BIOMOLECULES

SECTION A

Carbohydrates: Optically active polyhydroxy aldehydes or ketones or compounds which can be hydrolysed to them. Ex. Glucose

Preparation of glucose:

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} C_6H_{12}O_6 + C_6H_{12}O_6$$

sucrose (cane sugar) — dil.HCl or dil.H_2SO_4 in alc. solution — Glucose, Fructose

$$(C_6H_{10}O_5) + nH_2O \xrightarrow[393K,\ 2\text{-}3\ atm.]{H^+} n\ C_6H_{12}O_6$$

Starch / cellulose

Vitamins ,sources and deficiency diseases

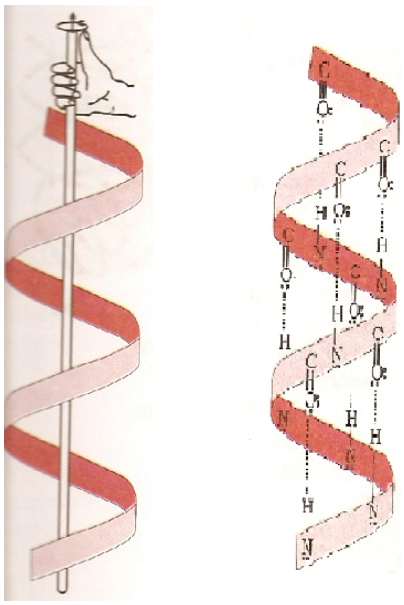
S.No.	Vitamin	Sources	Deficiency diseases
1	A	Fish liver oil,carrot,butter,milk	Night blindness,xeropthalmia
2	C	Citrus fruits,amla,green leafy vegetables	scurvy
3	D	Fish,egg yolk,exposure to sun light	Rickets,osteomalacia,
4	E	Sunflower oil,wheat germ oil	Muscular weakness,increased fragility of RBCs
5	K	Green leafy vegetables	Increased blood clotting time
6	B_1	Yeast,milk,cereals,green vegetables	Beri beri,
7	B_2	Milk,egg white,liver ,kidney	Cheilosis, digestive disorders,burning sensation of the skin
8	B_6	Yeast,milk,egg yolk,cereals ,grams	convulsions
9	B_{12}	fish ,meat, ,egg, curd	Pernicious anaemia

Difference in composition (1 and 2) and structure (3) of DNA and RNA and also other differences (4 to 7)

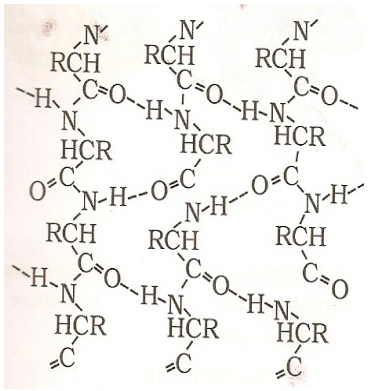
S.No.	DNA	RNA
1	Sugar moiety is 2-Deoxy -D(-) -ribose	Sugar moiety is D(-) ribose
2	Cotains thymine and cytosine as pyrimidine bases and guanine and adenine as purine bases	Contains cytosine and uracil as pyrimidine bases and guanine and adenine as purine bases
3	Has double stranded helix structure	Has single stranded helix structure
4	Chiefly occurs in nucleus of cell	Mainly occurs in the cytoplasm of the cell
5	Very large molecules - molecular mass may very from 6 million to 16 million	Smaller than DNA – molecular mass varies from 20000 to 40000
6	Has unique property of replication	Does not replicate
7	Controls transmission of hereditary effects	Controls synthesis of protein

Structure of proteins : can be explained under four headings.

1. **Primary structure:**refers to sequence of amino acids in a poly peptide chain.If this sequence changes then nature and function of protein changes.
2. **Secondary structure**: refers to the shape in which a long polypeptide chain can exist. This structure is resulted due to regular folding of long polypeptide chain. This folding is caused due to H- bonding between H atom of -NH group and oxygen atom of CO group of different amide same or different polypeptide chain. Chain exists in two different forms.
   (i) **α –helix structure**: a structure resulted due to twisting of polypeptide chain into a right handed screw(helix) . In this case –NH group of each amino acid residue is hydrogen bonded to the CO of an adjacent turn of helix.



α –helix structure



β- pleated structure

(ii) **β- pleated structure** :Structure of protein in which polypeptide chains are stretched out to nearly maximum extension and then laid side by side and held together by H-bond.

(iii) **Tertiary structure** :refers to overall folding of polypeptide chain i.e. further folding of 20 structures.Two shapes are

(a) fibrous proteins

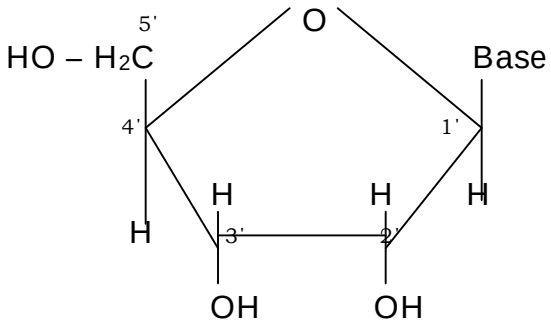
(b) globular proteins.

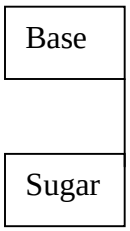
2^o and 3^o structures are stabilized by

- H –bonding
- Disulphide linkage
- Vander Wall's force
- Electrostatic force

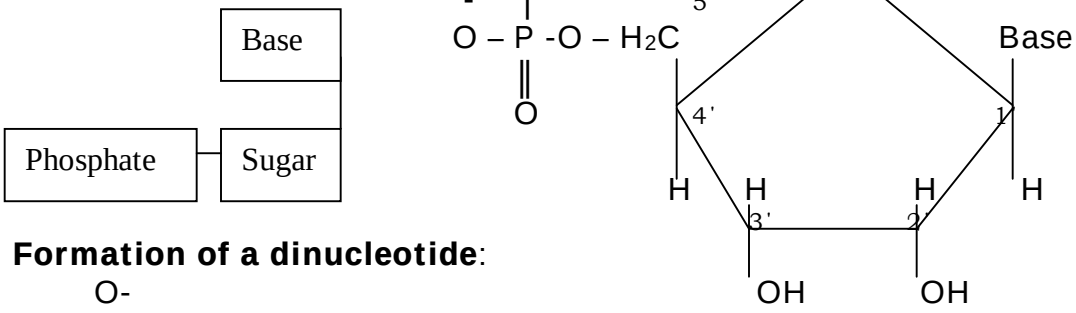
(iv) **Quarternary structure**: refers to spatial arrangement of two ro more polypeptide chains i.e sub-units with respect to each other.

