Biochemistry and Medicine

Objectives of the lecture:

1- To know what is meant by biochemistry

2- To understand the relationship between biochemistry and the other sciences

3- To explore the importance of biochemistry in understanding the causes of different diseases

4- To interrelate between the uses of biochemical testing and diseases

Biochemistry

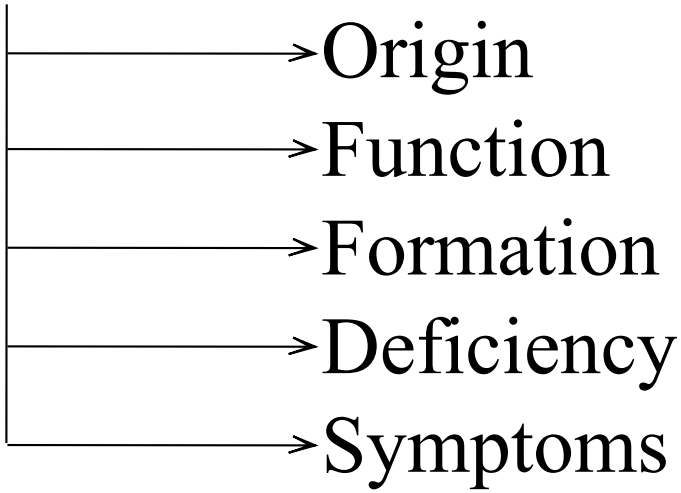
- It is the application of chemistry to the study of biological processes (structure, composition and chemical reactions of substances in living systems) at the cellular and molecular level.

- 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:



- All of these descriptions involves the macromolecules (proteins, carbohydrates, fats, nucleic acids, enzymes etc…) and their building units.

Types of biomolecules

Small molecules:

- Lipid, phospholipid, 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)

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. Utilization of energy
  b. Synthesis of molecules needed for cell structure and functioning (as proteins, nucleic acids, lipids, & CHO)
  c. Removal of waste products.

Biomolecules – Structure

Anabolism

Building block	**Macromolecule**
Simple sugar	Polysaccharide
Amino acid	Protein (peptide)
Nucleotide	RNA or DNA
Fatty acid	Lipids

