
	INDIAN SCHOOL AL WADI AL KABIR		
Class: XII	DEPARTMENT: SCIENCE 2022-23 SUBJECT: CHEMISTRY		Note: A4 FILE FORMAT
HANDOUTS	TOPIC: BIOMOLECULES		
NAME OF THE STUDENT	CLASS & SEC:	ROLL NO.	

- Living systems are made up of various complex biomolecules like carbohydrates, proteins, nucleic acids, lipids, etc.
- Some simple molecules like vitamins and mineral salts also play an important role in the functions of organisms.

Carbohydrates

general formula, $C_x(H_2O)_y$,

Chemically, *the carbohydrates may be defined as optically active polyhydroxy aldehydes or ketones or the compounds which produce such units on hydrolysis.*

Sugars	Non sugars
Carbohydrates which are sweet in taste Glucose , sucrose, lactose	Carbohydrates that are not sweet in taste Starch, cellulose,

Classification of Carbohydrates

Based on the behavior of hydrolysis:

- (i) **Monosaccharides:** 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.
- (ii) **Oligosaccharides:** Carbohydrates that yield two to ten monosaccharide units, on hydrolysis, are called oligosaccharides. They are further classified as disaccharides, trisaccharides, tetrasaccharides, etc., depending upon the number of monosaccharides, they provide on hydrolysis. Amongst these the most common are disaccharides. The two monosaccharide units obtained on hydrolysis of a disaccharide may be same or different. For example, sucrose on hydrolysis gives one molecule each of glucose and fructose whereas maltose gives two molecules of glucose only.
- (iii) **Polysaccharides:** Carbohydrates which yield a large number of monosaccharide units on hydrolysis are called polysaccharides. Some common examples are starch, cellulose, glycogen, gums, etc. Polysaccharides are not sweet in taste, hence they are also called non-sugars.

Reducing sugars	Non reducing sugars
Carbohydrates which can reduce Fehling's solution and Tollen's reagent	Carbohydrates which cannot reduce Fehling's solution and Tollen's reagent
Eg. All monosaccharides whether aldose or ketose .Eg. maltose ,lactose	Eg. Monosaccharides in which the aldehydic or ketonic groups are bonded. Eg. Sucrose

Monosaccharides

Based on the number of carbon atoms and the functional group present:

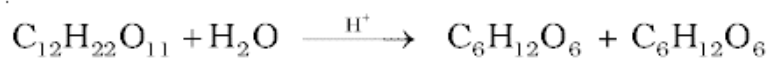
Aldose	Ketose
If a monosaccharide contains an aldehyde group	If a monosaccharide contains an ketone group

Carbon atoms	General term	Aldehyde	Ketone
3	Triose	Aldotriose	Ketotriose
4	Tetrose	Aldotetrose	Ketotetrose
5	Pentose	Aldopentose	Ketopentose
6	Hexose	Aldohexose	Ketohexose
7	Heptose	Aldoheptose	Ketoheptose

Preparation of Glucose

Glucose

1. *From sucrose (Cane sugar)*: If sucrose is boiled with dilute HCl or H₂SO₄ in alcoholic solution, glucose and fructose are obtained in equal amounts.

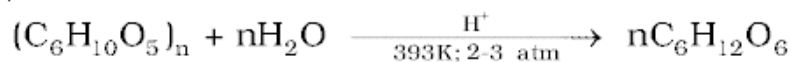


Sucrose

Glucose

Fructose

2. *From starch*: Commercially glucose is obtained by hydrolysis of starch by boiling it with dilute H₂SO₄ at 393 K under pressure.

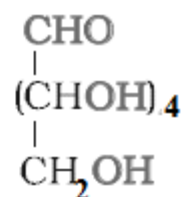


Starch or cellulose

Glucose

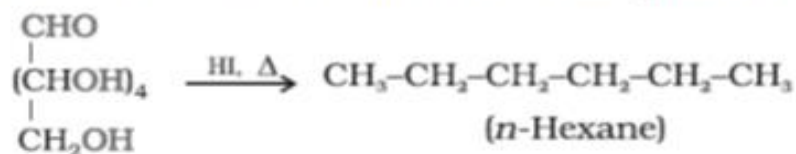
Structure of Glucose

- ☆ an aldohexose
- ☆ dextrose.
- ☆ monomer of larger carbohydrates, starch, cellulose.

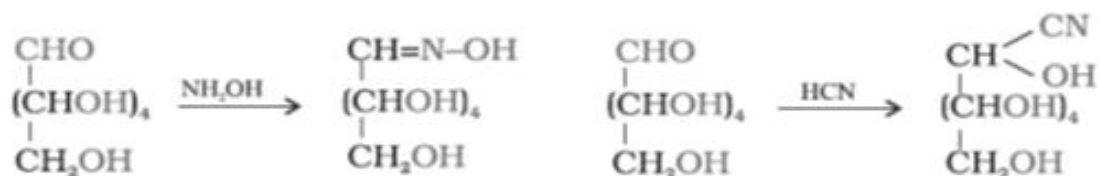


Evidences for the Structure of Glucose:

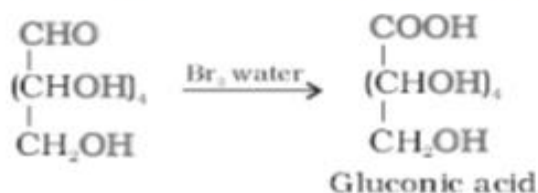
1. Its molecular formula was found to be $C_6H_{12}O_6$.
2. On prolonged heating with HI, it forms n-hexane, suggesting that all the six carbon atoms are linked in a straight chain.



