BIOMOLECULES

The molecules present in living system like carbohydrates, proteins, nucleic acids, lipids, vitamins etc. which are essential for the growth and maintenance of our body are called **Biomolecules.**

Carbohydrates

These are the hydrates of carbon and most of them have a general formula $C_x(H_2O)y$. They can be defined as polyhydroxy aldehydes or ketones or the compounds which produce such units on hydrolysis. Some of the carbohydrates are crystalline, water soluble and sweet in taste. They are called sugars. Carbohydrates which are not crystalline, water insoluble and have no sweet taste are called non-sugars. Carbohydrates are also called 'Saccharides'.

Classification of carbohydrates

Based on their behaviour on hydrolysis:

Based on this, carbohydrates are classified into three types:

Monosaccharides: These are carbohydrates which cannot be hydrolysed into simpler units of polyhydroxyaldehydes or ketones. E.g. glucose, fructose, ribose, galactose etc.

Oligosaccharides: These are carbohydrates which give two to ten monosaccharide units on hydrolysis. They are further classified as disaccharides, trisaccharides, tetrasaccharides etc. e.g. Sucrose, maltose, lactose etc. Sucrose on hydrolysis gives one molecule each of glucose and fructose, maltose gives two molecules of glucose while lactose gives one molecule each of glucose and galactose.

Polysaccharides: These are carbohydrates which give a large number of monosaccharide units on hydrolysis. E.g. starch, cellulose, glycogen etc.

Based on their reducing character: Based on this, carbohydrates are of two types – reducing sugar and non-reducing sugar. Carbohydrates which contain free aldehydic or ketonic groups are called reducing sugars. While those which do not contain free aldehydic or ketonic group are called non-reducing sugars. All monosaccharides are reducing sugars. Disaccharides like maltose and lactose are reducing while sucrose is non-reducing.

Based on the functional group and no. of carbon atoms: A monosaccharide containing an aldehyde group is known as aldose, while a monosaccharide containing a ketonic group is known as ketose. Monosaccharides containing 3 carbon atoms are called triose, 4 carbon atoms are called tetrose etc.

Q1. Give the methods used for the preparation of glucose?

From sucrose (Cane sugar): If sucrose is boiled with dilute HCl or H_2SO_4 in alcoholic solution, glucose and fructose are obtained in equal amounts

$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$

From starch: Commercially glucose is obtained by hydrolysis of starch by boiling it with dilute H_2SO_4 at 393 K under pressure.

$(C_6H_{10}O_5)n + nH_2O \longrightarrow nC_6H_{12}O_6$

Q2. Write a note on the structure of glucose?

Glucose is an aldohexose and is also known as dextrose. Its molecular formula is $C_6H_{12}O_6$. Experiments suggest that i) all the six carbon atoms are linked in a straight chain ii) there is a free aldehydic group and 5 hydroxyl groups and iii) one of the alcoholic group is primary. Based on the above informations, Fischer proposed an open chain structure for glucose as follows:

But this open chain structure cannot explain the following observations:

1. Glucose does not react with 2,4-Dinitrophenyl hydrazine, Schiff's reagent and with $NaHSO_3$.

2. The existence of two different crystalline forms of glucose (α and β form). In order to explain the above, it was proposed that one of the –OH groups may add to the –CHO group and form a cyclic hemi-acetal structure. The –OH at C_5 is involved in ring formation. (1,5 – oxide ring).

Q3. Hydrolysis of cane sugar is also called inversion of cane sugar. Why?

Cane sugar is sucrose, which on hydrolysis gives an equimolar mixture of D(+)glucose and D(-)fructose. $C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$ Sucrose D(+)Glucose ($+52.5^0$) D(-)Fructose (-92.4^0) Sucrose is dextro rotatory but after hydrolysis gives dextro rotatory glucose and laevo rotatory fructose. Since the laevo rotation of fructose ((-92.4^0) is more than dextro rotation of glucose ($+52.5^0$), the HSSLIVE.IN Page 3 mixture is laevo rotatory. So the process is called inversion of cane sugar and the product formed is called invert sugar.

Q5. Write a note on amino acids?

