Introduction

Biochemistry

biochemistry can described as the science concerned with the chemical constituents of living cells and with the reactions and processes, they undergo. By this definition, biochemistry includes large areas of cell biology, of molecular biology, and of molecular genetics.

Biomolecules elements: -

1- C, H, O,N represents about 96% of cell element.

2-Ca,P,K,S represents about 3%.

3-Fe,Na,Cl represents about 1%.

4-living cell contains traces of **Zn,Mg,Mn,Cu,I,F.B,Ce.**

Living cell components:-

1-Water 70-905%

2- Organic molecules 8-25%

3-In Organic molecules 2-5%

The principal classes of biomolecules(*= organic molecules associated with living organisms*) are:

1-Carbohydreat

2-lipid

3- Protein

4-Enzymes

5-Nucleic acids.

6- Vitamins

7-Hormons

Carbohydrates:-

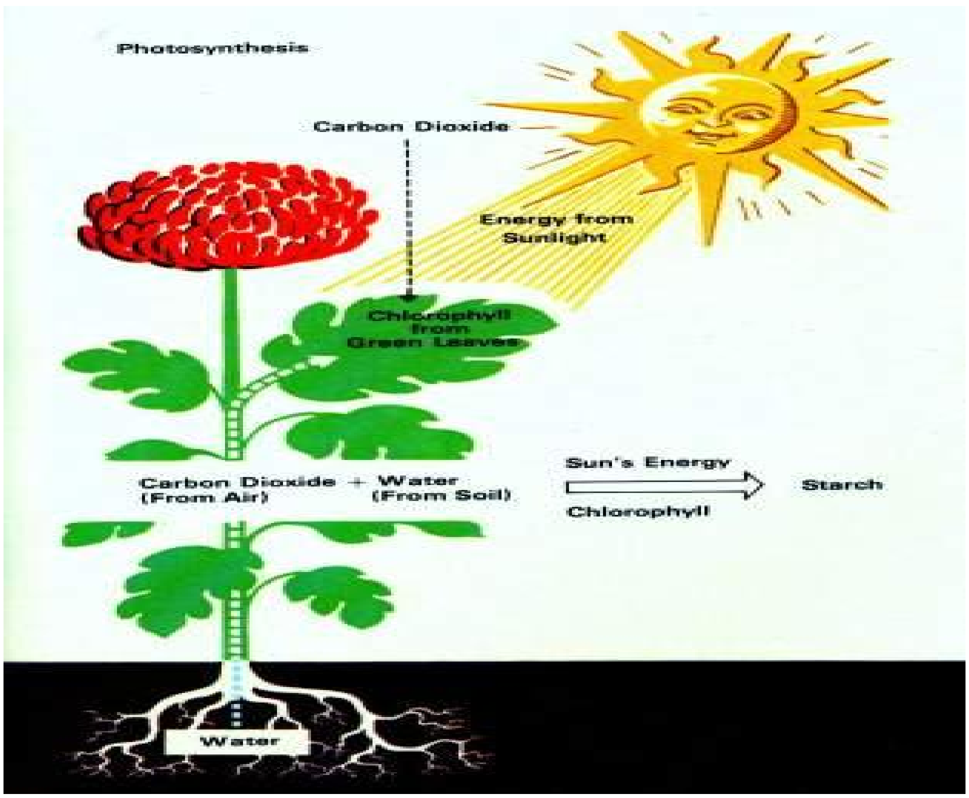
The Carbohydrates are widely distributed in both animal and plant tissues. The name carbohydrate, means "carbon hydrate ", stems from their chemical composition, which is

$(C.H_2O)$ n, where n=three or more. But later, it was found that some of carbohydrates, such as deoxyribose ($C_5H_{10}O_4$) do not have the required ratio of hydrogen to oxygen (H_2O). In addition to carbon, hydrogen and oxygen, certain other carbohydrates are posses' nitrogen (e.g., glucosamine $C_6H_{13}O_5N$), phosphorus or sulfur and they do not agree with the above general formula.

Occurrences of carbohydrates: -

Carbohydrates are widely distributed in plant and animal tissues.

