CARBOHYDRATES

LEC.1

ASSIST. PROF. HUDA SALEEM

OBJECTIVES :

- Definition of Carbohydrates & list their classification
- List the important monosaccharides and their derivatives
- List the types of di., oligo. and poly saccharides.
- Correlate some types of carbohydrates with health.

Carbohydrates

Carbohydrates are broadly defined as polyhydroxy aldehydes or ketones and their derivatives or as substances that yields one of these compounds

- Composed of carbon, hydrogen, and oxygen
- Functional groups present include hydroxyl groups
- -ose indicates sugar

Carbohydrates contained in foods such as pasta and bread provide energy for the body.

Definition - Carbohydrates are sugar polymers

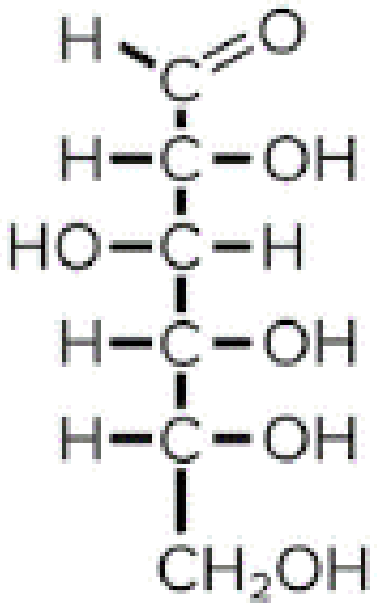
Carbohydrate = Carbon + Water

$C_n(H_2O)_n$

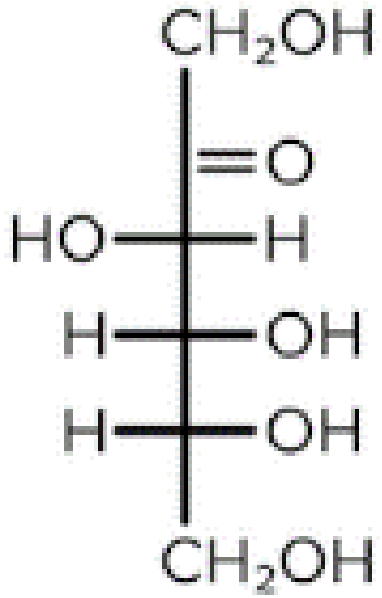
or $C_6H_{12}O_6$

Function Of Carbohydrates :

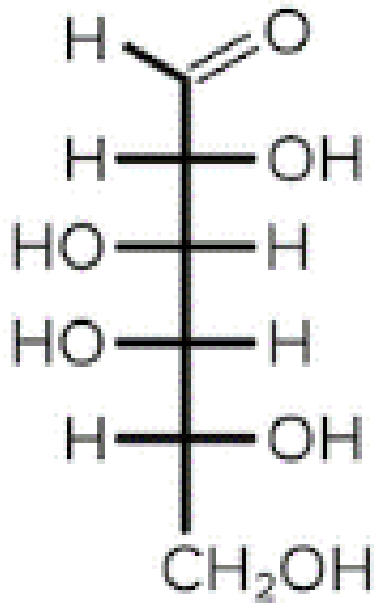
1. Carbohydrates provide energy and regulate blood glucose levels.
2. It will prevent the degradation of skeletal muscle and other tissues such as the heart, liver, and kidneys, by inhibiting the breakdown of protein for energy
3. Carbohydrates also assist in fat metabolism. when the body has sufficient energy for its immediate requirement , it stores excess energy as fat.
4. Carbohydrates a component of genetic material such as DNA and RNA in the form of deoxyribose and ribose sugars.



Glucose



Fructose



Galactose

Classification of Carbohydrates

- Carbohydrates are classified according to the number of subunits that make them up

3 Types of Carbohydrates

- ❑ Monosaccharides
- ❑ Oligosaccharides
  - Disaccharides
  - Trisaccharides
  - Tetrasaccharides
- ❑ Polysaccharides

Monosaccharides are simple sugars, or the compounds which possess a free aldehyde (CHO) or ketone (C=O) group and two or more hydroxyl (OH) groups. They are the simplest sugars and cannot be hydrolysed further into smaller units.

