Introduction :

Biomolecules are the organic compound which form the basis of life i.e they build up the living system and responsible for their growth and maintence

The sequence that relates biomolecule to living organism is

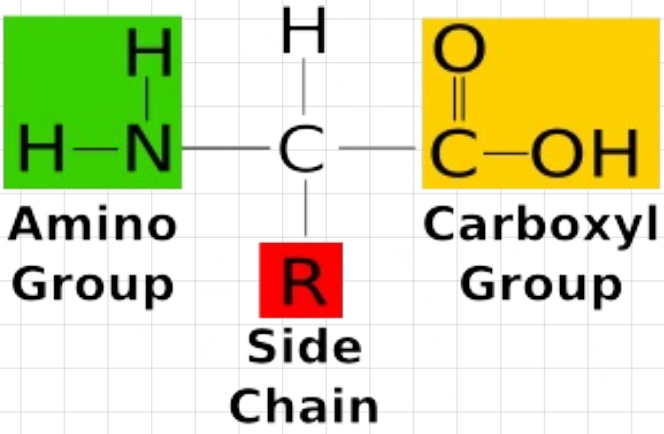
Biomolecules → Organells → cells → Tissues → Organs → living organism

→ Living systems are made up of various complex biomolecules like carbohydrate, proteins, nucleic acids, lipids etc. Proteins and carbohydrates are essential constituents of our food.

→ In addition, some simple molecules like vitamins and mineral salts also play an important role in the function of organism.

Amino Acids & Proteins

The compounds containing amino group ($-NH_2$) and carboxylic group ($-COOH$) are called amino acids.



where R = H, alkyl or aryl group

→ except glycine ($H_2N-\overset{H}{\underset{H}{C}}-COOH$), others are optically active in nature.

* Classification of amino acids ⇒

⇒ α, β, γ - amino acids depending upon the position of $-NH_2$ with respect to $-COOH$ group.

→ Neutral, having one $-NH_2$ and one $-COOH$ group.

e.g $NH_2-\underset{H}{\overset{|}{C}}-COOH$ (glycine)

→ Acidic, having one $-NH_2$ and two $-COOH$ group.

e.g $HOOC-CH_2-\underset{H}{\overset{NH_2}{\overset{|}{C}}}-COOH$ (Aspartic Acid)

→ Basic, having two or more $-NH_2$ and one $-COOH$ group.

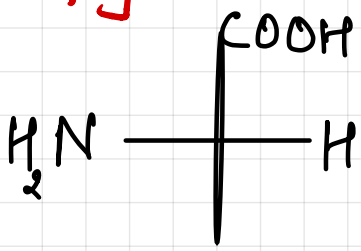
e.g $H_2N-(CH_2)_4-\underset{H}{\overset{NH_2}{\overset{|}{C}}}-COOH$ (Lysine)

* Essential and Non-Essential Amino Acids:

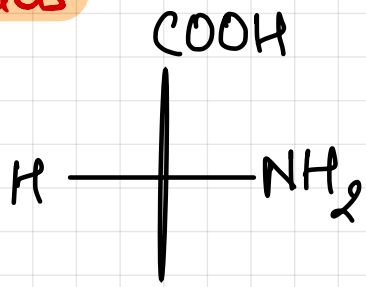
Those amino acids which can be synthesized by our body are known as non-essential amino acids while which can't be synthesized by our body so must be supplied through our diet are called essential amino acids.

Essential	Conditionally Non-Essential	Non-Essential
Histidine	Arginine	Alanine
Isoleucine	Asparagine	Asparatate
Leucine	Glutamine	Cysteine
Methionine	Glycine	Glutamate