In plant, they are produced by photosynthesis and include the starch of the plant. Glycogen is the storage form of carbohydrates in animals found abundantly in the liver and muscles.



photosynthesis

$$6CO_2 + 6H_2O + \underset{\text{energy in}}{\underline{energy}} \longrightarrow \boxed{C_6H_{12}O_6} + 6O_2$$

aerobic respiration

$$\boxed{C_6H_{12}O_6} + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \underset{\text{energy out}}{\underline{energy}}$$

Definition of carbohydrates:-

Chemically, the carbohydrates may define as polyhydroxy aldehydes, ketones, or the compounds, which produce such units on hydrolysis.

Functions of carbohydrates:

1- Source of energy e.g., glucose.

2- Storage form of energy, e.g., glycogen in animal tissue and starch in plants.

3- Serves as structural components, e.g., glycosaminoglycans in human, cellulose in plants and chitin in insects.

4- Constituent of nucleotide that form RNA & DNA. e.g., ribose and deoxyribose sugar.

5- Non digestible carbohydrates like cellulose, agar, gum and pectin serve as dietary fibers.

6- Carbohydrates also are used as drugs (antibiotics).

7- Glycoprotein's and glycolipids are components of cell membranes.

Classification of carbohydrates:

Carbohydrates are generally classified into three groups: **monosaccharide** (and their derivatives), **oligosaccharides**, and **polysaccharides**.

Monosaccharides, or simple sugars, consist of a single polyhydroxy aldehyde or ketone unit. The most abundant monosaccharide in nature is the six-carbon sugar D-glucose. Monosaccharides of more than four carbons tend to have cyclic structures.

Oligosaccharides consist of a few simple sugar molecules. Disaccharides are common in nature, and trisaccharides occur frequently.

Polysaccharides are polymers of the simple sugars . They may be either linear or branched polymers and may contain ten, hundreds, or even thousands of monosaccharide units. They are not sweet in taste and do not exhibit any of the properties of aldehyde or ketone group.

Monosaccharide:

No. of carbon atom	
3	Triose
4	Tetrose
5	Pentose
6	Hexose
7	Heptose

The monosaccharides are also called simple sugars and cannot be broken down into smaller sugars under mild conditions. Monosaccharides consist typically of three to eight carbon atoms and are described as either aldehyde or ketone with two or more hydroxyl groups. They may be subdivided into different groups as follows:

1- Depending upon the number of carbon atoms

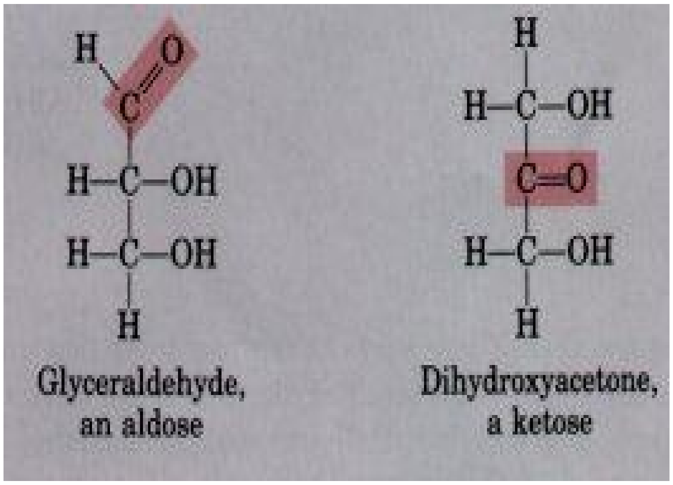
Monosaccharide contains three carbon atoms is called triose, four carbon atoms is tetrose, five carbon atoms is pentose…

8	Octose

2- Depending upon the functional groups contain:

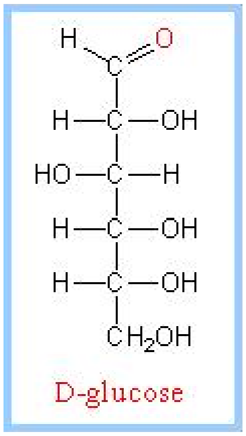
If a monosaccharide contains an aldehyde group, it is known as an aldose and if it contains a keto group, it is known as a ketose.

