CHAPTER
10

Biomolecules

NCERT FOCUS

ANSWERS

Topic 1

1. A carbohydrate that cannot be hydrolysed further to give simpler unit of polyhydroxy aldehyde or ketone is called a monosaccharide. About 20 monosaccharides are known to occur in nature. Some common examples are glucose, fructose, ribose, etc.

2. All those carbohydrates which reduce Fehling's solution and Tollens' reagent are referred to as reducing sugars. All monosaccharides and disaccharides having free aldehydic or ketonic group are reducing sugars (except sucrose).

3. Two main functions of carbohydrates are

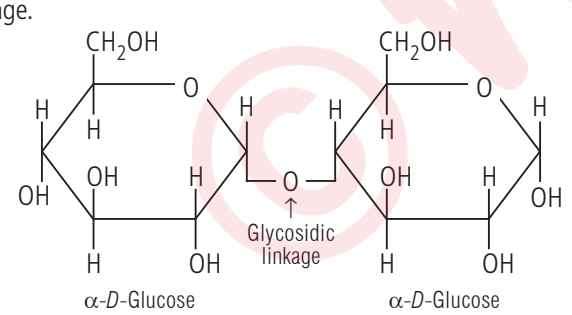
(i) Cell wall of bacteria and plants is made up of a polysaccharide, cellulose.

(ii) Starch is the major food reserve material in plants.

4. Monosaccharides : Ribose, 2-deoxyribose, galactose and fructose

Disaccharides : Maltose and Lactose

5. Disaccharides on hydrolysis with dilute acids or enzymes yield two molecules of either the same or different monosaccharides. The two monosaccharides are joined together by an oxide linkage formed by the loss of a water molecule. Such a linkage between two monosaccharides units through oxygen atom is called glycosidic linkage.



6. Glycogen is polysaccharide carbohydrate. It contains glycosidic linkage between C_1 and C_4 position of glucose. The carbohydrates are stored in animal body as glycogen. It is also known as animal starch because its structure is similar to amylopectin. It is present in liver, muscles and brain. When the body needs glucose, enzymes break the glycogen down to glucose. Glycogen is also found in yeast and fungi.

Starch is the main storage polysaccharide of plants. It is the most important dietary source for human being. High content of starch is found in cereals, roots, tubers and some vegetables. It is a polymer of two components–amylose (15-20%) which is water soluble and amylopectin (80-85%) which is water insoluble.

7. (i) Sucrose on hydrolysis gives one unit of glucose and one unit of fructose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

(ii) Lactose on hydrolysis with dilute acids yields an equimolar mixture of *D*-glucose and *D*-galactose.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\beta\text{-}D\text{-Glucose}}{C_6H_{12}O_6} + \underset{\beta\text{-}D\text{-Galactose}}{C_6H_{12}O_6}$$

8. The basic structural difference between starch and cellulose is of linkage between the glucose units. In starch, there is α-*D*-glycosidic linkage. Both the components of starch-amylose and amylopectin are polymer of α-*D*-glucose. On the other hand, cellulose is a linear polymer of β-*D*-glucose in which C_1 of one glucose unit is connected to C_4 of the other through β-*D*-glycosidic linkage.

9. (i) $\underset{\text{Glucose}}{\text{CHO-(CHOH)}_4\text{-CH}_2\text{OH}} \xrightarrow{\text{HI, }\Delta} \underset{n\text{-hexane}}{CH_3CH_2CH_2CH_2CH_2CH_3}$

(ii) $\underset{\text{Glucose}}{\text{CHO-(CHOH)}_4\text{-CH}_2\text{OH}} \xrightarrow{Br_2 \text{ water}} \underset{\text{Gluconic acid}}{\text{COOH-(CHOH)}_4\text{-CH}_2\text{OH}}$

(iii) $\underset{\text{Glucose}}{\text{CHO-(CHOH)}_4\text{-CH}_2\text{OH}} \xrightarrow{HNO_3} \underset{\text{Saccharic acid}}{\text{COOH-(CHOH)}_4\text{-COOH}}$