Structure of nucleoside:

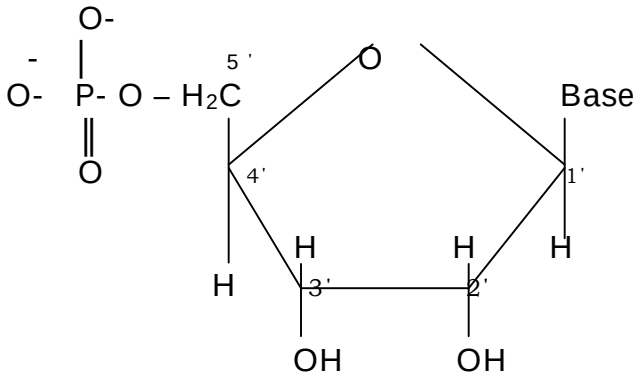




Structure of nucleotide:



Formation of a dinucleotide:



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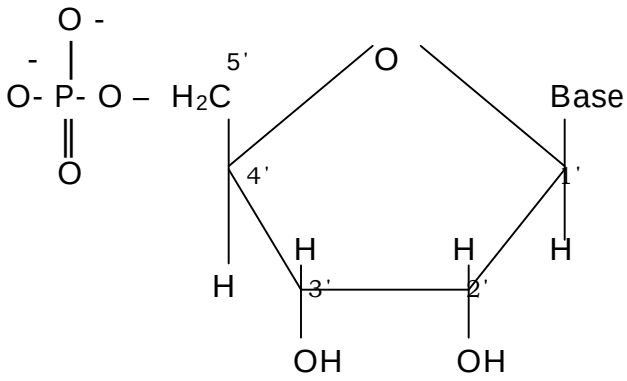
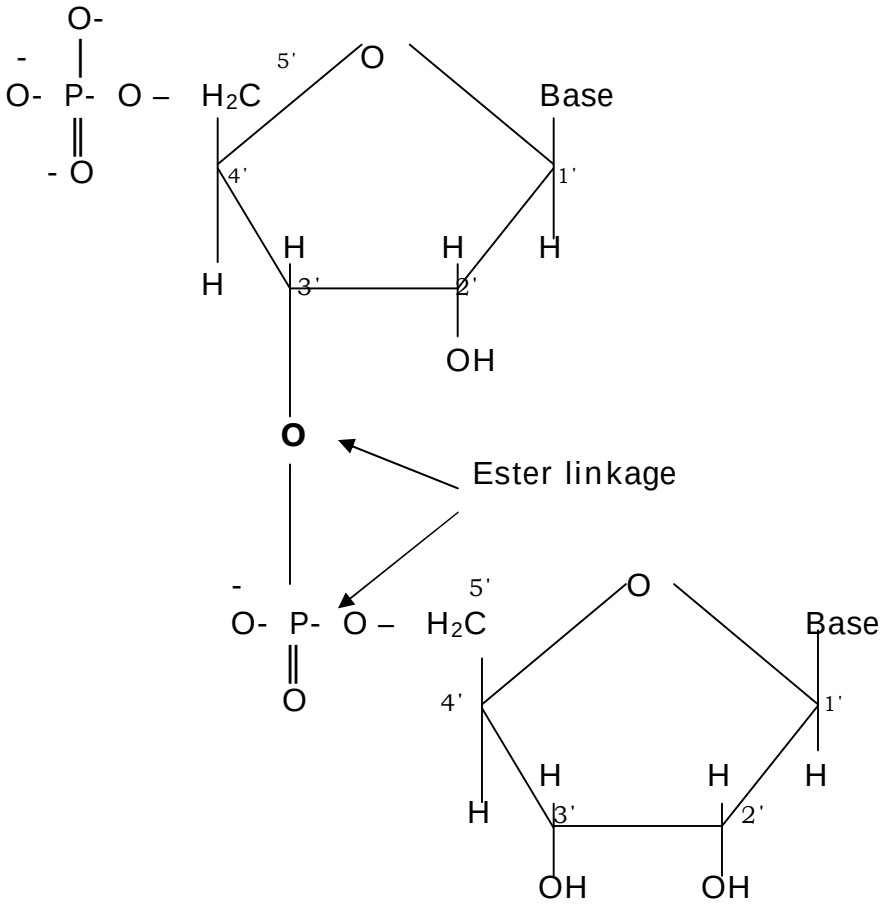
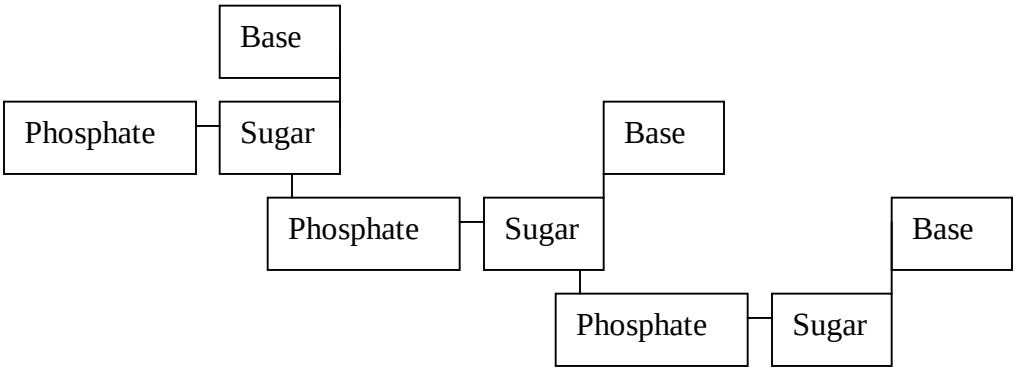




