Biomolecules

Introduction :-

A polyhydroxy compound that has an aldehyde or a Ketone functional group, present either in free state or as a hemiacetal or hemiKetal are called carbohydrate.
Carbohydrate are substances having general formula $C_x(H_2O)_y$.

Classification of Carbohydrates :-

1. Monosaccharides :-

- A carbohydrate that cannot be hydrolysed to simple compounds is called monosaccaride.
- Monosaccharide which have six carbon are either aldohexoses or Keto hexoses Eg Glucose, Fructose, Galactose etc.

2. Oligosaccharides :-

- Carbohydrates that yield 2 to 10 monosaccharide units, on hydrolysis, are called oligosaccharides.
- They are further classified as disaccharides, trisaccharides, tetrasaccharides etc depending upon the no. of monosaccharides, they provide on hydrolysis.
- The 2 monosaccharides units obtained by hydrolysis of a disaccharide may be same or different.
  Eg Sucrose, Maltose, Lactose etc.

3. Polysaccharides :-

- A carbohydrate that can be hydrolyzed to many monosaccharide molecules is called a polysaccharides Eg Starch, Cellulose etc.

Aldoses: Monosaccharides containing aldehyde group are called aldoses.
Ketoses: Monosaccharides containing Ketonic group are called Ketoses.

Sugars & Non-Sugars :-

- Both monosaccharides & oligosaccharide are crystalline solids, soluble in water & sweet in taste. These are collectively Known as Sugars.
- polysaccharides are amorphous, sparingly soluble in water & tasteless & are Known as Non-Sugars.

Reducing & Non Reducing Sugars :—

- The saccharides that reduce Fehling's reagent, Tollen's reagent, are called as reducing sugars.
- All monosaccharides whether aldose or ketose, are reducing sugars. Eg :— Glucose, Fructose, mannose, galactose.

Monosaccharides :—

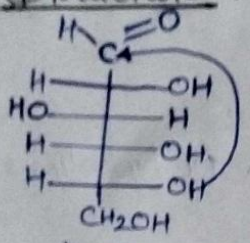
(1) Glucose ($C_6H_{12}O_6$) :—

- It is act as a reducing agent (reduces both Fehling's solution & ammonical silver nitrate solution).

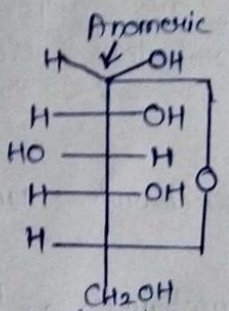
Physical properties :—

- Glucose is sweet in taste & also optically active (dextro rotatory)
- Glucose shows mutarotation.