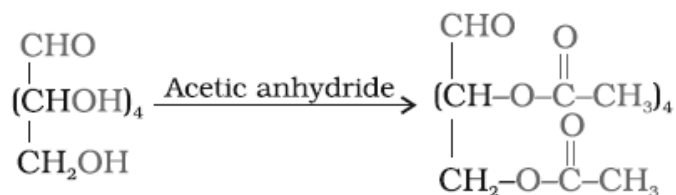
3. Glucose reacts with hydroxylamine to form an oxime and adds a molecule of hydrogen cyanide to give cyanohydrin. These reactions confirm the presence of a carbonyl group ($>C=O$) in glucose.



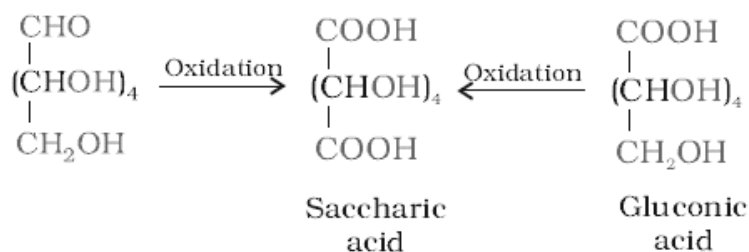
4. Glucose gets oxidised to six carbon carboxylic acid (gluconic acid) on reaction with a mild oxidising agent like bromine water. This indicates that the carbonyl group is present as an aldehydic group.



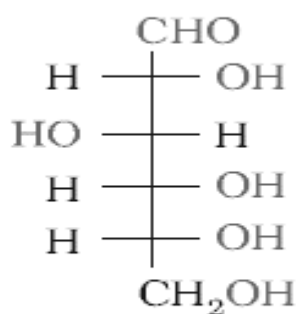
5. Acetylation of glucose with acetic anhydride gives glucose pentaacetate which confirms the presence of five -OH groups. Since it exists as a stable compound, five -OH groups should be attached to different carbon atoms.



6. On oxidation with nitric acid, glucose as well as gluconic acid both yield a dicarboxylic acid, saccharic acid. This indicates the presence of a primary alcoholic (-OH) group in glucose.

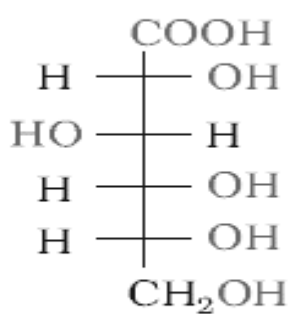


Fischer - Exact Spatial Arrangement of different --OH groups



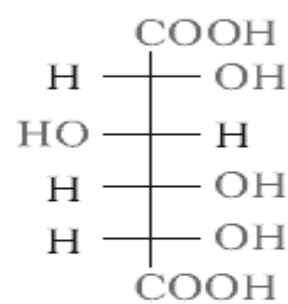
I

Glucose



II

Gluconic acid



III

Saccharic acid

Structural Aspects of Glucose:

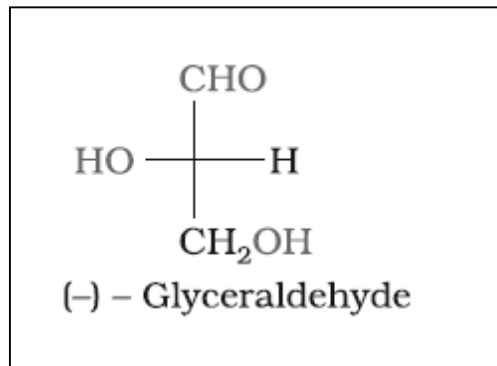
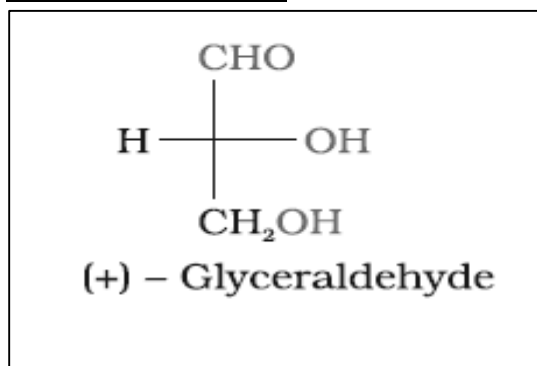
Glucose is correctly named as D(+)-glucose.