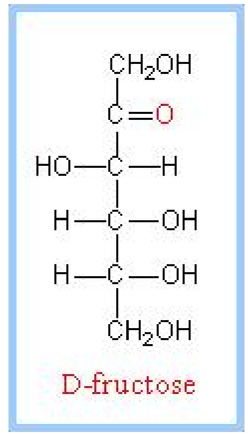
The simplest aldose is glyceraldehyde, and the simplest ketose is dihydroxyacetone. These two simple sugars are termed trioses because they each contain three carbon atoms.



Hexoses are the most abundant sugars in nature.

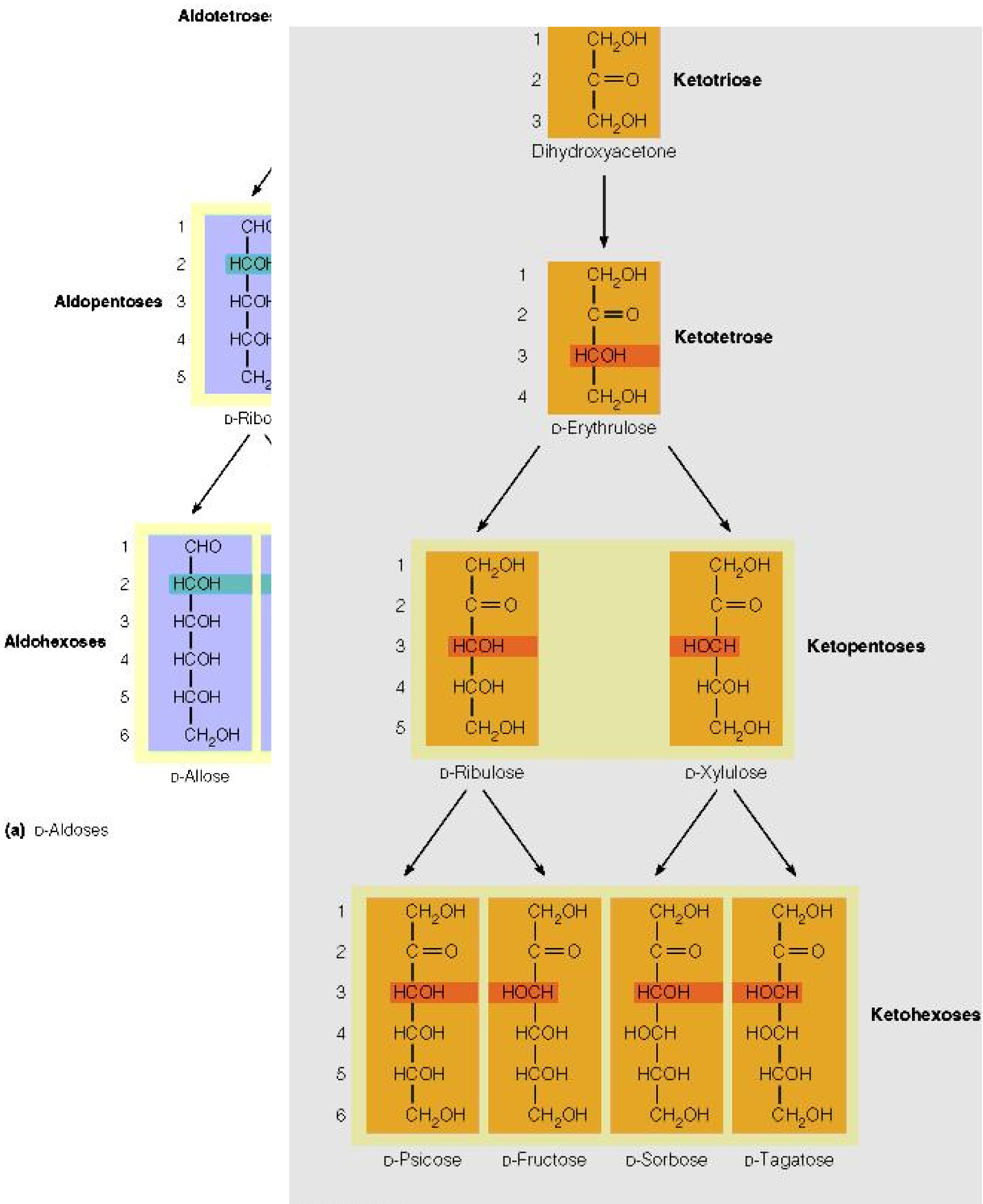
Monosaccharides, names to describe both the important functional groups and the total number of carbon atoms. Thus, one can refer to aldotetroses and ketotetroses, aldopentoses and ketopentoses, aldohexoses and ketohexoses, and so on.





