—: 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 Ketohexoses 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. E.g :— Glucose, Fructose, mannose, galactose.

Monosaccharides :—

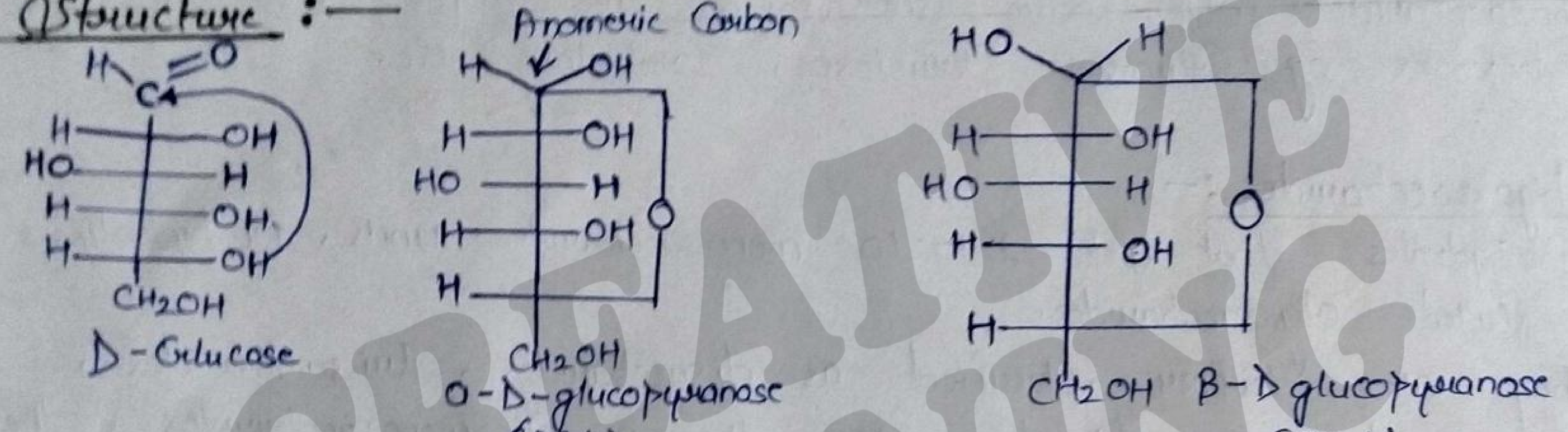
(1) Glucose ($C_6H_{12}O_6$) :—

- 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 :—



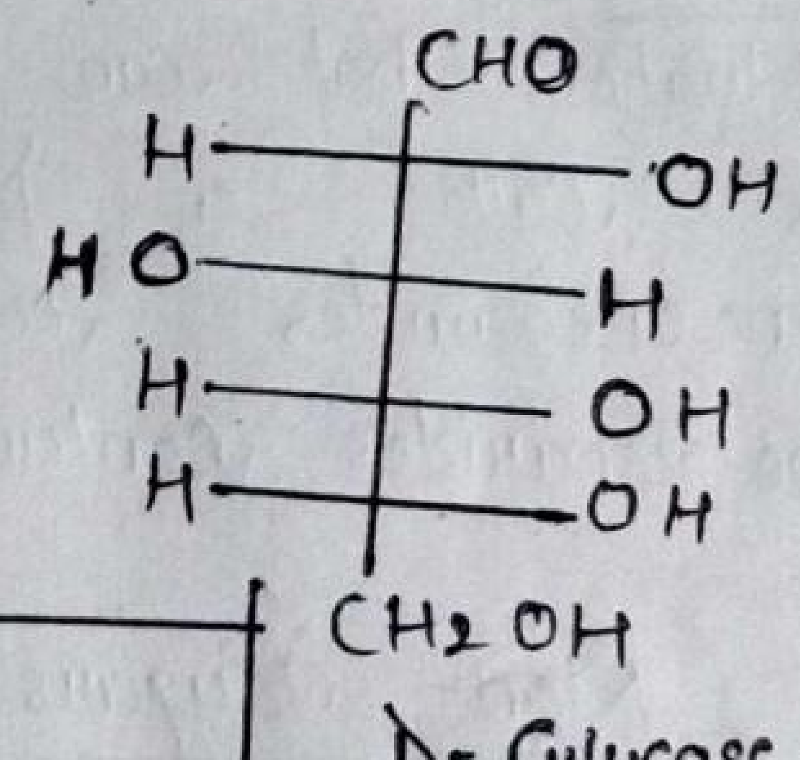
Chemical Reaction of Glucose :—

Glucose: CHO – (CHOH) – CH_2OH

- $\xrightarrow[ZnCl_2]{5CH_3COCl}$ CHO – $(CHOOCCH_3)_4$ – CH_2OOCCH_3 + 5HCl
  glucose penta acetate
- $\xrightarrow{PCl_5}$ CHO – $(CHCl)_4$ – CH_2Cl + $5POCl_3$ + 5HCl
  Penta chloro glucose
- $\xrightarrow[Na\text{-}Hg/H_2O]{2H}$ $CH_2OH(CHOH)_4CH_2OH$
  Sorbitol
- $\xrightarrow{2CuO}$ $CH_2OH(CHOH)_4COOH + Cu_2O\downarrow$
