DAY THIRTY FOUR

Biomolecules

Learning & Revision for the Day

- Carbohydrates
- Proteins
- Enzymes
- Hormones
- Vitamins
- Nucleic Acids

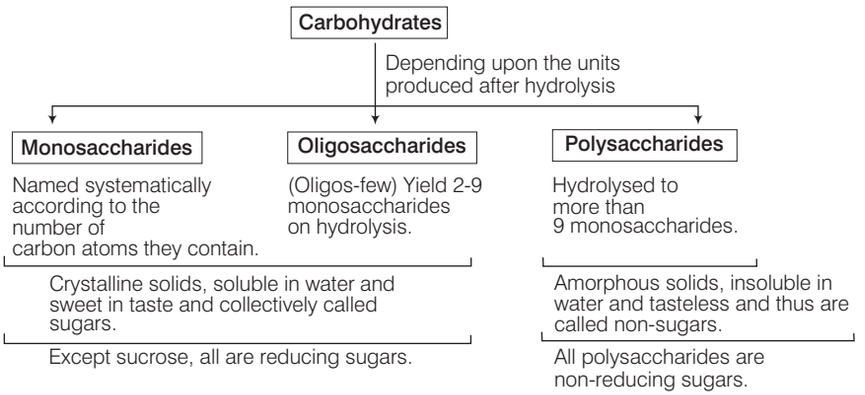
Biomolecules are the complex, lifeless organic substances. These build up living organisms and are required for their growth and maintenance. Carbohydrates, proteins, nucleic acids, lipids etc., are the examples of biomolecules. Vitamins and mineral salts also play an important role in functions of organisms.

Carbohydrates

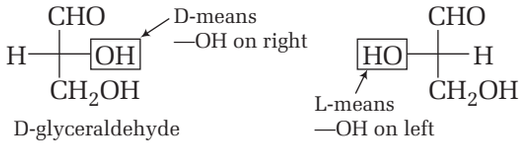
Carbohydrates are optically active polyhydroxy aldehydes or ketones or compounds which produce such units on hydrolysis.

Classification of Carbohydrates

Carbohydrates are also known as **saccharides** and classified according to their behaviour towards hydrolysis.



- **D, L - configuration** 'D' or 'L' letter before the name of any compound indicates the relative configuration of particular stereoisomer in relation to two enantiomeric forms of glyceraldehyde.



- The monosaccharides having configuration identical to D-glyceraldehyde are assigned D-configuration whereas those having configuration identical to L-glyceraldehyde are assigned L-configuration.

Monosaccharides

A carbohydrate that cannot be hydrolysed further to give simpler unit of polyhydroxy aldehyde or ketone is called monosaccharide.

If a monosaccharide contains an aldehydic group, it is known as an **aldose** and if it contains a keto group, it is known as a **ketose**.

e.g. glucose, fructose, galactose, are hexose, while ribose and arabinose are pentose.

1. Glucose ($C_6H_{12}O_6$)

It occurs freely in nature as well as in the combined form. It is present in sweet fruits and honey. Ripe grapes also contains glucose in large amount.

- It is an aldohexose and also known as dextrose (grape sugar).
- It is prepared as follows

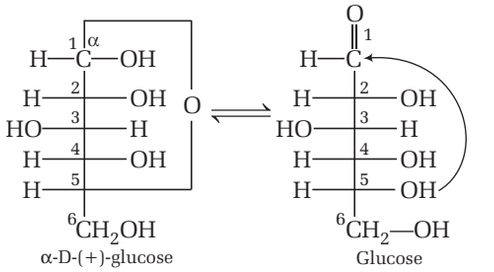
$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{or invertase}]{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

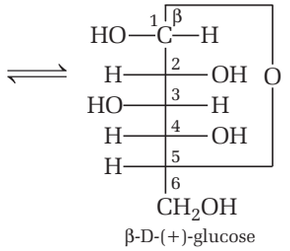
$$\underset{\text{Starch}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow[393\,K,\ 2\text{-}3\,atm]{H^+} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

Two types of structure have been suggested for glucose molecule.

Open Chain Structure

The open chain structure of glucose can be represented by using Fisher projection.





Following reactions give evidences in favour of open chain structure of glucose :

(i) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow{HI,\ \Delta}$ $CH_3-(CH_2)_4-CH_3$ (n-hexane)

(ii) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow[-H_2O]{NH_2OH}$ $(CHOH)_4$ ($CH{=}NOH$, CH_2OH) — Glucose oxime

(iii) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow{HCN}$ $(CHOH)_4$ ($CH(OH)CN$, CH_2OH) — Glucose cyanohydrin

(iv) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow{Br_2/water}$ $(CHOH)_4$ ($COOH$, CH_2OH) — Gluconic acid

(v) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow{(CH_3CO)_2O}$ $(CHOCOCH_3)_4$ (CHO, $CH_2-O-C(=O)-CH_3$) — Glucose pentaacetate

(vi) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow[\text{Oxidation}]{HNO_3}$ $(CHOH)_4$ ($COOH$, $COOH$) — Glucaric acid or saccharic acid; $\xleftarrow{\text{Oxidation}}$ $(CHOH)_4$ ($COOH$, CH_2-OH) — Gluconic acid

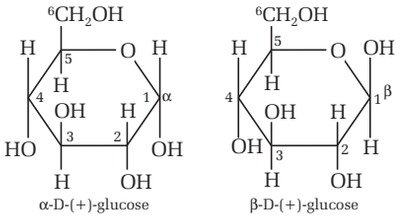
(vii) $(CHOH)_4$ (CHO, CH_2OH) $+ H_2N{\cdot}NH{\cdot}C_6H_5 \xrightarrow{-H_2O}$ $H-C(CH{=}N{\cdot}NHPh)-OH$, $(CHOH)_3$, CH_2OH — Glucose phenylhydrazone

$PhNH_2 + NH_3 +$ $C(CH{=}N{\cdot}NHPh)$, $(CHOH)_3$, CH_2OH — Glucosazone ($\xleftarrow{2H_2N{\cdot}NHPh}$)

Glycolysis is the anaerobic degradation of glucose into two molecules of pyruvic acid.

Cyclic Structure

The cyclic structure of glucose is represented by Haworth projection. This open chain structure was proposed as glucose, also show following chemical reactions that are against the open chain structure.