These are compounds containing amino ($–NH_2$) and carboxyl (–COOH) groups. Depending upon the relative position of amino group with respect to carboxyl group, the amino acids can be classified as α, β, γ, δ and so on. The simplest amino acid is glycine ($H_2N\text{-}CH_2\text{-}COOH$). Except glycine, all other naturally occurring α- amino acids are optically active, since the α-carbon atom is asymmetric. Amino acids are generally represented by a three letter symbol. (e.g. 'Gly' for glycine, 'Ala' for alanine etc). Amino acids are classified as acidic, basic or neutral depending upon the relative number of amino and carboxyl groups in their molecule. Amino acids having equal number of amino and carboxyl groups is neutral; those containing more number of amino groups are basic and those containing more number of carboxyl groups are acidic. For e.g. glycine, alanine, valine etc. are neutral, arginine, lysine etc. are basic and glutamic acid, aspartic acid etc. are acidic. The amino acids which can be synthesised in the body are known as non-essential amino acids. While which cannot be synthesised in the body and must be obtained through diet, are known as essential amino acids. In aqueous solution, the carboxyl group can lose a proton and amino group can accept a proton, giving rise to a dipolar ion known as zwitter ion. This is neutral

but contains both positive and negative charges. In zwitter ionic form, amino acids show amphoteric behaviour as they react both with acids and bases.

Q7. What are peptides and polypeptides?

A peptide is formed by the combination of α-amino acid molecules. Chemically peptide linkage is an amide formed between –COOH group and -NH_2 group. When two molecules of amino acids combine, the amino group of one molecule reacts with –COOH group of another molecule by losing one water molecule to form a CO-NH linkage, commonly called peptide linkage.

The peptide formed between two amino acid molecules is called a dipeptide. H_2N-CH_2-COOH +H_2N-CH_2-COOH → H_2N-CH_2-CO-NH-CH_2-COOH Glycine Glycine Glycylalanine (Gly-Ala) The peptide formed by the combination of 3 amino acid molecules is called a tripeptide. When the number of amino acid molecules is more than 10, the product is called a polypeptide. A polypeptide with more than 100 amino acid residues and molecular mass greater than 10,000u is called a protein.

Q8. Explain the different types of proteins?

Based on the shape of molecules, proteins are classified into 2 types: a) Fibrous proteins: They have fibre – like structure. Here the linear polypeptide chains are held together by H-bond and disulphide bond. They are generally insoluble in water. E.g. Keratin (present in hair, wool, silk etc.) and myosin (present in muscles). b) Globular proteins: Here the chains of polypeptides coil around to give a spherical shape. These are usually soluble in water. Insulin and albumins are the common examples of globular proteins.

Q9. Discuss the structure of proteins?

There are four types of structure for a protein. They are primary, secondary, tertiary and quaternary structure.

Primary structure: It gives the sequence of amino acid molecules in a polypeptide chain of protein. Any change in the primary structure creates a different protein.

Secondary structure: The secondary structure of protein refers to the shape in which a long polypeptide chain can exist. There are two different types of secondary structures - α-helix and β- pleated sheet structure. These structures arise due to the regular folding of the backbone of the polypeptide chain due to hydrogen bonding between >CO and –NH– groups of the peptide bond.

Tertiary structure: The tertiary structure represents overall folding of the polypeptide chains. i.e., further folding of the secondary structure. It gives rise to two major molecular shapes - fibrous and globular.

Quaternary structure: Some of the proteins contain two or more polypeptide chains called sub-units. The spatial arrangement of these sub-units is known as quaternary structure.

Q10. What is mean by denaturation of protein?

When a protein is subjected to physical change (like change in temperature) or chemical change (like change in pH), it loses the biological activities. This process is called denaturation of protein. During denaturation, secondary and tertiary structures are destroyed, while primary structure remains unaffected. e.g. coagulation egg white on boiling, curding of milk etc.

Q11. Which are the different types of vitamins?

Depending on the solubility, vitamins are of two types:

a) Fat soluble vitamins: e.g. Vitamins A, D, E, & K b) Water soluble vitamins: e.g. Vitamins B & C

Q12. Vitamin B cannot be stored in our body. Why?

Because Vitamin B is water soluble and so it is excreted through urine.

Q13. What are nucleic acids? Give their composition?

Nucleic acids are long chain polymers of nucleotides and are responsible for transmission of heredity. These are of two types – deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Nucleic acid contains a pentose sugar, phosphoric acid and a nitrogen base. In DNA, the pentose sugar is β–D-2-deoxy ribose, while in RNA it is β–D-ribose. DNA contains 4 bases – Adenine (A), Guanine (G), Cytosine (C) and Thymine (T). [A, G, C &T] RNA contains Adenine (A), Guanine (G), Cytosine (C) and Uracil (U). [A, G, C & U] The pentose sugar combines with the base to form nucleoside, which combines with the phosphoric acid group to form nucleotide. The nucleotide units combine to form nucleic acid.

Q14. What are biological functions of nucleic acids?

1. DNA is responsible for the transmission of hereditary characters from one generation to other. 2. Another important function of nucleic acids is protein synthesis.