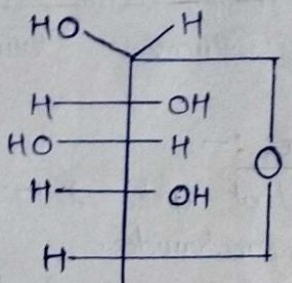
Structure :—



D-Glucose

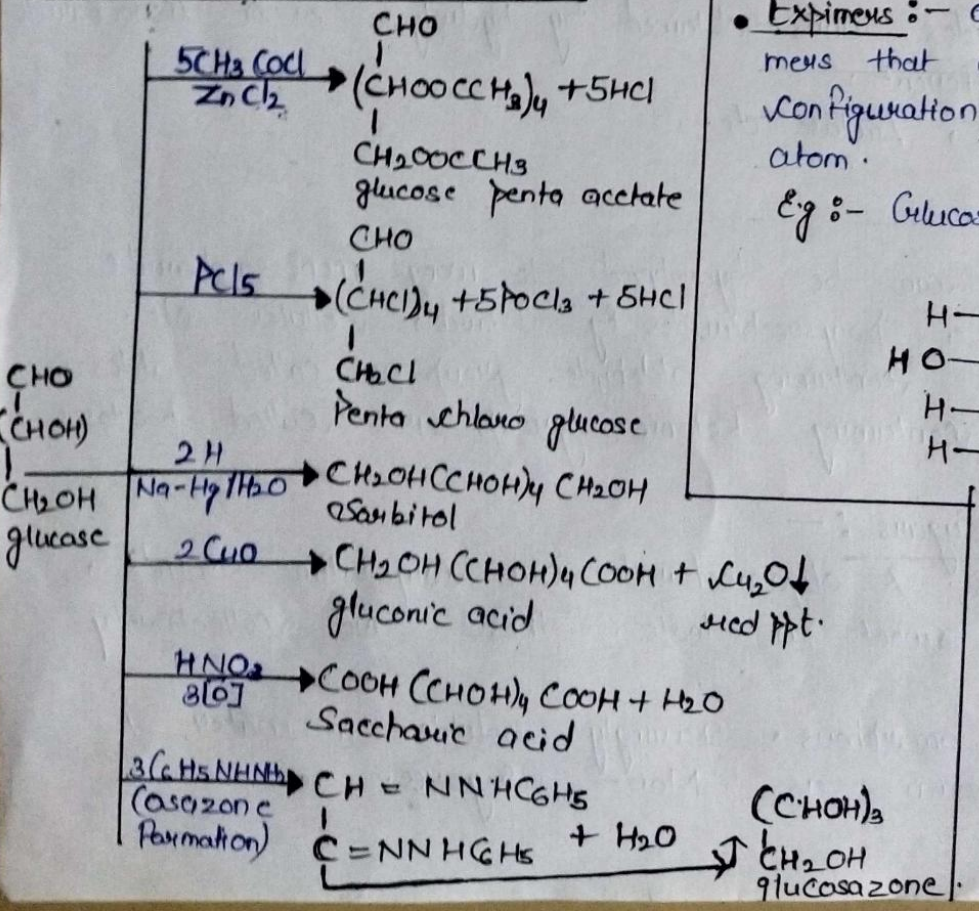


α-D-glucopyranose (36%)



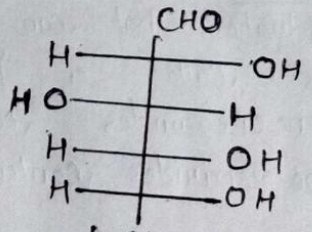
β-D glucopyranose (64%)

Chemical Reaction of Glucose :—



- **Epimers :—** are a pair of diastereomers that differ only in the configuration about a single carbon atom.

Eg :— Glucose & Mannose are C_2 epimers



D-Glucose.

Cyclic Structure of Glucose :—

- The open chain structure of glucose proposed by Baeyer experiment most of its properties. But it could not explain the following :—

1) Glucose does not give Schiff's test & does not react with $NaHSO_3$ & give hydrogensulphite addition product inspite of presence of -CHO group.

2) Pentaacetate of glucose does not react with NH_2OH group indicating absence of -CHO group.

Mutarotation of glucose :—

- This spontaneous change in specific rotations of an optically active compound is called mutarotation.
- These properties can be explained by cyclic structure of glucose. Glucose forms a stable cyclic hemiacetal. Initially five membered ring structure of glucose is proposed & it known as Furanose.

Anomers :—

Anomers are diastereomers that differ in the configuration at the acetal or hemiacetal C atom of a sugar in its cyclic form or Anomers are epimers whose conformations differ only about C-1.

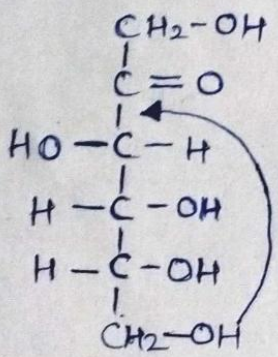
For eg α D(+) & β-D(+) glucose are anomers.
α-D(−) & β-D(−) Fructose are anomers.

- In glucose C_1 carbon is anomeric carbon & in Fructose C_2 carbon is anomeric carbon.