• Configuration of α-amino acids



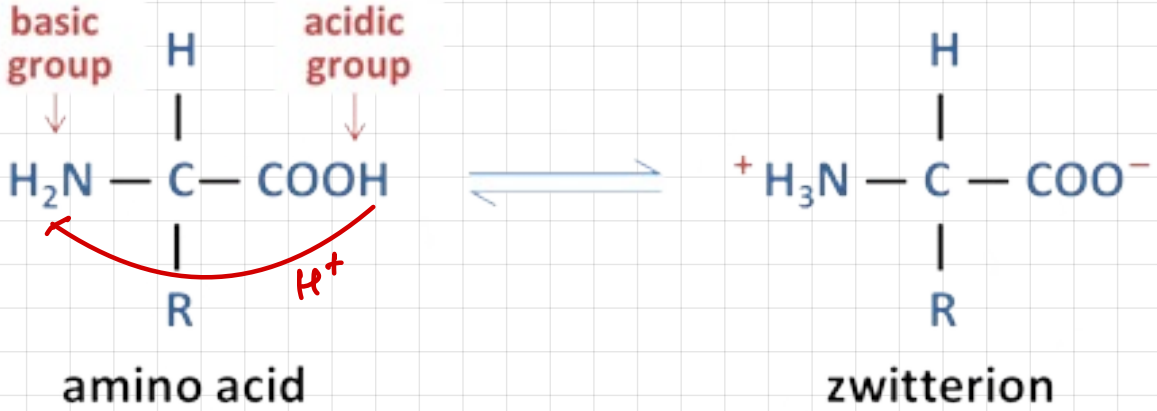
(L-amino acid)
(NH_2 on L.H.S)



(D-amino acid)
(NH_2 on R.H.S)

→ Naturally occuring α-amino acids are L-amino acids D-amino acids occur in some antibiotics and bacterial cell walls.

Zwitter ion: when a proton is migrated from carboxyl group to amino group, a dual ion is formed and this dual ion is called zwitter ion.



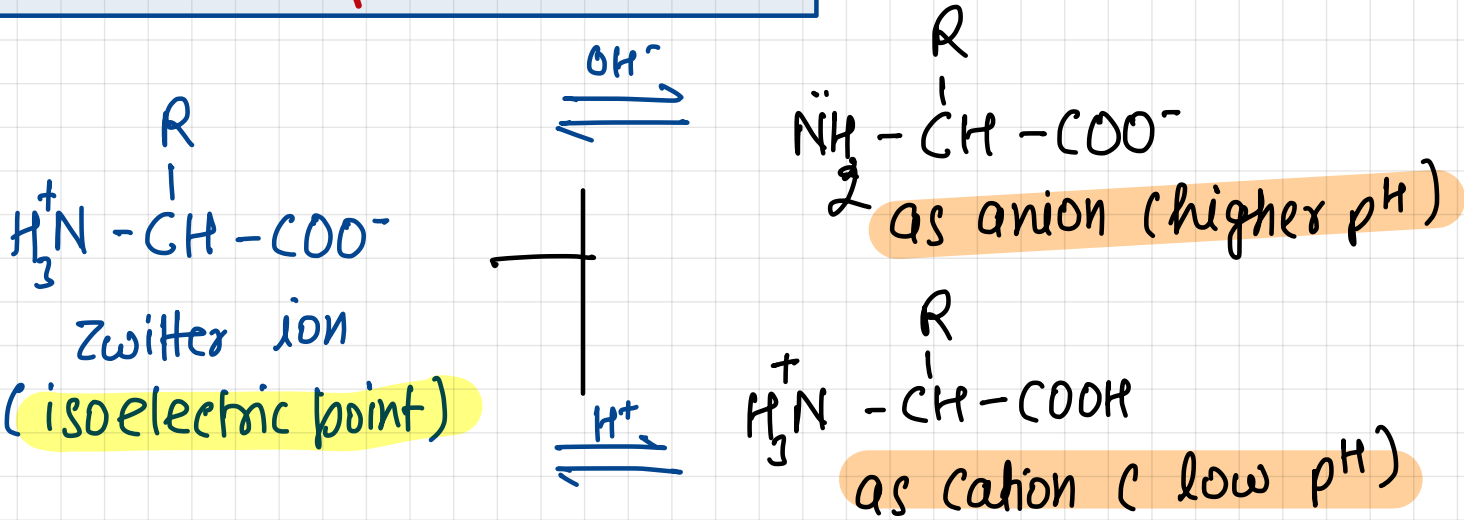
Isoelectric Point (p^I)

Zwitter ion, which is electrically neutral can only exist at a specific pH, that pH is called isoelectric point which is different for all amino acids.

