with physiology (the study of biological processes
.and functions)

Immunology; a science that deals with defense-
mechanisms against diseases, is considered a branch
.of biochemistry

Pathology; biochemistry explains, at the molecular-
.level, the symptoms and pathogenesis of diseases

Pharmacology and toxicology; advances in these-
sciences depend primarily on knowledge gained
from biochemistry as drugs and poisons are
metabolized inside the body in enzyme-
.catalyzed biochemical reactions

Biological sciences (microbiology, botany and zoology)-
use biochemical approaches in the study of different
.aspects of these sciences



Normal biochemical processes are the basis of health

World Health Organization (WHO) definition of -
health

situation in which all intra- and extracellular ()
reactions that

occur in the body are proceeding at rates with
maximal

)survival of the organism in the physiologic state

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

Because much of the subject matter of both-
biochemistry and nutrition is concerned with the
.study of various aspects of these chemicals

Moreover, the systematic attempts to maintain health-
and prevent disease is called (preventive
.medicine)

Thus, nutritional approaches depend to a great extent-
.on a knowledge of biochemistry

Branches of Biochemistry

Medical Biochemistry: it deals with chemical basis of human-body, biochemical constituents of human body, their interactions in body cells 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

: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-Tri Acyl Glycerol, 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,Bicarbonates-

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-

Most and perhaps all diseases have biochemical basis

Most if not all diseases are manifestations of **molecules-
.abnormalities, chemical reactions, or biochemical processes**

The major factors responsible for causing diseases in animals-
and humans are affecting one or more **critical chemical
.reactions or molecules in the body**

The major causes of diseases

,Physical agents: Mechanical trauma, extremes of temperature- 1
.radiation and electric shock

.Chemical agents, including drugs and toxic compounds. 2

Biologic agents: Viruses, bacteria, fungi, higher forms of. 3
.parasites

Oxygen lack: Loss of blood supply, depletion of the oxygen-. 4
carrying capacity of the blood, poisoning of the oxidative
.enzymes

.Genetic disorders: Congenital, molecular. 5

.Immunologic reactions: Anaphylaxis, autoimmune disease. 6

.Nutritional imbalances: Deficiencies, excesses. 7

.Endocrine imbalances: Hormonal deficiencies, excesses. 8

Some uses of biochemical laboratory tests in relation to diseases

Use

Example

To reveal the fundamental causes and mechanisms of diseases

- Demonstration of the causes of genetic defect as in **cystic fibrosis**

To suggest rational treatments of diseases based on 1 above

- A diet low in **phenylalanine** for treatment of **Phenylketonuria**

To assist in the diagnosis of specific diseases

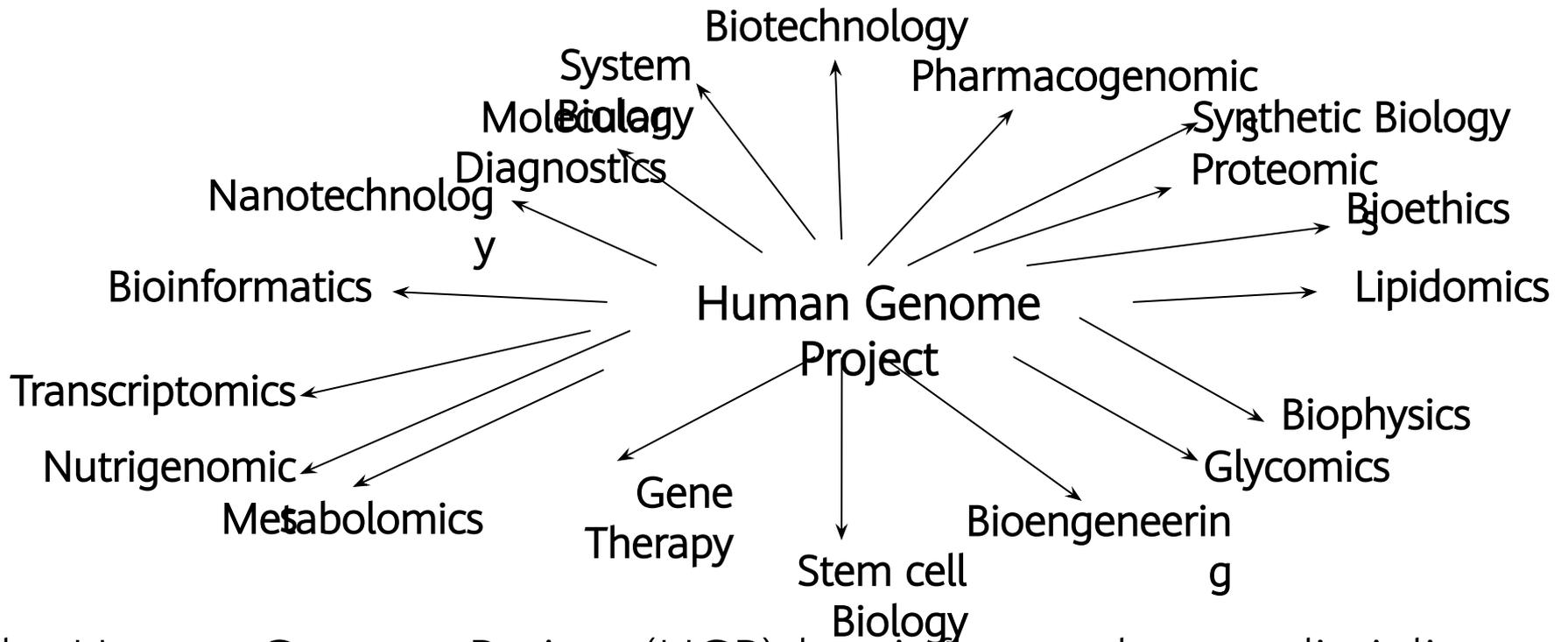
- Use of the plasma enzyme **creatinine kinase MB (CK-MB)** in the diagnosis of **myocardial infarction**

To act as screening tests for the early-diagnosis of certain diseases

Use of measurement of blood **thyroxine** or **(TSH)** in the diagnosis **congenital hypothyroidism**.

To assist in monitoring the progress (e.g, recovery, worsening, remission, or relapse) of certain diseases

- Use of the plasma enzyme **ALT** in monitoring the progress of **infectious hepatitis**



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,

References

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

samir_mhgb@yahoo.com