Structure of nucleic acid:



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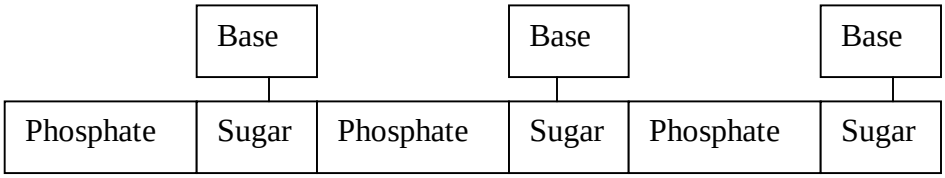


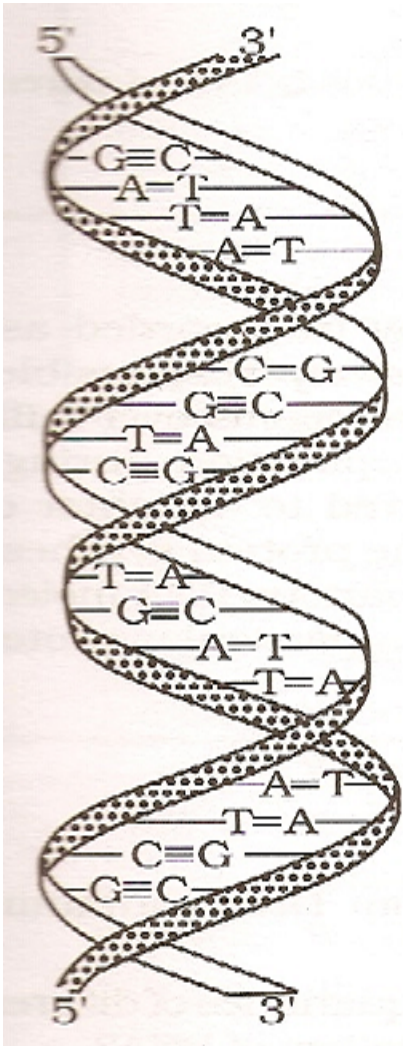
In nucleic acids thousands of nucleotides are joined together by phopsho diester linkages between 3' and 5' carbon atoms of pentose sugar. -OH group bonded to 3' carbon atom of one pentose sugar and –OH group bonded to P atom of phosphate group which is bonded to 5'carbon atom of another pentose sugar involve in the process of formation of second phospho ester linkage. Thus the back bone of nucleic acid consists of alternating sugar phosphate residues. Each sugar on this back bone is connected to one of the four nitrogenous bases.

Primary structure of nucleic acid: The sequence in which the four nitrogenous bases are attached to the sugar- phosphate back bone of a nucleotide chain is called as primary structure.

Structure of DNA:

Primary structure (same as above)

Secondary structure:



According to Watson and Crick DNA has double helix structure.It is composed of two right handed helical polynucleotide chains coiled around the same central axis. The two strands are antiparallel i.e their (5'⟶3') phosphodiester linkages run in opposite directions.

The bases are stacked inside the helices in planes perpendicular to the helical axis.(It is like a stack of flat plates held together by two ropes. Sugar – phosphate polymeric back bone running along out side the stack

The two strands are held together by H- bonds (shown by dashes). Only two base pairs A(Adenine) = = = T (Thymine) and C(Cytosine) ≡ ≡ ≡ G (Guanine) fit into this structure. Two hydrogen bonds are formed between A and T and three H-bonds are formed between C and G.Hydrophobic interactions between stacked bases are also responsible for stability and maintenance of double helix.

The diameter of double helix is 2 nm.The double helix structure(one complete turn corresponding to 10 base pairs) repeates at intervals of 3.4nm.This structure has two grooves,one minor and another major.

DNA halices can be right handed or left handed. The most stable form is the β - confirmation of DNA having right handed halice.

SECTION B

1. Glucose and sucrose are soluble in water but cyclohexane or benzene (simple six membered ring compounds) are insoluble in water .Explain.

Glucose and sucrose contain many polar -O-H bonds and hence form H-bond with water molecules but cyclohexane and benzene are non-polar hydrocarbons and hence do not form any H- bond with molecules of water.

2. What are expected product of hydrolysis of lactose?

3.How do you explain the absence of aldehyde group in the penta acetate of D-Glucose?

Pentaacetate of glucose when reacted with NH_2OH should have formed an oxime as an addition product. But it does not form indicating absence of free aldehyde group.

4.The melting point and solubility in water of amino acids are generally higher than that of corresponding halo acids . Explain.

In amino acids both amine and carboxylic acid involve in the process of formation of strong intermolecular H –bond formation within different molecules of amino acids ,but in halo acids in general no two groups involve in H –bonding and hence amino acids have higher melting point than corresponding halo acids.

Both amine group and –COOH group of amino acids form intermolecular H-bonding with water molecules and amino acid also forms a Zwitter ion in water but in case of halo acids in general only one group involves in the formation of inter molecular H-bond with water and hence solubility of amino acids is higher than that of halo acids.

5. Why can not vitamin C be stored in our body?

Vitamin C is highly soluble in water and readily excreted in urine.

6. What products would be formed when a nucleotide form a DNA containing

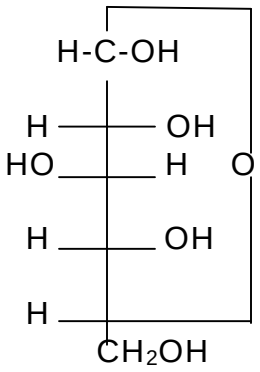
thymine is hydrolysed?

Phosphoric acid, 2-deoxyribose sugar and thymine base.

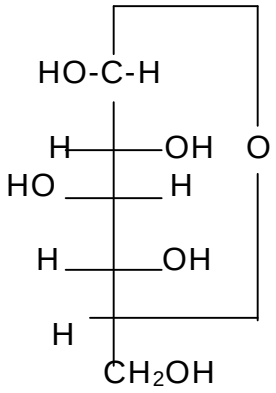
7. What are anomers?Give an example.