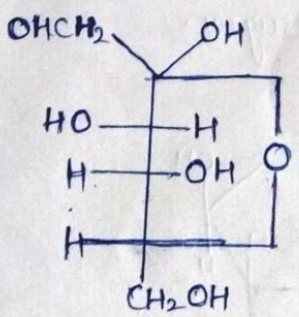
(2) Fructose :—

- It is also known as α-Laevulose i.e natural occuring compound is laevorotatory.
- It is pentahydroxy Ketone & shows mutarotation like glucose.
- It is reducing sugars.

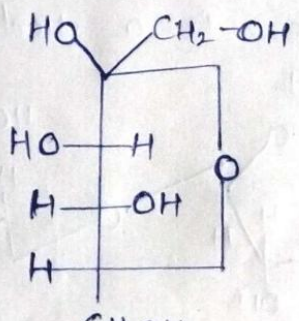
Structure :—



Open chain structure of Fructose
Specific Rotation (-92°)



α-D-Fructofuranose
Specific Rotation
(-21°)



β-D-Fructofuranose
Specific Rotation
(-133°)

Epimers :—

Diastereomers with more than one stereocentre that differ in the configuration about only one stereocentre are called epimers.

(i) D- Glyceraldehye & L-glyceraldehyde (this pair is an enantiomer as well as an epimer).

(ii) D- Erythrose & L- threose are epimers.

(iii) D-glucose & D-galactose are C-4 epimers.

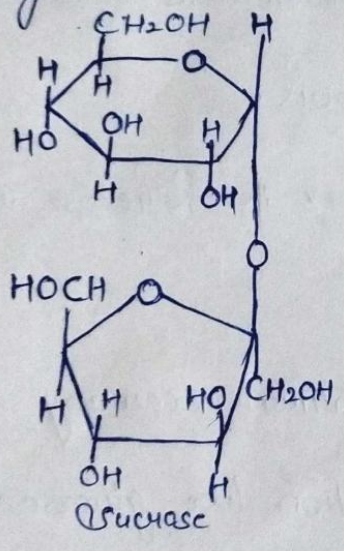
Disaccharides :—

Sucrose : (Sucrase, Invert-sugar $C_{12}H_{22}O_{11}$).

- Aqueous solution of sucrose is dextrorotatory its specific rotation being $+66.5°$.
- On hydrolysis with dilute acids sucrose yields an equimolar mixture of D(+)-glucose & D(-)- Fructose.

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

- Since D(-)-Fructose has a greater specific rotation than D(+)-glucose the resulting mixture is laevorotatory.
- Sucrose is not a reducing sugar.
- It does not form an oxime or an osazone, & does not undergo mutarotation.



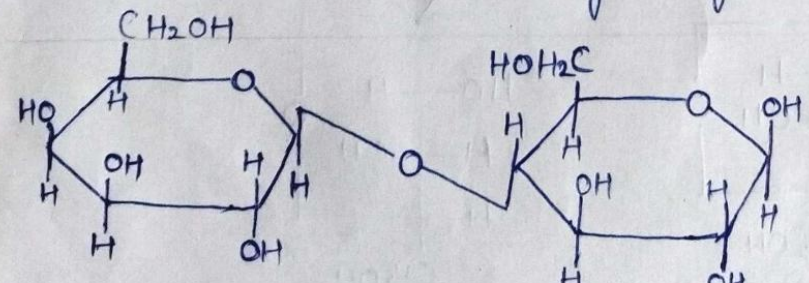
Sucrose

Maltose (malt sugar) $C_{12}H_{22}O_{11}$:—

- When it is hydrolysed with dilute acids or by the enzyme maltase, maltose yields two molecules of D(+)-glucose.
- Maltose is a reducing sugar, it forms an oxime & an osazone, & undergoes mutarotation.

Lactose (milk sugar) $C_{12}H_{22}O_{11}$

- It is hydrolysed by dilute acids or by the enzyme lactose, to an equimolar mixture of D(+)-glucose & D(+)-galactose.
- Lactose is a reducing sugar.