Catabolism

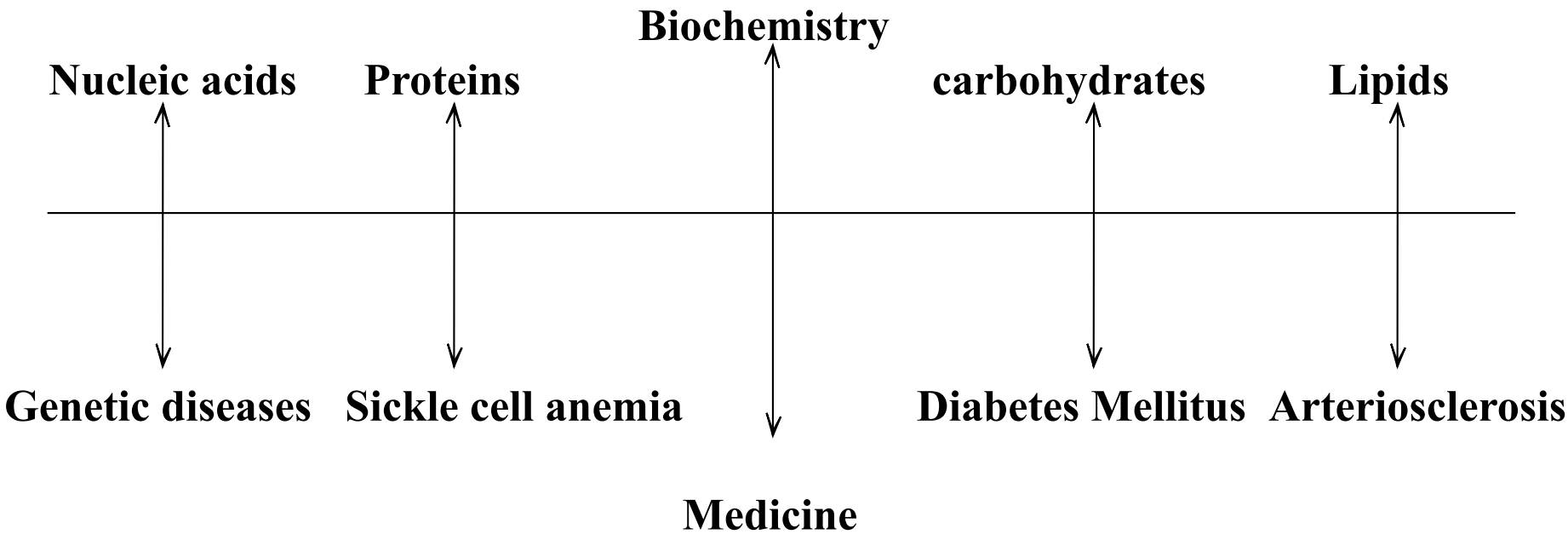
Principles of Biochemistry

- 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 the chemical processes associated with living cells.
- Also, structures and functions, metabolism and its regulation, gene expression modulation and how the life has begun (DNA $\longrightarrow$ RNA $\longrightarrow$ 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.

- 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.

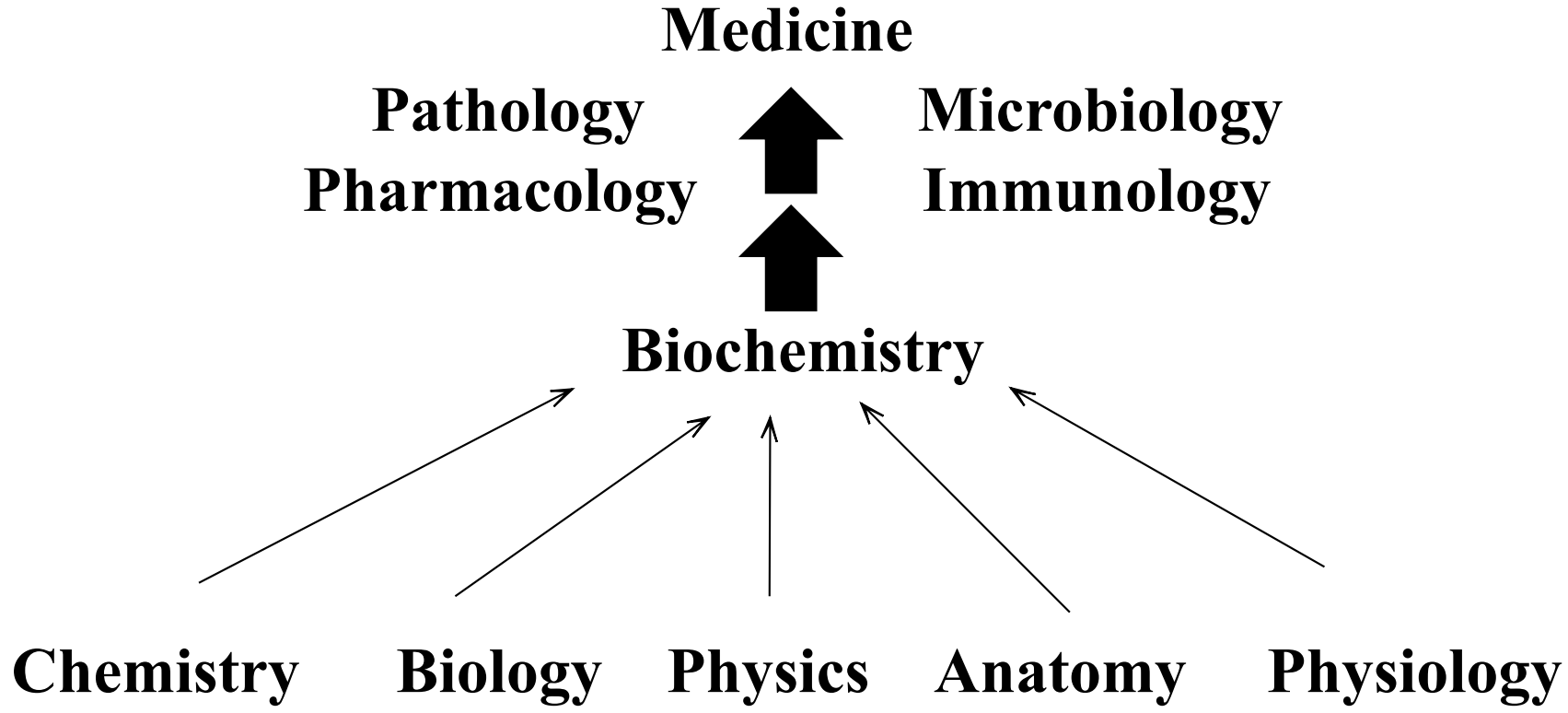
- Physiology; biochemistry overlaps almost completely with physiology (the study of biological processes and functions).

