Carbohydrates:

Carbohydrates are organic compounds that contain large quantities of hydroxyl groups. It has the general formula ($C_nH_{2n}O_n$). The simple carbohydrates also contain either an aldehyde moiety (these are termed **polyhydroxyaldehydes**) or a ketone moiety (**polyhydroxyketones**).

What are carbohydrates ?

Carbohydrates are the sugars, starches and fibers found in fruits, grains, vegetables and milk products. carbohydrates - one of the basic food groups - are important to a healthy life.

Carbohydrates are the body's main source of energy. They are called carbohydrates because, at the chemical level, they contain carbon, hydrogen and oxygen.

Importance of Carbohydrates:

1- Energy source (glucose) .
2- Energy storage (glycogen, starch) .
3- They are essential components of nucleic acids (D-ribose (RNA) and 2-deoxy-D-ribose(DNA)) .
4- Carbon source (pyruvate used to make Ile, Leu, Val, Ala) .
5- Structure/Protection (chitin, cellulose, connective tissue) .
6- Can be attached to other macromolecules (glycoproteins and glycolipids).

Carbohydrate Classifications

1. **Monosaccharides :** carbohydrates that cannot be hydrolyzed to simpler carbohydrates; eg. Glucose or fructose.

2. **Disaccharides :** carbohydrates that can be hydrolyzed into two monosaccharide units; eg. Sucrose, which is hydrolyzed into glucose and fructose.
3. **Oligosaccharides :** carbohydrates that can be hydrolyzed into a few monosaccharide units.
4. **Polysaccharides :** carbohydrates that are polymeric sugars; eg Starch or cellulose.

1- Monosaccharaides

- The monosaccharides are the simple of the carbohydrates, since they contain only one polyhydroxy aldehyde or ketone unit.
- Monosaccharides are classified according to the number of carbon atoms they contain:

No. of carbons	Class of Monosaccharide	Relevant examples
٣	triose	Glyceraldehyde, Dihydroxyacetone
٤	tetrose	Erythrose
٥	pentose	Ribose, Ribulose, Xylulose
6	hexose	Glucose, Galactose, Mannose, Fructose

- The presence of an aldehyde is indicated by the prefix **aldo-** and a ketone by the prefix **keto-**.

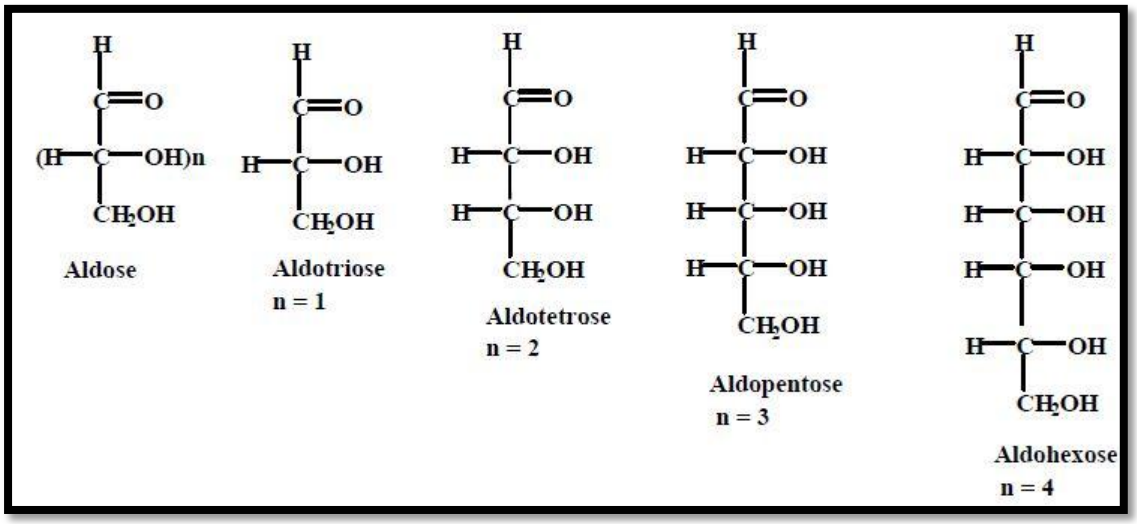
Classification of Monosaccharides

- Thus, glucose is an aldohexose (**aldehyde + 6 Cs**)
- and ribulose is a ketopentose (**ketone + 5 Cs**)
- All other sugars have the ending ose (glucose, galactose, ribose, lactose, etc…)
- The suffix -ose is added to a molecule that is a carbohydrate, and prefixes tri-, tetr-, and pent- are used to indicate the number of carbons
- D-glyceraldehyde is the simple of the aldoses (aldotriose)
- Pentoses and hexoses dominating