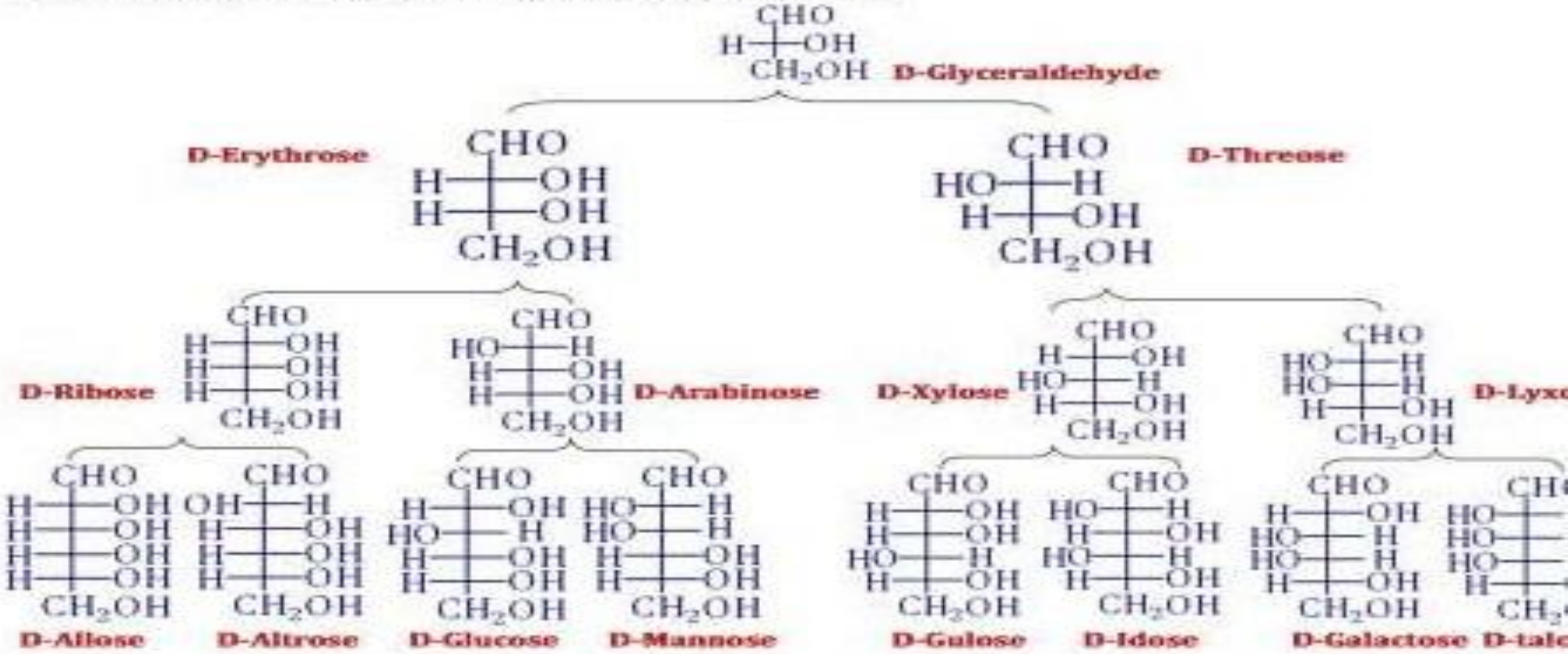
Monosaccharides contain a single carbon chain and are classified on the basis of number of carbon atoms they possess, and as aldoses or ketoses depending upon their groups.

Monosaccharides

Classification by Carbon Atoms

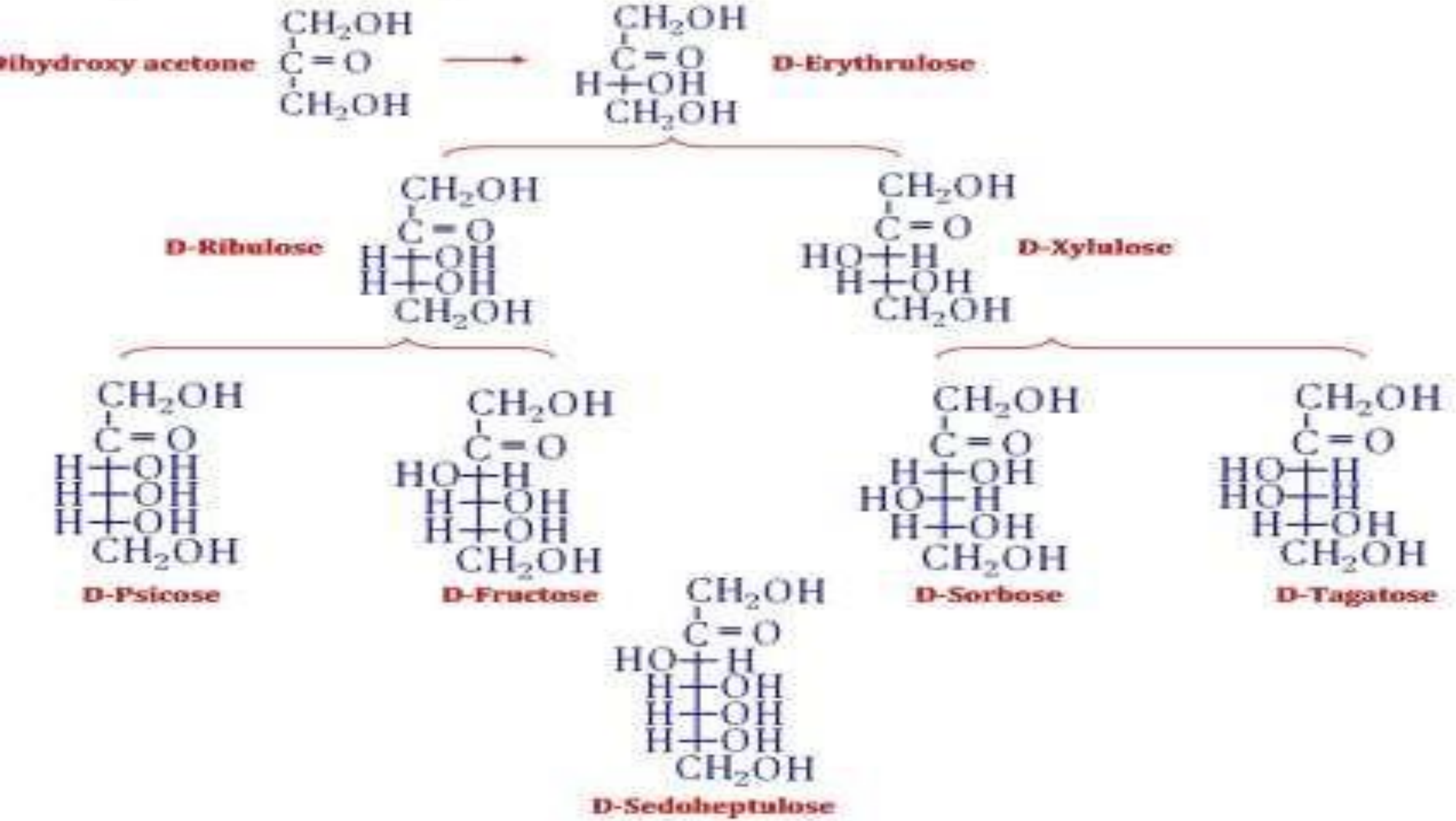
	Sugar	Structure formula	Aldoses	Ketoses
1.	Triose	$C_3H_6O_3$	Glyceraldehydes	Dehydroxy acetone
2.	Tetroses	$C_4H_8O_4$	Erythrose, Threose	Erthrulose
3.	Pentoses	$C_5H_{10}O_5$	Xylose Ribose Arabinose	Ribulose
4.	Hexoses	$C_6H_{12}O_6$	Glucose Galactose Mannose	Fructose