The two isomeric optically active structures of glucose [α – D (+)Glucose and β – D(+) glucose] which differ in the stereochemistry of C-1 carbon atom(-OH on the right side of C-1 , α –anomer and –OH on the LHS of C-1 , β – anomer) in their Fischer projection formulae and which differ in their melting point and specific rotation are called as anomers.

8. Draw cyclic structures for anomeric forms of Glucose.

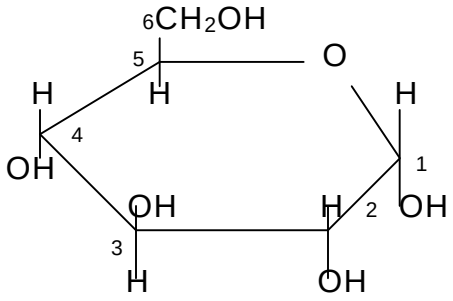


α – D -(+) –Glucose

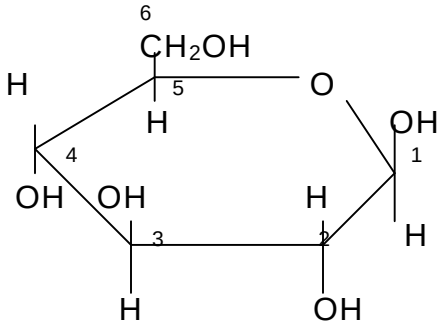


β – D-(+) Glucose

9. Draw Haworth structure /Pyranose ring structure for glucose

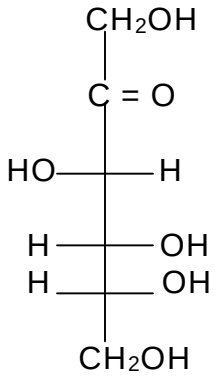


α – D -(+) –Glucopyranose

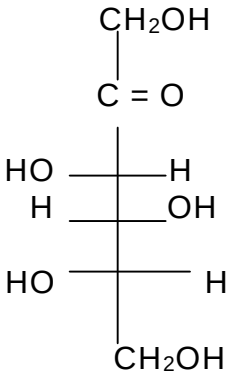


β – D-(+) Glucopyranose

10.Draw Fischer projection formula for open chain structure of fructose

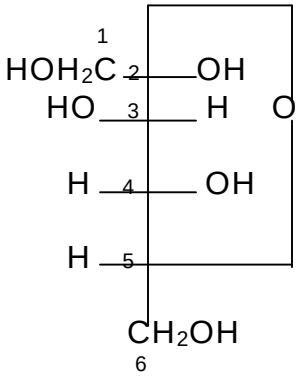


D- (-) Fructose

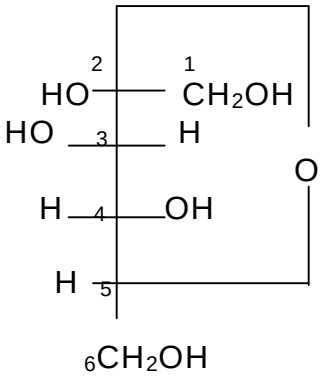


L- (-) Fructose

11. Draw Fischer projection formula for two cyclic structures(anomers) of fructose

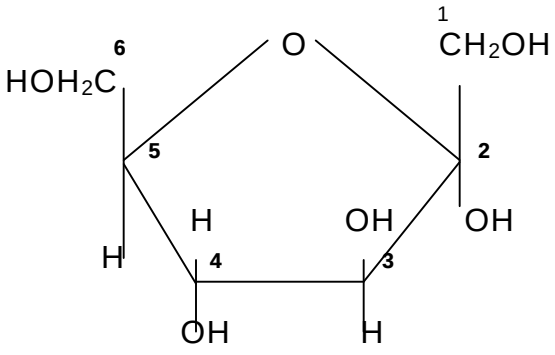


α – D -(-) –Fructose

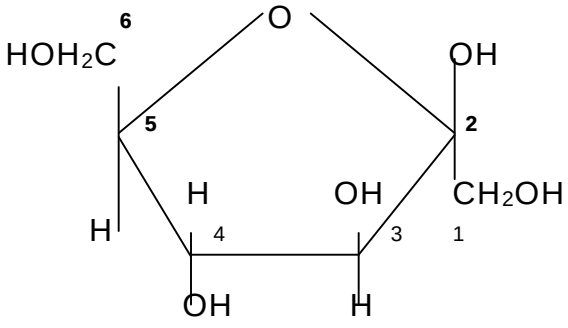


β – D-(-) Fructose

12. Draw Furanose ring structure or Haworth structure for anomers of Fructose

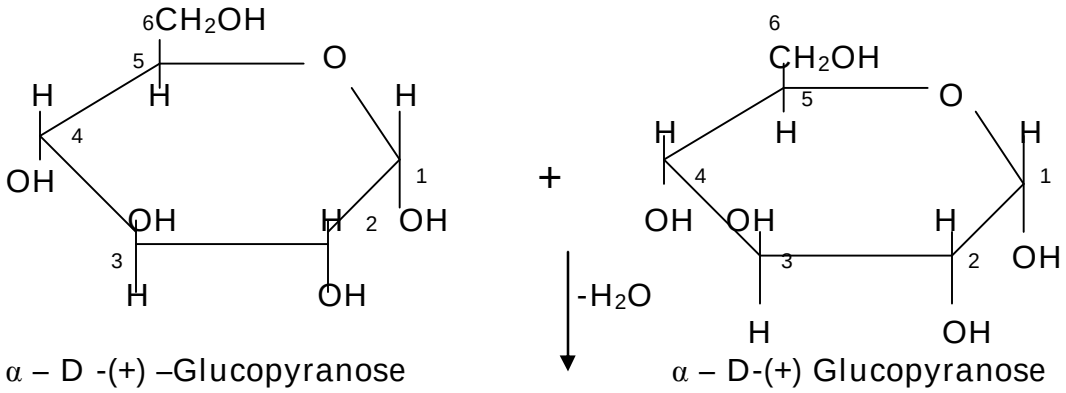


α – D -(-) –Fructofuranose



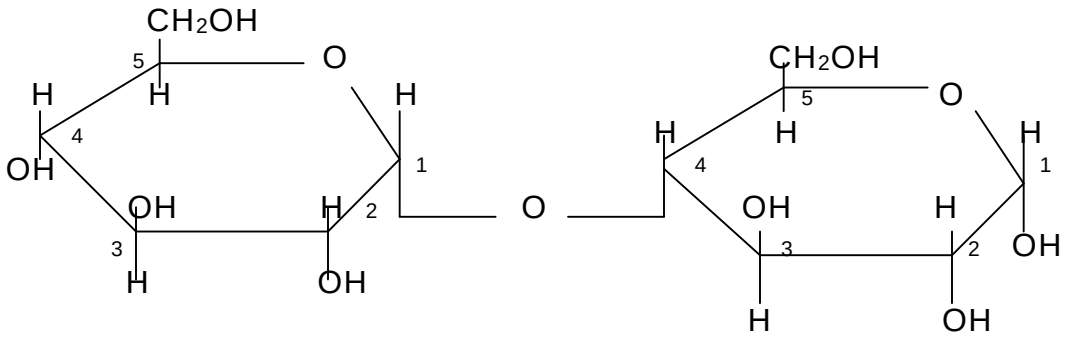
β – D-(-) -Fructofuranose

13. Draw Haworth structure for maltose and show how is a glycosidic linkage formed?



α – D -(+) –Glucopyranose

α – D-(+) Glucopyranose

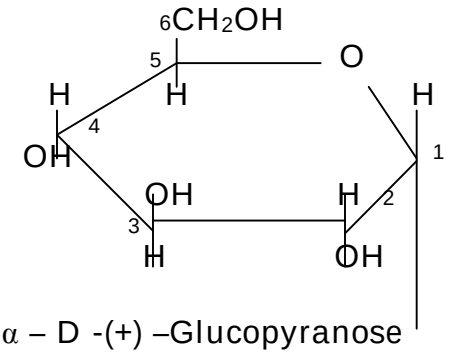


Maltose

14.Maltose is a reducing sugar.Why?

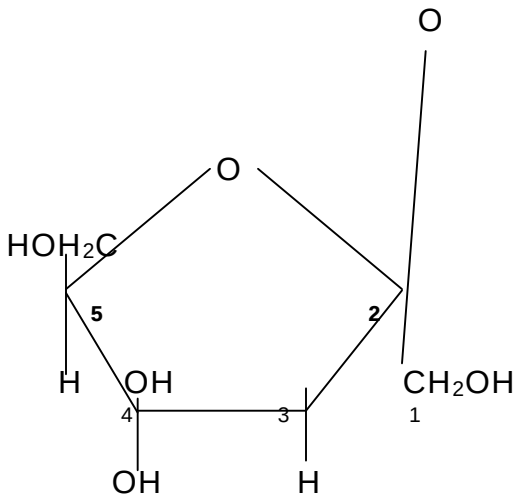
Maltose is composed of two α- D –(+) –Glucose units. In glycosidic linkage formation (two α links) C-1 of one glucose and C-4 of another glucose involve leaving hemiacetal –OH group free which can produce free –CHO group at C-1 of second (another) α-D-(+) Glucose.