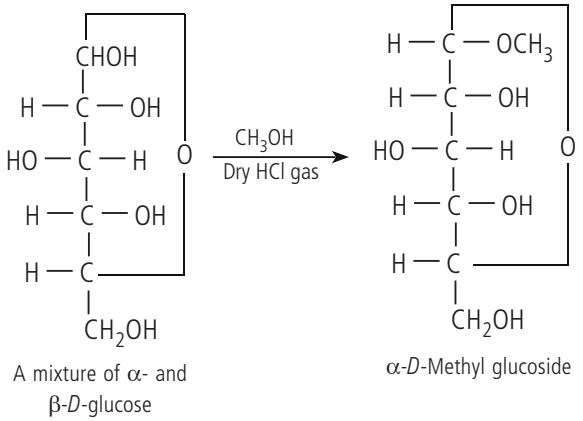
10. The open chain structure of *D*-glucose $OHC-(CHOH)_4-CH_2OH$ fails to explain the following reactions :

(i) Though it contains the aldehyde (–CHO) group, glucose does not give 2,4-DNP test, Schiff's test and it does not form the hydrogen sulphite addition product with $NaHSO_3$.

(ii) The pentaacetate of glucose does not react with hydroxylamine (NH_2OH) to form the oxime indicating the absence of free –CHO group.

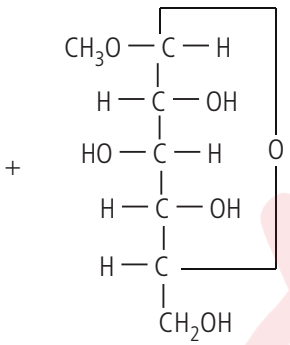
(iii) The formation of two anomeric methyl glycosides by glucose on reaction with CH_3OH and dry HCl can be explained in terms of the cyclic structure. The equilibrium mixture of α-and β-glucose

react separately with methanol in the presence of dry HCl gas to form the corresponding methyl *D*-glucosides.



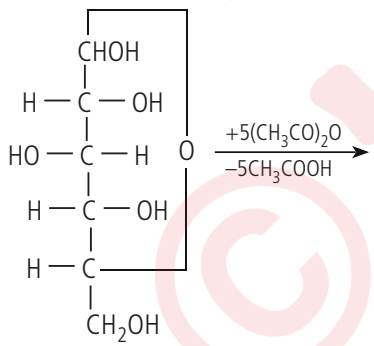
A mixture of α- and β-*D*-glucose

α-*D*-Methyl glucoside

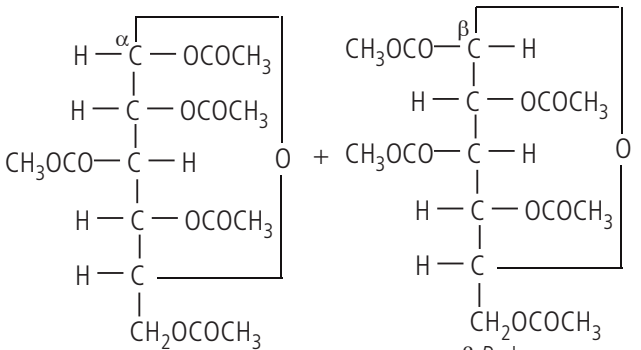


β-*D*-Methyl glucoside

(iv) Like methyl glycosides, glucose pentaacetate also exists in two anomeric formes as explained below :



A mixture of α- and β-*D*-glucose

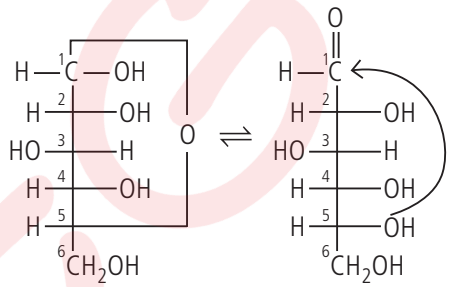


α-*D*-glucose pentaacetate

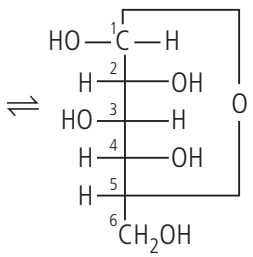
β-*D*-glucose pentaacetate

These pentaacetates do not have a free –OH group at C_1 and hence are not hydrolysed in aqueous solution to produce the open chain aldehyde form and hence do not react with NH_2OH to form glucose oxime.