The family of D-aldoses containing from 3 to 6 carbons are:



- **D- Glucose, D-mannose, and D-galactose are the most abundant of the aldohexoses**
- **D-Mannose and D-galactose differ stereochemically from D-Glucose at only one chiral center (C2 for mannose) (C4 for galactose)**

The family of D-ketose containing from 3 to 6 carbons:



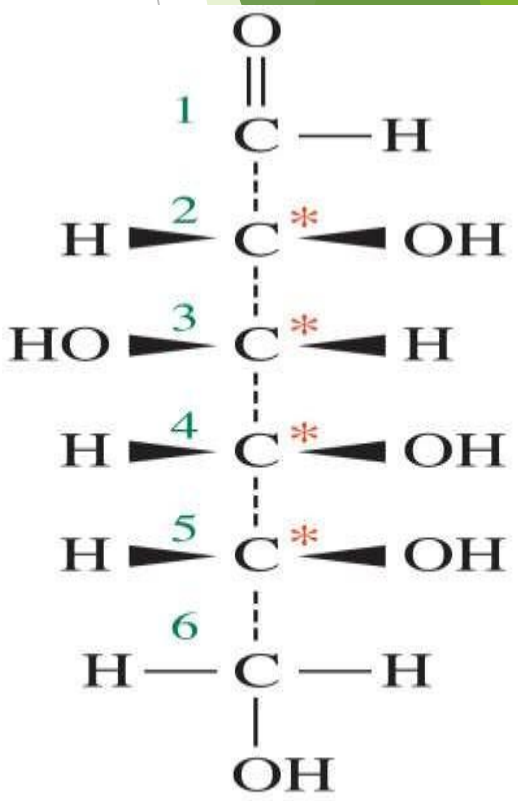
Stereochemistry in Monosaccharides

chiral centers

- Recall that a chiral center is a carbon atom that has four different atoms or groups of atoms attached to it.
- Aldoses with at least three carbons and ketosis with at least four carbons contains chiral centers.

Multiple chiral centers

- Carbons 2 through 5 of glucose are tetrahedral and have four different atoms or groups of atoms attached. Carbons 1 and 6 are not chiral centers.



* Chiral centers in glucose

Multiple chiral centers

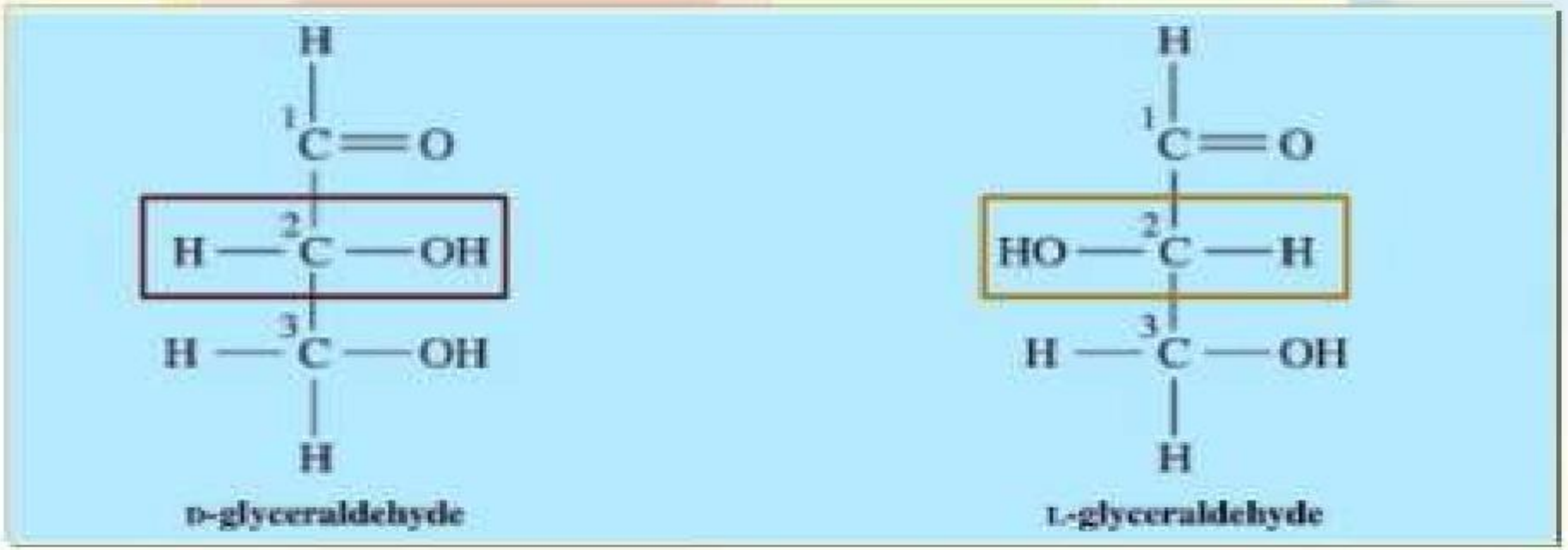
- Groups bonded to each chiral center have two different arrangements or mirror images, which result in stereoisomers.
- The number of stereoisomers for a molecule increases when the number of chiral centers increase.
- The general formula for determining the number of stereoisomers is $I = 2^n$, where (*n)* is the number of chiral centers present in the molecule, while (I) is the number of stereoisomers.
- Glucose has 4 chiral centers, so there are 16 stereoisomers, $2^4 = 16$.
- Chiral center= chiral carbon= asymmetric carbone