15. Draw Haworth structure for sucrose.



Sucrose

α – D -(+) –Glucopyranose

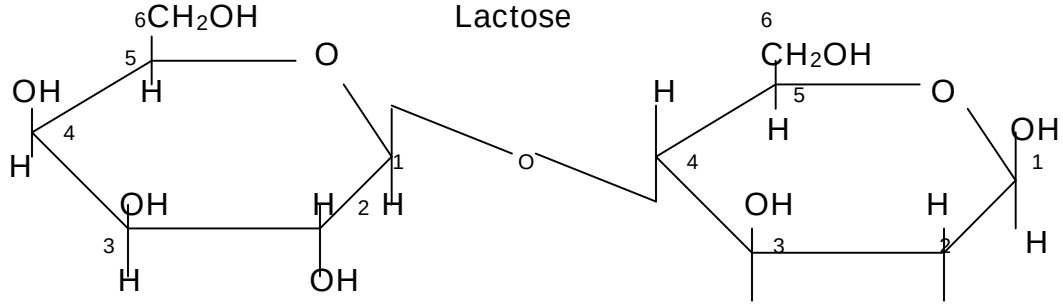


β – D-(-) -Fructofuranose

16. Sucrose is a non-reducing sugar.Why?

Sucrose is composed of α – D -(+) –Glucose and β – D-(-) –fructose.Glycosidic linkage is formed between C-1 of α – D -(+) –Glucose and C-2 of β – D-(-) –fructose and hence hemiacetal –OH groups of both the molecules involve in linkage leaving no –OH group to become reducing free aldehyde groupsl.

18.Draw Haworth structure for lactose.



H OH

β – D -(+) - Galactose β – D-(+) Glucose

17.Lactose is a reducing sugar.

Lactose is composed of β – D -(+) - Galactose and β – D-(+) Glucose.Glycosidic linkage is formed between C-1 of β – D -(+) - Galactose and C-4 of β – D-(+) Glucose leaving hemiacetal –OH group onC-1 of β – D-(+) Glucose free so that it is converted to free –CHO group when it acts as a reducing sugar.

18. Distinguish between amylose and amylopectin

	Amylose		Amylopectin
1	Long unbranched polymer of α – D -(+) –Glucose	1	Long branched polymer of α – D -(+) –Glucose
2	Water soluble part of starch	2	Water insoluble part of starch
3	Constitutes about 15-20% starch	3	Constitutes about 80 – 85%starch
4	Monomers held by C-1 and C-4 linkage	4	Monomers held by C-1 and C-4 linkage and branching occurs by C-1 and C-6 glycosidic linkage

SECTION C

CBSE 2008

1.Write two main functions of carbohydrates in plants. (1)

2.Define the following terms used in relation to proteins (i) Denaturation (ii) Peptide linkage (iii) Primary structure (3)

1. (i) used as storage molecules as starch in plants. (ii) Cell wall of plants is made up of cellulose.
2. (i) **Denaturation:**Loss of biological activity of native protein when it is subjected to physical change like change in temperature or chemical change like change in pH is called denaturation.