Sugar Nomenclature

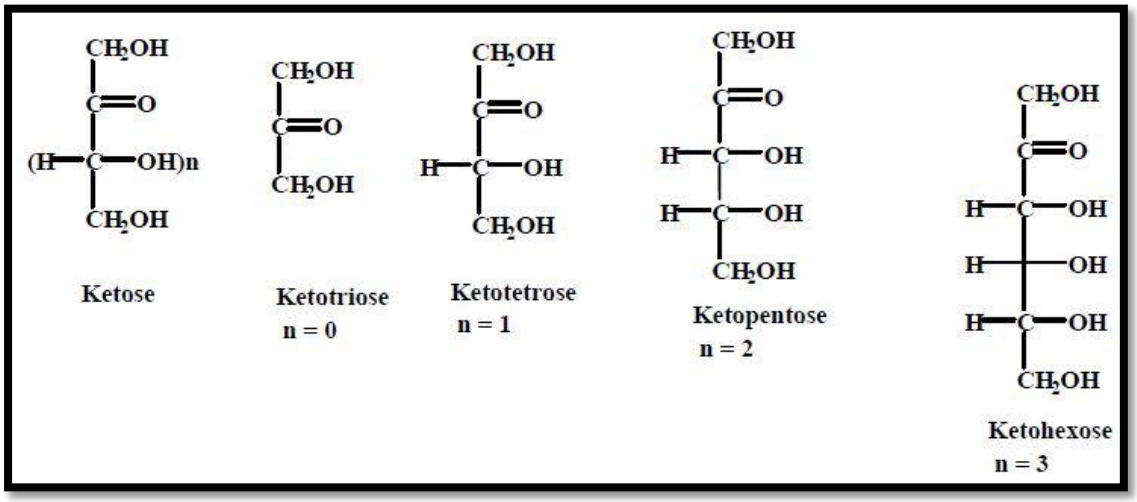
- 3 carbon sugar - triose
- 4 carbon sugar - tetrose
- 5 carbon sugar - pentose
- 6 carbon sugar - hexose
- 7 carbon sugar - heptose
- 8 carbon sugar – octose

Aldose sugars



Where **n** is the number of asymmetric centers.

Ketose sugars

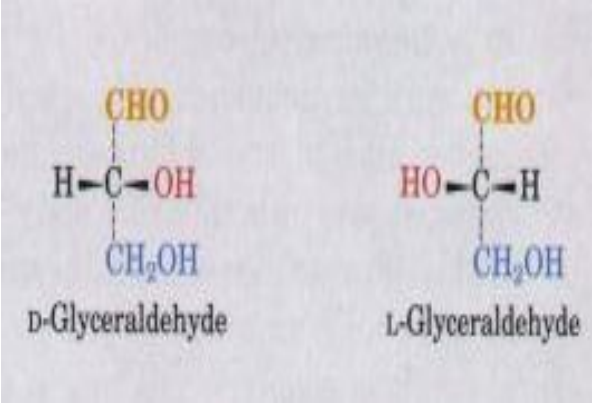


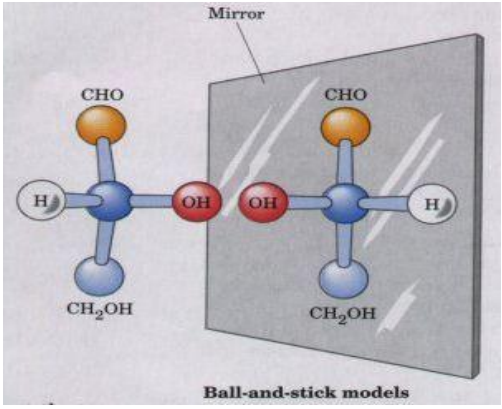
Where **n** is the number of asymmetric centers.

Stereoisomerism of Monosaccharides

All the monosaccharides except dihydroxyacetone contain one or more asymmetric (chiral) carbon atoms. The simplest aldose, glyceraldehyde, contains a chiral center (the middle carbon atom) and therefore has two different enantiomers. one of these two forms is designated the **D** isomer of glyceraldehyde; the other is the **L** isomer. To represent three-dimensional sugar structures on paper .