  gluconic acid, red ppt.
- $\xrightarrow[3[O]]{HNO_3}$ $COOH(CHOH)_4COOH + H_2O$
  Saccharic acid
- $\xrightarrow[\text{(osazone formation)}]{3(C_6H_5NHNH_2)}$ $CH = NNHC_6H_5$ – $C = NNHC_6H_5$ – $(CHOH)_3$ – CH_2OH + H_2O
  glucosazone

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

  E.g :— 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) Pentacetate 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.

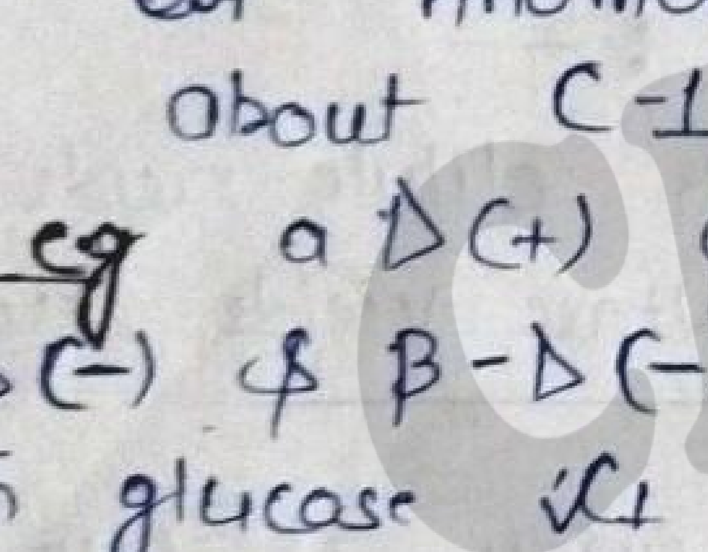
For eg α D(+) & β-D(+) glucose are anomers.
α-D(-) & β-D(-) fructose are anomers.

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

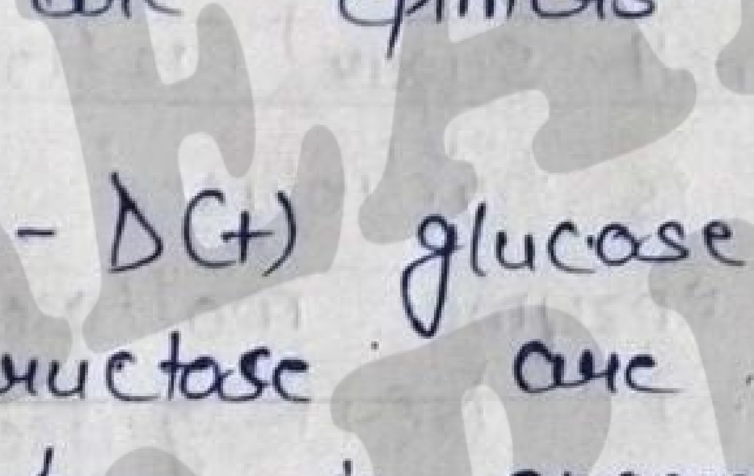
(2) Fructose :-

- 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.