   Ex. Coagulation of egg white on boiling,curdling of milk(lactose to lactic acid)

   (ii) **Peptide linkage:** A bond or linkage formed when an amino group of an amino acid reacts with a carboxyl group of another molecule amino acid to form proteins .

   (iii) **Primary structure**: Specific sequence of amino acids in proteins refers to primary structure.

CBSE 2007

1. Answer the following questions briefly.

(i) What are reducing sugars? (ii) What is meant by denaturation of protein? (iii) How is oxygen replenished in our atmopsphere?

(b) Define enzymes.

OR

1. Answer the following questions briefly

(i) What are any two good sources of vitamin A

(ii) What are nucleotides? (2)

2.How are carbohydrates classified? (2)

Reducing sugars:Sugars which contain free aldehyde group or sugars in which hemiacetal -OH group (-OH group formed by intermolecular reaction between aldehyde or keto group and an alcoholic -OH group of same sugar molecule) do not involve in glycosidic linkage formation reduce reagents such as Fehling's solution and Tollen's reagent and are called as reducing sugars.

(iii) Combustion of glucose takes place in in cells of animals to obtain energy.

$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O$ + Energy.

Plants prepare carbohydrates by absorbing water and using CO_2 by photosynthesis.

$6\ CO_2 + 6\ H_2O$ + Energy. $\longrightarrow C_6H_{12}O_6 + 6\ O_2$

Plants become energy source for animals and plants.

(b) **Enzymes:** Globular proteins which make the biochemical reactions to take place at very milder conditions.

OR

1. (i) Milk and fish liver oil are two very good sources of vitamin A.
   (ii) **Nucleotides:** A monomer of nucleic acid in which sugar moiety is linked to a base at 1' position and phosphoric acid at 5' position of sugar .
2. Carbohydrates are classified on four bases.

On the basis of number of products produced on hydrolysis of carbohydrate there are 3 types.

(i) Monosaccharides: Carbohydrates which can not be hydrolysed to give simpler units of poly hydroxy aldehydes or ketones.Ex. Glucose,Fructose

(ii) Oligosaccharides: Carbohydrates which produce 2 to 10 monosaccharide units on hydrolysis .

Oligosaccharides are again classified into

Disaccharides : oligosaccharides which produce two monosaccharide units on hydrolysis .Ex. Sucrose,maltose

Trisaccharides: oligosaccharides which produce three monosaccharide units on hydrolysis.

Tetrasaccharides etc.

(iii) Polysaccharides: Carbohydrates which give large number of monosaccharide units on hydrolysis.starch,glycogen,cellulose

On the basis of their reducing action there are two types of carbohydrates

(i) **Reducing sugars**:Sugars which contain free aldehyde group or sugars in which hemiacetal

-OH group (-OH group formed by intermolecular reaction between aldehyde or keto group and an alcoholic -OH group of same sugar molecule) do not involve in glycosidic linkage formation reduce reagents such as Fehling's solution and Tollen's reagent and are called as reducing sugars. Ex. Maltose,lactose

(ii) **Non –reducing sugars**:Due to absence of free aldehyde group or due to involvement of hemiacetal – OH group in glycosidic linkage formation some

sugars do not reduce reagents such as Fehlig's solution and Tollen's reagent and are called non-reducing sugars.

On the basis of type of functional group present there are two types of carbohydrates

(i) **aldoses**: Carbohydrates containing aldehyde group. Ex. Glucose

(ii) **ketoses**: Carbohydrates containing keto group. Ex. Fructose

On the basis of their taste there are two types

Sugars: carbohydrates i.e monosaccharides and oligosaccharides which are sweet in taste and soluble in water.Ex. Glucose,Fructose,Sucrose

Non sugars: Amorphous water insoluble tasteless polysaccharides .

Ex. Starch,cellulose,glycogen

CBSE 2006

1. What are essential and non essential aminoacids?Give two example of each . (2marks)

OR

1. Define the following terms (i) nucleotides (1)

(b) List out main functions of carbohydrates in organisms. (2)

1. **Essential amino acids**: Amino acids which can not be synthesized in our body but must be supplied through diet. Ex. Valine,Lucine

Non- essential amino acids: Amino acids which can be synthesized in our body. Glutamic acid,Asparitic acid

Functions of carbohydrates : (i) used as storage molecules as starch in plants and glycogen in animals.

(ii) Carbohydrates are major portions of our food.

(iii) cell wall of bacteria and plants is made up of cellulose.

CBSE 2005

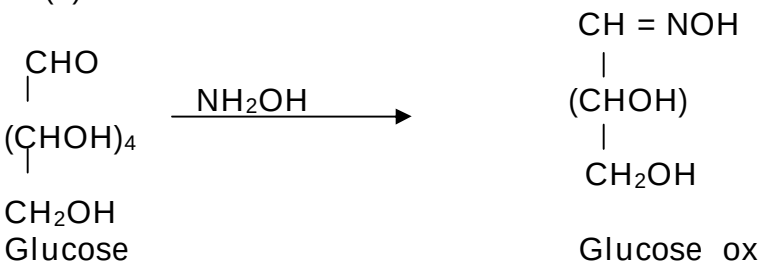
1. (a) Write the chemical reactions of Glucose with (i) NH_2OH (ii) $(CH_3CO)_2O$.Also draw simple Fischer projection of D – Glucose and L - Glucose. (2)

(b) Name the food sources and deficiency diseases caused due to lack of any two of the vitamins A,C,E and K. (2)

