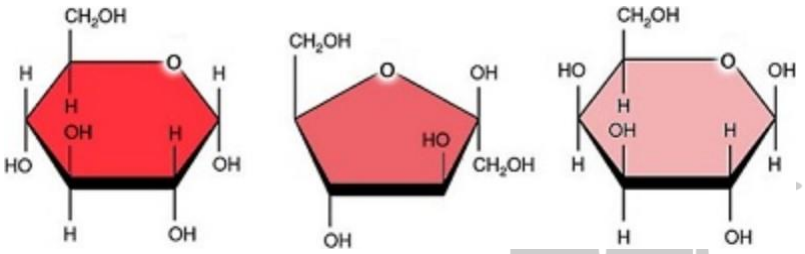
Carbohydrates

Carbohydrates are made up of carbon, hydrogen, and oxygen. Hence, carbohydrates like cellulose, starch, glycogen, glucose, fructose etc. are the most abundant biomolecules on earth. There are three types of carbohydrates:

Monosaccharides:

These are the simplest of carbohydrates and are known as sugars. They are the building units of complex carbohydrates. These cannot be hydrolysed.

Monosaccharides



Glucose Fructose Galactose

It can be further classified based on:

I. The number of the carbon atom present

Composed of 3-7 carbon atoms and are classified according to the number of C atoms as trioses (3C), tetroses (4C), pentoses (5C), hexoses (6C) and heptoses (7C).

trioses (3C)	Glyceraldehyde and Dihydroxyacetone
tetroses (4C) – Rare	Erythrose
pentoses (5C)- Most Common	Ribose, ribulose, xylulose, and arabinose.
hexoses (6C)- Most Common	Glucose), fructose, mannose, galactose.
heptoses (7C)	Sedoheptulose

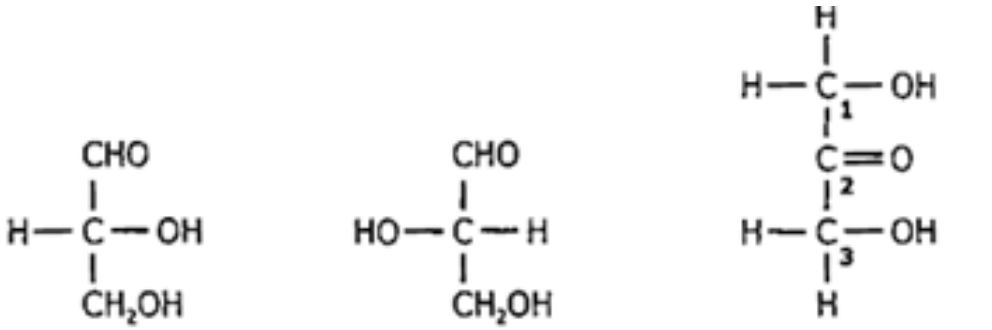
II. Presence of aldehyde or ketone group

Suppose a monosaccharide contains an aldehyde group [–CHO]. In that case, it is known as an aldose (reducing centre always lies at Carbon No. 1), and if it contains a keto group [=C=O], it is known as a ketose (reducing centre always lies at Carbon No. 2).

- Optical activity of monosaccharides

All monosaccharides contain one or more chiral carbon atoms (except Dihydroxyacetone), therefore, exist in optically active isomeric forms (enantiomers).

A molecule with one chiral carbon will have two different optical isomers (enantiomers). As the number of chiral carbon increases, the number of possible isomers also increases. Therefore, if a compound has an 'n' asymmetric carbon atom, it will have 2^n possible stereoisomers.