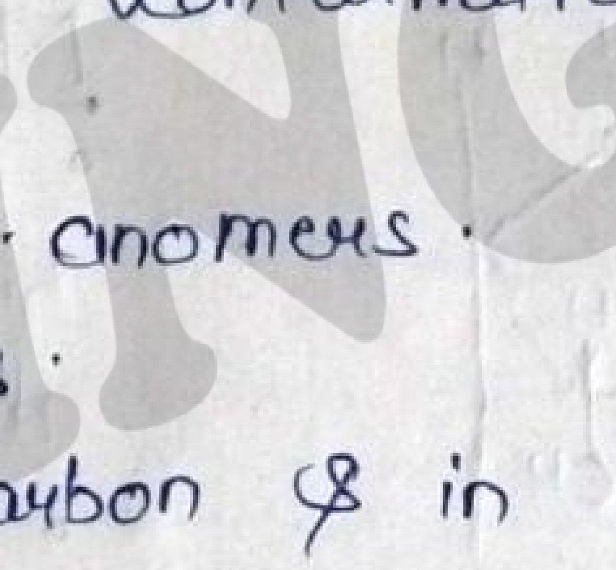
Structure :-



Open chain structure of fuctose
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.

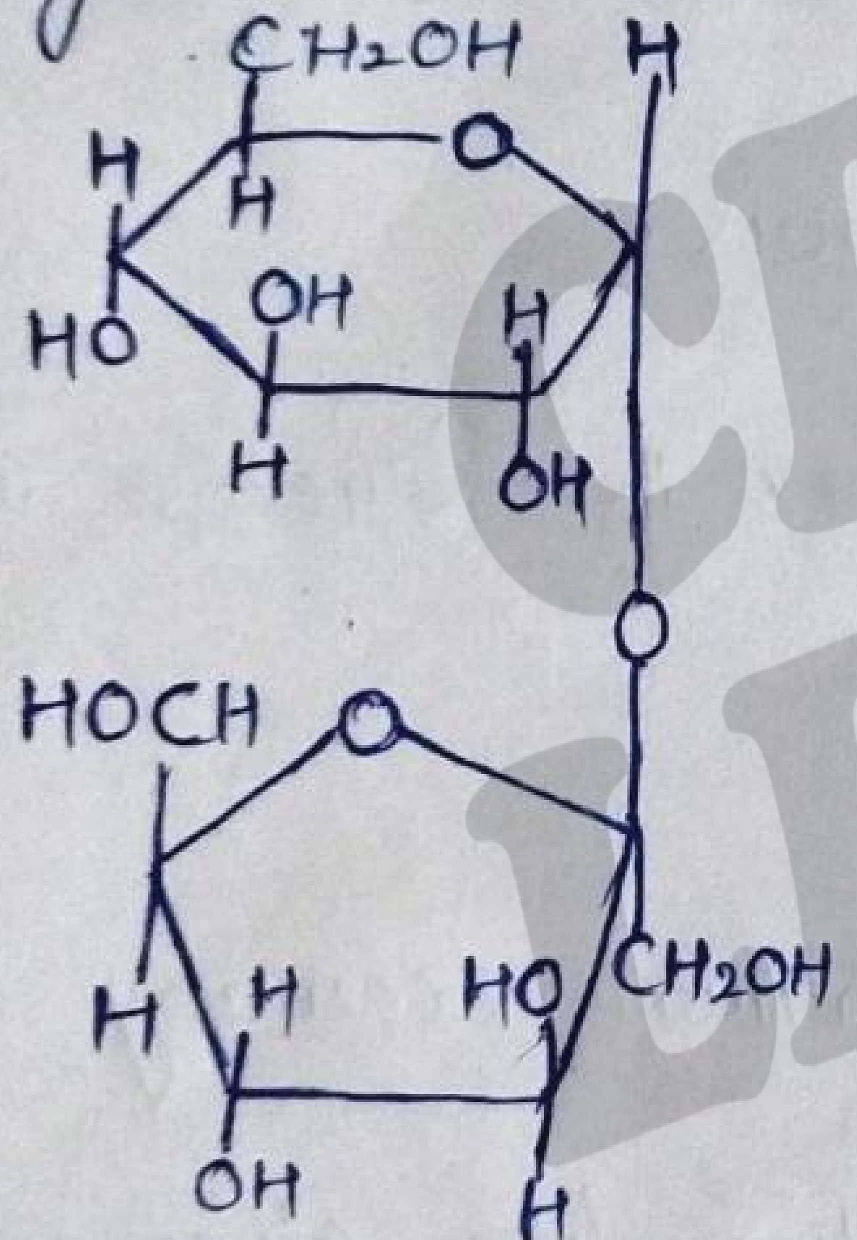