(v) The existence of glucose in two crystalline forms termed as α and β-*D*-glucose can again be explained on the basis of cyclic structure of glucose and not by its open chain structure. It was proposed that one of the –OH groups may add to –CHO group and form a cyclic hemiacetal structure. It was found that glucose forms a 6-membered ring in which –OH at C–5 is involved in ring formation. This explains the absence of –CHO group and also existence of glucose in two forms as shown below. These two forms exist in equilibrium with open chain structure.



α – *D* – (+) – Glucose



β – *D* – (+) – Glucose

Topic 2

1. There are about 20 amino acids which make up the bio-proteins. Out of these, 10 amino acids (non-essential) are synthesised by our bodies and rest are essential in the diet (essential amino acids) and supplied to our bodies by food which we take because they cannot be synthesised in our body.

e.g. Essential amino acid - Valine and Leucine

Non-essential amino acid - Glycine and Alanine

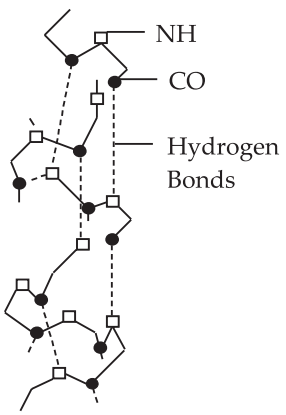
2. (i) Peptide lnkage : Proteins are the polymers of α-amino acids which are connected to each other by peptide bond or peptide linkage. Chemically, peptide linkage is an amide formed between –COOH group and $–NH_2$ group. The reaction between two molecules of similar or different amino acids, proceeds through the combination of the amino group of one molecule with the carboxyl group of the other. This results in the elimination of a water molecule and formation of a peptide bond –CO–NH–. The product of the reaction is called a dipeptide because it is made up of two amino acids. For example, when carboxyl group of glycine

combines with the amino group of alanine we get a dipeptide, glycylalanine.

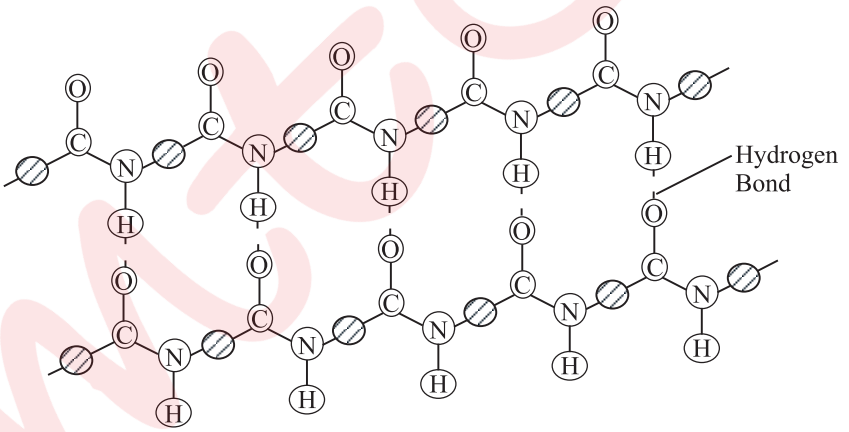
(ii) Primary structure : Proteins may have one or more polypeptide chains. Each polypeptide in a protein has amino acids linked with each other in a specific sequence and it is this sequence of amino acids that is said to be the primary structure of that protein. Any change in this primary structure *i.e.*, the sequence of amine acids creates a different protein.