Steriochemistry

Optical isomers (= enantiomers) differ from each other in the disposition of the various atoms or groups of atoms in space around the asymmetric carbon atom. These are, in fact, the mirror image of each other. These may also be likened to left- and right-handed gloves.

One form in which H atom at carbon 2 is projected to the left side and OH group to the right is designated as D-form and the other form where H atom is projected to the right side and OH group to the left is called as L-form (note the use of small capital letters D and L)

For example, the glyceraldehyde has only one asymmetric carbon atom (numbered as 2) and it can, therefore, exist in 2 isomeric forms :



Monosaccharides

Hexoses

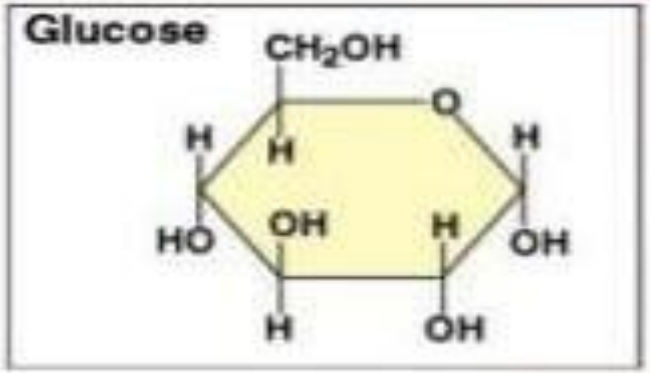
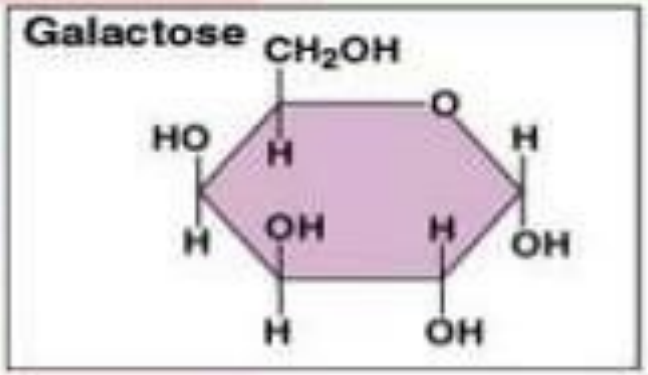
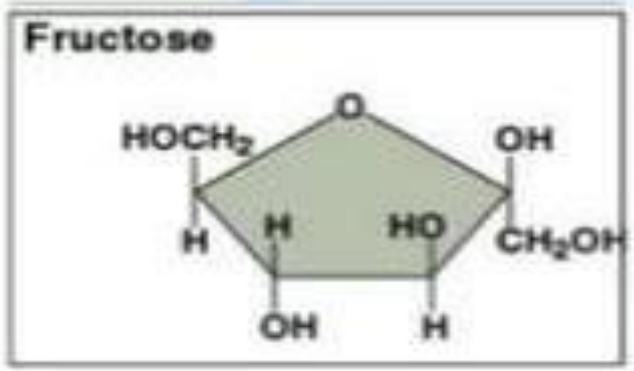
Glucose

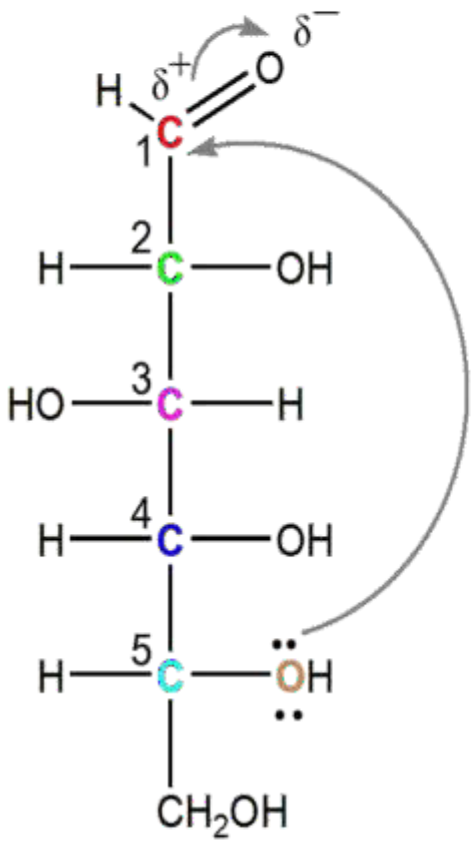
- The essential energy source for all body functions.
- Other names: Dextrose and Blood Sugar.
- A component of each disaccharide.