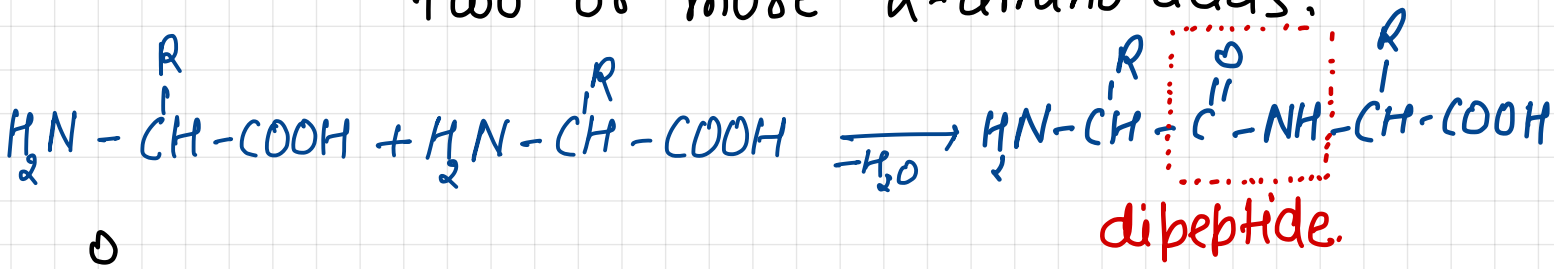
e.g p^I of Leucine pH = 6.0

p^I of Arginine pH = 10.8.

Structure of amino acids:



- **Peptide** ⇒ peptides are condensation products of two or more α-amino acids.



$-\overset{O}{\overset{\|}{C}}-NH-$ is known as peptide linkage or peptide bond.

→ 2 molecules of α-amino acid form dipeptide.
3 molecules of α-amino acid form tripeptide.

→ Dipeptide has only one peptide bond.
Tripeptide has only two peptide bond.

Polypeptide: Condensation products of many amino acid (≃ 10000) is known as polypeptide and those polypeptide which have molecular mass above than 10000 u are called proteins.

Proteins They are linear polymers of α-amino acid.

Str. of Proteins:

1.) **Primary Structure**: It simply reveals the sequence of amino acids.

2.) **Secondary Structure**: α-helix str. maintained by H-Bond or β-pleated sheet str. when R is small group.

3.) **Tertiary Structure**: The folding and superimposition of polypeptide chains forms a compact globular shape. termed as tertiary str.
It is stabilised by covalent, ionic, H-Bond and disulphide bonds.

4.) **Quaternary Structure**: The precise arrangement of constituents.

Classification on the Basis of Hydrolysis

Simple Protein: which give only α-amino acid upon hydrolysis e.g albumin

Conjugated Protein: These proteins give α-amino acid and non protein part, called prosthetic group

Protein	Prosthetic Group
Metalloproteins	Metal ions (Zn^{2+}, Fe^{2+}, Cu^{2+})
Haemoproteins	Haeme group
Glycoproteins	Carbohydrates
Lipoproteins	Lipid
Nucleoproteins	Nucleic acid (DNA, RNA)

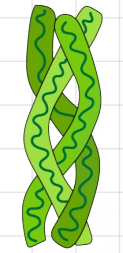
Derived Proteins

These are obtained by partial hydrolysis of simple or conjugated Proteins.

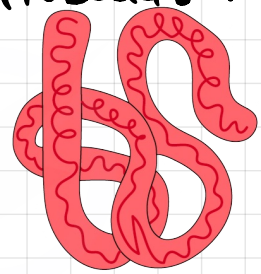
[Proteins → Proteoses → Peptones → Polypeptides]

On the Basis of Molecular Shape

Fibrous Protein | Globular Protein



FIBROUS



GLOBULAR

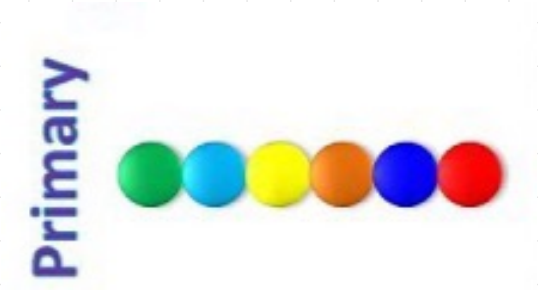
Do not have a tertiary structure.	Have tertiary structure. Quaternary may or may not be present
Long fibres or sheets in shape.	Spherical in shape
Insoluble in water	Dissolve in water to form colloidal solution
The length of polypeptide chain may vary in two samples of the same fibrous protein	The length of polypeptide chain is always identical in two samples of the same globular protein.
eg. Keratins, collagen, elastin and fibroin.	Egg albumin, serum globulin etc.

