MODULE 4- BIOMOLECULES

All living and non-living things consist of matter, which can be anything that occupies space and has mass. Mass is the amount of matter in any object, which does not change while weight, the force of gravity acting on matter, does change. Matter exists in three states as solid, liquid and gas. All forms of matter, both living and non-living, are made up of a limited number of building blocks called chemical elements. what is micromolicules and macromolicules

Chemical Composition of Living Forms what are biomolicules?

Elemental analysis reveals the presence of several elements in both living and non-living matter. Twenty-six elements are present in the human body; four elements, called the major elements constitute about 96% of the body's mass viz. oxygen, carbon, hydrogen and nitrogen. Eight others, the lesser elements contribute to 3.6% to the body's mass. An additional 14 elements called the trace elements are present in tiny amounts.

All living organisms are made up of same chemicals though their relative amounts may be different. Most of the chemicals in your body exist in the form of compounds. Biologists and chemists divide these compounds into two principal classes:

1. Inorganic compounds: They usually lack carbon and are structurally simple. Their molecules also have only a few atoms and cannot be used by cells to perform complicated biological functions. They include Na, K, Ca, Mg, water and many salts of NaCl and $CaCO_3$, acids and bases, compounds of sulphate and phosphate. They may have either ionic or covalent bonds. Water makes up 55-60% of a lean adult's total body mass.

2. Organic compounds: They always contain carbon and usually hydrogen, and always have covalent bonds. Most of them are large molecules and many are made up of long chains of carbon atoms. Organic compounds make the remaining 38-43% of the human body. Many organic molecules are relatively large and have unique characteristics that allow them to carry out complex functions. Important categories of organic compounds include carbohydrates, lipids, proteins, nucleic acids and adenosine triphosphate (ATP).

The study of chemistry of living organisms is known as biochemistry. The carbon compounds obtained from the living tissue are known as biomolecules. The different types of biomolecules present in the cell are collectively called cellular cell. The compounds of carbon are central to life on this planet. Carbon compounds include DNAs, the giant helical molecules that contain all of our genetic information. They also include proteins that catalyse all of the reactions in our body and that constitute the essential compounds of our blood, muscle and skin. These biomolecules are mainly (1) amino acids, peptides and proteins, (2) carbohydrates, (3) nucleotides and (4) lipids.

Monomeric Units and Polymeric Structures

The bond linking in the monomers of the various polymers are discussed below.

1. <u>Proteins:</u> The covalent bond joining each pair of amino acids (or monomers) is a peptide bond or amide linkage. It always forms between the carbon of the carboxyl group (--COOH) of one amino acid and the nitrogen of the amino group (--NH_2) of another. As

the peptide bond is formed, a molecule of water is removed, making this a dehydration synthesis reaction.

2. <u>Lipids:</u> Lipids are esters of fatty acids with glycerol. Since the lipids contain small proportion of electronegative oxygen, there are fewer polar covalent bonds. The saturated fatty acids have only single covalent bond. Further they contain hydrophilic groups and hydrophobic groups. The hydrophilic groups are present near the surface of the lipid and are capable of forming hydrogen bonds with water.
3. <u>Carbohydrates:</u> The covalent bond that joins one sugar molecule to another is called as the glycosidic bond. The glycosidic bond between the anomeric carbon of one monosaccharide is joined with the hydroxyl group of another monosaccharide to form polysaccharides by dehydration.
4. <u>Nucleic acids:</u> Covalent bonds, hydrogen bonds, hydrophobic bonds are the chemical bonds that are important in DNA structure. Nucleic acids are macromolecules made up of nucleotides connected by phosphodiester bond.

Carbohydrates

Carbohydrates are hydrates of carbon containing C, H and O, with the empirical formula $(CH_2O)_n$. The ratio of hydrogen to oxygen atoms is usually 2:1, the same as in water. Although there are exceptions, carbohydrates generally contain one water molecule for each carbon atom. This is the reason why they are called carbohydrates, which means ‘watered carbon’. Based on their sizes, carbohydrates can be of the following types.

1. Small carbohydrates: They can cross plasma membrane. They are, further, classified as follows.

Monosaccharides: They are simple sugars that contain from 3 to 7 carbon atoms. Eg. glucose (the main blood sugar), fructose (found in fruits), galactose (found in milk sugar) and ribose (in RNA).

Derived monosaccharides: Eg. Glucuronic acid, D-glucosamine, Deoxyribose in DNA.

Disaccharides: They are simple sugars formed from the combination of two monosaccharides by dehydration synthesis.