'D' represents the configuration

'(+)' represents dextrorotatory nature

optical activity

Reference Molecule:

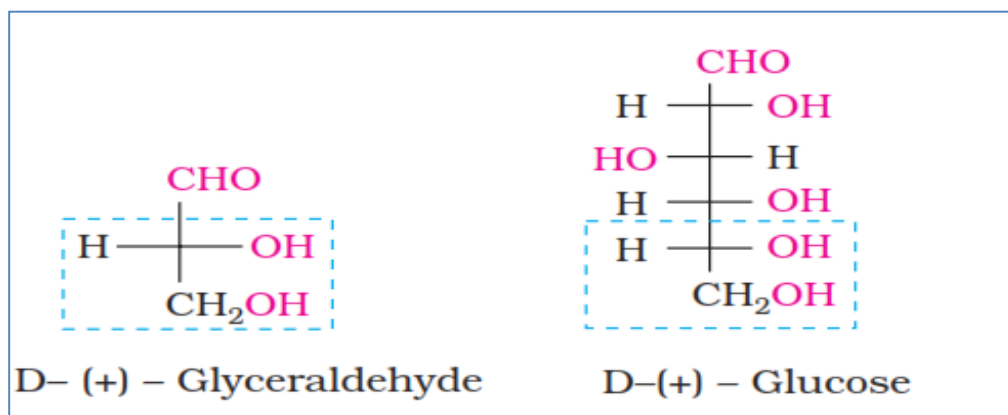


The letters 'D' or 'L' before the name of any compound indicate the relative configuration of a particular stereoisomer.

This refers to their relation with a particular isomer of glyceraldehyde.

Glyceraldehyde contains one asymmetric carbon atom and exists in two enantiomeric forms as shown

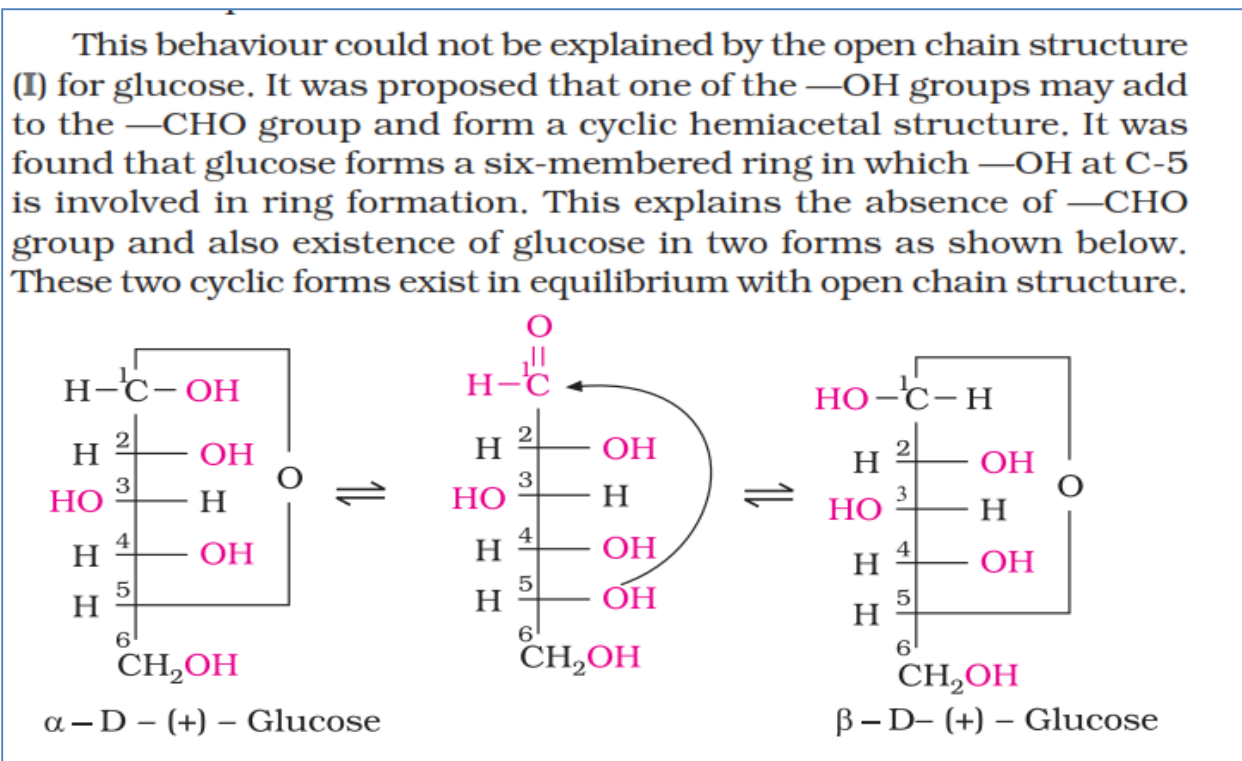
Comparing the structures of Glucose with Glyceraldehyde:



Cyclic Structure of Glucose:

The structure (I) of glucose explained most of its properties but the following reactions and facts could not be explained by this structure.

1. Despite having the aldehyde group, glucose does not give 2,4-DNP test, Schiff's test and it does not form the hydrogensulphite addition product with NaHSO_3 .
2. The pentaacetate of glucose does not react with hydroxylamine indicating the absence of free $-\text{CHO}$ group.
3. Glucose is found to exist in two different crystalline forms which are named as α and β . The α -form of glucose (m.p. 419 K) is obtained by crystallisation from concentrated solution of glucose at 303 K while the β -form (m.p. 423 K) is obtained by crystallisation from hot and saturated aqueous solution at 371 K.