Primary str. of Proteins:

Proteins may have one or more polypeptide chains

→ each polypeptide in a protein has amino acids linked with each other in a specific sequence and it is this sequence of amino acids that is said to be the 1° str. of that protein

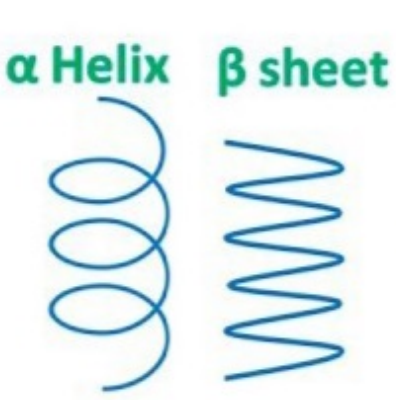
Any change in this 1° str. i.e the sequence of amino acid creats a different protein



Secondary Structure of Proteins:

The secondary str. of proteins refers to the shape in which a long polypeptide chain can exist.

They are found to exist in two different types of str.



α-helix str.
most common ways in which a polype-ptide chain form all possible H-Bond by twisting into a right handed screw (helix) with the -NH- group of each amino acid residue

β-pleated sheet str.
In this str. all peptide chains are stretched out to nearly maximum extension and then laid side by side are held together by intermolecular H-Bond.

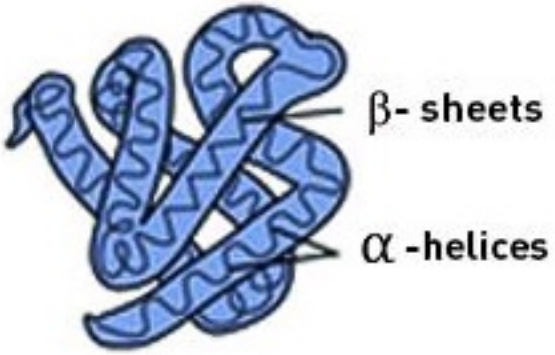
Tertiary str. of Proteins:

The tertiary str. of proteins represents overall folding of polypeptide chains i.e further folding of the secondary structure

It gives rise to 2 major molecular shapes i.e **Fibrous and Globular**

The main forces which stabilize the 2° and 3° str. of proteins are H-Bonds, disulphide linkage, van. der waal and electrostatic forces of attraction.

TERTIARY STRUCTURE



Quaternary str. of Proteins

Some of the proteins are composed of two or more polypeptide chains referred to as sub. units

The spatial arrangement of these subunits with respect to each other is known as quaternary structure

QUATERNARY STRUCTURE

Denaturation of Proteins

The process that changes the 3-D str. of native protein is called denaturation of proteins.

It can be caused by change in pH, change in temp. addition of electrolyte, addition of solvent like water, alcohol, acetone.

Nucleic Acids:

These are the polymers which are prepared by Nucleotide also known as polynucleotide

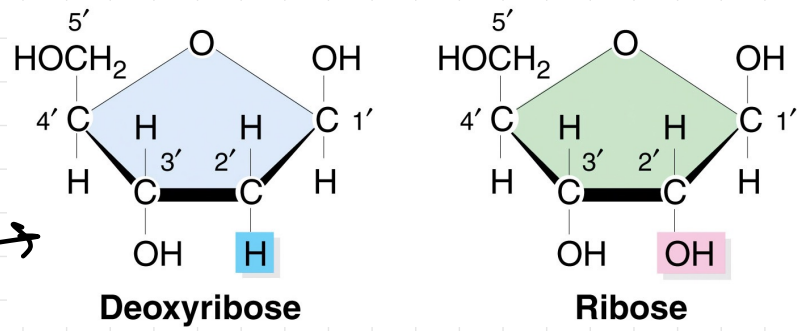
a nucleotide contain....