Disaccharides :—

Sucrose : (Sucrose, 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

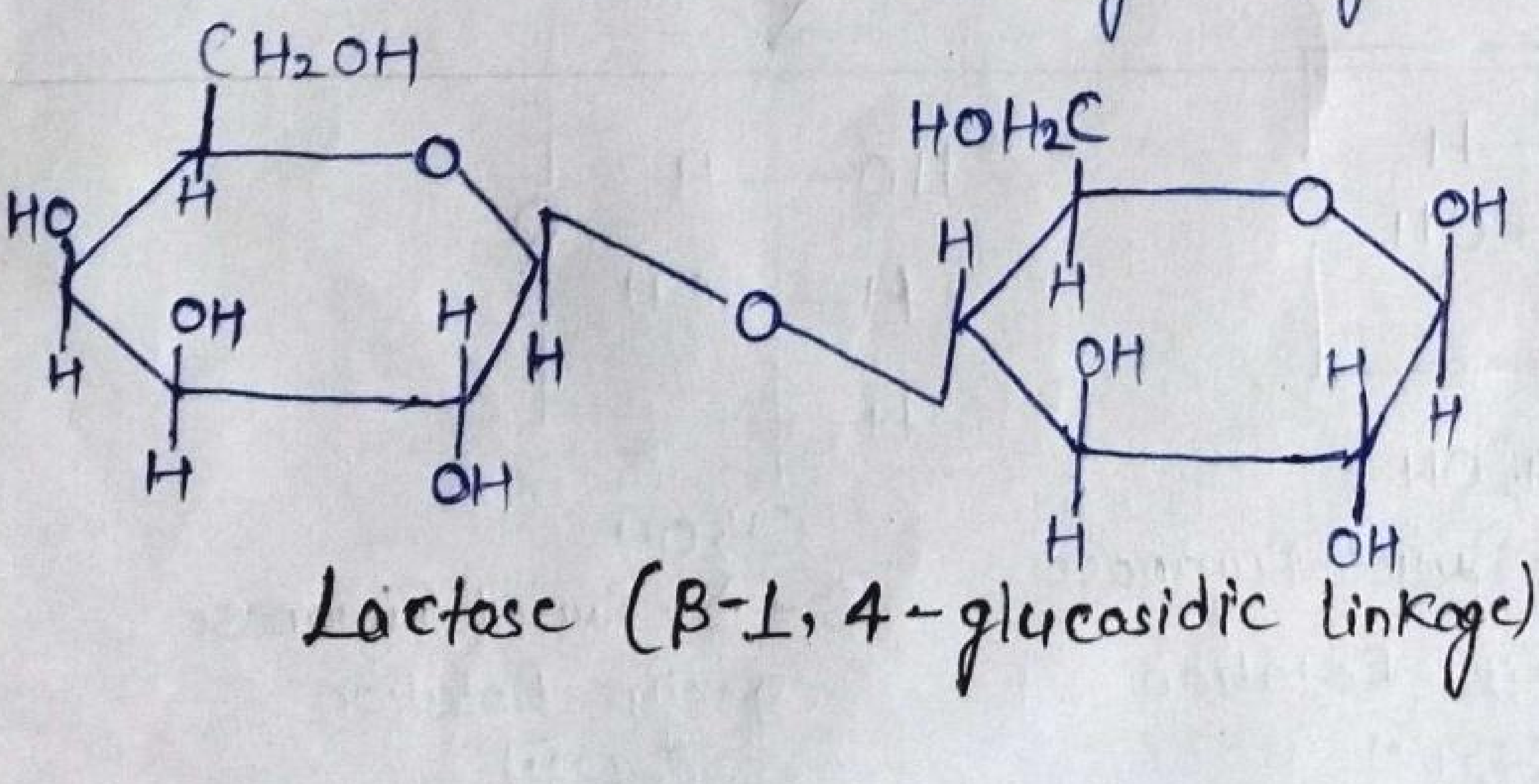
Maltose (malt sugar) $C_{12}H_{22}O_{11}$:—