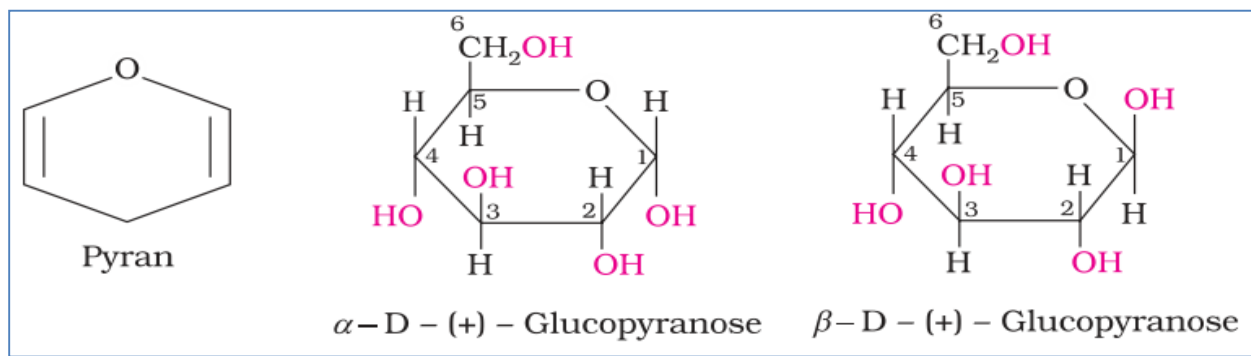


Anomers:

The two cyclic hemiacetal forms of glucose differ only in the configuration of the hydroxyl group at C1, is called anomeric carbon, the aldehyde carbon before cyclisation. Such isomers both (alpha) form and (beta) form are called anomers.

Pyranose structure: (Haworth structure)

The six-membered cyclic structure of glucose is called pyranose structure. It is in analogy with pyran, which is a cyclic organic compound with one oxygen atom and five carbon atoms in the ring. The cyclic structure of glucose is represented by Haworth structure.



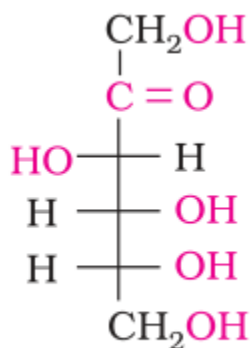
Fructose

Fructose is an important ketohexose. It is obtained along with glucose by the hydrolysis of disaccharide, sucrose.

Structure of Fructose:

• molecular formula $C_6H_{12}O_6$

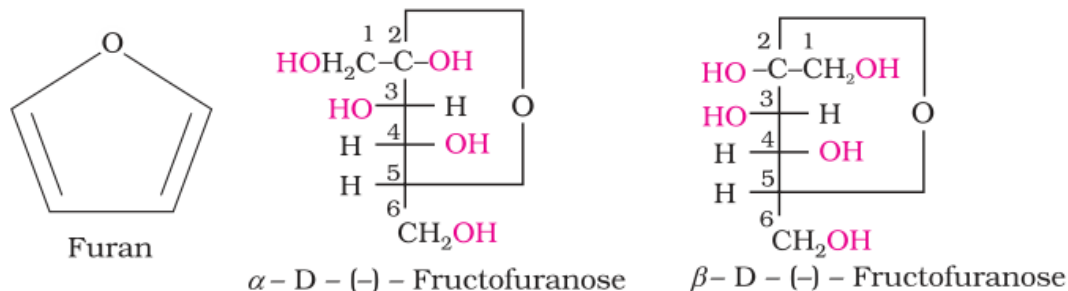
ketonic functional group at carbon number 2 and six carbons in straight chain as in the case of glucose. It belongs to D-series and is a laevorotatory compound. It is appropriately written as D-(-)-fructose. Its open chain structure is as shown.



D - (-) - Fructose

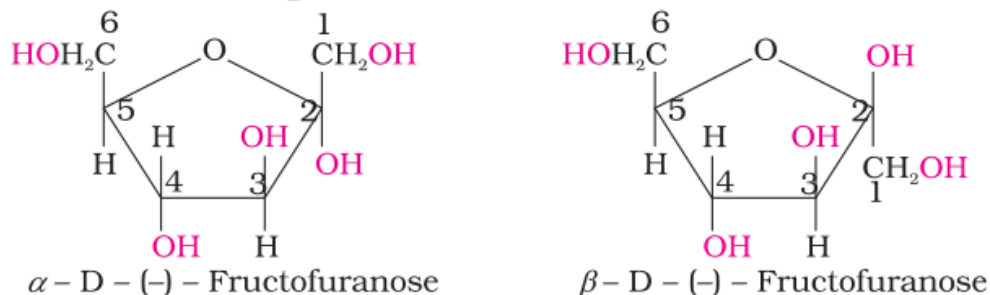
Cyclic structure of Fructose

It also exists in two cyclic forms which are obtained by the addition of —OH at C5 to the (>C=O) group. The ring, thus formed is a five membered ring and is named as furanose with analogy to the compound furan. Furan is a five membered cyclic compound with one oxygen and four carbon atoms.



Haworth structures

The cyclic structures of two anomers of fructose are represented by Haworth structures as given.