- Galactose
  - Seldom occurs freely in nature
  - Binds with glucose to form sugar in milk: lactose.
  - Once absorbed by the body, galactose is converted to glucose to provide energy.

Fructose:

- The sweetest of all sugars
  - (1.5 X sweeter than sucrose)
- Occurs naturally in fruits and honey "the fruit sugar"

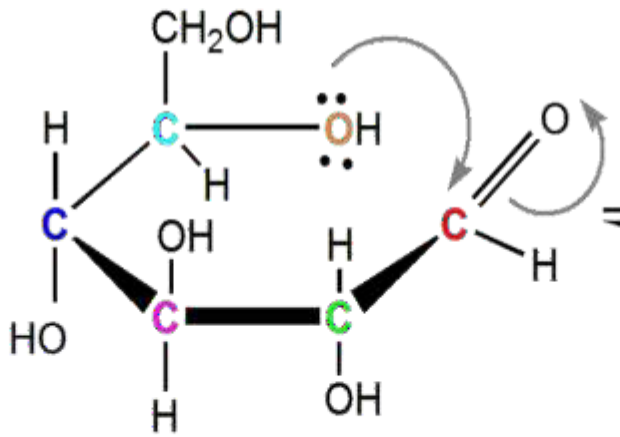
D-glucose "dextrose" Blood sugar	D-galactose	D-fructose "Levulose" Fruit sugar
		



up on the ring | down on the ring

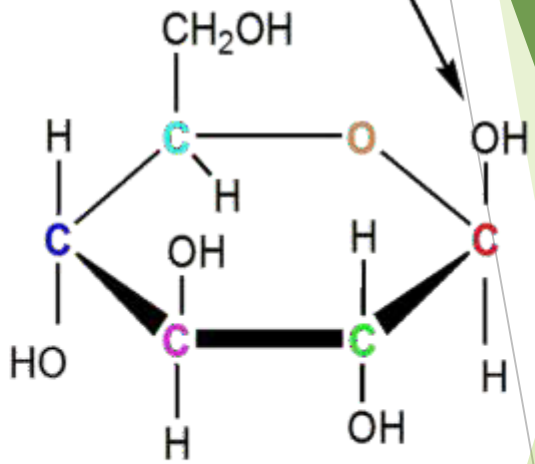
D-Glucose

Fischer projection



Groups on left side of Fischer projection are facing upwards, while groups on right side are facing downwards in this representation

It's **beta-anomer** when CH_2OH and OH are on the same side



β-D-Glucopyranose

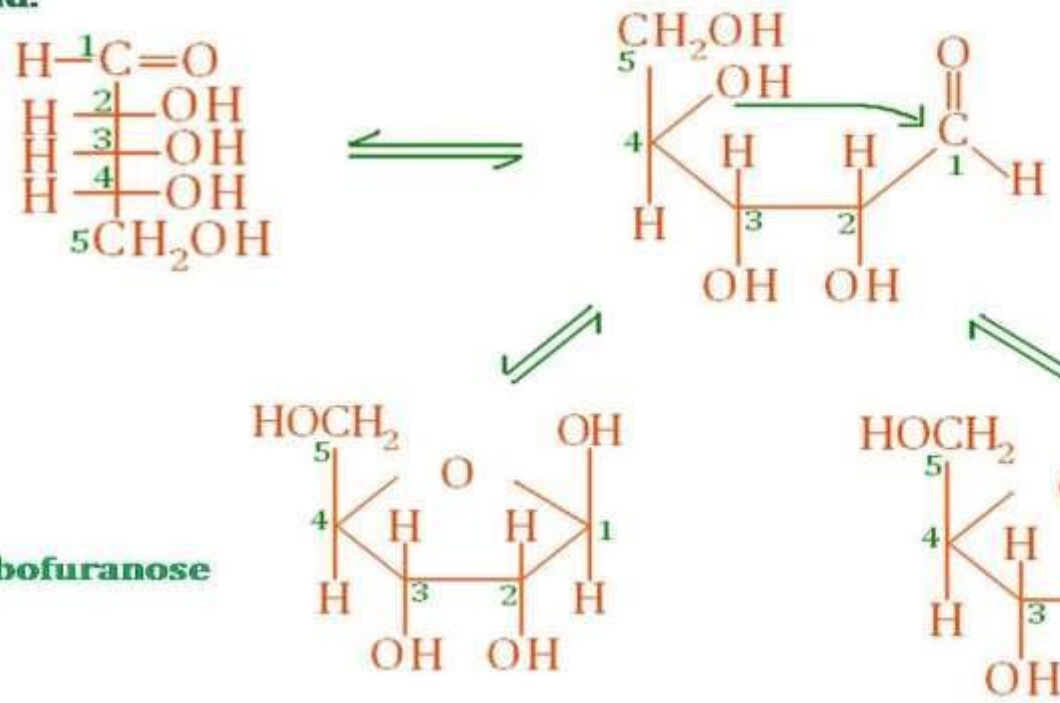
(hemiacetal of D-glucose)

Haworth projection

The Cyclic Structure of Monosaccharides

The monosaccharides with five or more carbon atoms spend most of their time in solution as cyclic structures.