Eg. 1. Sucrose (table sugar) = glucose + fructose

2. Lactose (milk sugar) = glucose + galactose

3. Maltose = glucose + glucose

2. Large carbohydrates: They cannot cross plasma membrane. They are **polysaccharides** from tens to hundreds of monosaccharides joined by dehydration synthesis. Glycogen is the stored form of carbohydrates in animals. Starch is the stored form of carbohydrates in plants and main carbohydrates in food. Cellulose is the part of cell walls in plants that cannot be digested by humans but aids movement of food through intestines.

Based on the composition, polysaccharides are classified as (i) homopolysaccharides, containing only one type of monosaccharides, for e.g. glycogen, starch etc.; (ii) heteropolysaccharides, containing more than one type of monosaccharides or their derivatives, for e.g. agar, pectin etc.

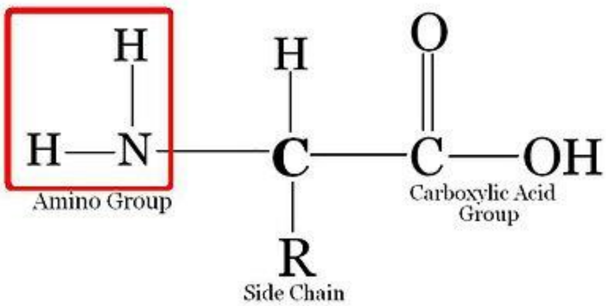
Based on their function, polysaccharides are classified as (i) storage polysaccharides which serve as food reserve, e.g. starch and glycogen; (ii) structural polysaccharides which play role in formation of cell wall in plants (eg. cellulose) and skeleton in animals (eg. chitin).

Functions of Carbohydrates

1. Glucose is the main respiratory substrate, and it is called as blood glucose which exists in the body in ring form.
2. Fructose is also called levulose and is found in fruit, honey, corn syrup etc., which accounts for the major sugar content in our diet. It is absorbed into the small intestine and after transported to the liver, it is metabolized into glucose by glycolytic pathway.
3. Galactose is not present freely in nature, but combines with glucose to form lactose, a disaccharide. When absorbed into the body, it is either converted into glucose in the liver, or stored as glycogen.
4. Ribose is an important sugar found in variety of chemicals such as ATP besides beng a constituent of nucleotides that form RNA. Similarly, deoxyribose sugar is a part of nucleotides that form DNA.
5. Mucopolysaccharides help in lubrication of ligaments and tendons, form synovial fluid, build strength and flexibility of skin, connective tissues and cartilage, bind proteins in cell walls and store water in the interstitial spaces.

Amino Acids

Amino acids are the monomers of proteins. Each amino acid has an amino group (-NH_2), an acidic carboxyl group (-COOH) and a side chain (R group). The amino acids are known as α-amino acids because they have a primary amino group (-NH_2) as a substituent of the α-carbon atom, the carbon next to the carboxylic acid group (-COOH). The amino acids are the organic compounds that are substituted methane.

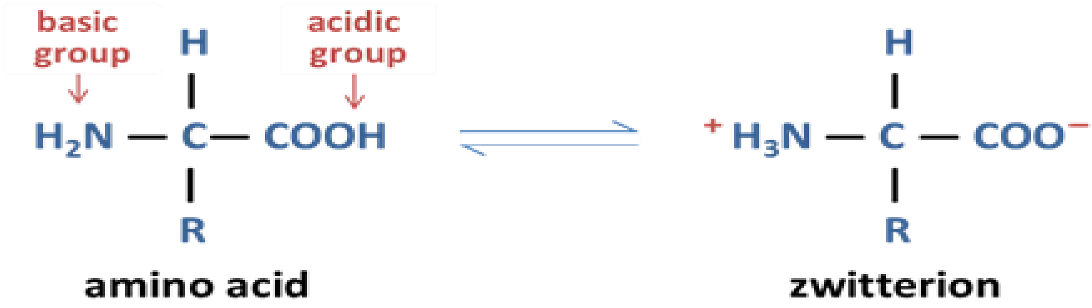


Classification of Amino Acids

1. Amino acids with non-polar R groups (eg. glycine, valine etc.)
2. Amino acids with uncharged polar R groups or neutral amino acids (eg. serine, glutamine etc.)
3. Amino acids with charged polar R groups (eg. lysine, glutamic acid etc.)

Zwitterionic Form of Ionic Acids

The amino acids contain both acidic (-COOH) and basic (-NH_2) groups. These groups are ionizable. The amino acids occur as dipolar ions or zwitterions in dry state. In this form, the carboxyl group is present as carboxylate ion (-CO_2^-) and the amino group is present as an aminium ion (-NH_3^+). The pH at which the concentration of the dipolar ion (zwitterion) is at its maximum and the concentration of the cations and the anions are equal is called the isoelectric point. At this pH, there is no net charge on the protein. It is specific for each amino acid.