The suffix (-oses) is used for aldose and the suffix (-ulose) is used for ketoses. Thus ribose is a pentose, and ribulose is a pentulose. However, a few ketoses are named otherwise, such as fructose. The most abundant monosaccharide in nature is six carbon sugar.

The structures and names of a family of aldoses and ketoses with three, four, five, and six carbons are shown bellow:

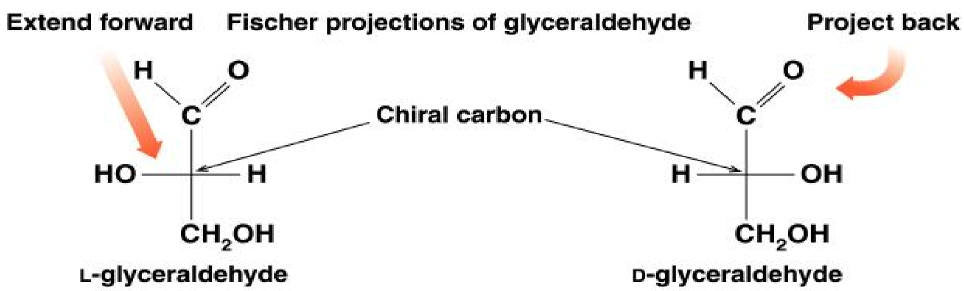

Aldotetroses
Aldopentoses
Aldohexoses
D-Allose
(a) D-Aldoses
Ketotriose
Dihydroxyacetone
Ketotetrose
D-Erythrulose
Ketopentoses
D-Ribulose
D-Xylulose
Ketohexoses
D-Psicose
D-Fructose
D-Sorbose
D-Tagatose

(b) D-Ketoses

General properties of monosaccharide:-

A- Asymmetric carbon:

A carbon atom to which four different atoms are attached to it is called a symmetric carbon atom.



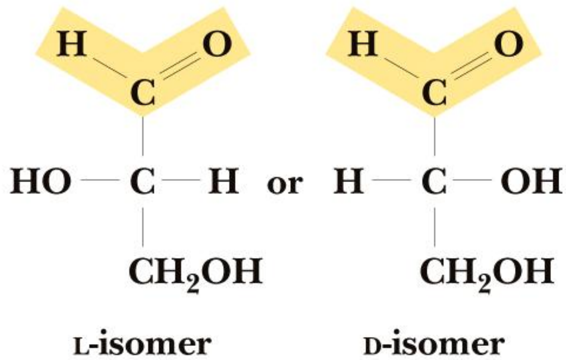
Van Hoff's rule of n:

The number of possible isomer of any given compound depends upon the number of a symmetric carbon atom the molecules have.

According to Van Hoff's rule of n:

2^n equals the possible isomers of that compound

Glyceraldehyde=2^n=2^1=2 isomer.



Glyceraldehyde

B- Isomerism:

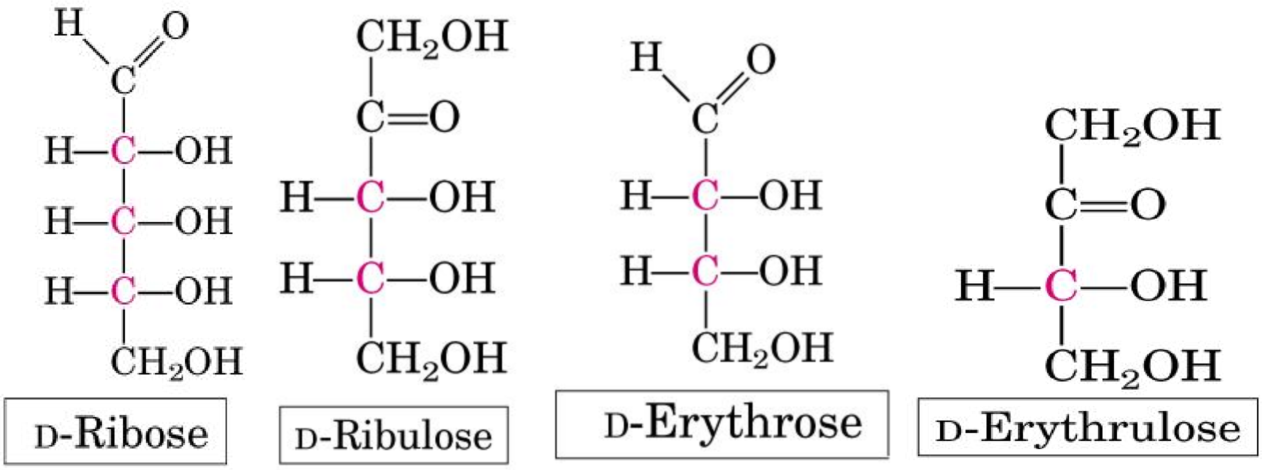
The compounds possessing identical molecular formula but different structures are called isomers. Various types of isomerism exhibited by sugar are:

a- Structural isomerism.

b- Stereo isomerism (due to presence of a symmetric carbon atom).

a- Structural isomerism:

Structural isomers have the same formula but differ each other by having different structures. For example, Aldose-Ketose isomerism. As ribose and ribulose are isomers of each other having the same chemical formula $C_5H_{10}O_5$ but they differ in structural formula with respect to their functional groups. Glucose have aldehyde group in carbon number one but fructose have keto group in carbon number two.



b- Stereoisomerism:

Stereoisomerism has same molecular formula and same structure but they differ in configuration that is the arrangement of their atoms.

The important types of stereoisomerism are:

1- L & D isomerism(Enantiomers).

2- Optical isomerism.

3- Epimerism.

4- α & β anomerism.

1- L & D isomerism:

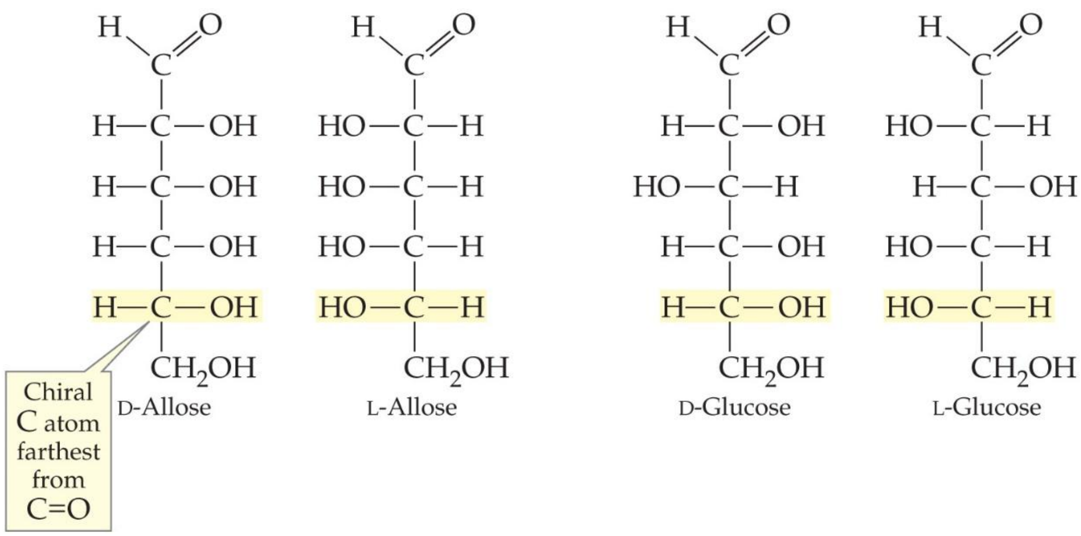
Enantiomers are the stereoisomers that are mirror images of each other.