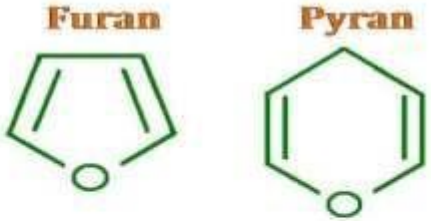
The ring is formed by reaction of the aldehyde or ketone on one end of the molecule with a hydroxyl on the other end.



β-D-Ribofuranose

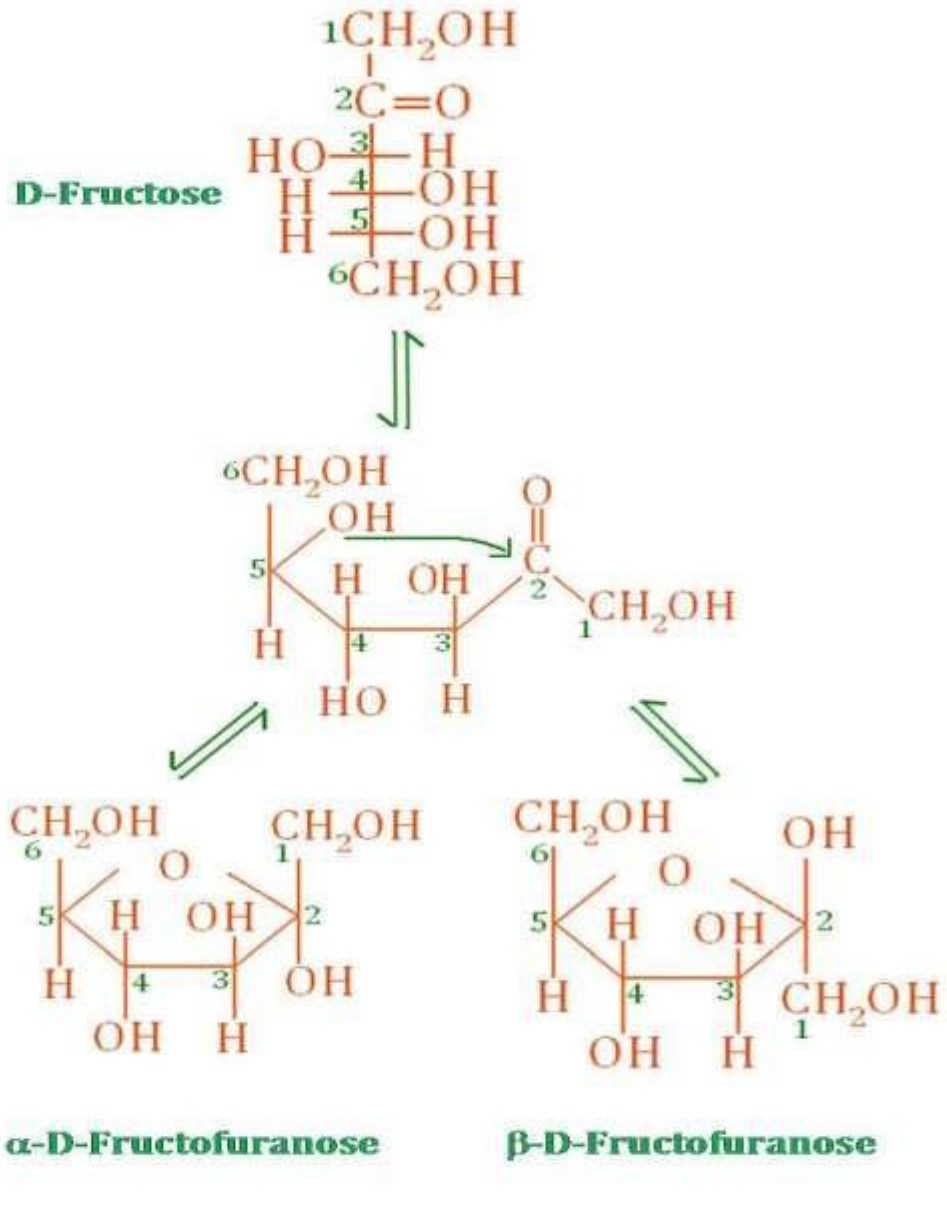
α-D-Ribofuranose

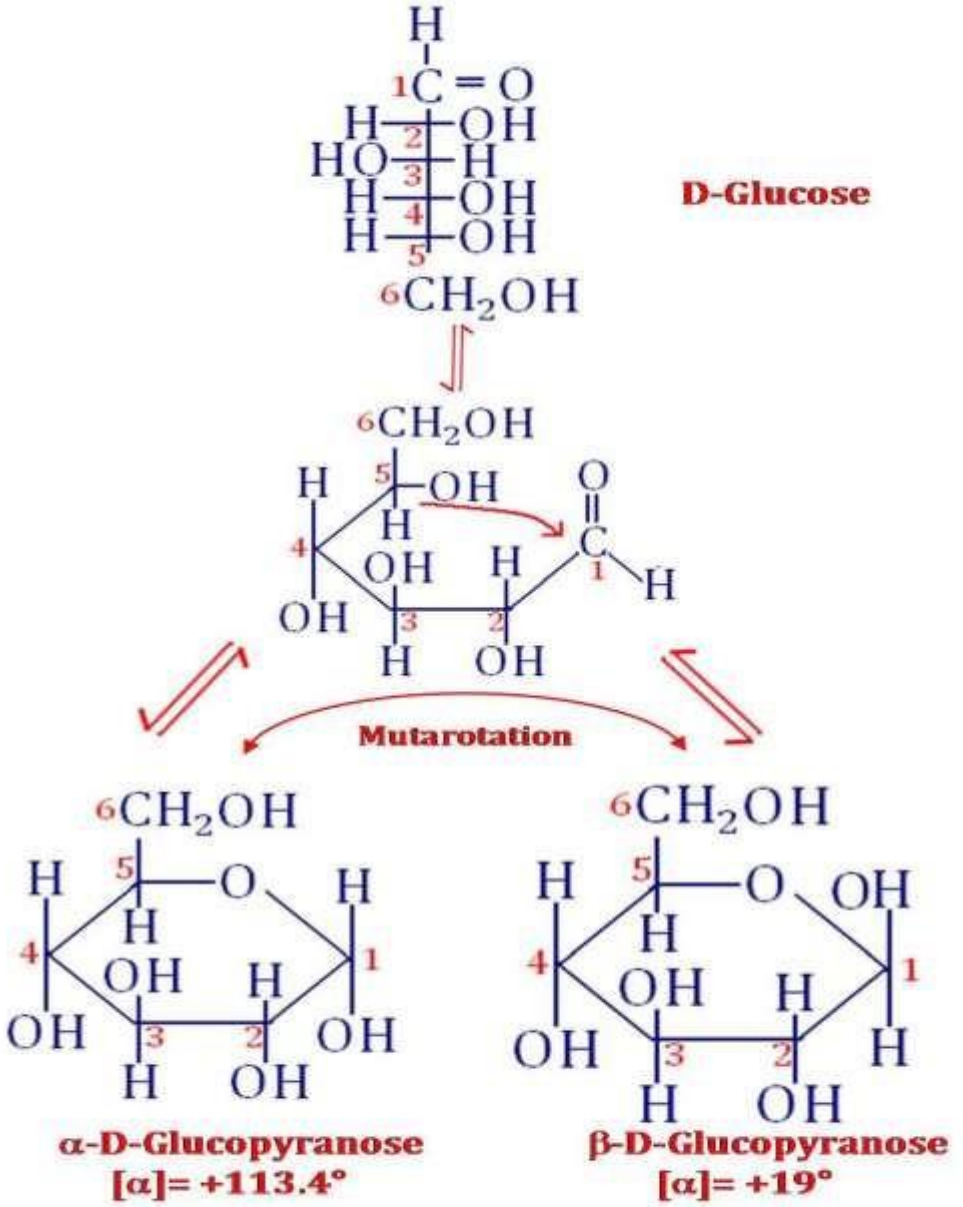
Furan **Pyran**



Cyclization of the open-chain form of D-ribose.

* **The carbonyl group of D-ribose reacts with the hydroxyl group on C4 to form a hemiacetal.**
* **When the ring closes, the former carbonyl carbon (aldehyde or ketone) becomes a chiral center, therefore , two structures can be drawn to represent the stereoisomeric products.**


D-Fructose
α-D-Fructofuranose
β-D-Fructofuranose


D-Glucose
Mutarotation
α-D-Glucopyranose
[α]= +113.4°
β-D-Glucopyranose
[α]= +19°

The hydroxyl group at carbon 1 (in aldoses) and carbon 2 (in ketoses) is below the plane (α-Configuration) and in the other structure, the hydroxyl group is above the plane of the ring (β-Configuration).

* The α and β form of sugars are called anomers
* The cyclic structure for ribose, fructose and glucose are drawn in the Haworth Projection Form.

This representation shows all hydroxyl groups & hydrogen atoms but does not show carbon atoms in the ring.

* When dissolved in aq. solution, the cyclic forms of the monosaccharides are in equilibrium with the open chains, thus, the α-form can be readily converted to the β form.

* The gradual change of the optical rotation with time of a solution of pure anomer until a constant value is reached, this called (mutarotation)