Nomenclature for stereoisomers: D and **L** designations are based on the configuration about the single asymmetric carbon in glyceraldehyde.





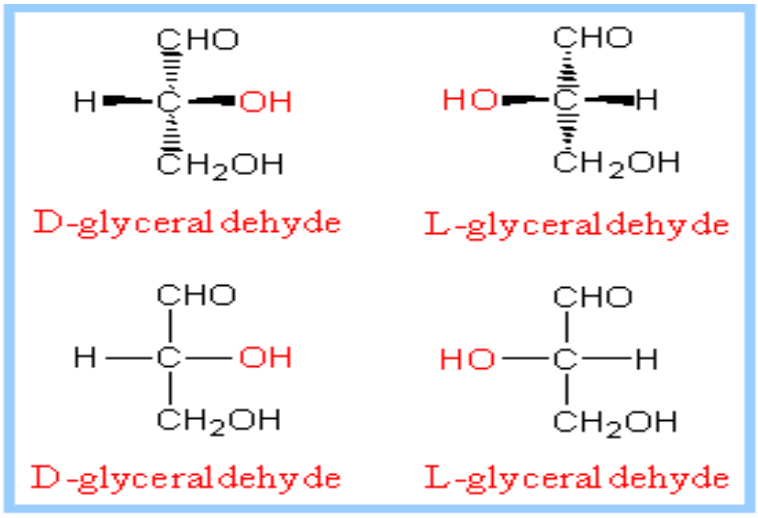
- **CHIRAL center:** Carbon with 4 different groups bonded to it
- In general, a molecule with n chiral centers can have 2^n stereoisomers.
- Glyceraldehyde has $2^1 = 2$
- the aldohexoses, with 4 chiral centers, have $2^4 = 16$ stereoisomers.

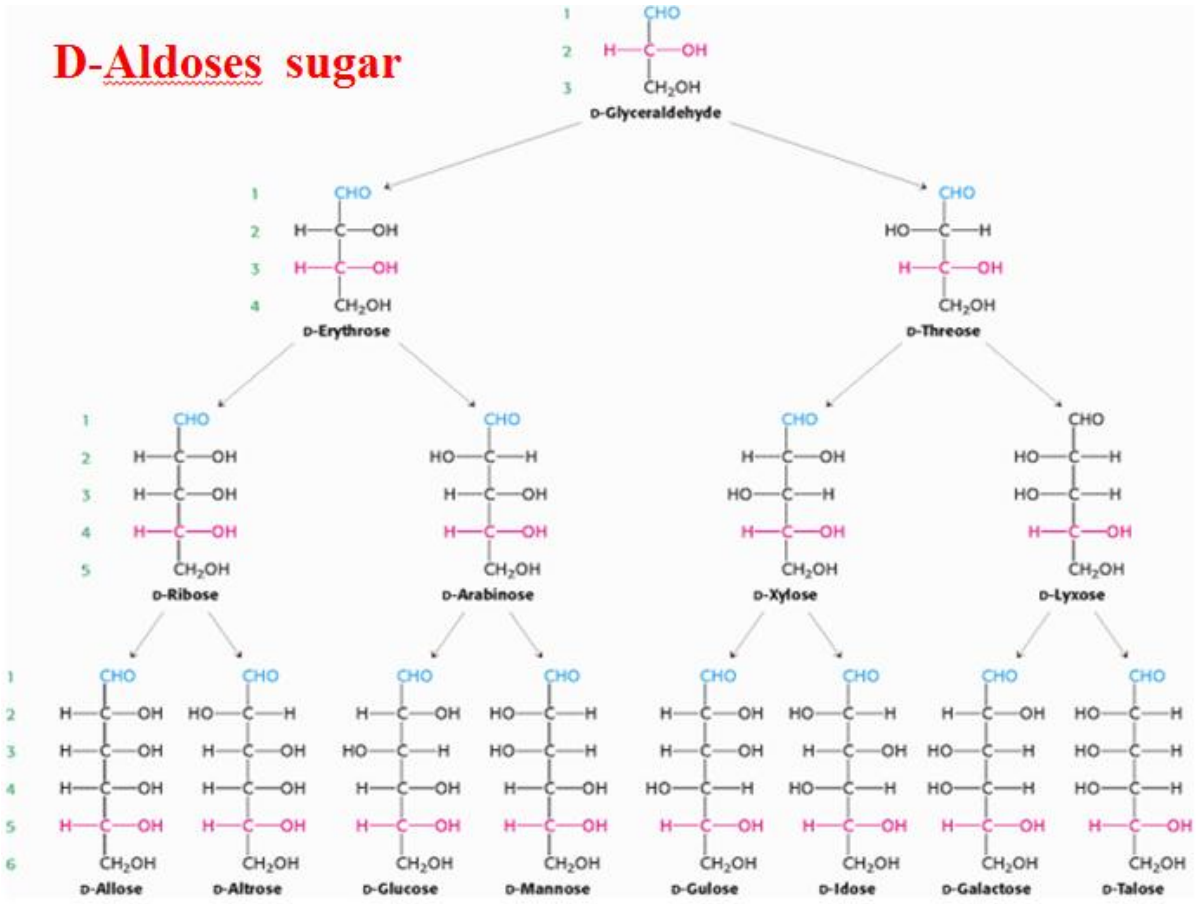
How many **aldooctoses** are possible ? How many **D- aldooctoses** are possible ?