L & D isomerism depends on the configuration of a symmetric carbon farthest from the carbonyl group (the aldehyde or ketone group).

When the OH group around the carbon atom adjacent to the terminal primary alcohol carbon (e.g., carbon atom 5 in glucose) is on the right of the sugar is D-form. But when it is on the left, it is L-form.

Most of the monosaccharides occurring in the living beings belong to the D- form, except L- fucose found in glycoprotein

Two pairs of aldohexose enantiomers

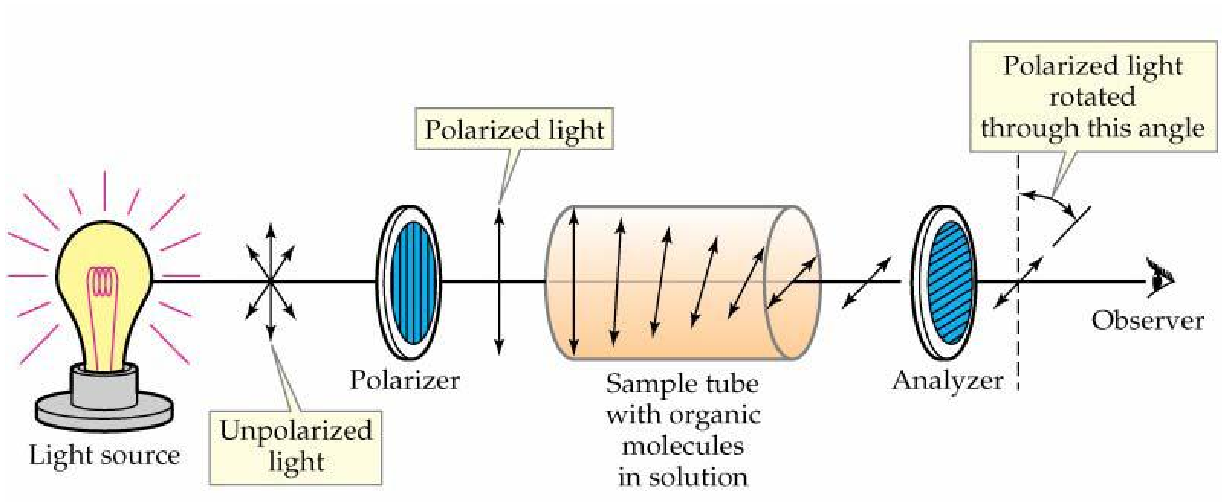


2- Optical isomerism:

The presence of a symmetrical carbon atom causes optical activity. When a beam of plane-polarized light is passed through a solution of carbohydrates, it will rotate the light either to right or to left. Depending on the rotation, molecules are called dextrorotatory (+) or (d) when it rotate the plane of polarized light in a clockwise. However, the molecules are called levorotatory (-) or (l) when it rotate the plane of polarized light in the opposite or counter clock wise (anti clockwise).

When an equal amount of d and l isomers are present, the resulting mixture has no optical activity. Since the activity of each isomer cancel one another, such a mixture is said to be a racemic or dL mixture.

D-fructose is levorotatory, while D-glucose is dextrorotatory.