*) Pentose Sugar *) Nitrogenous Base *) Phosphate group.

Pentose Sugar:

5 carbon sugar either ribose or deoxy ribose

(not contain oxygen at 2nd position) →



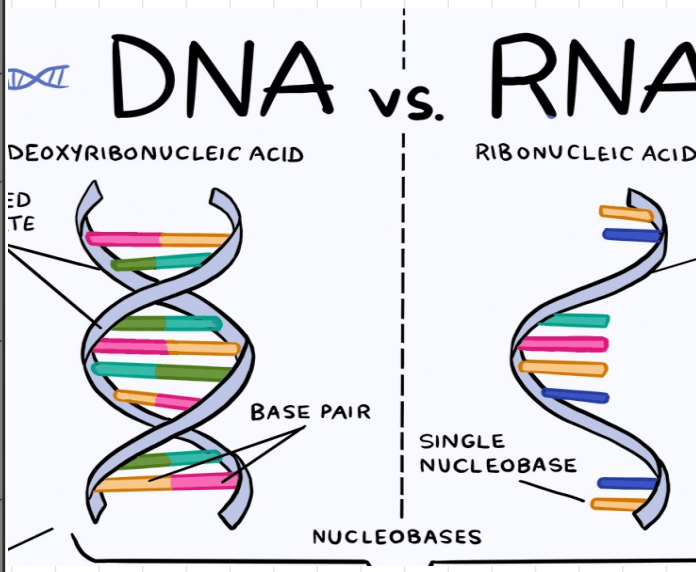
Nitrogeneous Base

Purine
- → Adenine
- → Guanine

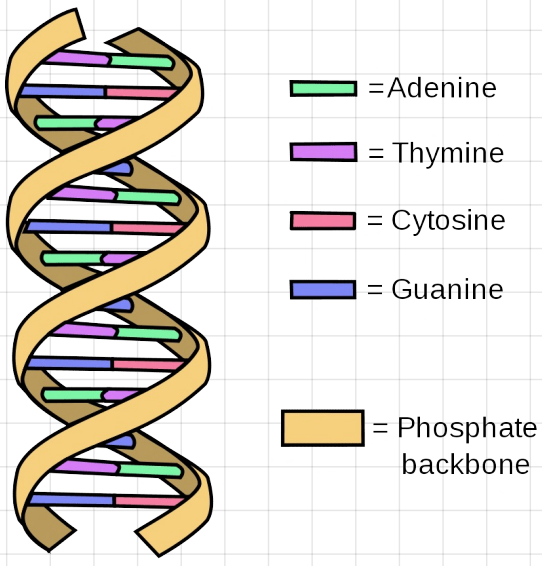
Pyrimidine
- → Thymine
- → Uracil
- → Cytosine

Two H-Bonds are present between A & T (A=T) while three hydrogen bonds are present between C & G (C≡G)

DNA	RNA
It is double stranded nucleic acid.	It is single stranded nucleic acid.
It contains deoxyribise sugar.	It contains ribose sugar.
It contains Thymine (T) as a nitrogenous base.	It contains Uracil (U) instead of Thymine.
It is the genetic and hereditary material of the cells.	It is involved in synthesis of proteins.
It is present in the nucleus of the cells.	It is present in both nucleus and cytoplasm.



Structure of D.N.A



DNA

It consist of two polynucleotide chains, each chain form a right handed helical spiral with ten bases in one turn of the spiral

The two chains coil to double helix and run in opposite direction. These are held together by H-Bonding.

Types of RNA

1.) Messanger RNA (m-RNA) It is produced in the nucleus and carries information for the synthesis of protein.

2.) Transfer RNA It is found in cytoplasm. Its function is to collect amino acids from cytoplasm for protein synthesis.

3.) Ribosomal RNA (r-RNA) This provide site for protein synthesis

Functions of Nucleic Acid

- Direct the synthesis of protein
- Transfer the genetic informations.

→ **Replication :-** It is a process in which a molecule can duplicate.

→ **Template** It means pattern, in the process of replication of DNA, the parent strand serves as template.