Essential and Non-Essential Amino Acids

The amino acids that can be synthesized by the body are non-essential amino acids. Those that cannot be synthesized by the body need to be supplemented in the diets. Such amino acids are known as essential amino acids. For eg. valine, leucine, histidine, lycine etc.

Proteins

Short chains of amino acids are called peptides. The chains which have fewer than 40 or 50 amino acids are called polypeptides, while still larger chains are called as proteins. They consist of carbon, hydrogen, oxygen, nitrogen elements, and some others may contain sulphur, phosphorous, iron and other elements.

Nucleic Acids

A nucleic acid is a chain of repeating monomers called as nucleotides. Nucleotides are monomeric unit or building blocks of nucleic acids. Each nucleotide consists of three parts namely nitrogen base (e.g. adenine), a five-carbon sugar (e.g. ribose), a phosphate group.

Types of Nucleic Acids

There are two types of nucleic acids viz., Deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA).

- **Deoxyribonucleic acid (DNA):** The structure of DNA is given by the Watson-Crick double helix model. DNA is double-stranded structure. The sugar is 2’ deoxyribose. Nitrogen bases present in DNA are Adenine, Guanine, Thymine and Cytosine. The two strands of the double helix DNA are complementary to each other, and this property makes DNA suitable to store and transmit genetic information from generation to generation.
- **Ribonucleic acid (RNA):** It is a single-stranded structure. It consists of ribose sugar. Nitrogen bases present in RNA are Adenine, Guanine, Uracil and Cytosine. There are three types of RNA viz., rRNA, mRNA and tRNA. All the RNAs are required for protein synthesis.

Functions of Nucleotides

1. They are building blocks of nucleic acids (RNA, DNA).
2. They act as carriers of chemical energy (ATP, GTP).
3. They function as coenzymes for dehydrogenases or oxidases.
4. They are intermediaries in cellular communications and signal transduction.

Lipids

Lipids make up 18-25% of adult body mass, and contain carbon, hydrogen and oxygen. They are insoluble in polar solvents such as water, hence hydrophobic.

Fatty Acids

Fatty acids are the simplest and major constituents of all lipids. They are basically monocarboxylic acid containing short/long-chain hydrocarbon molecules. A fatty acid consists of a carboxyl group and an R group. The R group can be methyl or ethyl group or can even go up to 19 carbon atoms.

Types of Fatty Acids

1. Saturated which contain only single covalent bonds between the carbon atoms of the hydrocarbon chain (eg. stearic acid, palmitic acid)
2. Unsaturated which contains one or more double covalent bonds between the carbon atoms of the hydrocarbon chain

Essential and Non-Essential Fatty Acids

Both plants and animals have the biosynthetic machinery to manufacture fatty acids. A group of fatty acids called the essential fatty acids (EFAs) is important for human health. However, they cannot be synthesized by the human body and must be obtained from foods or supplements. They occur mostly in oils derived from sunflower, coconut, groundnut etc. Among the more important EFAs are omega-3 fatty acids, omega-6 fatty acids and cis-fatty acids.

Classification of Lipids

1. Triglyceride (fats and oils)
2. Phospholipids: It is a major lipid component of cell membranes.
3. Sphingolipids: Major component of cell membranes
4. Steroids: These are compounds that have four rings of carbon atoms.
5. Waxes: They are esters of long-chain fatty acids and long-chain alcohols.

Function of Lipids

1. Lipids provide more than twice as much energy per gram as do carbohydrates and proteins.
2. Excess dietary carbohydrates, proteins, fats and oils are deposited in adipose tissue which provides thermal insulation to the body.
3. Useful products like cooking oil can be manufactured from hydrogenation of triglycerides, and soaps can be manufactured by saponification of triglycerides.
4. Phospholipids and glycolipids are major constituents of cell walls and cell membranes, with phospholipids forming lipids bilayers.
5. Cholesterol is an important steroid, which is known to act as an intermediate in the synthesis of other steroids in the human body.
6. Other important steroids are sex hormones (for reproduction), vitamin D (for bone strength), adrenocortical hormones, bile acids and bile salts (for digestion process)
7. Prostglandins found in most of the animal tissues are known to affect heart rate, blood pressure, blood clotting, fertility, while leukotrienes regulate allergic and anti-inflammatory responses.
8. Lipoproteins play an important role in protein modification and recognition.

9. Waxes form protective coatings on the skin, fur, and feathers of animals and on the leaves and fruits of plants.

Tutorial

1. Write a note on the bond linking in the monomers of the various polymers.
2. What is meant by zwitterion and its isoelectric point?
3. What are polysaccharides? List various functions of polysaccharides.
4. List some important organic compounds present in living organisms.
5. List different types of lipids.

6. what are carbohydrates? 10 marks.

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