(i) α and β-D-glucose have different configuration at anomeric (C-1) carbon atom, hence are called **anomers.**

(ii) While the pair of diastereomeric aldoses, e.g. glucose and mannose that differ only in configuration about C-2 are called **epimers.** Glucose and galactose differ in configuration at C-4 are called C-4 epimers.

(iii) α-D-glucose and β-D-glucose exist in different crystalline forms. Thus, they have different melting points and specific rotations. $[\alpha]_D$. When these cyclic forms are dissolved in water then they exist in equilibrium with the solution. This equilibrium solution has a different specific rotation from those of α-and β-forms.

α - D - glucose $\rightleftharpoons$ equilibrium solution $\rightleftharpoons$ β-D- glucose

$[\alpha]_D = +18.7°$ $[\alpha]_D = +112.2°$

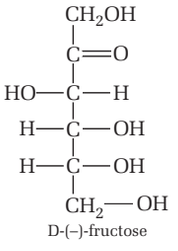
The above spontaneous change in specific rotations of solution of an optically active compound is called **mutarotation**.

2. Fructose ($C_6H_{12}O_6$)

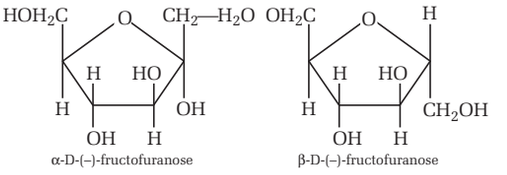
It is a functional isomer of glucose and has ketone group. It is found in most fruits, hence also called **fruit sugar**. As the natural fructose is laevorotatory, thus is called leavulose. In can be produced by the hydrolysis of insulin (a polysaccharide)

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow[\Delta]{H_2SO_4} \underset{\text{Fructose}}{nC_6H_{12}O_6}$$

The open chain structure of fructose is represented as shown below :

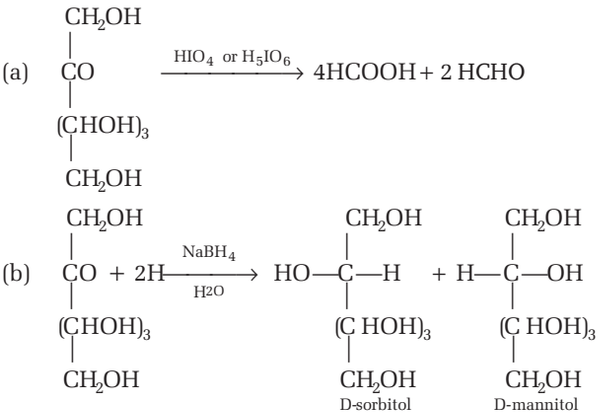


The cyclic structure of fructose can be represented using Haworth's projection.



NOTE The cyclic fructose is called fructofuranose as it resembles with furan.

Fructose reacts in chemical reactions as follows :



Oligosaccharides

- These are the carbohydrates that yield two to ten monosaccharide units on hydrolysis.
- Oligosaccharides are further, classified as **disaccharides**, **trisaccharides**, **tetrasaccharides** etc., on the basis of number of monosaccharide units obtained on their hydrolysis.
  e.g. disaccharides : sucrose, maltose, lactose etc., trisaccharides : raffinose; tetrasaccharides : stachyose.
- Except sucrose, all other disaccharides are reducing in nature and hence, are called reducing sugars.
- In disaccharides, the two monosaccharide units are joined together by an oxide linkage formed by the loss of a water molecule, this linkage is known as glycosidic linkage.

e.g. $\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{D-(+)-glucose}}{C_6H_{12}O_6} + \underset{\text{D-(−)-fructose}}{C_6H_{12}O_6}$

$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} 2$ moles of α-D-glucose

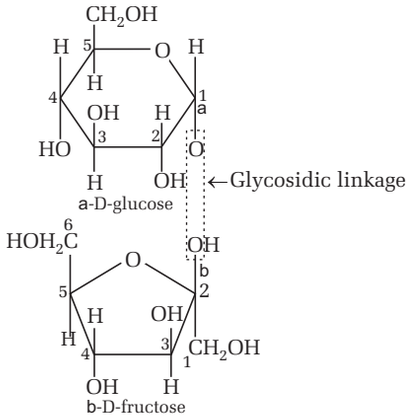
$\underset{\text{Milk sugar}}{C_{12}H_{22}O_{11}}$ (lactose) $+ H_2O \xrightarrow{H^+} \beta$ -D-galactose + β -D-glucose

1. Sucrose ($C_{12}H_{22}O_{11}$)

It is non-reducing due to absence of free aldehyde or ketone group. It is cane sugar or table sugar.

- Sucrose is also known as **invert sugar.** It is due to the fact that on hydrolysis, (+)-sucrose gets inverted to give a mixture of D-(+)-glucose and D-(–)-fructose.
- In sucrose, free aldehyde or ketone group is absent. It is shown by the facts that it does not form osazone, does not exist in anomeric forms and also does not show **mutarotation**.

  Sucrose on hydrolysis gives equimolar mixture of D-(+)-glucose and D-(–)-fructose. These two monosaccharides are held together by a glycosidic linkage between C-1 of α-glucose and C-2 of β-fructose.

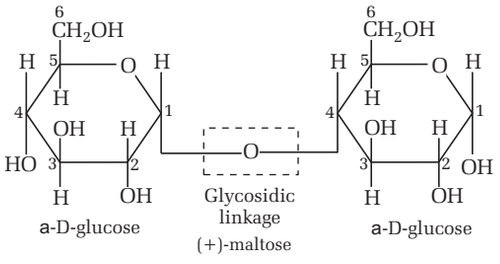


2. Maltose

$(C_{12}H_{22}O_{11})$ It is obtained by partial hydrolysis of starch by diastase enzyme present in **malt**, i.e. sprouted barley seeds (hence named **maltose** or **malt sugar**).

$$2(C_6H_{10}O_5)_n + nH_2O \xrightarrow{\text{Diastase}} \underset{\text{Maltose}}{nC_{12}H_{22}O_{11}}$$

- Maltose is a white crystalline solid (with m.p. 160°-165°C), soluble in water and dextrorotatory.
- When it is hydrolysed with dilute acid or by enzyme maltase, maltose yields two molecules of D-(+)-glucose. Hence, maltose is a condensation product of two α-D-glucose units.