- 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 lactase, to an equimolar mixture of D(+)-glucose & D(+)-galactose.

- Lactose is a reducing sugar.



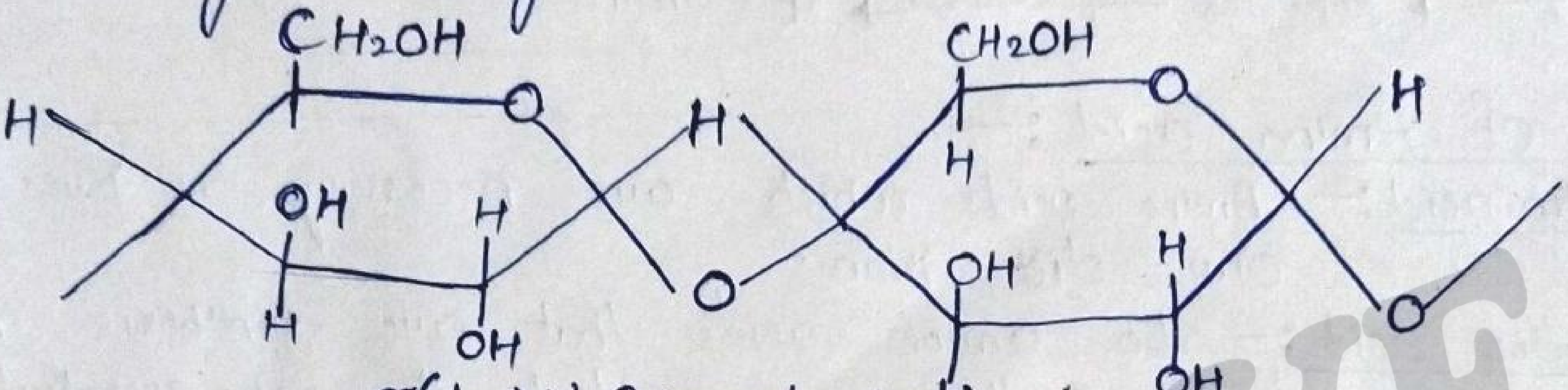
Lactose (β-1, 4-glucosidic linkage).