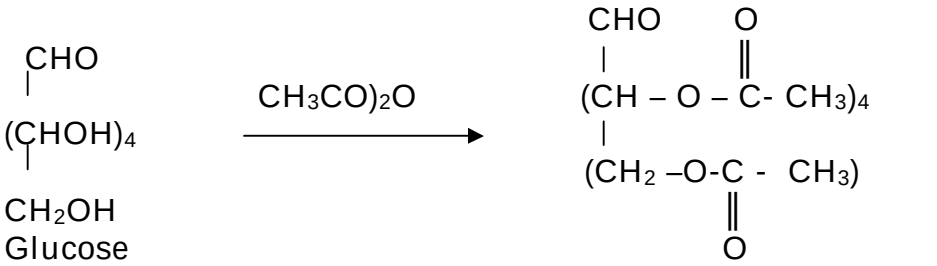
OR

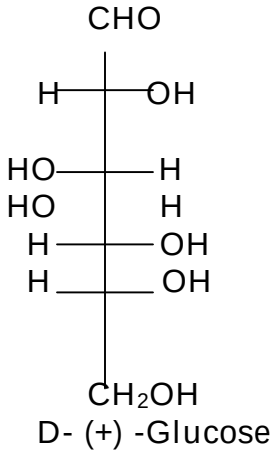
1. State the composition and functional differences between DNA and RNA (4)

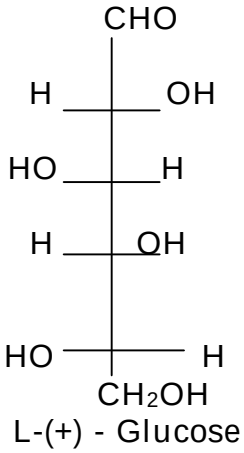
1. (a)



Glucose Glucose oxime







CBSE 2004

1. What is meant by inversion of sugar ? (1)
2. Define the term native state as applied to proteins. (1)

1. **Inversion of cane sugar:**The process of conversion of dextrorotatory cane sugar to a leavorotatory on hydrolysis with dilute acids or enzyme invertase equimolar mixture of D- Glucose and D – fructose

2. **Native state of protein:** Proteins found in in a biological system with a unique three dimensional structure (secondary and tertiary) and specific biological activity

CBSE 2003

Write the major classes in which carbohydrates are divided depending upon whether these undergo hydrolysis and if so on the number of products formed. (2marks)

OR

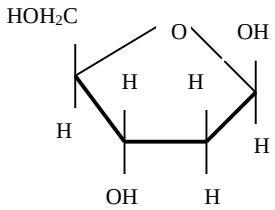
1. Explain mutation taking D- Glucose as an example. (2)
2. Enumerate the structural difference between DNA and RNA.Write down the structure of sugar present in DNA.(3)

Mutation in D-Glucose/ mutarotation in D –glucose/Mutation in biomolecules: The spontaneous change in specific rotation of optically active compounds is called muta rotation.

α-D (+) glucose $\rightleftharpoons$ equilibrium mixture $\rightleftharpoons$ β-D (+) glucose
+111° +52.5° +19.2°

When α-D (+) glucose or β-D (+) glucose is dissolved in water and introduced in a polarimeter tube this happens.

2. Structure of sugar present in DNA:



2- deoxy-D(-) ribose

1. What are poly saccharides ? Name two such substances of immense use to us and state their usefulness (2)

(i) Starch is a rich source of energy stored in plants and used by animals and humans.

(ii) cellulose is present in cell wall of bacteria and plants.

CBSE 2002

Differentiate between (i) Primary strcture and secondary strcture of proteins (2)

CBSE 1998

1.The two strands of DNA are not identical but are complementary. Explain this statement. (2)

2.Why are carbohydrates are generally optically active? (1)

1. The two strands are antiparallel i.e their (5' $\longrightarrow$ 3') phosphodiester linkages run in opposite directions and hence they are not identical.

The two strands of DNA are complementary to each other because in DNA helix structure only two base pairs are possible.i.e A and T , C and G pairs. Adenine of one strand makes two H- bonds with Thymine of another strand and vice versa. Cytosine of one strand makes three H-bonds with Gaunine of another strand and vice versa. A of one strand can not make bond A of another strand. C of one strand can not make bond with C of another strand. T of one strand can not make bond T of another strand. G of one strand can not make bond with G of another strand.

2. Carbohydrates generally satisfy the conditions of a molecule to be optically active i.e.they have chiral centers or they do not have plane of symmetry or axis of symmetry.(asymmetric molecules)

SECTION - D (Higher order questions for high achievers)

1. Where does the water present in the egg go after boiling the egg?

2. When RNA is hydrolysed there is no relationship among the quantities of different bases obtained . What does this fact suggest about the structure of RNA

3. Define the following terms (i) Co-enzymes. (ii) mutation in biomolecules.

(i) Co- enzyme : A prosthetic group which gets attached the enzyme at the time of reaction .

4. What is photosynthesis ? Where does it occur in plants?

Combination of CO_2 and water in presence of sunlight to produce glucose by plants is called as photosynthesis.

It occurs in chloroplasts in plant cells.

5.Mammals can digest cellulose but not human. Why?

Cellulose is a polymer of β – D – Glucose One glucose unit is joined to the next by β-glycosidic linkage between C-1 and C-4 carbon atoms.Ruminant mammals have enzyme cellulose in their stomachand can digest cellulose but human stomach is different and does not have enzyme capable of breaking cellulose molecules.

Human stomach can digest starch because starch is a polymer of α- D-glucose.

SECTION E Exercise questions

1. What are monosaccharides?
2. What are reducing sugars?
3. Write two main functions of carbohydrates in plants.
4. Classify the following into monosaccharides and disaccharuides Ribose,2-deoxyribose, maltose, galactose. Fructose and lactose.

   Monosacchrides: Ribose,2-deoxyribose, galactose and Fructose .

   Disaccharides: maltose, lactose
5. What do you understand by the term glycosidic linkage ?

   A linkage between two monosacchride units through oxygen atom, formed by the condensation of two pyranose or furanose ring structures of monosaccharides with the elimination of a molecule of water
6. What is glycogen? How is it different from starch?

   Carbohydrate (Oligosaccharide) stored in animal body as a source of energy is called glycogen. Glycogen has structure similar to amylopectin.

   Amylopectin in glycogen is more branched.
7. What are the hydrolysis products of (i) sucrose and (ii) lactose.