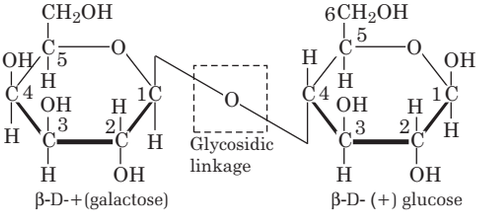
- Maltose is a reducing sugar. It reduces Fehling's solution and Tollen's reagent, it forms an oxime and an osazone and undergoes mutarotation. This indicates that atleast one aldehyde group is free in maltose.

3. Lactose $(C_{12}H_{22}O_{11})$

It occurs in the milk of all animals (milk sugar). It is a white crystalline solid (with melting point 203°C), soluble in water and is dextrorotatory.

- It is hydrolysed by dilute acid or enzyme lactase, to an equimolar mixture of D-(+)-glucose and D-(+)-galactose. Lactose is a reducing sugar, forms an oxime and osazone and also undergoes mutarotation.

  It gets hydrolysed by emulsin also, an enzyme which specifically hydrolysis β-glycosidic linkage.



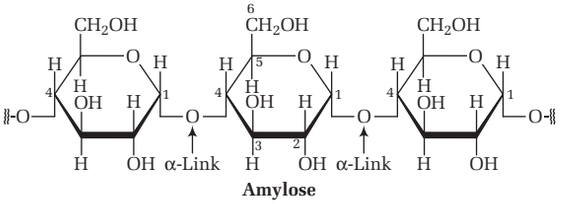
Polysaccharides

Carbohydrates which yield a large number of monosaccharide units on hydrolysis are called polysaccharides, e.g. starch, cellulose, glycogen, gums arabic etc.

Polysaccharides are not sweet in taste, hence they are also called non-sugars. Moreover, all polysaccharides are non-reducing due to absence of free —CHO or r⟩CO group.

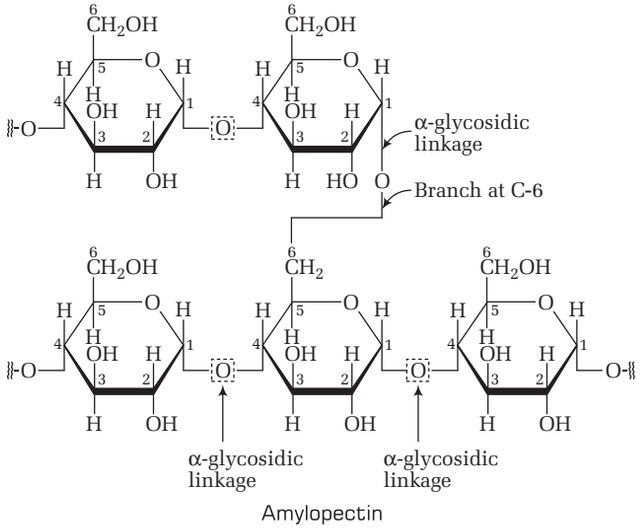
- **Starch** is the main storage polysaccharide of plants. It is a polymer of α-D-glucose units and consists of two components-amylose and amylopectin.

  (i) Amylose is a long unbranched chain with 200-100 α-D-glucose units, which are held together by C_1 –C_4 glycosidic linkage.



Amylose

  (ii) Amylopectin is branched chain with 25-30 α-D-glucose units, which are held together by C_1 –C_4 glycosidic linkage.



Amylopectin

- **Cellulose** is a predominant constituent of cell wall of plant cells. It is a straight chain polysaccharide composed only of β -D-glucose units which are joined together by β -1, 4-glycosidic linkage, i.e. the β-glycosidic linkages between C-1 of one glucose and C-4 of the next glucose unit.
- **Glycogen** is the carbohydrate (a condensation polymer of α-D-glucose) which is stored in animal body. When the body needs glucose, enzymes break the glycogen down to glucose.

NOTE
- Wood contains 50% cellulose, rest being lignin and resins. In cotton, cellulose is 90%, the rest being fats and waxes. Cellulose is not digestible by humans due to the absence of enzyme cellulose in digestive system.
- Starch and cellulose are homopolysaccharides while gums and pectins are heteropolysaccharides.
- Gums arabic are acidic polysaccharides.

Importance

(i) Carbohydrates are essential for life in both plants and animals. They form a major portion of our food.

(ii) Honey (a carbohydrate) has been used for a long time as an instant source of energy by 'Vaids' in ayurvedic system of medicines.

(iii) They are used as storage molecules as starch in plants and glycogen in animals.

(iv) They provide raw materials for many important industries like textiles, paper, lacquers and breweries.

Proteins

Proteins are the basic unites of our life. These are made of amino-acids.

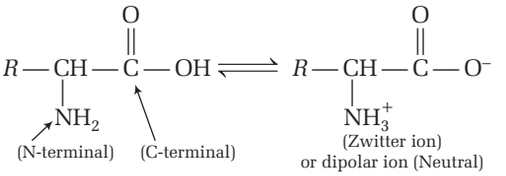
Amino-Acids

Proteins are polymers of **amino acids** (the compounds which have both the acid and amino group). The total number of amino acids that have been found in proteins are **twenty**.

On the basis of their synthesis, **amino acids** are divided into two classes

- **Essential amino acids** are the amino acids which cannot be synthesised in the body and must be obtained through diet, e.g. valine, leucine, lysine, isoleucine, arginine etc.
- **Non-essential amino acids** are the amino acids which can be synthesised in the body, e.g. glycine, alanine, glutamic acid, aspartic acid etc.

(i) Amino acids behave like salts rather than simple amines or carboxylic acids. This is due to the presence of both acidic and basic groups in the same molecule.



(ii) This type of structure where both acidic and basic groups are present is called **Zwitter ionic structure**.

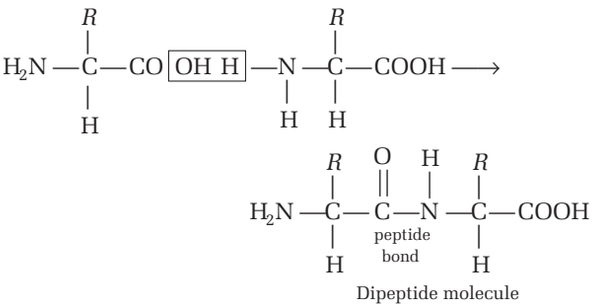
(iii) At a certain pH of the medium, called the **isoelectric point** of an amino acid, the structure behaves as a dipolar ion and does not migrate to wards any electrode on passing current.

(iv) Proteins give biuret test, Millon's test, ninhydrin test. Those proteins give Molisch's test, which contain a carbohydrate group.