(iii) Denaturation : Protein found in a biological system with a unique three-dimensional structure and biological activity is called a native protein. When a protein in its native form, is subjected to physical change like change in temperature or chemical change like change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix get uncoiled and protein loses its biological activity. This is called denaturation of protein. During denaturation 2° and 3° structures are destroyed but 1° structure remains intact. The coagulation of egg white on boiling is a common example of denaturation. Another example is curdling of milk which is caused due to the formation of lactic acid by the bacteria present in milk.

3. The secondary structure of protein refers to the shape in which a long polypeptide chain can exist. They are found to exist in two different types of structures viz, 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 $-\overset{\overset{O}{\|}}{C}-$ and –NH– groups of the peptide bond. α-Helix is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right handed screw (helix) with the –NH group of each amino acid residue hydrogen bonded to the $>C=O$ of an adjacent turn of the helix. In β-structure all peptide chains are stretched out to nearly maximum extension and then laid side by side which are held together by intermolecular hydrogen bonds. The structure resembles the pleated folds of drapery and therefore is known as β-pleated sheet.



α-helix structure of a protein



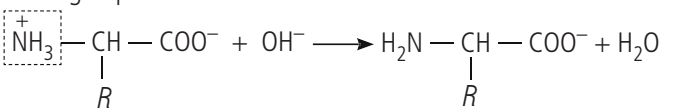
β-pleated sheet structure of a protein

4. α-Helix is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right handed screw (helix) with the –NH group of each amino acid residue, hydrogen bonded to the $>C=O$ of an adjacent turn of the helix.

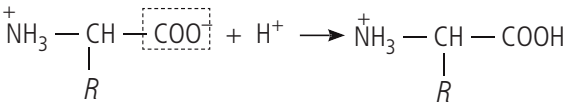
5. Characteristic differences between globular and fibrous proteins can be given as:

	Globular Proteins	Fibrous Proteins
(i)	These are cross linked proteins and are condensation product of acidic and basic amino acids.	These are linear condensation polymer
(ii)	These are soluble in water, mineral acids and bases.	These are insoluble in water but soluble in strong acids and bases.
(iii)	These proteins have three dimensional folded structure. These are stabilised by internal hydrogen bonding, *e.g.*, egg albumin enzymes.	These are linear polymers held together by intermolecular hydrogen bonds, *e.g.*, hair, silk.

6. Due to dipolar or zwitter ionic structure, amino acids are amphoteric in nature. The acidic character of the amino acids is due to the $-\overset{+}{N}H_3$ group while the basic character is due to the COO^- group.



Acidic part



Basic part

7. Life is possible due to the coordination of various chemical processes in living organisms. An example is the digestion of food, absorption of appropriate molecules and ultimately production of energy. This process involves a sequence of reactions and all these reactions occur in the body under very mild conditions. This occurs with the help of certain biocatalysts called enzymes. Almost all the

enzymes are globular proteins. Enzymes are specific for a particular reaction and for a particular substrate. They are generally named after the compound or class of compounds upon which they work. For example, the enzyme that catalyses hydrolysis of maltose into glucose is named as maltase.

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Maltase}} \underset{\text{Glucose}}{2C_6H_{12}O_6}$$

8. Proteins are very sensitive to the action of heat, mineral acids, alkalies etc. On heating or on treatment with mineral acids, soluble forms of proteins such as globular proteins often undergo coagulation or precipitation to give fibrous proteins which are insoluble in water. This coagulation also results in the loss of the biological activity of the protein. That is why the coagulated proteins so formed are called denatured proteins. Chemically, denaturation does not change the primary structure but brings about changes in the secondary and tertiary structure of proteins.

Topic 3

1. Vitamins are classified into two groups depending upon their solubility in water or fat.

(i) Fat soluble vitamins : Vitamins which are soluble in fats and oils but insoluble in water are kept in this group. These are vitamins A, D, E and K. They are stored in liver and adipose (fat storing) tissues.

(ii) Water soluble vitamins : B group vitamins and vitamin C are soluble in water so they are grouped together. Water soluble vitamins must be supplied regularly in diet because they are readily excreted in urine and cannot be stored (except vitamin B_{12}) in our body.