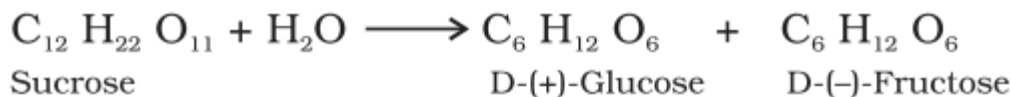


Disaccharides

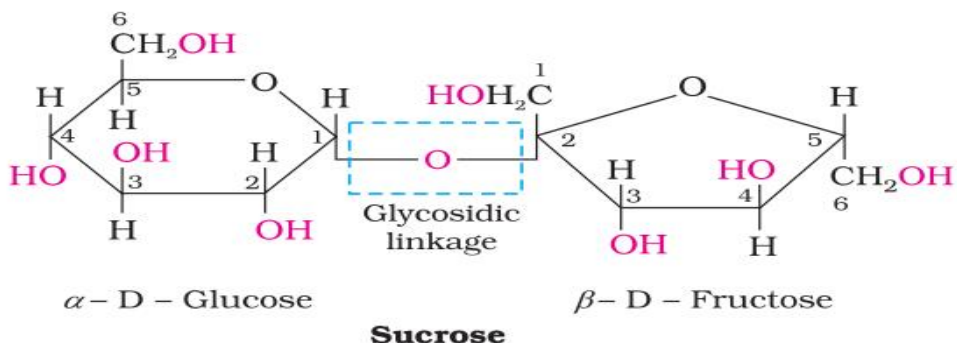
glycosidic linkage.

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 monosaccharide units through oxygen atom is called *glycosidic linkage*.

Hydrolysis of Disaccharides: Eg. Sucrose



These two monosaccharides are held together by a glycosidic linkage between C1 of α -glucose and C2 of β -fructose. Since the reducing groups of glucose and fructose are involved in glycosidic bond formation, sucrose is a non reducing sugar.

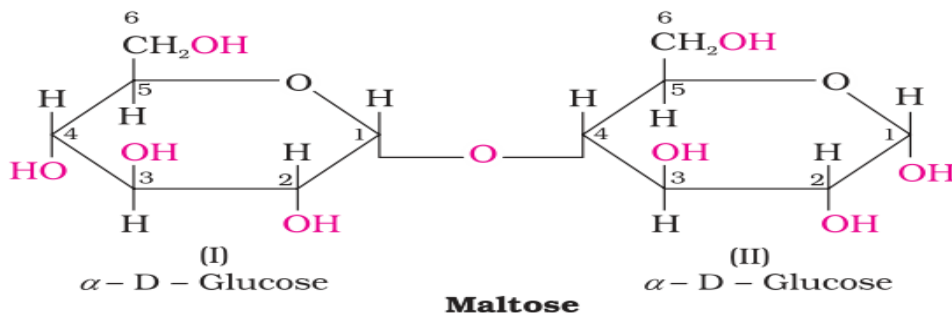


INVERT SUGAR:

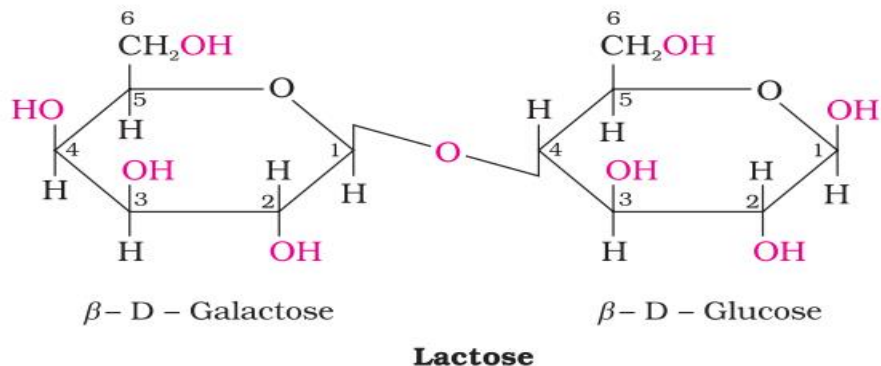
Sucrose is dextrorotatory but after hydrolysis gives dextrorotatory glucose and laevorotatory fructose. Since the laevorotation of fructose (-92.4) is more than dextrorotation of glucose ($+52.5$), the mixture is laevorotatory. Thus, hydrolysis of sucrose brings about a change in the sign of rotation, from dextro (+) to laevo (-) and the product is named as **invert sugar**.

Short notes on Maltose (Disaccharide)

Maltose: Another disaccharide, maltose is composed of two α -D-glucose units in which C1 of one glucose (I) is linked to C4 of another glucose unit (II). The free aldehyde group can be produced at C1 of second glucose in solution and it shows reducing properties so it is a reducing sugar.



(iii) **Lactose:** It is more commonly known as milk sugar since this disaccharide is found in milk. It is composed of β -D-galactose and β -D-glucose. The linkage is between C1 of galactose and C4 of glucose. Hence it is also a reducing sugar.



Polysaccharides

Polysaccharides contain a large number of monosaccharide units joined together by glycosidic linkages.

Starch: Starch is the main storage polysaccharide of plants. It is the most important dietary source for human beings. High content of starch is found in cereals, roots, tubers and some vegetables. It is a polymer of α -glucose and consists of two components—**Amylose** and **Amylopectin**.

AMYLOSE	AMYLOPECTIN
Amylose is water soluble component 15-20% of starch.	Amylopectin is insoluble in water 80- 85% of starch
a long unbranched chain with 200-1000 α -D-(+)-glucose units	a branched chain polymer of α -D-glucose units
held by C1- C4 glycosidic linkage	chain is formed by C1-C4 glycosidic linkage whereas branching occurs by C1-C6 glycosidic linkage.