Peptide Bond

Amino acids may be joined together by an amide linkage called **peptide linkage** (—CO—NH—).

e.g.



Dipeptide molecule

- The molecule derived from two amino acids containing a single peptide linkage is called a dipeptide, that derived from three amino acids is termed as a tripeptide.
- The peptides having 2-10 amino acid residues are called oligopeptides while those with greater than 10 amino acid residues are called polypeptides.

Polypeptide

- Polypeptide with molecular weight greater than 10,000 u is termed as a protein. Proteins generally have more than 70 amino acid residues, but a polypeptide with fewer α-amino acids may also be called a protein if it has a well defined conformation characteristic of a protein such as insulin.

NOTE • Polypeptides are amphoteric in nature because of the presence of terminal ammonium and carboxylate ions as well as the ionised side chains of amino acid residues.

Classification of Proteins

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

(i) **Fibrous Proteins** Polypeptide chains form fibre like structure, e.g. **keratin** and **myosin** etc.

(ii) **Globular Proteins** This structure results when the chains of polypeptides coil around to give a spherical shape. These are usually soluble in water, e.g. **insulin** and **albumins**.

Structure of Proteins

N-terminal of one amino acid combines with C-terminal of other amino acid and forms peptide bond (—NHCO—). In the same way, many amino acids combine to each other and form polypeptide bonds. Polypeptides with fewer amino acids are likely to be called proteins.

Structure and shape of proteins may be discussed at four different levels.

(i) **Primary Structure** Proteins may have one or more polypeptide chains. Specific sequence of amino acids in a chain gives the primary structure of that protein. Any change in this structure gives a different protein.

(ii) **Secondary Structure** The polypeptide chains are linked by hydrogen bonds. They are found to exist in two different types of structures *viz.* α-helix and β -pleated sheet structure.

(iii) **Tertiary Structure** It has polypeptide bonds, hydrogen bonds, disulphide linkages, van der Waals' forces and electrostatic forces of attraction. It gives rise to two major molecular shapes *viz.* **fibrous** and **globular**.

(iv) **Quarternary Structure** Some of the proteins are composed of two or more polypeptide chains referred to as subunits. The spatial arrangement of these subunits with respect to each other is known as quarternary structure.

Denaturation of Proteins

Disturbance of hydrogen bonds either by acids or alcohols or heat, results in unfolding of globules. Thus, helix get uncoiled and protein loses its biological activity due to change in temperature or pH. This is called denaturation of proteins. During denaturation, secondary and tertiary structures of proteins are destroyed while primary structures remains intact.

Enzymes

These are globular protein bodies, which are biological catalysts. Enzyme inhibitors reduce the activity of a particular enzyme. These are mostly inorganic ions or complex organic molecules. Congenital and albinism diseases are caused by the deficiency of the enzymes phenyl ketone urea and tryosinase respectively.

Hormones

The communication among cells is established by certain biomolecules called hormones which act as messengers. These are defined as a group of biomolecules which are produced in the ductless (endocrine) glands and are carried to different parts of the body by the blood stream where they control various **metabolic processes** or show **physiological activity** which may be **inhibitory** or **stimulatory**. They are required only in very small amounts and are not stored in the body.

The communication among cell is established by hormones which act as messengers.

NOTE • Insulin is a polypeptide hormone contains 51 amino acids arranged in two chains (of 21 and 30 amino residues) which are cross-linked with each other at two places by disulphide (—S—S—) bonds. Insulin maintains sugar level in the blood and its deficiency causes diabetes.

Based on their chemical composition, hormones are divided into following two main classes:

- **Based on their structure** steroid hormones and non-steroid hormones.
- **Based on activity in the cell** important hormones, their types source and functions are listed in the following table.

Classification and Function of Hormones

Type	Sub-type	Examples	Source	Functions
(i) **Steroids**	Sex hormones	(i) Male sex hormones (Androgens)	Testis	**Testosterone** is responsible for male characteristics (deep voice, facial hair, physical constitution) during puberty. Synthetic testosterone analogs are used in medicine to promote muscle and tissue growth.
		(ii) Female sex hormones (Estrogens and progesterone)	Ovary	(a) **Estradiol** is responsible for secondary female characteristics and participates in control of menstrual cycle. (b) **Progesterone** is responsible for preparing the uterus for implantation of the fertilised egg and also plays important role as **birth-control agents**.

Type	Sub-type	Examples	Source	Functions
	Corticosteroids (Adrenal cortical hormones)	(i) Mineralocorticoids	Adrenal cortex	These regulate NaCl in the body and cause excretion of potassium in urine; are made by different cells in adrenal cortex.
		(ii) Glucocorticoids	Adrenal cortex	They modify certain metabolic reactions and have anti-inflammatory effect; are made by adrenal cortex.
(ii) **Non-steroids**	Peptide hormones	Insulin	Pancreas	Insulin has much effect on carbohydrate metabolism. This decreases glucose concentration in blood and is thus known as **hyperglycemic** factor. It promotes anabolic processes and inhibits catabolic ones. Its deficiency causes **diabetes mellitus**. Sanger (Nobelist) determined the structure of insulin.
		Oxytocin	Posterior pituitary	Causes contraction of smooth muscle, including contraction of uterus during child birth. It helps in milk ejection from mammary gland.
		Vasopressin	Posterior pituitary	It inhibits excretion of water from the body in form of urine.
		Glucogen	Pancreas	It hydrolyses glycogen and elevates blood sugar level.
	Amino acid derivatives	Thyroidal hormones	Thyroid	Thyroxin and triiodothyronine affect the general metabolism independent of their nature and specific activity. Thyroid gland is known as pace-setter of the endocrine system.

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, are termed as vitamins.

Depending on their solubility, the vitamins can be classified into two groups.

- **Fat or oil soluble vitamins**, e.g. A, D, E and K.
- **Water soluble vitamins**, e.g. B and C vitamins.

NOTE
- Provitamins are the biologically inactive compounds that have almost same structure as vitamins and can be converted easily into active vitamins, e.g. β-carotene is a provitamin for vitamin A.
- Iodine number is a measure of the extent of unsaturation present in an oil or fat.
- Higher the iodine value, more unsaturated is the oil or fat.