Polysaccharides :—

(A) Starch $(C_6H_{10}O_5)_n$:—

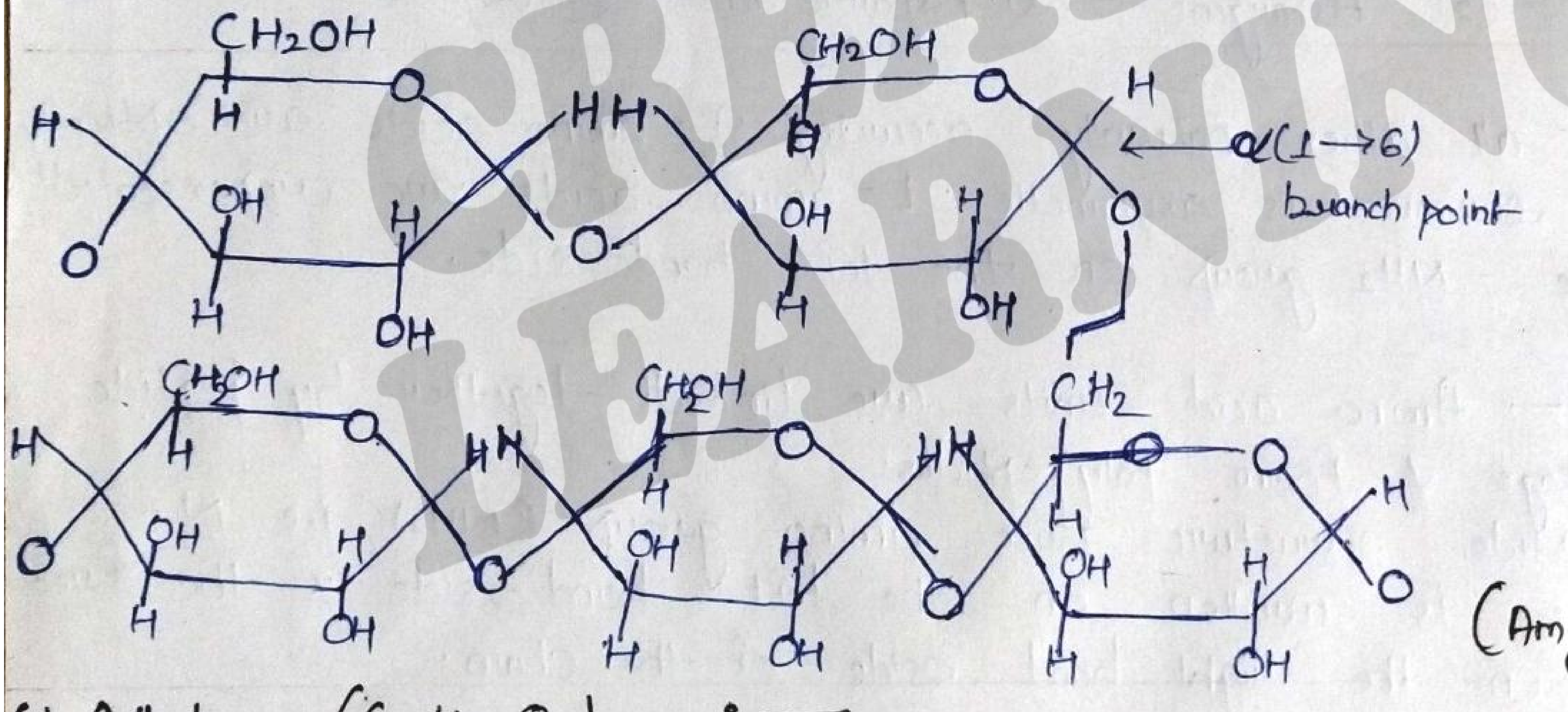
Starch → Amylose (20%) (water soluble)
Starch → Amylopectin (80%) (water insoluble).

- 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.



(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 said to be non-essential acids.

(i) **Essential Amino acid :—**
Eg (1) Leucine (2) Isoleucine (3) Lysine.

(ii) **Non-Essential Amino acid :—**
(1) Alanine (2) Aspargine (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 $-\overset{\overset{\displaystyle O}{\|}}{C}-NH-$ 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 side of the chain.

$$H_2N-\underset{\underset{\displaystyle CH_3}{|}}{CH}-\overset{\overset{\displaystyle O}{\|}}{C}-NH-CH_2-\overset{\overset{\displaystyle O}{\|}}{C}-NH-\underset{\underset{\displaystyle CH_3}{|}}{CH}-COOH$$

alanine — glycine — alanine

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, thyoglobulin, antiadiodies, 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 : (ix) 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.

Hormones :—

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

Eg :—

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

(2) Thyroxine hormones 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 B1 (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 :—

- Nuclic 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 ribonucleic 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.

$$\text{Nucleic acid} \longrightarrow \text{Nucleotides} \longrightarrow \text{Nucleosides} + H_3PO_4$$

$$\downarrow$$

$$\text{Base} + \text{Sugar}$$

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 (H_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 $3' \rightarrow 5'$ 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).