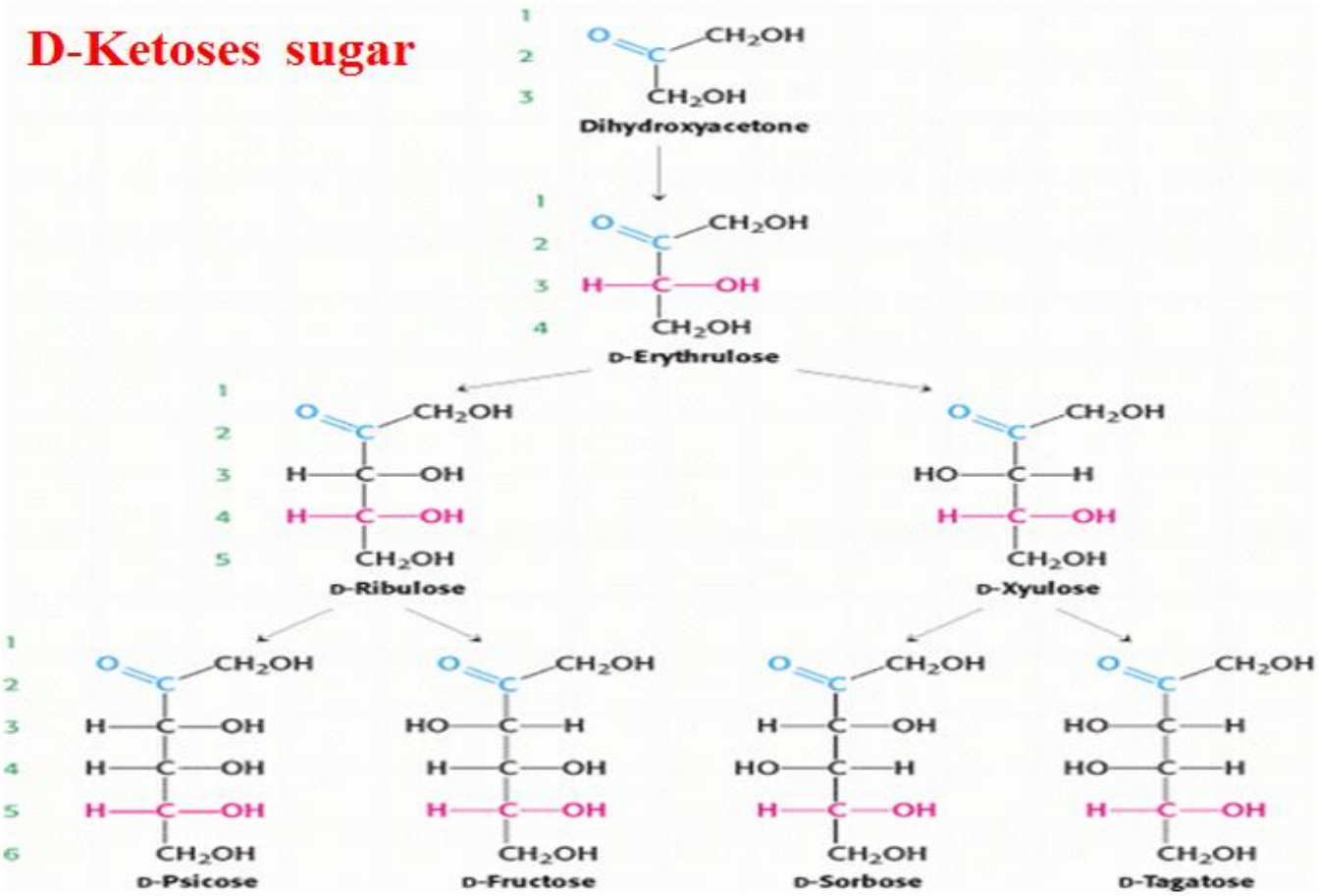
Fischer Projections

- representation of a 3D molecule as a flat structure where a tetrahedral carbon is represented as two crossed lines.

- These representations are only used for molecules that contain chirality centers, where the chirality centers are represented as simple crosses.
- Fischer projections also allow an easy classification of the sugar as either the D-enantiomer or the L-enantiomer.

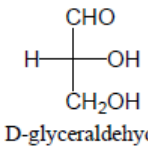






The Family of D-aldoses

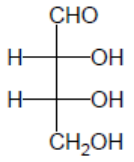
(L-forms not shown)



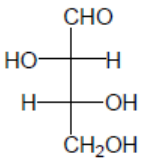
D-glyceraldehyde

Aldotriose

$2^1 = 2$



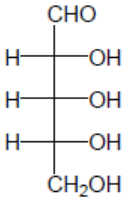
D-erythrose



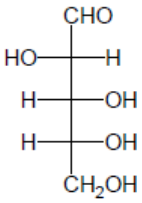
D-threose

Aldotetroses