Cellulose:

occurs exclusively in plants :

abundant organic substance

constituent of cell wall of plant cells.

a straight chain

polysaccharide composed only of β -D-glucose units which are joined by glycosidic linkage between C1 of one glucose unit and C4 of the next glucose unit.

Glycogen: The carbohydrates are stored in animal body as glycogen.

also known as *animal starch* because its structure is similar

to amylopectin and is rather more highly branched.

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.

Intext Questions

- 14.1 Glucose or sucrose are soluble in water but cyclohexane or benzene (simple six membered ring compounds) are insoluble in water. Explain.
- 14.2 What are the expected products of hydrolysis of lactose?
- 14.3 How do you explain the absence of aldehyde group in the pentaacetate of D-glucose?

Proteins

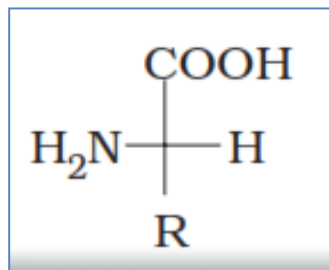
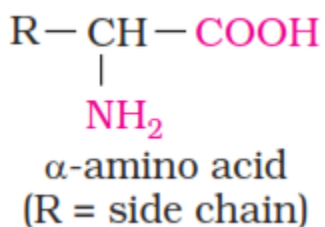
biomolecules of the living system.

basis of structure and functions of life.

growth and maintenance of body.

All proteins are polymers of α -amino acids.

Amino Acids



IMPORTANT AMINOACIDS (REFER P.NO. 413 – NCERT TEXTBOOK)

Name of the amino acids	Characteristic feature of side chain, R	Three letter symbol	One letter code
1. Glycine	H	Gly	G
2. Alanine	- CH ₃	Ala	A
3. Valine*	(H ₃ C) ₂ CH-	Val	V
4. Leucine*	(H ₃ C) ₂ CH-CH ₂ -	Leu	L
7. Lysine*	H ₂ N-(CH ₂) ₄ -	Lys	K
16. Phenylalanine*	C ₆ H ₅ -CH ₂ -	Phe	F

* *essential amino acid,*

Classification – I : based on the relative position :

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. Only α -amino acids are obtained on hydrolysis of proteins. They may contain other functional groups also.

Classification – II : based on the no. of amino and carboxyl groups:

Amino acids are classified as acidic, basic or neutral depending upon the relative number of amino and carboxyl groups in their molecule.

amino groups are equal in number with carboxyl groups = neutral aminoacids

amino groups are greater in number than carboxyl groups = basic aminoacids

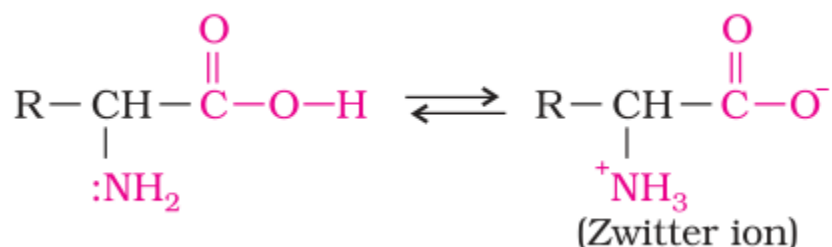
amino groups are lesser in number than carboxyl groups = acidic aminoacids

Classification – III : based on the synthesis:

amino acids, which can be synthesised in the body, are known as **non-essential amino acids**.

aminoacids which cannot be synthesised in the body and must be obtained through diet, are known as **essential amino acids** (marked with asterisk)

Zwitter ion of aminoacid:



Complete the following:

tripeptide.

tetrapeptide,

pentapeptide

hexapeptide,

polypeptides.

protein. A polypeptide with more than hundred amino acid residues, having molecular mass higher than 10,000u

Polypeptides with fewer amino acids are likely to be called proteins if they ordinarily have a well defined conformation of a protein such as insulin which contains 51 amino acids.

Classification IV : based on molecular shape of proteins:

Proteins can be classified into two types on the basis of their molecular shape.

(a) Fibrous proteins

When the polypeptide chains run parallel and are held together by hydrogen and disulphide bonds, then fibre- like structure is formed. Such proteins are generally insoluble in water. Some common examples are keratin (present in hair, wool, silk) and myosin (present in muscles), etc.

(b) Globular proteins

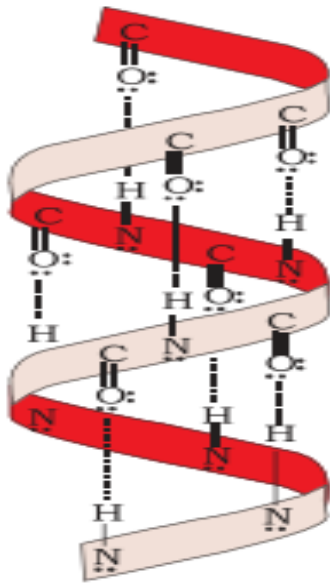
This structure results when the chains of polypeptides coil around to give a spherical shape. These are usually soluble in water. Insulin and albumins are the common examples of globular proteins.