D-glucose

33% α-anomer ⟶ + 113° ⟶ +53°

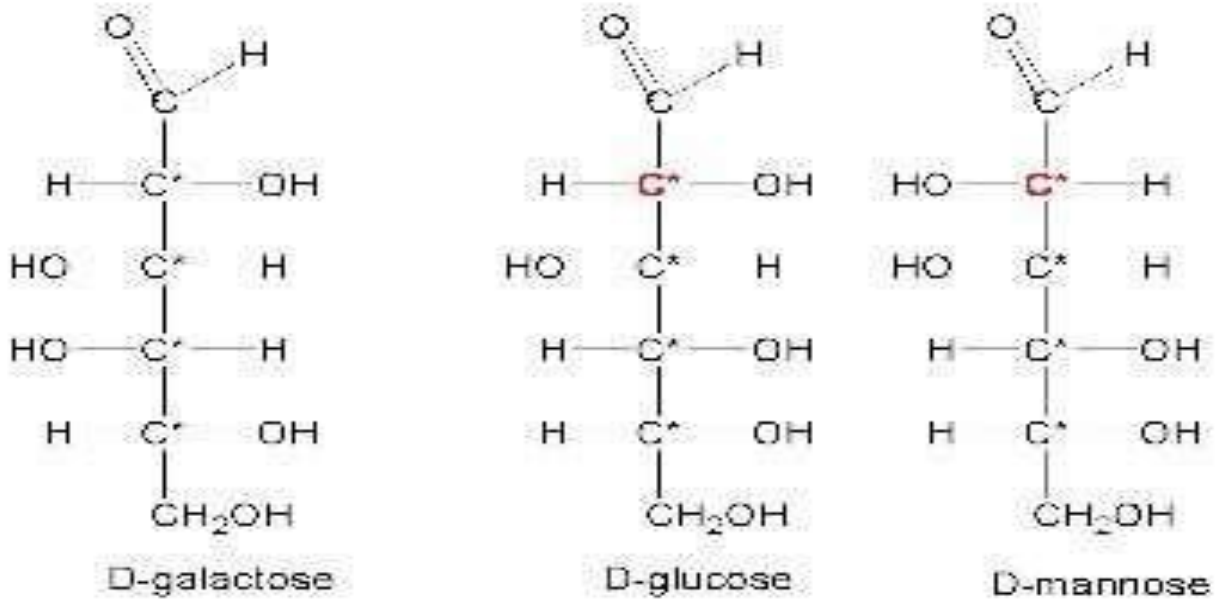
66% β-anomer ⟶ + 19° ⟶ +53°

most stable ⟶ equilibrium mixture.

1% open polyhydroxyl aldehyde chain

3. Epimers

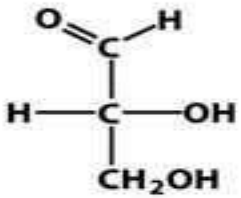
- **When sugars differ from one another in configuration at only one (chiral center) asymmetric atom they are called epimers.**
- **E.G. Glucose and mannose are the epimers with respect of C_2, similarly glucose and galactose are epimers of C_4**



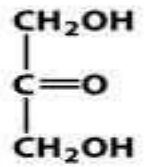
Carbohydrate Isomeric Forms

ISOMERS
Have the same molecular formula but different structures

CONSTITUTIONAL ISOMERS
Differ in the order of attachment of atoms



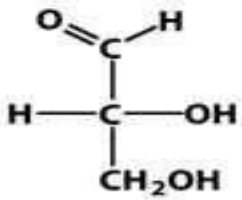
Glyceraldehyde ($C_3H_6O_3$)



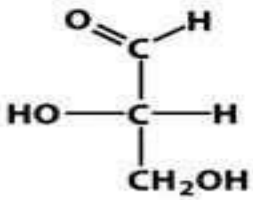
Dihydroxyacetone ($C_3H_6O_3$)

STEREOISOMERS
Atoms are connected in the same order but differ in spatial arrangement

ENANTIOMERS
Nonsuperimposable mirror images

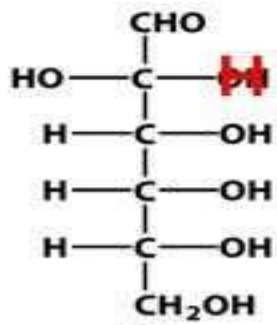


D-Glyceraldehyde ($C_3H_6O_3$)

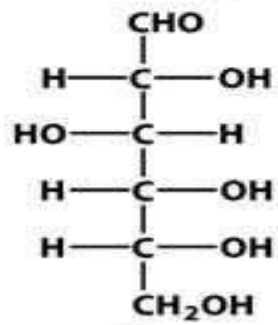


L-Glyceraldehyde ($C_3H_6O_3$)

DIASTEREOISOMERS
Isomers that are not mirror images

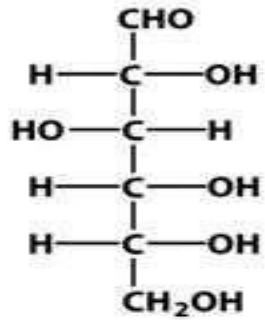


D-Altrose ($C_6H_{12}O_6$)

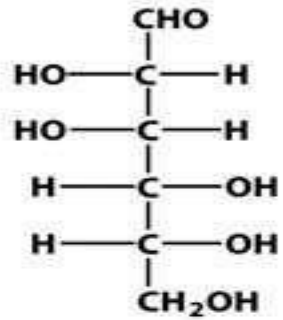


D-Glucose ($C_6H_{12}O_6$)

EPIMERS
Differ at one of several asymmetric carbon atoms

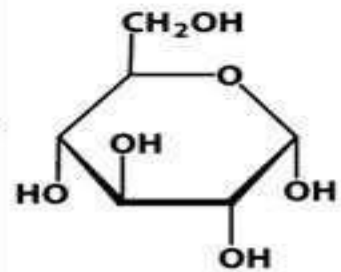


D-Glucose ($C_6H_{12}O_6$)

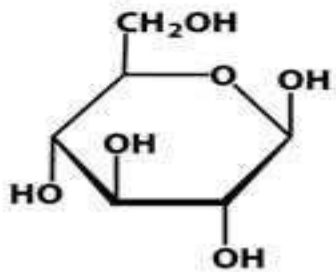


D-Mannose ($C_6H_{12}O_6$)

ANOMERS
Isomers that differ at a new asymmetric carbon atom formed on ring closure



α-D-Glucose ($C_6H_{12}O_6$)



β-D-Glucose ($C_6H_{12}O_6$)


THANK
YOU!