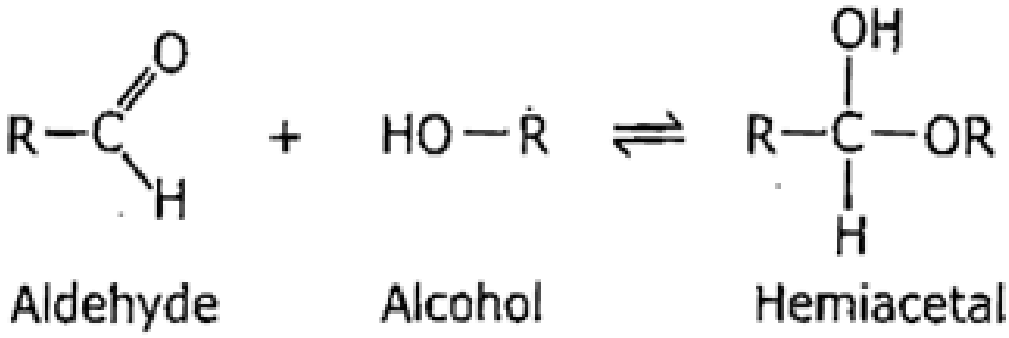


- Cyclic Forms of Monosaccharides

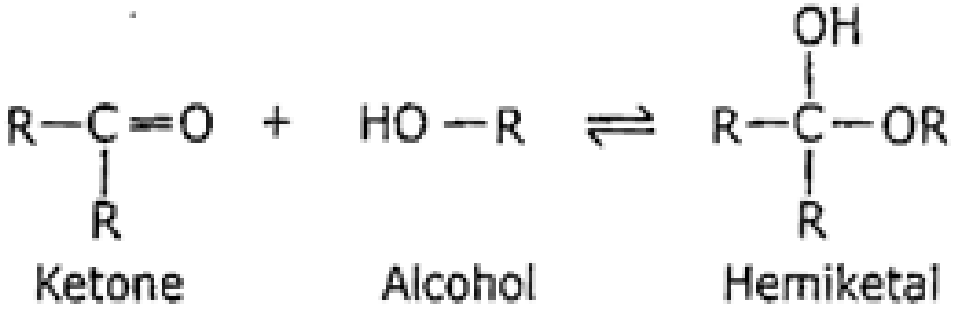
Many monosaccharides, such as glucose, ribose, fructose etc., exist both in open straight-chain and ring form. Sugar with a 5-membered ring is called furanose sugar. Sugar with a 6-membered ring is called pyranose sugar.

They are formed via internal hemiacetal (aldehyde reacts with alcohol) or hemiketal formation (ketone reacts with alcohol).

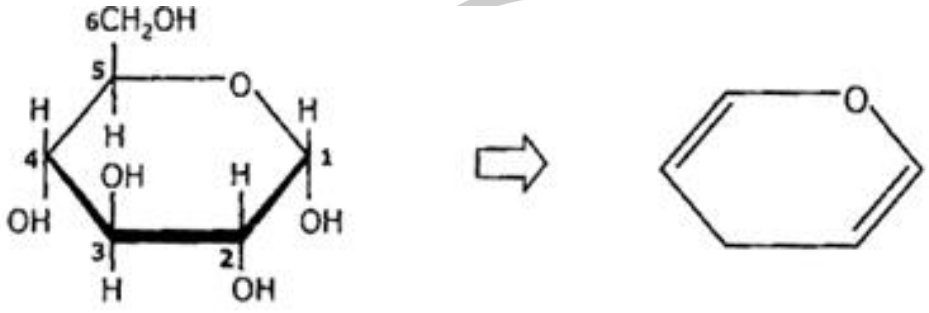
<u>Hemiacetal:</u>

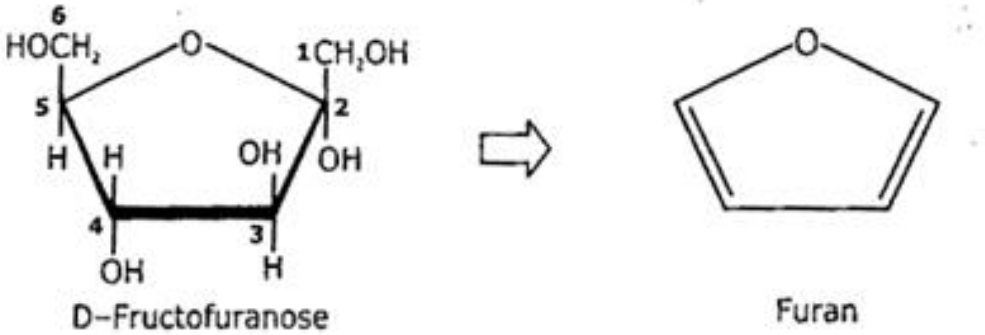


Hemiketal:



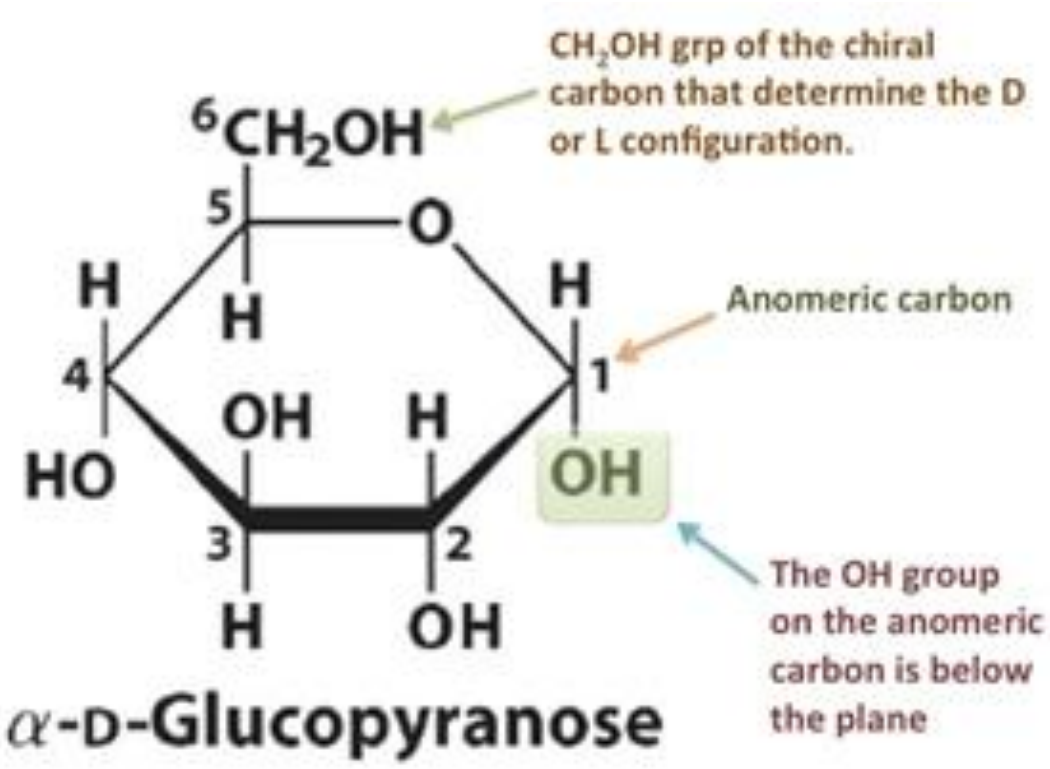
The cyclic form of glucose is a six-membered ring; such sugars are called pyranose because they resemble the cyclic form pyran Same in the case of fructose (5-membered rings) called furanose because they resemble furan.





- The hemiacetal or hemiketal bond formation creates a new asymmetric centre at C1 in aldose sugar and C2 in ketose sugar which is now called an anomeric carbon atom.

- The—OH group at the reducing centre (i.e., C No. 1 in aldose sugars and C No. 2 in ketose sugars) is present below the plane of the ring; the sugar is said to be in α-form. And if it is present above the plane of the ring, the sugar is said to be β-form. Thus α-form and β-forms are called Anomers. , The two anomers have different physical and chemical properties.



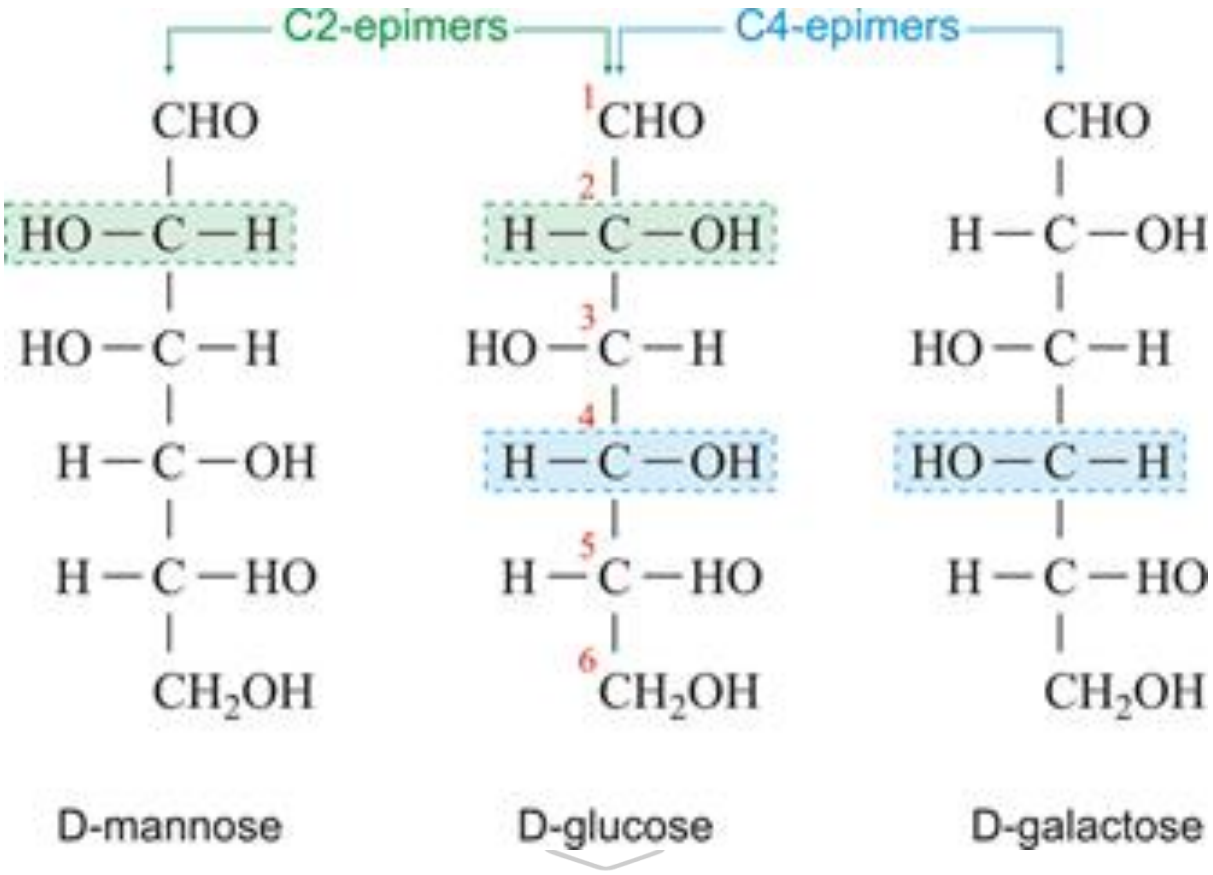
- In an aqueous solution, interconversion of α and β-forms via the open-chain structure gives rise to an equilibrium mixture This phenomenon is called Mutarotation.