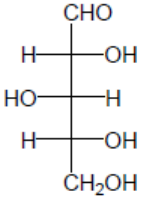
$2^2 = 4$



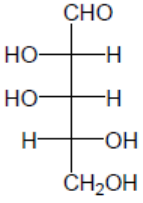
D-ribose



D-arabinose



D-xylose



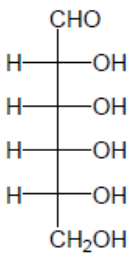
D-lyxose

Aldopentoses

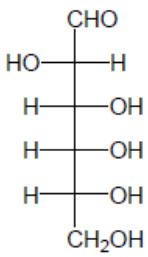
$2^3 = 8$

The Family of D-aldoses

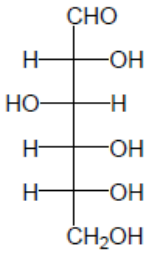
(L-forms not shown)



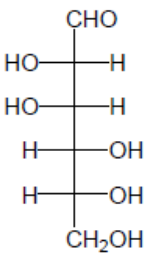
D-allose



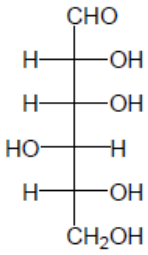
D-altrose



D-glucose

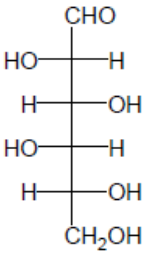


D-mannose

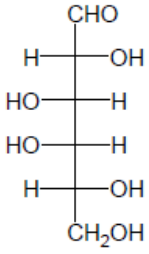


D-gulose

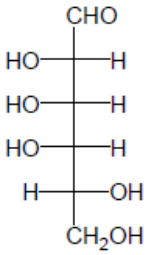
Aldohexoses
$2^4 = 16$



D-idose



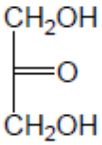
D-galactose



D-talose

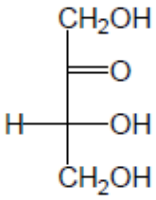
The Family of D-ketoses

(L-forms not shown)