Gene The portion of DNA carrying information about a specific protein is called gene.

Genetic Code: The relation between the amino acid and the the nucleotide triplet is called genetic code.

Codons The nucleotide bases in RNA function in group of three (triplet) in coding amino acid. These based triplets are called codons.

Carbohydrates

These are optically active poly hydroxy aldehydes / ketones or the substance which give these on hydrolysis are called carbohydrates.

General formula $C_x(H_2O)_y$

Classification on the basis of hydrolysis

- **Monosaccharides** - can not be hydrolysed further e.g glucose, fructose
- **Oligo saccharides** - give 2-10 molecules of monosaccharides e.g glucose, fructose
- **Polysaccharides** - give large no. of monosaccharides e.g starch, cellulose.

• Preparation of Glucose:

From Sucrose

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

From Starch

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow{H^+} n\,C_6H_{12}O_6 \text{ glucose}$$

Structure

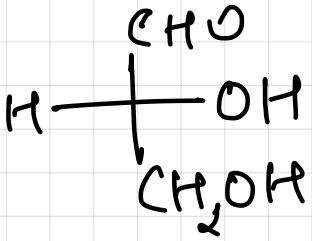
CHO ← one aldehyde group

$(CHOH)_4$ ← four 2° alcohol

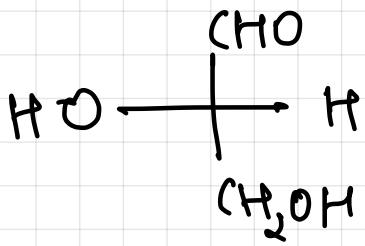
CH_2OH ← one 1° alcohol

Str.

D-Glyceraldehyde



L-Glyceraldehyde

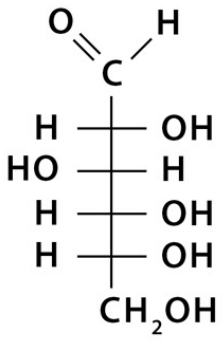


(D) means OH in R.H.S

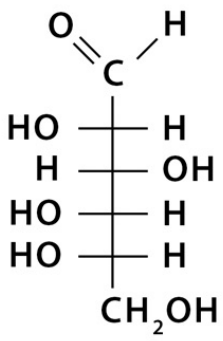
(L) means OH in L.H.S

Str. of Glucose

Fischer Projection

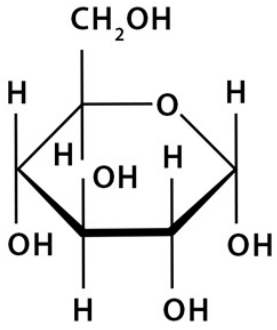


D- Glucose

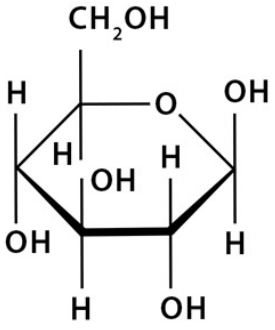


L- Glucose

Haworth Projection



α-D-Glucopyranose



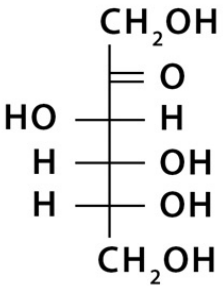
β-D-Glucopyranose

Str. of fructose :

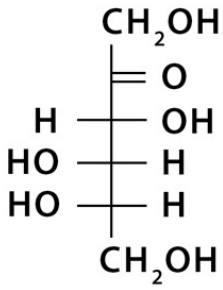
{ The C_1 is known as anomeric carbon and these compounds are called anomers }