EPIMERS

They are called epimers if sugars are closely related but differ only by stereochemistry at a single carbon atom (other than anomeric carbon).

- D- Glucose and D- mannose are epimers because they differ at Carbon 2. Similarly, D-Glucose and D-galactose are epimers because they differ at Carbon 4.

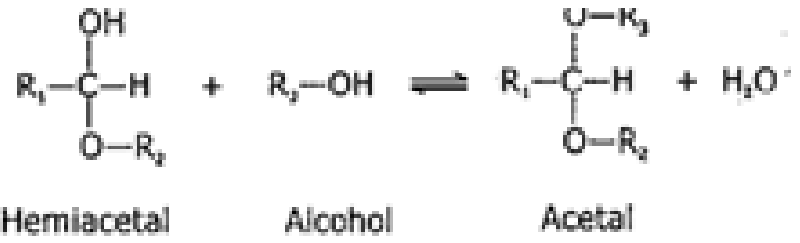
- However, D- Mannose and D- Galactose is not epimers because their configuration differs at more than one carbon.

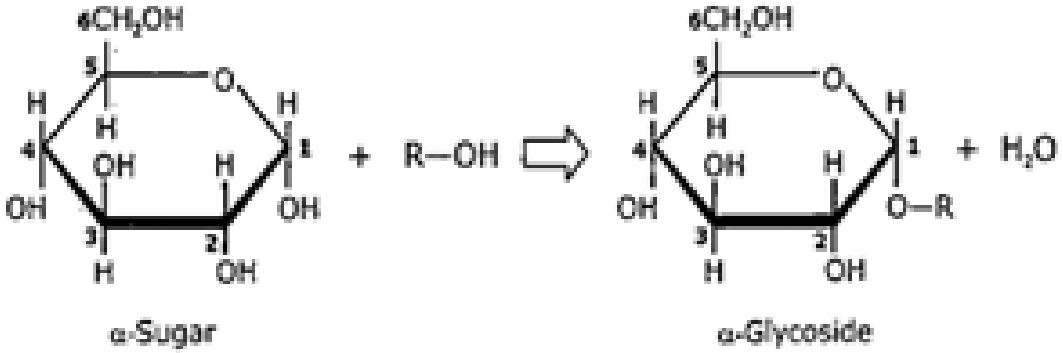


- Derived Monosaccharides

i. Glycosides: When hemiacetals react with alcohol, they form acetals, and if a hemiacetal of sugar reacts with an alcohol to form acetyl, it is known as a glycoside. It is formed by condensation between the hydroxyl group of anomeric Carbon of monosaccharides, whereas the second compound may or may not be another monosaccharide