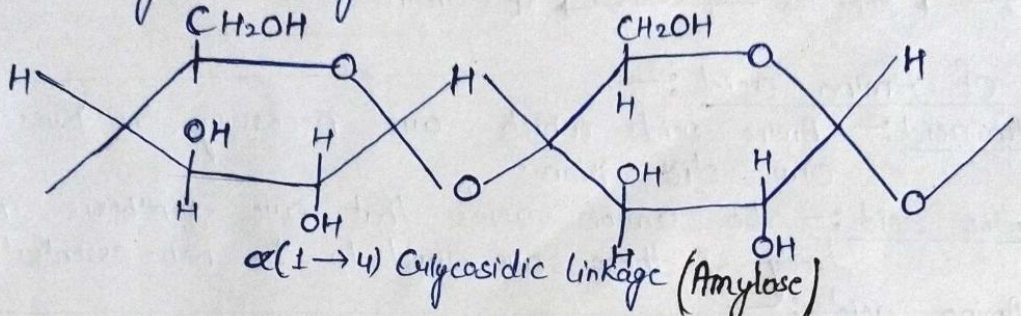
Lactose (β-1, 4-glucosidic linkage).

Polysaccharides :—

(A) Starch $(C_6H_{10}O_5)_n$:—

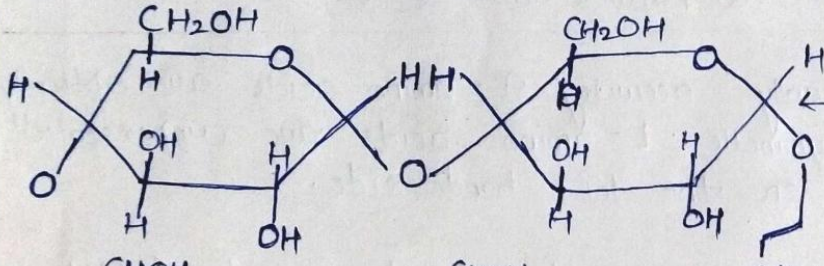
Starch → Amylose (20%) (water soluble)
Starch → Amylopectin (80%) (water insoluble).

- Both amylose & amylopectin are composed of D-glucose units.
- The amylose molecule is made up of D-glucose unit joined by α-glycosidic linkages between C-1 of one glucose unit & C-4 of the next glucose unit. The no. of D-glucose units in amylose range from 60-300.

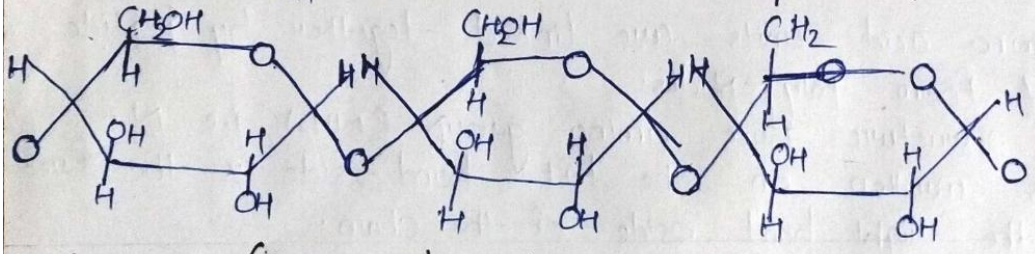


α(1→4) Glycosidic linkage (Amylose)

- Amylopectin has a branched-chain structure, linkages between C-1 to one glucose unit & C-4 of the next glucose unit. These chains are in turn connected to each other by 1,6-linkages.



α(1→6) branch point



(Amylopectin)

(B) Cellulase $(C_6H_{10}O_5)_n$:—

- It is non-reducing sugar.
- It is a straight chain of β-D-glycosidic linkage.
- Tollen's, Fehling's & Benedict's Reagents.
- Sugars which give positive tests with these reagents are known as reducing sugars & all the carbohydrates which contain a hemiacetal group give positive tests.

(i) $[Ag(NH_3)_2]$ + OH + (Glucose or Fructose) → Ag↓ + Oxidation products
Tollen's Reagent. Silver Reduction products.

(ii) Benedict's reagent :— (They oxidise an aldose or Ketose & give brick red precipitates of Cu_2O.