Vitamin K is responsible for coagulation of blood.

2. Deficiency of vitamin A causes xerophthalmia (hardening of cornea of the eye) and night blindness. So its use is essential to us. It is available in fish liver oil, carrots, butter and milk. It promotes growth and increases resistance to diseases. Vitamin C is very essential to us because its deficiency causes scurvy (bleeding of gums) and pyorrhea (loosening and bleeding of teeth). Vitamin C increases resistance of the body towards diseases, maintains healthy skin and helps cuts and abrasions to heal properly. It is soluble in water. It is present in citrus fruits, *e.g.*,oranges, lemons, amla, tomatoes, green vegetables, sprouted pulses and germinated grains.

Topic 4

1. Nucleic acids : constitute an important class of biomolecules which are found in the nuclei of all living cells in the form of nucleoproteins (*i.e.*, proteins containing nucleic acid as the prosthetic group). Nucleic acids are the genetic materials of the cells and are responsible for transmission of hereditary effect from one generation to the other and also carry out the biosynthesis of proteins. nucleic acids are biopolymers (*i.e.*, polymers present in the living system). The genetic information coded in nucleic acids controls the structure of all proteins including enzymes and thus governs the entire metabolic activity in the living organism.

Two important functions of nucleic acids are :

(i) Replication : The process by which a single DNA molecule produces two identical copies of itself is called replication.

(ii) Protein synthesis : DNA may be regarded as the instrument manual for the synthesis of all proteins present in the cell.

2. Nucleoside : A nucleoside contains only two basic components of nucleic acids, *i.e.*, a pentose sugar and a nitrogenous base. It may be represented as sugar-base.

Depending upon the type of sugar present, nucleosides are of two types :

(i) Ribonucleosides and

(ii) Deoxyribonucleosides.

Nucleotides : A nucleotide contains all the three basic components of nucleic acids, *i.e.*, a phosphoric acid group, a pentose sugar and a nitrogenous base. In other words, nucleotides are nucleoside monophosphates.

Depending upon the type of sugar present, nucleotides like nucleosides are of two types :

(i) Ribonucleotides and

(ii) Deoxyribonucleotides.

3. Two nucleic acid chains are wound about each other and held together by hydrogen bonds between pairs of bases. The two strands are complementary to each other because the hydrogen bonds are formed between specific pairs of bases. Adenine forms hydrogen bonds with thymine whereas cytosine forms hydrogen bonds with guanine.

4. Difference between DNA and RNA.

	DNA	RNA
1.	It usually occurs inside nucleus and some cell organelles.	Very little RNA occurs inside nucleus. Most of it is found in the cytoplasm.
2.	DNA is the genetic material.	RNA is not the genetic material except in certain viruses, *e.g.*, TMV, reovirus.
3.	It is double stranded with α-helix structure in which two strands are coiled spirally.	RNA is single stranded with the exception of some viruses (*e.g.*, double stranded in reovirus).
4.	DNA shows regular helical coiling.	There is no regular coiling except in parts of *t*RNA.
5.	DNA is of only two types, nuclear and extra-nuclear.	There are at least three types of RNA–*m*RNA, *r*RNA and *t*RNA.

6.	It contains deoxyribose sugar.	It contains ribose sugar.
7.	Nitrogen base thymine occurs in DNA along with three other – adenine, cytosine and guanine.	Thymine is replaced by uracil in RNA. The other three are adenine, cytosine and guanine.
8.	It has a unique property of replication.	It does not replicate.
9.	DNA transcribes genetic information to RNA.	RNA translates the transcribed message for forming polypeptides.
10.	DNA controls heredity, evolution, metabolism, structure and differentiation	RNA controls only protein synthesis.
11.	DNA controls metabolism and genetics including variations.	It only controls metabolism under instructions from DNA.

5. RNA molecules are of three types and they perform different functions. They are named as messenger RNA (*m*-RNA), ribosomal RNA (*r*-RNA) and transfer RNA (*t*-RNA).

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