- 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.



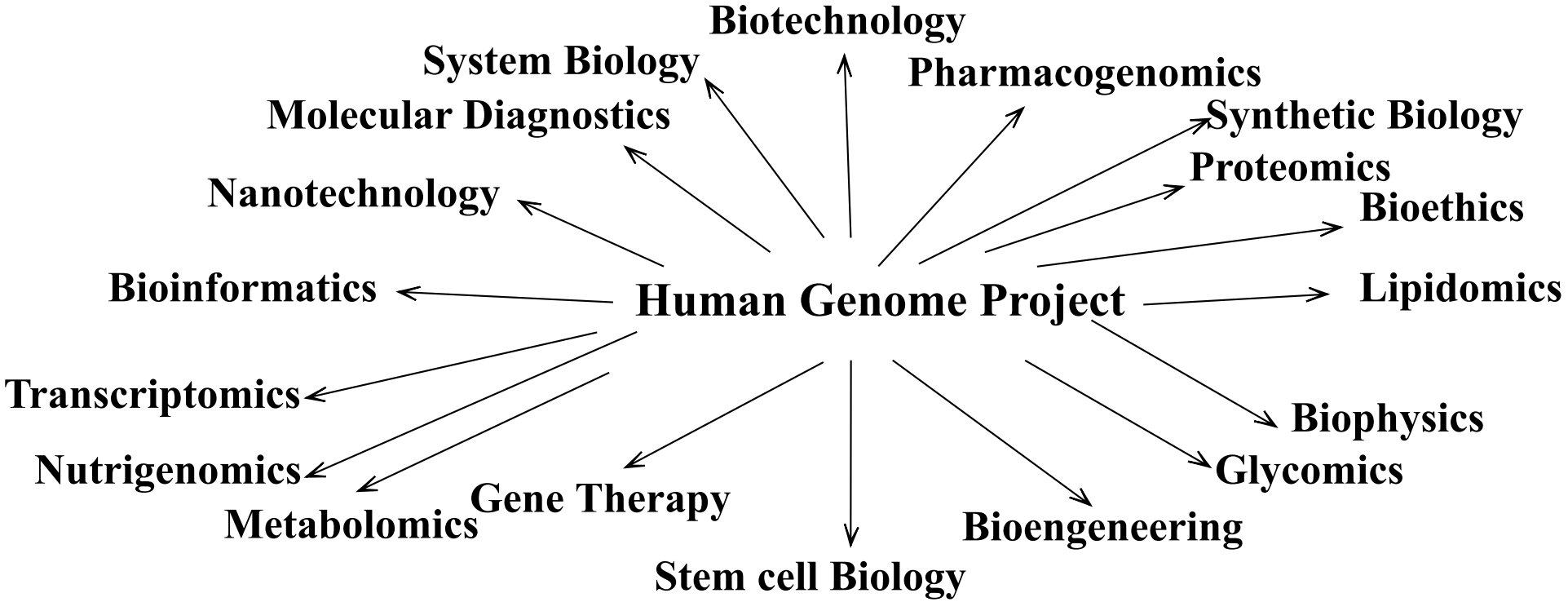
Normal biochemical processes are the basis of health

- 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.



- 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.

Most & perhaps all disease has a 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

1- Physical agents: Mechanical trauma, extremes of temperature, radiation and electric shock.
2. Chemical agents, including drugs and toxic compounds.
3. Biologic agents: Viruses, bacteria, fungi, higher forms of parasites.
4. Oxygen lack: Loss of blood supply, depletion of the oxygen-carrying capacity of the blood, poisoning of the oxidative enzymes.
5. Genetic disorders: Congenital, molecular.
6. Immunologic reactions: Anaphylaxis, autoimmune disease.
7. Nutritional imbalances: Deficiencies, excesses.
8. Endocrine imbalances: Hormonal deficiencies, excesses.

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 **creatine 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**
- To assist in assessing the response of diseases to therapy	- Use of measurement of blood **CEA** in patients who have been treated for **cancer colon**.

References

1- Harper's Illustrated Biochemistry, 29th edition

2- Lippincott illustrated biochemistry, 5th edition

3- Biochemistry, Stryer, 8th edition

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