Cu^{2+} (Complex) + (Glucose or Fructose) $\longrightarrow$ $Cu_2O\downarrow$ + Oxidation products
Benedict's reagent. Aldose or Ketose. Brick red Reduction product.

Amino Acids & Proteins :—

Amino Acid :—

- The bond between two amino acid molecules is peptide bond 'or' amide bond & the resultant is known as dipeptide.
- All protein are polymers of α-amino acids & on partial hydrolysis give peptides of varying molecular masses which upon complete hydrolysis give α-amino acids.

proteins $\xrightarrow{\text{hydrolysis}}$ peptides $\xrightarrow{\text{hydrolysis}}$ α-amino acids.

Classification of Amino acid :—

Essential Amino acid :— Amino acids which are necessary be present in our diet plan.

Non-Essential Amino acid :— 10 amino acids that are synthesis in our body & these are caaid to be non-essential acids.

(i) **Essential Amino acid :—**

Eg (1) Leucine (2) Isoleucine (3) Lysine.

(ii) **Non-Essential Amino acid :—**

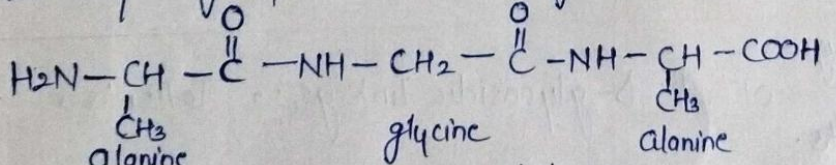
(1) Alanine (2) Asparagine (3) Aspartic acid (4) Cystine.

(5) **Properties :—**

Except glycine all other naturally occuring α-amino acids are optically active, since α-carbon is asymmetic. L-amino acids are represented by writing the $-NH_2$ group on the left hand side.

Acidic linkage :— Amino acid units are linked together by peptide $-\overset{\overset{O}{\|}}{C}-NH-$ linkage & form polypeptides.

- In a polypeptide structure free amino group (NH_2) i.e N-terminal residue is written on the left hand side & the free carboxyl group on the right hand aside of the chain.



Alanylglycylalanine.

In the above structure -COOH group is C-terminal residue & group is C-terminal residue & group is N-terminal residue.

proteins :—

- Those are high molecular mass complex, biopolymers of amino acids.

Classification of proteins :—

(i) On the basis of molecular structure :-

Fibrous proteins :- Eg Keratin, myosine, collagen etc.

Globular proteins :- Eg Insulin, albumin, thyroglobulin, antibodies, haemoglobin, fibrinogen etc.

Structure of proteins:

This conformation is of 4 types :-

Primary → Secondary → Tertiary → Quaternary.

1. Primary structure :-

- Primary structure is conformed by a single polypeptide chain in a linear manner.

2. Secondary structure:-

- The conformation which the polypeptide chain assume as a result of H-bonding is called secondary structure of protein.
- The H- Bonds are present between hydrogen of amino group & oxygen atom of carboxylic of protein.
- The structure is of two types :-

α-Helix · β-pleated sheet.

i) α-Helix :- Intermolecular H-bonds are present Eg. Myosin, Keratin etc.

ii) β-pleated sheet :- Intermolecular H- bonds hold together the neighbouring polypeptide chains. Eg. Silk fibres.

3. Tertiary structure :-

- Tertiary structure refers to its three dimensional structure i.e, folding & bonding of the long peptide chains.
- This structure is formed by 4 types of bonds.

(i) Hydrogen bond : (ii) Hydrophobic bond : (iii) Ionic bond : (iv) Disulphide bond.

(4) Quaternary Structure :-

When two or more polypeptide chains unite by forces other than covalent bonds (i.e not peptide & disulphide bonds) · we get quaternary structure of protein · It is most stable structure.

Eg :- Haemoglobin.

- Changing the PH denatures proteins because it changes the charges on many of the side chains. This disrupts electrostatic attractions & hydrogen bonds.
- The coagulation of egg white on boiling & curdling of milk caused by the bacteria present in milk are common eg. of denaturation of protein.

Harmones :—

These are water soluble harmones containing groups. These are derived from amino hydroxine & adrenaline.