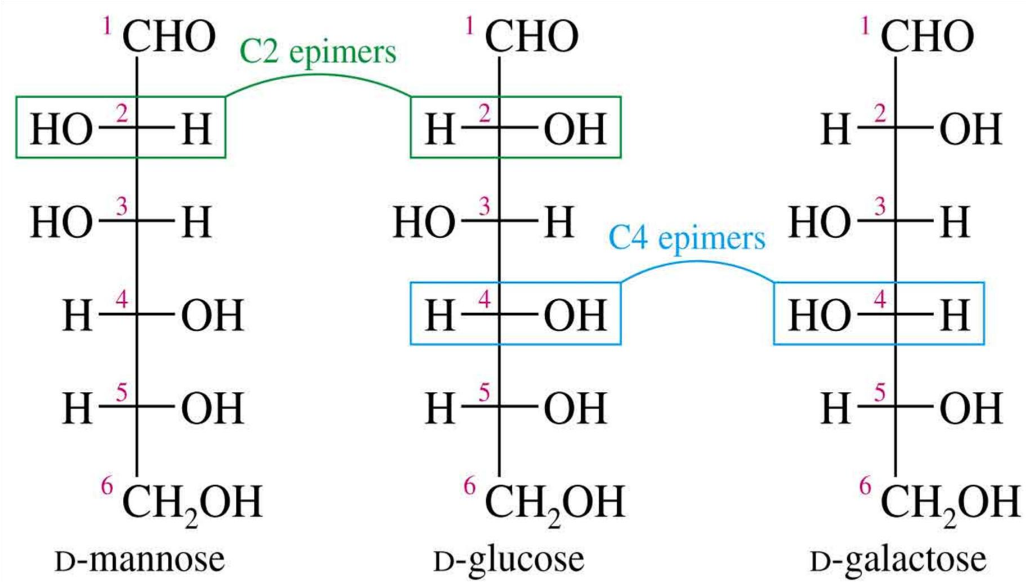


Principles of a polarimeter, used to determine optical activity. A solution of an optically active isomer rotates the plane of the polarized light by acharacteristic amount.

3- Epimers:

Two sugars, which differ from one another only in configuration around one carbon atom, are called epimers.

Glucose and galactose are epimers, which differ only in carbon number 4. Similarly, mannose and glucose are epimers in carbon number 2. But galactose and mannose are not epimers with each other because they differ at two carbon atoms 2 and 4. Ribose and xylose are epimers differing in C number 3.



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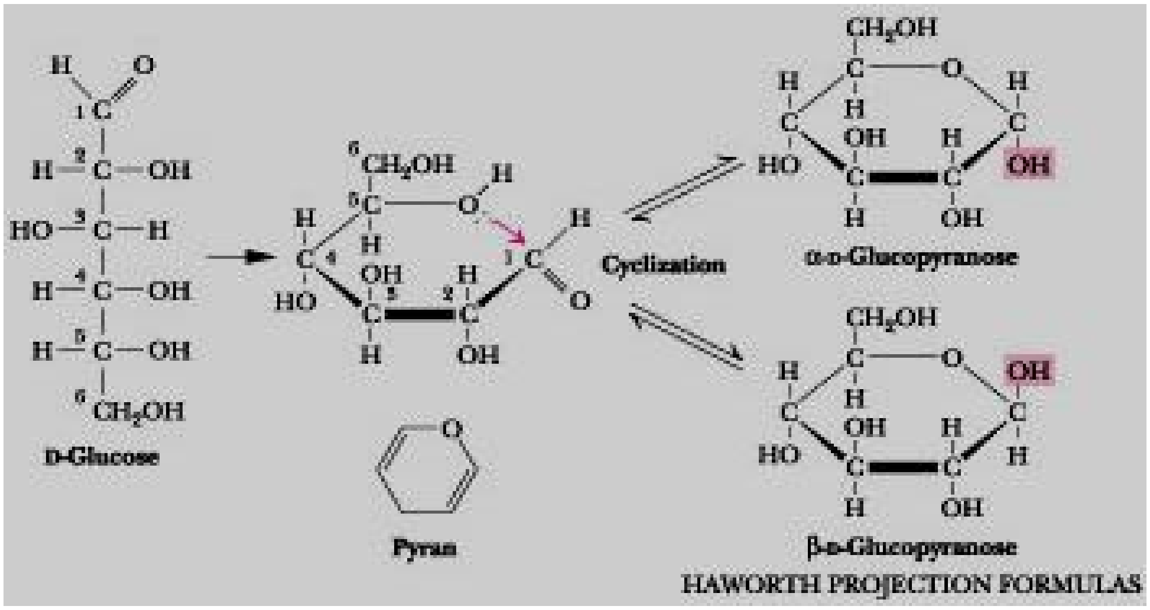
4- α & β anomerism(Cyclization of monosaccharides) :

The representations of the opened formula of sugars are called Fischer formula or Fischer projection and the representations of the cyclic sugars are called Haworth projections.