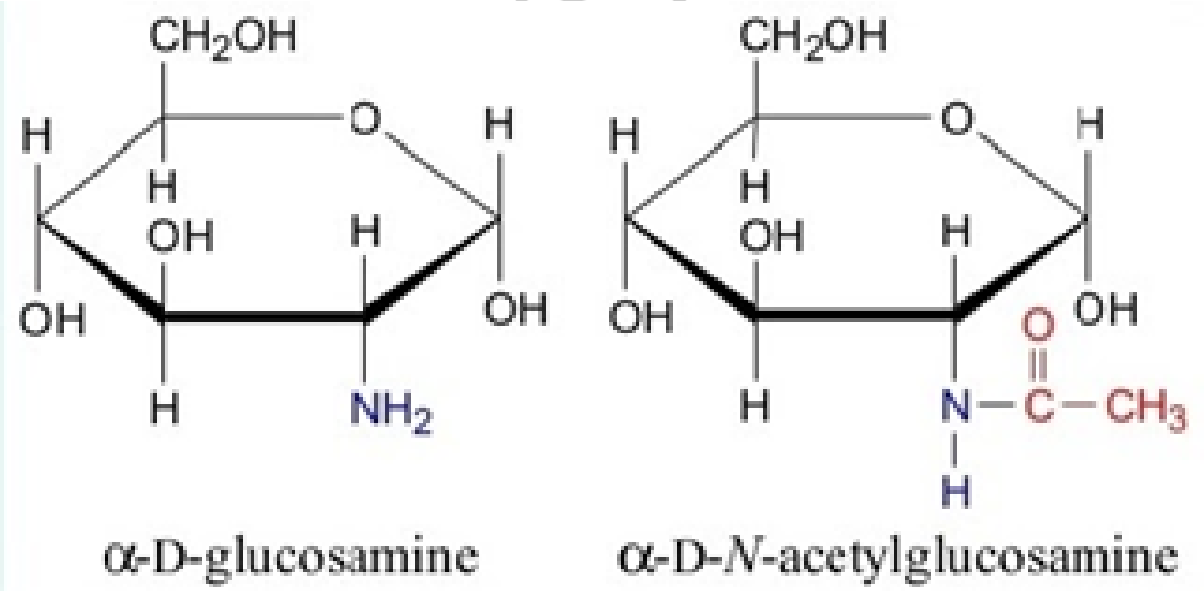
Example: Ouabain, which inhibits the enzyme action that pumps NA+ and K+ across the cell membrane



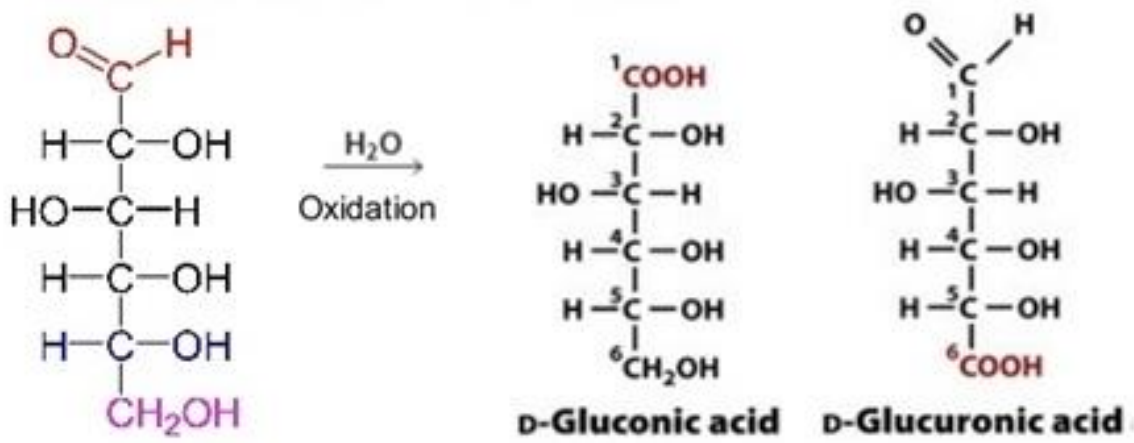


ii. Amino sugar – Hydroxyl group is replaced by an amino or acetylamino group.

Example: Glucosamine, Galactosamine.



iii. Sugar-acid – Aldehyde group at C1 or Hydroxyl group at C6 is oxidized to produce sugar acid. Example: Ascorbic acid, Glucuronic acid (oxidation of glucose), Galacturonic acid (oxidation of galactose)



iv. Sugar alcohol – Carbonyl group reduced to the hydroxyl group to form sugar alcohols Example: *G*lycerol and Mannitol (present in brown algae).

Oligosaccharides:

These consist of more than one but fewer number of monosaccharide molecules joined together by glycosidic bonds. On hydrolysis, they yield the monosaccharide units which may be similar or dissimilar.

Polysaccharides:

These consist of a large number of (often thousands) monosaccharide units to form branched or unbranched chains. These can be hydrolysed to yield monosaccharide units which are usually similar.