Eg :—

(1) Epinephine or Adrenaline is a harmone that helps to control blood pressure & increase pulse rate.
It helps to reduce Fatty acids from get & glucose from liver glycogen.

(2) Thyroxine harmones secreted by Thyroid.
It regulates metabolism of lipids, proteins & carbohydrates.

(3) Testosterone Regulates & stimulates male sex organs.

Vitamins :—

Vitamins may be defined as a group of biomolecules which are required in small amounts for normal metabolic process & for the life, growth & health of human beings & animals.

Classification of Vitamins :—

Vitamins are broadly classified into two catagories :—

(1) Water soluble Vitamins :- Vitamin B-complex & Vitamin C, are water soluble vitamins & must be supplied regularly in diet.

(2) Fat soluble vitamins :- These are oily substances & soluble in Fats. These are A, D, E & K. They are stored in liver & adipose (Fat storing) tissues.

(3) Biotin (Vitamin H) :- It is neither soluble in water nor in Fats. Lack of particular Vitamin causes a specific deficiency disease.

Eg :- of some important vitamins & deficiency disease are :-

Vitamin A (Retinol) :- Xeropthalmia (Hardening of eye). cornea night blindness & xerosis (drying of skin).

Vitamin B_1 (Thiamine) :- Beriberi (paralysis of legs & general weakness) loss of appetite.

Vitamin D (Ergocalciferol) (Sun shine Vitamin) :- Rickets (deformation of bones) Osteomalacia (soft bones & joint pain).

Vitamin C :- is chemically known as ascorbic acid - Scurvy.

Nucleic Acid :—

- Nucleic acids are colourless, complex, amorphous compounds

made up of three units: bases, sugar & phosphoric acid. These are obtained by the hydrolysis of nucleoproteins which is a class of conjugated.

Nucleic acids are of two types:—

(i) Pentose nucleic acids or ribbonucleic acids (R.N.A).

(ii) Deoxypentose nucleic acids or deoxyribonucleic acids (D.N.A).

- Nucleic acids can be hydrolysed in stages to nucleotides, nucleosides & phosphoric acid & ultimately to base & sugar.

Nucleic acid → Nucleotides → Nucleosides + H_3PO_4

Nucleosides → Base + Sugar

Base:— Important purine bases are adenine & guanine; while pyrimidine bases are uracil, thymine & cytosine.

- Adenine, guanine & cytosine are present in RNA as well as in DNA, while thymine is present only in DNA & uracil only in RNA.

Nucleoside:—

- Each nucleoside consists of sugar molecule & a nitrogenous base.

The relationship can be shown as given below.

Nucleic acid = many nucleotides

Nucleotide = nucleosides + phosphate

Nucleoside = Sugar + nitrogenous base.

Thus nucleotide = phosphate + Sugar + hydrogenous base.

Deoxyribose Nucleic - Acid (DNA):—

(a) It is found in nucleus.

(b) DNA is made up of 3 units -

- Nitrogen base
  - Pyrimidine
  - Purine.
- Deoxyribose (sugar)
- Phosphoric acid (CH_3PO_4)

Structure of DNA:—

- DNA has a double helix structure & is made up of two chains of polynucleotides.
- DNA is a polymer of deoxynucleotides.
- The two strands are joined by 3' → 5' phosphodiester bonds.
- Sugar & phosphates are alternately arranged.
- In both chains in between A & T, 2 hydrogen bonds (A≡≡=T) are present, while in C & G, 3H-bonds (C≡≡≡G) are present.
- A always attaches with T while C always attaches with G.

Functions of DNA :-

(i) Self - replication or self - duplication

(ii) Protein synthesis.

The specific sequence of base pair in DNA represents coded information for the manufacture of specific proteins. T.

Ribonucleic Acid (RNA) :-

Ribonucleic acid is a polymer of purine & pyrimidine ribonucleotides linked by 3' → 5' phosphodiester bridges. RNA exists basically as a single - stranded molecule rather than as a double - stranded helical molecule, as does DNA, H-RNA (r- RNA).