Classification V : based on the structure and shape of protein

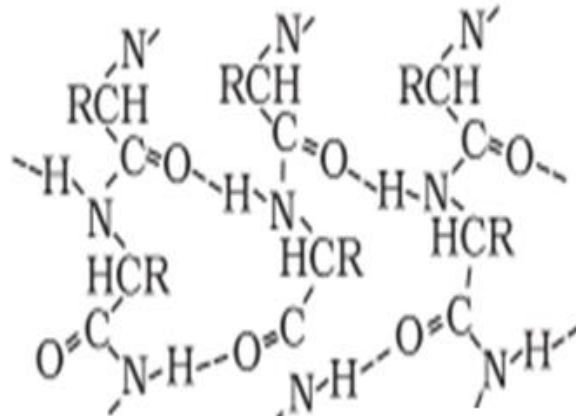
Structure and shape of proteins can be studied at four different levels, i.e., primary, secondary, tertiary and quaternary, each level being more complex than the previous one.

(i) *Primary structure of proteins:* 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 amino acids creates a different protein.

(ii) *Secondary structure of proteins:* 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 $\text{—}\overset{\text{O}}{\parallel}{\text{C}}\text{—}$ and —NH— groups of the peptide bond.



Helix



pleated sheets

helix structure

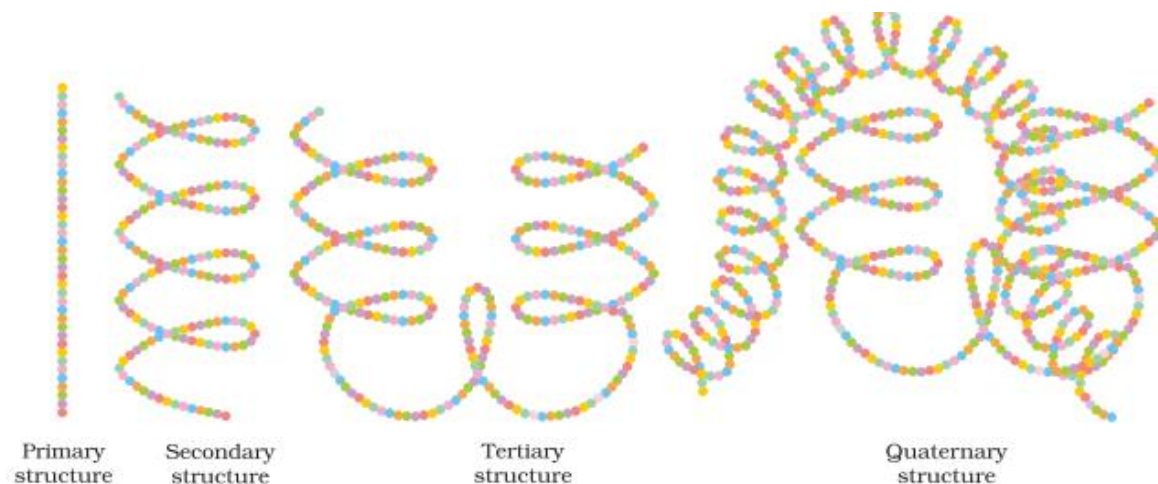
α -Helix is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right handed screw (helix) with the -NH group of each amino acid residue hydrogen bonded to the >C=O of an adjacent turn of the helix

pleated structure

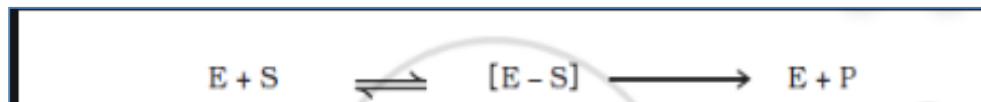
In β -structure all peptide chains are stretched out to nearly maximum extension and then laid side by side which are held together by intermolecular hydrogen bonds. The structure resembles the pleated folds of drapery and therefore is known as β -pleated sheet.

(iii) Tertiary structure of proteins: The tertiary structure of proteins represents overall folding of the polypeptide chains i.e., further folding of the secondary structure. It gives rise to two major molecular shapes viz. fibrous and globular. The main forces which stabilise the 2 and 3 structures of proteins are hydrogen bonds, disulphide linkages, van der Waals and electrostatic forces of attraction.

(iv) Quaternary structure of proteins: Some of the proteins are composed of two or more polypeptide chains referred to as sub-units. The spatial arrangement of these subunits with respect to each other is known as quaternary structure.



Mechanism of enzyme action:



Vitamins

organic compounds

required in the diet in small amounts to perform specific biological functions for normal maintenance of optimum growth

and health of the organism. Vitamins are designated by alphabets A, B, C, D, etc. Some of them are further named as sub-groups e.g. B₁, B₂, B₆, B₁₂, etc. Excess of vitamins is also harmful and vitamin pills should not be taken without the advice of doctor.

Classification of Vitamins

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

- (i) *Fat soluble vitamins*: Vitamins which are soluble in fat 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 B₁₂) in our body.