Fischer Projection

Fructose



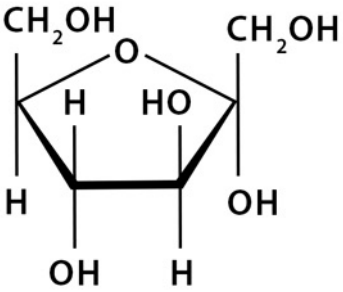
D- Fructose



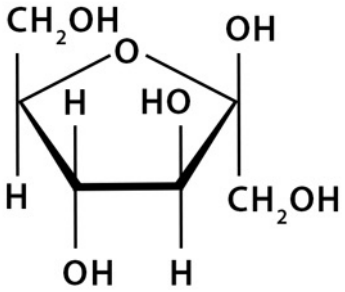
L- Fructose

Haworth Projection

Fructose



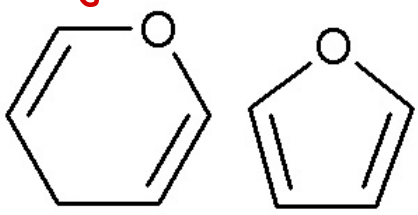
α-D-Fructofuranose



β-D-Fructofuranose

Six membered cyclic ring

Five membered Cyclic ring



Pyran Furan

Reducing Sugar

- Free Aldehydic or Ketonic group
- Reduce Fehling soln or Tollen's Reagent
- e.g Maltose & Fructose

Non Reducing Sugar

- Do not have any free aldehydic or ketonic group.
- Do not reduce tollens Reagent and Fehling soln

e.g Sucrose

Chemical Properties of Glucose

•) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow[\text{Anhydride}]{\text{Acetic}}$ $(CH\text{-}O\text{-}C(=O)\text{-}CH_3)_4$ (CHO, $CH_2\text{-}O\text{-}C(=O)\text{-}CH_3$)

Glucose Penta acetate

•) $(CHOH)_4$ (CHO, CH_2OH) $+ [O] \xrightarrow[H_2O]{Br_2}$ $(CHOH)_4$ (COOH, CH_2OH)

Gluconic acid

•) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow{HNO_3}$ $(CHOH)_4$ (COOH, CH_2OH)

Saccharic acid

•) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow[\Delta]{HI}$ $(CH_2)_4$ (CH_3, CH_3)

n-Hexane

•) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow{H_2N\text{-}OH}$ $(CHOH)_4$ ($CH{=}N\text{-}OH$, CH_2O)

Glucoxine

•) $(CHOH)_4$ (CHO, CH_2OH) $\xrightarrow{HCN}$ $(CHOH)_4$ ($HO\text{-}CH\text{-}CN$, CH_2OH)

Glucose Cyano hydrin

Mutarotation when either of the two forms of glucose is dissolved in water, there is a spontaneous change in specific rotation till the equilibrium value of $+52.5°$. This is known as mutarotation.

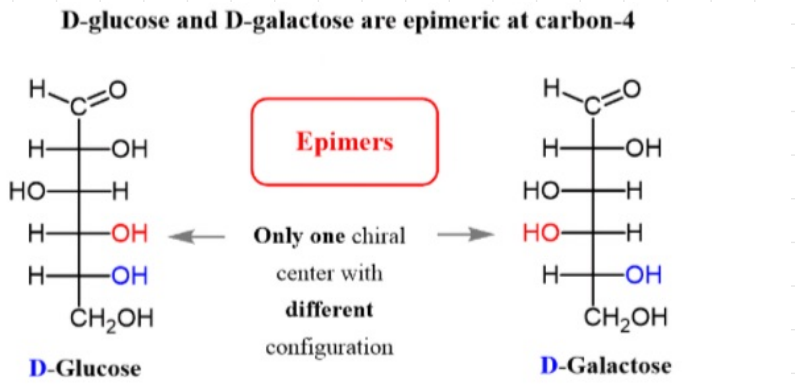
α-D(+) Glucose ⇌ Equilibrium mixture ⇌ β-D(+) Glucose

+111.5° +19.5°

• Importance of Carbohydrate

- Carbohydrates are essential for life in both plants and animals
- They are major portion of our food.
- Carbohydrates are used as storage molecule as starch in plants and glycogen in animals.
- Cell wall of bacteria and plants is made up of cellulose
- Honey has been used for a long time as an instant source of energy.

- **Epimers** Monosaccharides differing in configuration at a carbon other than anomeric carbon are called epimers e.g glucose and galactose differ in configuration at C4, hence called epimers.



Sugars and Non-Sugars

- monosaccharides and Oligosaccharides having sweet taste, soluble in water are known as **Sugars**
- Polysacchides which are insoluble in water and not sweet in taste are known as **non-sugars**