Some Important Vitamins, their Sources and their Deficiency Diseases

Name of vitamin	Sources	Deficiency diseases
Vitamin-A (Retinol)	Fish liver oil, carrots, butter and milk	Xerophthalmia (hardening of cornea of eye) or night blindness
Vitamin-B_1 (Thiamine)	Yeast, milk, green vegetables	Beri-beri (loss of appetite)
Vitamin-B_2 (Riboflavin)	Milk, egg white, liver, kidney	Cheilosis (fissuring at corners of mouth and lips)
Vitamin-B_6 (Pyredoxine)	Yeast, milk, egg yolk, cereals	Convulsions, nervousness
Vitamin-B_{12} (Cyanocobalamine)	Meat, fish, egg and curd	Pernicious anaemia (RBC deficient in haemoglobin)
Vitamin-C (Ascorbic acid)	Citrus fruits, amla and green leafy vegetables	Scurvy (bleeding gums)
Vitamin-D	Exposure to sunlight, fish and egg yolk	Rickets and osteomalacia
Vitamin-E	Wheat, germ oil, sunflower oil	Increased fragility of RBC and muscular weakness
Vitamin-K	Green leafy vegetables	Increased blood clotting time

Nucleic Acids

These are biological polymers. They function as the chemical carriers of cell's genetic information.

Nucleic acids → DNA (Deoxyribose nucleic acid)
Nucleic acids → RNA (Ribose nucleic acid)

1. DNA
(Deoxyribose Nucleic Acid)

- DNA is the polymer of nucleotide.
- It is a **genetic material**.
- It has **double helical structure**.
- **Nucleotide** has deoxyribose sugar, phosphate and nitrogenous base.
- **Nucleoside** has deoxyribose sugar and nitrogenous base. 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. When nucleoside is linked to phosphoric acid at 5′-position of sugar moiety, we get a nucleotide.
- Nucleotides are joined together by **phosphodiester linkage between 5′ and 3′ carbon.**

Nitrogenous base in DNA → Purine → Adenine (A)
Purine → Guanine (G)
Nitrogenous base in DNA → Pyrimidine → Thymine (T)
Pyrimidine → Cytosine (C)

- DNA has A = T, C ≡ G

2. RNA (Ribose Nucleic Acid)

- It is also a polymer of nucleotide units but in it, the nucleotide unit contains ribose sugar instead of deoxyribose sugar.
- RNA has uracil (U) instead of thymine (T).
- RNA molecules are of three types, these are messenger RNA (*m*RNA), ribosomal RNA (*r*RNA) and transfer RNA (*t*RNA). They perform different functions.

Biological Functions of Nucleic Acids

- DNA has an ability of self duplication during cell division and identical DNA strand are transferred to daughter cell. In this way, DNA is responsible for maintaining the identity of different species of organisms over million of years.
- RNA molecules synthesised various types of proteins in the cell but the message for the synthesis of a particular type of protein is present in DNA.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 Which one given below is a non-reducing sugar? ➞ **NEET 2016, Phase I**
(a) Lactose (b) Glucose
(c) Sucrose (d) Maltose

2 Number of chiral carbon atoms in β-D-(+)-glucose is
(a) five (b) six (c) three (d) four

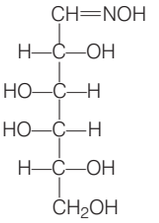
3 The term anomers of glucose refers to
(a) isomers of glucose that differ in configuration at carbons one and four (C-1 and C-4)
(b) a mixture of D-glucose and L-glucose
(c) enantiomers of glucose
(d) isomers of glucose that differ in configuration at carbon one C-1

4 Artificial sweetener which is stable under cold conditions only is ➞ **CBSE-AIPMT 2014**
(a) saccharine (b) sucralose
(c) aspartame (d) alitame

5 The change in the optical rotation of freshly prepared solution of glucose is known as
(a) tautomerism (b) racemisation
(c) specific rotation (d) mutarotation

6 Which one of the following does not exhibit the phenomenon of mutarotation? ➞ **CBSE-AIPMT 2010**
(a) (+) sucrose (b) (+) lactose
(c) (+) maltose (d) (–) fructose

7 D-(+)-glucose reacts with hydroxylamine and yields an oxime. The structure of the oxime would be ➞ **CBSE-AIPMT 2010**

(a)


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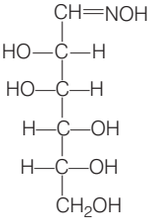

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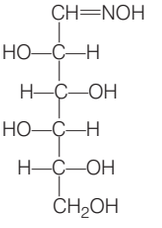
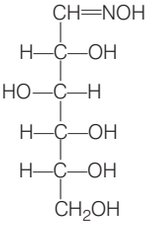


(d)


8 Which one of the following sets of monosaccharides forms sucrose? → **CBSE-AIPMT 2012**

(a) α-D-galactopyranose and α-D-glucopyranose
(b) α-D-glucopyranose and β -D-fructofuranose
(c) β -D-glucopyranose and α-D-fructofuranose
(d) α-D-galactopyranose and β -D-fructofuranose

9 Sucrose (cane sugar) is a disaccharide. One molecule of sucrose on hydrolysis gives _____.

(a) 2 molecules of glucose
(b) 2 molecules of glucose + 1 molecule of fructose
(c) 1 molecule of glucose + 1molecule of fructose
(d) 2 molecules of fructose

10 Which of the following is an example of ketohexose?

(a) Mannose (b) Galactose (c) Maltose (d) Fructose

11 Which one of the following statements is not true regarding (+) lactose? → **CBSE-AIPMT 2011**

(a) (+) lactose is a β -glycoside formed by the union of a molecule of D-(+)-glucose and a molecule of D-(+)-galactose
(b) (+) lactose is a reducing sugar and does not exhibit mutarotation
(c) (+) lactose, $C_{12}H_{22}O_{11}$ contains 8 —OH groups
(d) On hydrolysis, (+) lactose gives equal amount of D-(+)-glucose and D-(+)-galactose

12 Hydrolysis of sucrose is called

(a) inversion (b) esterification
(c) hydration (d) saponification

13 Which one of the following biomolecules is insoluble in water?

(a) α-keratin (b) Haemoglobin
(c) Ribonuclease (d) Adenine

14 Complete hydrolysis of cellulose gives

(a) D-fructose (b) D-ribose (c) D-glucose (d) L-glucose

15 The difference between amylose and amylopectin is → **NEET 2018**

(a) amylopectin have 1→ 4 α-linkage and 1→ 6β-linkage
(b) amylose have 1→ 4 α-linkage and 1→ 6β-linkage
(c) amylopectin have 1→ 4 α-linkage and 1→ 6α-linkage
(d) amylose is made up of glucose and galactose