Lower sugars exist as opened chain form (opened formula), where as, pentose and hexoses exist in the ring form.

An aldehyde can react with an alcohol to form a hemiacetal.

For an aldohexose such as glucose, the C-1 aldehyde in the open-chain form of glucose reacts with the C-5 hydroxyl group to form an intramolecular hemiacetal. The resulting cyclic hemiacetal, a six-membered ring, is called pyranose because of its similarity to pyran.



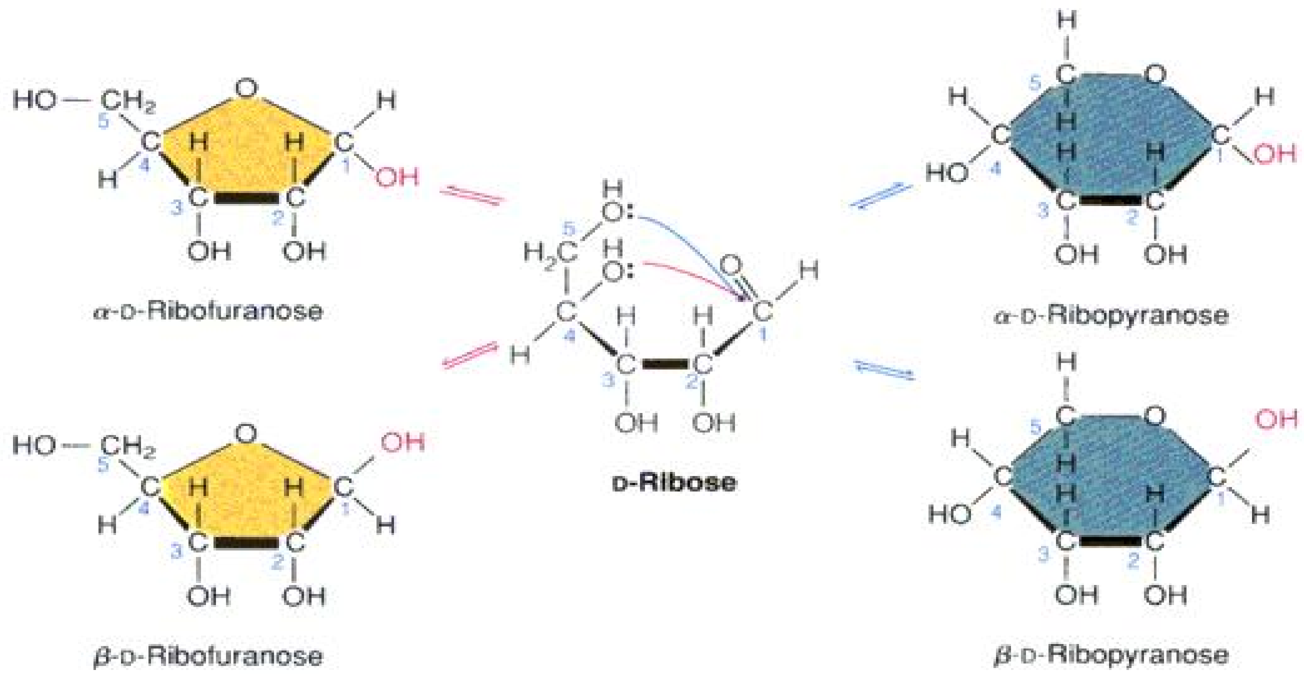
Two sugars, which differ from one another only in configuration around anomeric carbon atom are called **anomers**

Due to Position of OH & H groups around anomeric carbon atom ,

When OH group set to top of anomeric carbon atom the sugar is called α .

When OH group set to down of anomeric carbon atom the sugar is called β .

Either D-Ribose, with five carbons, readily forms five- membered rings (α & β -D-ribofuranose).



Similarly, a ketone can react with an alcohol to form a hemiketal.

The C-2 keto group in the open-chain form of a ketohexose, such as fructose, can form an intramolecular hemiketal by reacting with the C-5 hydroxyl group to form a five-membered cyclic hemiketal. The five-membered ring is called a furanose because of its similarity to furan.