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Stage two

practical biochemistry

Lecture 1

Qualitative analysis of Biomolecules

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In Chemistry, qualitative analysis is a branch of chemistry that examines the chemical composition of a sample.

In Chemistry, qualitative analysis determines the presence or absence of several chemical components in a sample.

In chemistry, qualitative analysis includes techniques such as distillation, extraction, colour change, chromatography, and so on.

Introduction to Biomolecules:

- Biochemistry is the study of the chemistry of cells and organisms.
- Thus it is concerned with the types of molecules found in biological systems, their structure, and their chemical properties.
- Biochemistry also deals with the function of these molecules, how they interact, and what reactions they undergo.

Properties of Biomolecules:

A. General Properties:

- Biomolecules are organic molecules, not fundamentally different from other, typical organic molecules.
- They are the same types of molecules, react in the same ways, and obey the same physical laws.

B. Composition and Structure:

- Biomolecules contain mainly carbon, which behaves as it always does in organic compounds, forming 4 bonds, usually with a tetrahedral arrangement.
- The carbon skeleton can be linear, branched, cyclic, or aromatic.
- Other important elements are H, O, N, P and S. About 30 elements are required by biological systems, including iodine and many metals, though most of these are needed in only trace amounts.

C. Stereochemistry:

- As is common with organic compounds, many biomolecules exhibit stereochemistry.
- When four different types of atoms or functional groups are bonded to one carbon atom, the carbon is stereogenic (or chiral or asymmetric) and the 1 compound can exist in two different isomeric forms that have different configurations in space.
- The two configurations are mirror images of each other and are not superimposable. When two compounds are mirror images of each other they are called **enantiomers or optical isomers**, a subclass of stereoisomers.
- Enantiomers usually have identical chemical properties, and differ only in the way they rotate planepolarized light or interact with other chiral compounds.
- Most biomolecules have several or many asymmetric carbons and so may have many diastereomers, a subclass of stereoisomers that are non-mirror images and have different properties. Stereochemistry is important because biological systems usually use only one specific isomer of a given compound.

Types of Biomolecules:

Biomolecules can be divided into several major classes and a few minor classes.

A. Amino Acids and Proteins:

- Amino acids are relatively small molecules with molecular weights around 100-200
- They are used to produce energy, to synthesize other molecules like hormones, and to make proteins.
- Proteins are polymers of amino acids.
- They fold into specific shapes and range in molecular weight from several thousand to over a million.
- Proteins function as enzymes (which catalyze reactions), structural elements, transport molecules, antibodies, etc.

B. Carbohydrates (sugars & starches) :

- The smallest carbohydrates are the monosaccharides with molecular weights of around 100-200.
- They are a major source of energy for biological systems. Polysaccharides are polymers of monosaccharides with molecular weights often in the millions.
- Polysaccharides also have definite shapes and serve as structural elements or as stored metabolic energy.

C. Lipids (fats & oils) :

- Lipids are relatively small water-insoluble molecules with molecular weights of up to 750-1500.
- Because they are defined by their water-insolubility, they are chemically more diverse than the other classes of biomolecules, with about half a dozen major types.
- Lipids are used for energy production and storage, hormones, structural elements of cell membranes, and vitamins.
- Lipids do not polymerize to form macromolecules, but they can aggregate non-covalently to form very large structures.

D. Nucleotides and Nucleic Acids:

- Nucleotides are relatively small molecules with molecular weights in the hundreds.
- They function in transferring energy and in helping enzymes to catalyze reactions.
- Nucleic acids (DNA and RNA) are large polymers of nucleotides, with molecular weights up into the billions.
- They form structures like the double helix, and they function in storing, transmitting, and utilizing genetic information.

E. Small Organic Molecules:

- In addition to the major classes of biomolecules, there are many relatively small organic molecules required by cells for very specific functions; these molecules do not fall neatly into one of the above major categories.
- These molecules can be precursors of biomolecules that help enzymes function (often related to vitamins), or can be intermediates in metabolic pathways, etc.

F. Inorganic Ions :

Though not actually biomolecules, many inorganic ions are required by cells, often in trace amounts. These include calcium, sodium, iron, magnesium, potassium, chlorine, etc. Inorganic ions perform a variety of functions such as structural elements (calcium in bone), regulation of osmotic pressure and transport (sodium), and components of proteins and enzymes (iron).

G. Combinations of Biomolecules:

Sometimes one biomolecule can contain components from two of the major classes, such as a lipoprotein (lipid plus protein) or a glycoprotein (carbohydrate plus protein).

Testing for Biological Molecules:

There are a number of tests that can be carried out quickly and easily in a lab to determine if a sample contains one of the key biological molecules (carbohydrates, proteins and lipids).

The following tests are qualitative - they do not give a quantitative value as to how much of each type of molecule may be present in a sample.

1. Benedict's test for reducing sugars.
2. Iodine test for starch.
3. Emulsion test for Lipids.
4. Biuret test for proteins.

INDICATOR	MACRO-MOLECULE	NEGATIVE TEST	POSITIVE TEST
Benedict's solution	simple carbohydrate	blue	orange
Iodine solution	complex carbohydrate	dark red	black
Biuret solution	protein	blue	violet, black
Sudan IV	lipid	dark red	reddish-orange