16 In a protein molecule various amino acids are linked together by → **NEET 2016, Phase I**

(a) β-glycosidic bond (b) peptide bond
(c) dative bond (d) α-glycosidic bond

17 Casein contained in milk is a/an

(a) carbohydrate (b) lipid
(c) protein (d) important molecule

18 Which of the following set consists only of essential amino acids?

(a) Alanine, tyrosine, cystine (b) Leucine, lysine, tryptophan
(c) Alanine, glutamine, lycine (d) Leucine, proline, glycine

19 Which of the following has an imino (NH) group instead of an amino group (—NH_2)?

(a) Proline (b) Isoleucine
(c) Tyrosine (d) Serine

20 Which of the following compounds can form a Zwitter ion? → **NEET 2018**

(a) Benzoic acid (b) Acetanilide
(c) Aniline (d) Glycine

21 Which functional group participates in disulphide bond formation in proteins?

(a) Thiolactone (b) Thiol
(c) Thioether (d) Thioester

22 Which one of the following is a conjugated protein?

(a) Phosphoprotein (b) Glycoprotein
(c) Chromoprotein (d) All of these

23 Which of the following statements is not correct? → **NEET 2017**

(a) Insulin maintains sugar level in the blood of a human body
(b) Ovalbumin is a simple food reserve in egg white
(c) Blood proteins thrombin and fibrinogen are involved in blood clotting
(d) Denaturation makes the proteins more active

24 Which of the following contains cobalt?

(a) Vitamin-A (b) Vitamin-C
(c) Vitamin-B_{12} (d) Vitamin-K

25. Which of the following acid is a vitamin?

(a) Aspartic acid (b) Ascorbic acid
(c) Adipic acid (d) Saccharic acid

26 Which of the following hormones is produced under the condition of stress which stimulates glycogenolysis in the liver of human beings? → **CBSE-AIPMT 2014**

(a) Thyroxine (b) Insulin
(c) Adrenaline (d) Estradiol

27 Deficiency of vitamin B_1 causes the disease → **CBSE-AIPMT 2012**

(a) convulsions (b) beri-beri
(c) cheilosis (d) sterility

28 The pyrimidine bases present in DNA are

(a) cytosine and adenine (b) cytosine and guanine
(c) cytosine and thymine (d) cytosine and uracil

29 DNA and RNA contain four bases each. Which of the following base is not present in RNA?

(a) Adenine (b) Uracil
(c) Thymine (d) Cytosine

30 The couplings between base units of DNA is through

(a) hydrogen bonding (b) electrostatic bonding
(c) covalent bonding (d) van der Waals' forces

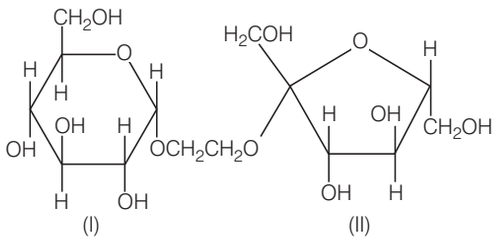
DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 In both DNA and RNA, heterocyclic base and phosphate ester linkages are at

(a) C_5' and C_1' respectively of the sugar molecule
(b) C_1' and C_5' respectively of the sugar molecule
(c) C_2' and C_5' respectively of the sugar molecule
(d) C_5' and C_2' respectively of the sugar molecule

2 The correct statement about the following disaccharide is



(I) (II)

(a) Ring (I) is pyranose with α-glycosidic link
(b) Ring (I) is furanose with α-glycosidic link
(c) Ring (II) is furanose with α-glycosidic link
(d) Ring (II) is pyranose with α-glycosidic link

3 A compound give negative test with ninhydrin and positive test with Benedict's solution. The compound is

(a) a protein
(b) an amino acid
(c) a lipid
(d) a monosaccharide

4 Insulin production of its action in human body are responsible for the level of diabetes. This compound belongs to which of the following categories?

(a) A coenzyme (b) A hormone
(c) An enzyme (d) An antibiotic

5 RNA and DNA are chiral molecules, their chirality is due to

(a) L-sugar component
(b) chiral bases
(c) D-sugar component
(d) chiral phosphate ester units

6 In an amino acid, the carboxyl group ionises at $pK_{a_1} = 2.34$ and ammonium ion at $pK_{a_2} = 9.6$. The isolectric point of the amino acid is at pH

(a) 5.97 (b) 2.34 (c) 9.60 (d) 6.97

7 The enzyme which facilitates internal rearrangement in 3-phosphoglyceric acid to form 2-phosphoglyceric acid is

(a) aldolase
(b) triose phosphate isomerase
(c) phosphoglycero mutase
(d) pyruvate kinase

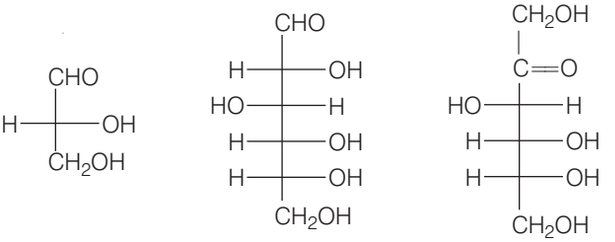
8 An organic compound consumes 4 moles of periodic acid to form following copounds, per mole of the starting compound HCHO, 3HCOOH and CHOCOOH. The organic compound is

(a) glucose (b) fructose
(c) gluconic acid (d) sorbitol

9 Which of the following statements is not true about glucose?

(a) It is an aldohexose
(b) On heating with HI it forms *n*-hexane
(c) It is present in furanose form
(d) It does not give 2,4-DNP test

10 Optical rotations of some compounds along with their structures are given below which of them have D configuration.



(+) rotation I (+) rotation II (–) rotation III

(a) I, II and III (b) II and III
(c) I and II (d) Only III

11 Identify the correct statement regarding enzymes.

(a) Enzymes are specific biological catalysts that can normally function at very high temperatures ($T \sim 100$ K)
(b) Enzymes are normally heterogeneous catalysts that are very specific in their action
(c) Enzymes are specific biological catalysts that cannot be poisoned
(d) Enzymes are specific biological catalysts that possess well defined active sites

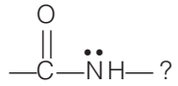
12 In an electric field, if an amino acid migrate towards cathode, the pH of the solution is said to be

(a) less than pI (b) more than pI
(c) equal to pI (d) 7

13 The correct statement in respect of protein haemoglobin is that it

(a) acts as an oxygen carrier in the blood
(b) forms antibodies and offers resistance to diseases
(c) functions as a catalyst for biological reactions
(d) maintains blood sugar level