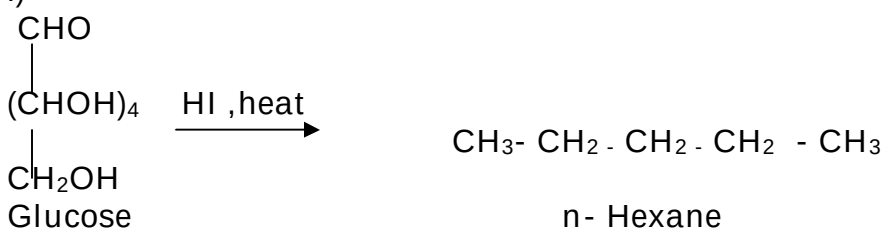
   Sucrose: (i) Glucose (ii) Fructose

   Lactose: (i) Galactose (ii) Glucose
8. What is the basic structural difference between starch and cellulose.

   Starch is a polymer of α – D(+) Glucose and cellulose is a polymer of β- D(+) Glucose.
9. What happens when D- Glucose is treated with the following reagents?(i) HI (ii) Bromine water (iii) HNO_3

10.

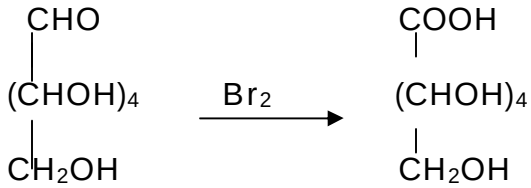
(i)



Glucose n- Hexane

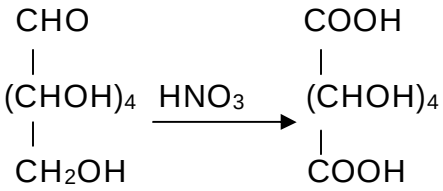
Formation of n- Hexane indicates that all the bonds between C atoms in Glucose are single bonds.

(ii)



Glucose Gluconic acid

Formation of Gluconic acid indicates that carbonyl group is an aldehyde Group.



Glucose Sacchric acid.

Formation of Sacchric acid indicates the presence of primary alcoholic –OH group in glucose.

11. Enumerate the reactions of glucose which can not be explained by its open chain strcture.
    (i) 2,4 –DNP test for aldehyde group
    (ii) Schiff' s test for aldehyde group
    (iii) Addition reaction with $NaHSO_3$
    (iv) Reaction of pentaacetate of glucose with hydroxyl amine to indicate presence of free -CHO group.
12. What are essential and non-essential amino acids.Give two examples of each type.
13. Define the following as related to proteins (i) peptide linkage (ii) Primary structure (iii) Denaturation

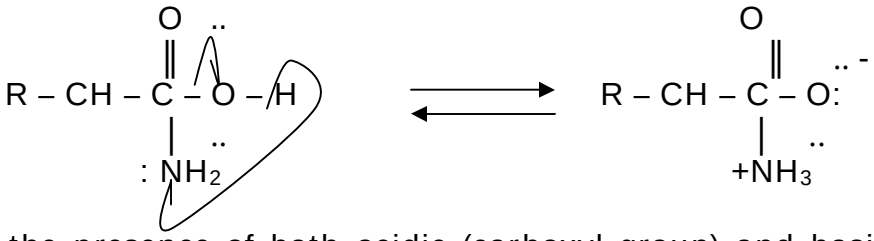
14. What are the common types of secondary strcture of proteins?
(i) α –helix structure (ii) β - pleated structure

14. What type of bonding helps in stabilizing the α - helix structure of proteins.
2^o structures are stabilized by
a. H –bonding (mainly)
b. Vander Wall's force
c. Electrostatic force

15.Differentiate between globular and fibrous proteins.

	fibrous proteins		**globular**
1	Linear condensation product	1	Cross linked condensation polymers of acidic and basic amino acids
2	Insoluble in water and common solvents but soluble in strong acidic or basic solutions	2	Soluble in water or an aqueous solution of a base, acid or salt
3	have rigid rod like shape	3	have spherical or spheroidal shape
4	parallel polypeptide chains are held together by H-bond and disulphide bond to form a fibre like structure.	4	coiling of polypeptide chain takes place to give a spherical shape.
5	Ex. Keratin(hair,wool,silk) myosin (muscles)	5	Insulin,albumin

16. How do you explain the amphoteric behaviour of amino acids.



Due to the presence of both acidic (carboxyl group) and basic (amino group) groups in the same molecule amino acids exist as a dipolar ion known as Zwitter ion. This ion reacts with acids as well as bases and hence shows amphoteric behaviour.

17.What are enzymes?

18.What is the effect of denaturation on the structure of proteins ?

Denaturation does not change primary structure but changes secondary and tertiary structure . On denaturation globules unfold,helix uncoil and H – bonds are disturbed.

19. How are vitamins classified? Name the vitamin responsible for the co-agulation of blood .

On the basis of solubility of vitamins either in oil/fat and water there are two types

(i) Fat/oil soluble /water insoluble vitamins Ex. Vitamin A,D,E,K

(ii) Water soluble/fat or oil insoluble vitamins Ex. Vitamin B and C

Vitamin K is responsible for co-agulation of blood.

20. Why are vitamin A and vitamin C essential to us ? Give their important sources.

Deficiency of vitamin A causes night blindness and xeropthalmia and deficiency of vitamin C causes scurvy.Vitamin C is higly water soluble and hence readily excreted in urine.

Sources of vitamin A: Milk,carrot,fish liver oil, butter

Vitamin C : citrus fruits,amla and green leafy vegetables.

21. What are nucleic acids ? Mention their two important functions.

Polynucleotides biopolymers/macromolecules present in high concentration in the nuclei of cells are called as nucleic acids.

(1) Nucleic acids (DNA) are the genetic materials of the cell and are responsible for transmission of hereditary effects from one generation to another.

(2) Nucleic acids (RNA) carry out biosynthesis of proteins

22. What is the difference between a nucleoside and a nucleotide?

nucleoside	nucleotide
Part of a nucleic acid in which D(-) ribose sugar is bonded to one of the two purine or four pyrimidine bases	Part of a nucleic in which a phosphate group, D(-) ribose sugar is bonded to one of the two purine or four pyrimidine bases

23. The two strands in DNA are not identical but are complementary . Explain.

24. Write the important structural and functional differences between DNA and RNA.

25. What are the different types of RNA found in the cell?

m-RNA (messenger RNA)

r-RNA (ribosomal RNA)

t – RNA (transfer RNA)