Sl. No.	Name of Vitamins	Sources	Deficiency diseases
1.	Vitamin A	Fish liver oil, carrots, butter and milk	Xerophthalmia (hardening of cornea of eye) Night blindness
2.	Vitamin B ₁ (Thiamine)	Yeast, milk, green vegetables and cereals	Beri beri (loss of appetite, retarded growth)
3.	Vitamin B ₂ (Riboflavin)	Milk, eggwhite, liver, kidney	Cheilosis (fissuring at corners of mouth and lips), digestive disorders and burning sensation of the skin.
4.	Vitamin B ₆ (Pyridoxine)	Yeast, milk, egg yolk, cereals and grams	Convulsions
5.	Vitamin B ₁₂	Meat, fish, egg and curd	Pernicious anaemia (RBC deficient in haemoglobin)
6.	Vitamin C (Ascorbic acid)	Citrus fruits, amla and green leafy vegetables	Scurvy (bleeding gums)
7.	Vitamin D	Exposure to sunlight, fish and egg yolk	Rickets (bone deformities in children) and osteomalacia (soft bones and joint pain in adults)
8.	Vitamin E	Vegetable oils like wheat germ oil, sunflower oil, etc.	Increased fragility of RBCs and muscular weakness
9.	Vitamin K	Green leafy vegetables	Increased blood clotting time

Nucleic Acids

heredity.

nucleus of a living cell is responsible for this transmission of inherent characters, also called **heredity**.

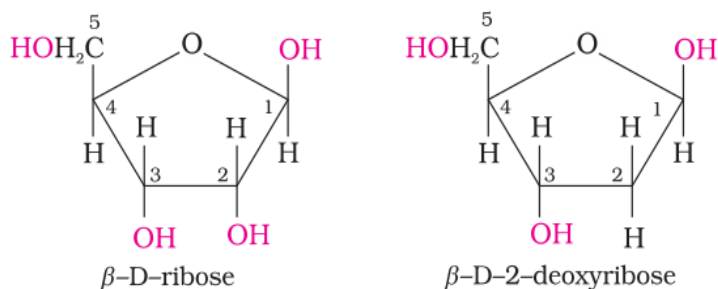
nucleic acids.

The particles in nucleus of the cell, responsible for

heredity, are called chromosomes which are made up of proteins and another type of biomolecules called **nucleic acids**. These are mainly of two types, the **deoxyribonucleic acid (DNA)** and **ribonucleic acid (RNA)**. Since nucleic acids are long chain polymers of **nucleotides**, so they are also called polynucleotides.

Chemical Composition of Nucleic Acids

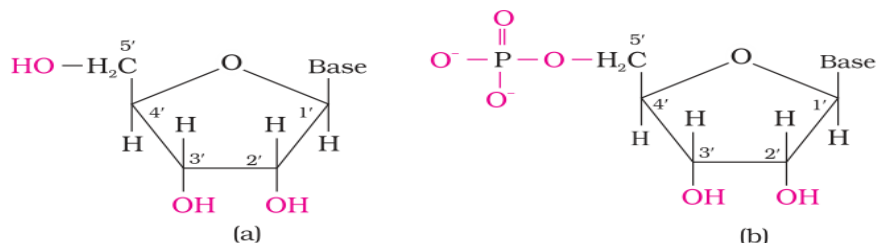
Complete hydrolysis of DNA (or RNA) yields a pentose sugar, phosphoric acid and nitrogen containing heterocyclic compounds (called bases). In DNA molecules, the sugar moiety is β -D-2-deoxyribose whereas in RNA molecule, it is β -D-ribose.



DNA contains four bases viz. adenine (A), guanine (G), cytosine (C) and thymine (T). RNA also contains four bases, the first three bases are same as in DNA but the fourth one is uracil (U).

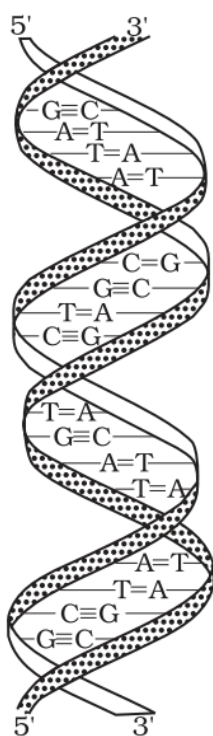
Structure of Nucleic Acids

A unit formed by the attachment of a base to 1' position of sugar is known as **nucleoside**. In nucleosides, the sugar carbons are numbered as 1', 2', 3', etc. in order to distinguish these from the bases (Fig. 14.5a). When nucleoside is linked to phosphoric acid at 5'-position of sugar moiety, we get a nucleotide

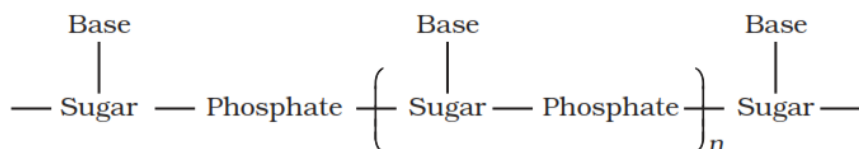


Structure of (a) a nucleoside and (b) a nucleotide

Nucleotides are joined together by phosphodiester linkage between 5' and 3' carbon atoms of the pentose sugar. The formation of a typical dinucleotide



A simplified version of nucleic acid chain is as shown below.



Information regarding the sequence of nucleotides in the chain of a nucleic acid is called its primary structure. Nucleic acids have a secondary structure also. James Watson and Francis Crick gave a double strand helix structure for DNA. 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.

In secondary structure of RNA, helices are present which are only single stranded. Sometimes they fold back on themselves to form a double helix structure. 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)**.