14 Which statement is incorrect about peptide bond



(a) C—N bond length in proteins is longer than usual bond length of C—N bond

(b) Spectroscopic analysis show planar structure of

group

(c) C—N bond length in proteins is smaller than usual bond length of C—N bond

(d) None of the above

15 The α-D glucose and β-D-glucose differ from each other due to difference in carbon with respect to its

(a) conformation (b) configuration

(c) number of —OH groups (d) size of hemiacetal ring

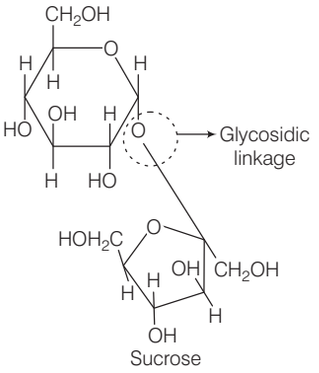
ANSWERS

SESSION 1	**1** (c)	**2** (a)	**3** (d)	**4** (c)	**5** (d)	**6** (a)	**7** (d)	**8** (b)	**9** (c)	**10** (d)
	11 (b)	**12** (a)	**13** (a)	**14** (c)	**15** (c)	**16** (b)	**17** (c)	**18** (b)	**19** (a)	**20** (d)
	21 (b)	**22** (d)	**23** (d)	**24** (c)	**25** (b)	**26** (c)	**27** (b)	**28** (c)	**29** (c)	**30** (a)
SESSION 2	**1** (a)	**2** (a)	**3** (d)	**4** (b)	**5** (c)	**6** (a)	**7** (c)	**8** (c)	**9** (c)	**10** (a)
	11 (d)	**12** (a)	**13** (a)	**14** (c)	**15** (b)					

Hints and Explanations

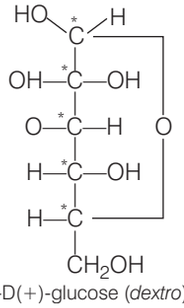
SESSION 1

1 Sucrose is non-reducing sugar because reducing part of glucose (—C(=O)—H) and fructose (>C=O) are involved in glycosidic linkage.



While, lactose, glucose and maltose are reducing sugars.

2



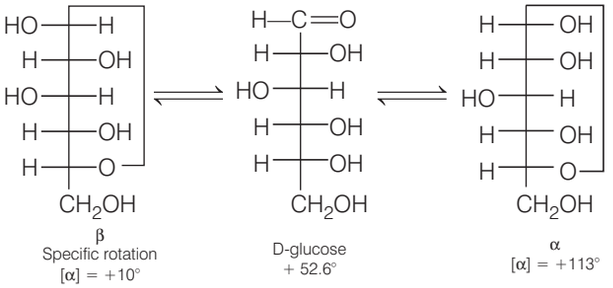
β-D(+)-glucose (*dextro*)

Chiral carbon atoms = 5 .

3 Anomers of glucose are cyclic diastereomers differ in configuration at C-1 existing in two forms α and β respectively.

4 Aspartame is the only artificial sweetener which is stable at lower temperature and decomposes at higher temperature. It is also called Nutra sweet. It's relative sweetness value is 180.

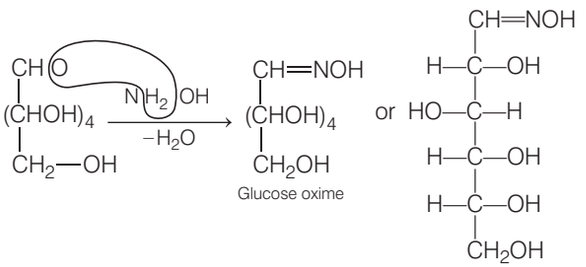
5 A spontaneous change in the specific rotation of a solution of an optically active compound is called mutarotation. Hemiacetal forms of α and β-D-glucose are stable in solid state but in aqueous solution, there is opening of the cyclic structure which gives solution of constant specific rotation.



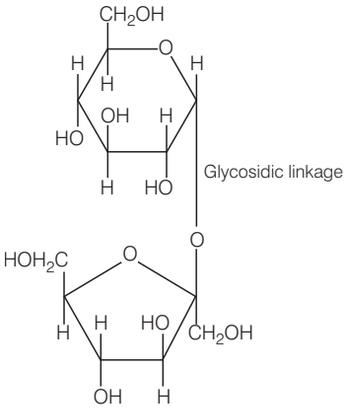
6 Reducing sugars that exist in hemiacetal and hemiketal forms, undergo mutarotation in aqueous solution.

Among the given carbohydrates, only sucrose is a non-reducing sugar as in it, the hemiacetal and hemiketal groups of glucose and fructose are linked together through O-atom and thus, not free. Due to the absence of free hemiacetal or hemiketal group, sucrose does not exhibit mutarotation.

7



8 Sucrose is composed of α-D-glucopyranose and a β-D-fructofruanose units which are joined by α, β-glycosidic linkage between C-1 of the glucose unit and C-2 of the fructose unit.



Structure of sucrose

9 $\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \longrightarrow \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$

10 Fructose is an example of ketohexose while glucose is an example of aldohexose.

11 Lactose is a reducing sugar and all reducing sugars show mutarotation.

12 On hydrolysis, sucrose gives an equimolar mixture of D-(+)-glucose and D-(–) fructose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \longrightarrow \underset{(+)\text{Glucose}}{C_6H_{12}O_6} + \underset{(-)\text{ Fructose}}{C_6H_{12}O_6}$$

Here, the configuration of sucrose changes (gets inverted) after hydrolysis, thus its hydrolysis is called inversion.

13 α-keratin is water insoluble fibrous protein. It is the major constituent of nail, hair and skin.

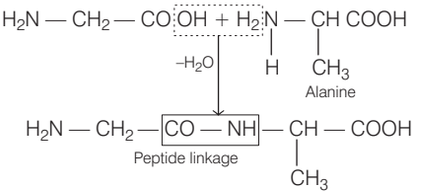
14 Cellulose is a polysaccharide, composed of D-glucose units which are joined by β-glycosidic linkages.

$$\underset{\text{Cellulose}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow{H^+} \underset{\text{D-glucose}}{nC_6H_{12}O_6}$$

15 Starch contains two components amylose and amylopectin. Chemically, amylose is a long unbranched chain with 200-1000 α-D- (+)-glucose units held by C_1-C_4 glycosidic linkage.