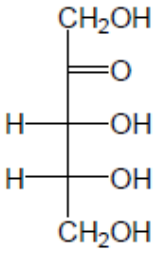
Dihydroxyacetone

Ketotriose
$2^0 = 1$

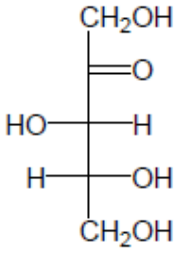


D-erythrulose

Ketotetroses
$2^1 = 2$



D-ribulose

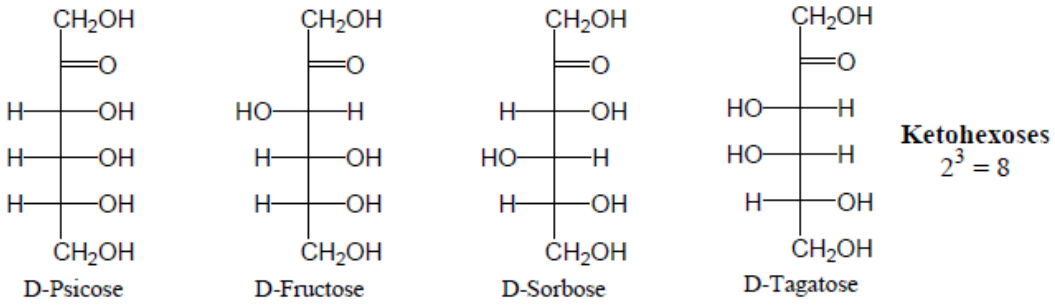


D-xylulose

Ketopentoses
$2^2 = 4$

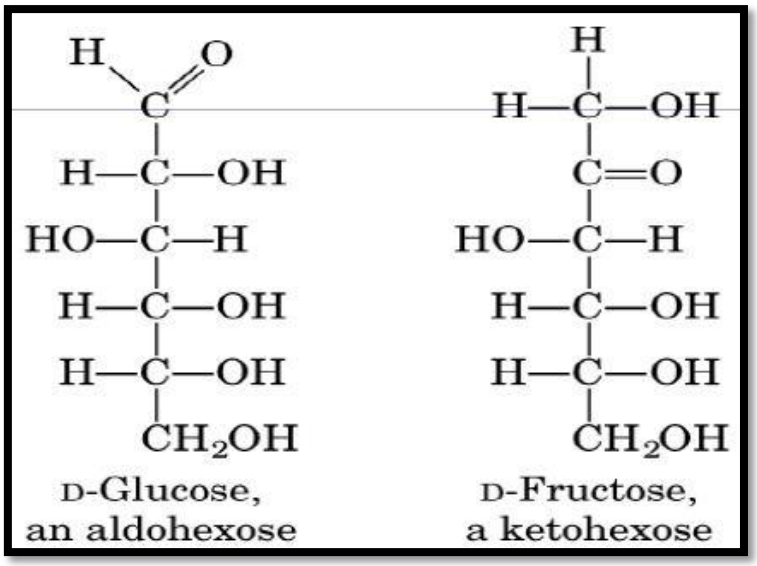
The Family of D-ketoses

(L-forms not shown)



Isomers

- Isomers are molecules that have the same molecular formula, but have a different arrangement of the atoms in space. (different structures).
- For example: Glucose and Fructose.

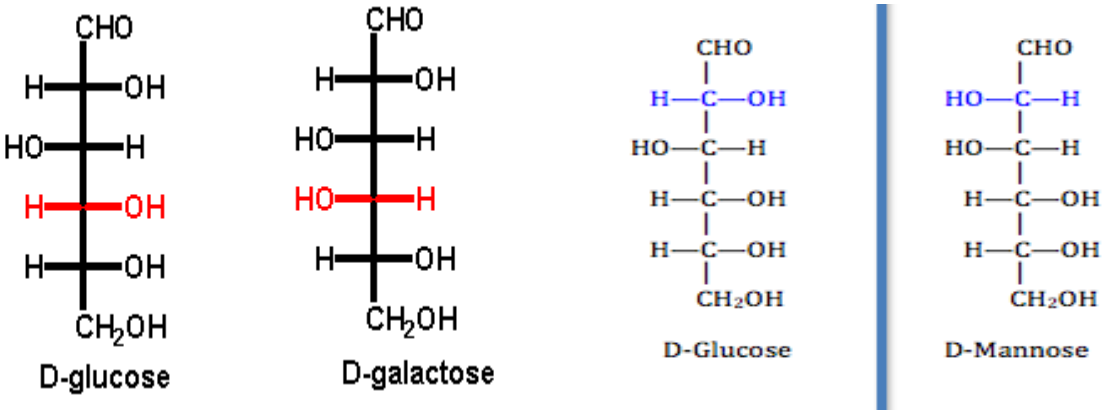


EPIMERS

- ❖ EPIMERS are sugars that differ in configuration at only one position.

❖ Examples of epimers :

- D-glucose & D-galactose (epimeric at C_4)
- D-glucose & D-mannose (epimeric at C_2)
- D-idose & L-glucose (epimeric at C_5)



D-glucose and L-glucose are **enantiomers**