Amylopectin is a branched chain polymer of α -D-glucose units in which chain is formed by C_1-C_4 glycosidic linkage where branching occurs by C_1-C_6 glycosidic linkage.

16 Two amino acids in a protein are linked by a peptide bond. e.g. glycylalanine is formed when carboxyl group of glycine combines with the amino group of alanine.



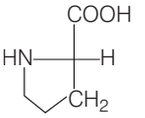
Glycylalanine (Gly-Ala)

17 Casein contained in milk is a protein.

18 Essential amino acids (10) are as follows:

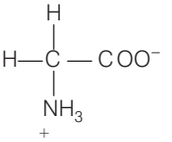
(i) Arginine	(vi) Methionine
(ii) Histidine	(vii) Phenylalanine
(iii) Isoleucine	(viii) Threonine
(iv) Leucine	(ix) Tryptophan
(v) Lysine	(x) Valine

19 Proline;



20 Ion containing positive as well as negative charge is called **Zwitter ion**.

Among the given options, only glycine (H_2N—CH_2—COOH) is an amino acid which contains both acidic (acquiring negative charge) and basic group (acquiring positive charge). Glycine can form a Zwitter ion. It is because glycine behave like salts rather than simple amines or carboxylic 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.



Zwitter ion

The pH at which the amino acid has no net charge is called isoelectric point. The isoelectric point of glycine is 5.97.

21 Disulphide bond may be reduced to thiol by means of reagents, i.e. $NaBH_4$, which shows the presence of thiol group in disulphide bond formation.

22 Conjugated proteins on hydrolysis give a non-protein portion alongwith α-amino acid. The non-protein portion is called prosthetic group.

Protein	Prosthetic group
Phosphoprotein	Lipid (e.g. lecithin)
Glycoprotein	Sugar
Chromoprotein	Coloured matter such as red coloured protophyrin

Since, all of them have non-protein part hence, all of them are conjugated proteins.

23 Denaturation of protein occur when it is subjected to physical change like change in temperature or chemical change like change in pH, the hydrogen bonds are disturbed. As a result, globules unfolds and helix get uncoiled so that protein losses its biological activity. Hence, the denaturation of protein makes the protein inactive is not correct.

24 Vitamin B_{12} contains cobalt and its chemical name is cyanocobalamin. Its deficiency causes pernicious anaemia.

25 Vitramin C is also known as ascorbic acid.

26 Epinephrine (adrenaline) hormone produced, the adrenal medulla that helps the body to respond to emergency situations. This stimulates glycogenolysis in the liver of human beings.

27 Deficiency of vitamin B_1 causes beri-beri, which causes loss of appetite and vigour, weak heart beat etc.

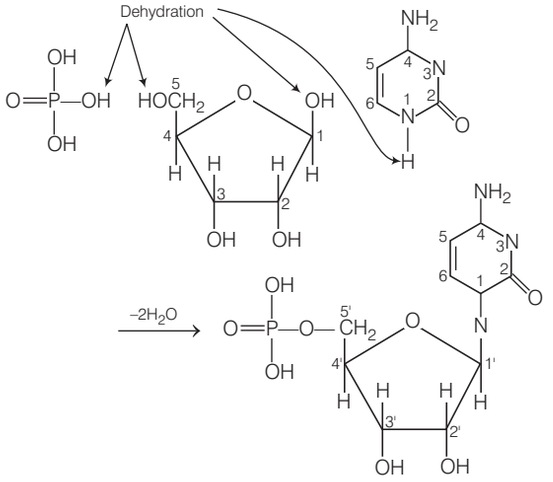
28 The pyrimidine bases present in DNA are cytosine and thymine while adenine and guanine are purine bases.

29 In RNA, uracil is present instead of thymine.

30 In DNA, the two strands are held together by hydrogen bonds. For example guanine is bonded to cytosine and adenine to thynine by hydrogen bonding.

SESSION 2

1 Synthesis of RNA/DNA from phosphoric acid, ribose and cytosine is given below :



Thus, ester linkages are at C_5' and C_1' of sugar molecule.

2 Ring *A* is pyranose (6 membered ring containing one O-atom) with α-glycosidic linkage and ring II is furanose with β -glycosidic linkage.

3 Proteins gives blue voilet colour with ninhydrin while carbohydrate gives negative test with ninhydrin. Carbohydrates give brown red precipitate with benedict's solution. Hence, compound is monosaccharide.

4 Insulin is a proteinaceous hormone. It is secreted by pancreas and controls the metabolism of glucose and maintains glucose level in the blood.

5 RNA and DNA molecules have ribose and deoxyribose sugar respectively. Both are chiral, their chirality is due to D-ribose or deoxyribose sugar component.

6 pH (at isoelectric point) $= \frac{2.34 + 9.6}{2} = 5.97$

7 The internal rearrangement of 3-phosphoglyceric acid into 2-phospho glyceric acid takes place in the presence of enzyme phosphoglyceromutase.

8 $CH_2(OH)-CH(OH)-CH(OH)-CH(OH)-CH(OH)-COOH \xrightarrow{4HIO_4} HCHO + 3HCOOH + HCOCOOH$

Gluconic acid

9 Glucose is present in pyranose form.

10 In all the three structures (I, II and III), the configuration of OH at C-1 is towards right and hence, all have D-configuration.

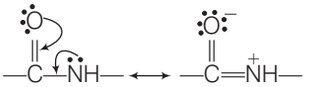
11 Enzymes have well defined active sites and their action are specific in nature. They are called biological catalysts and work at optimum temperature between 25 to 40°C.

12 Cations move towards cathode and when pH < pI, thus cationic form dominates.

13 Haemoglobin act as an oxygen carrier in the blood because four Fe^{2+} ions of haemoglobin can bind with 4 molecules of O_2 and from oxyhaemoglobin.

$$Hb + O_2 \longrightarrow \text{Oxyhaemoglobin}$$

14 Peptide bond is formed by the reaction of —COOH group of one amino acid with the $—NH_2$ group of another amino acid and represented as



As partial double bond character found between C—N bond, the bond length of C—N in protein should be smaller than usual C—N bond.

15 The isomer having the hydroxyl group (—OH) on the right is called α-D-glucose and one having the hydroxyl group (—OH) on the left is called β-D-glucose. Such pairs of optical isomers which differ in the configuration only around C_1 atom are called anomers. Thus α-D-glucose and β-D-glucose are anomers.