Republic of Iraq Ministry of Higher
Education & Scientific Research
University of Al-Maarif
College of Dentistry

Carbohydrates

Lec(11)

First stage

By

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Carbohydrates (glycans) have the following basic composition:

$(CH_2O)_n$ or 

- Monosaccharides - simple sugars with multiple OH groups. Based on number of carbons (3, 4, 5, 6), a monosaccharide is a triose, tetrose, pentose or hexose.
- Disaccharides - 2 monosaccharides covalently linked.
- Oligosaccharides - a few monosaccharides covalently linked.
- Polysaccharides - polymers consisting of chains of monosaccharide or disaccharide units.

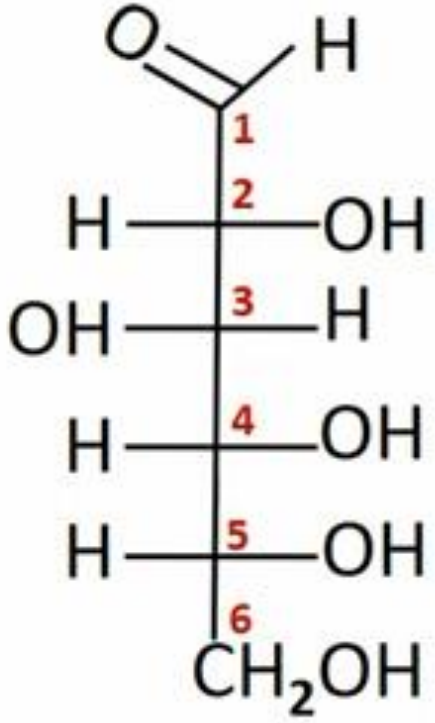
- Carbohydrates are “Sugars” or “Saccharides” consist of the empirical formula $(CH_2O)n$ where $n \geq 3$.
- Empirical formula, Molecular formula, Structural formula

Carbohydrates

C **H2O**

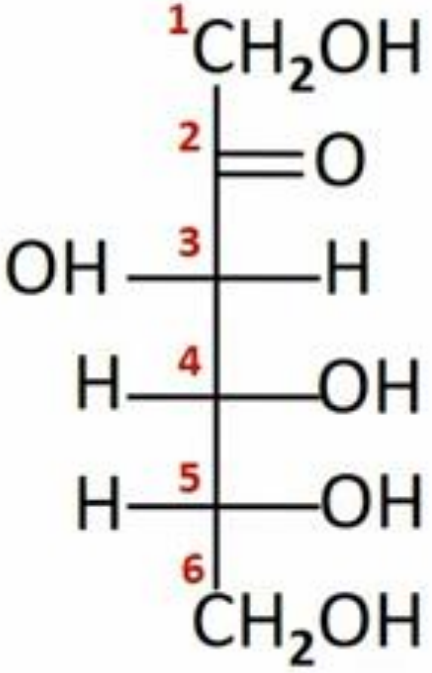
Monosaccharides

Hexose $C_6H_{12}O_6$



D-glucose

"grape or blood sugar"

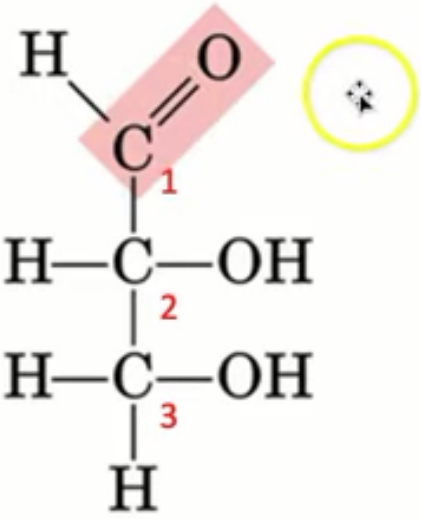


D-fructose

"fruit sugar"

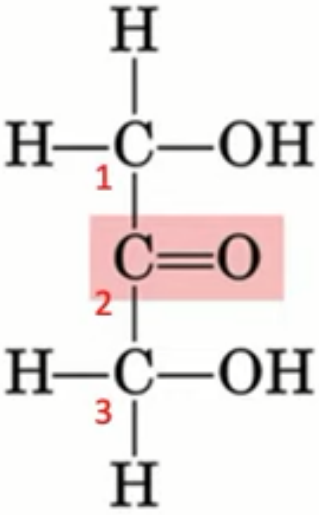
Carbohydrates

- Smallest molecules are called trioses
- Carbonyl on end carbon = aldehyde
- Carbonyl in middle = ketone
- Suffix –OSE means carbohydrate
- Aldehydes are more reactive



Aldose

D-Glyceraldehyde



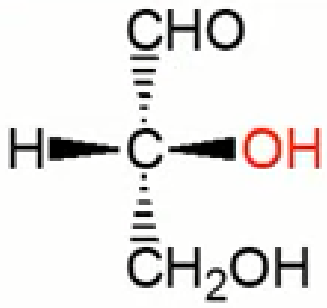
Ketose

Dihydroxyacetone

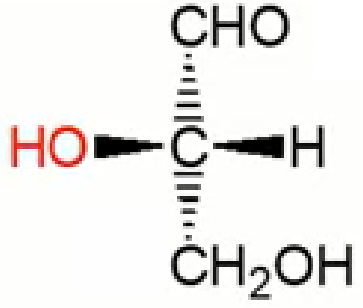
D vs L Designation

D & L designations are based on the configuration about the single asymmetric C in glyceraldehyde.

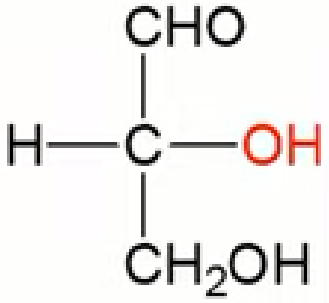
The lower representations are Fischer Projections.



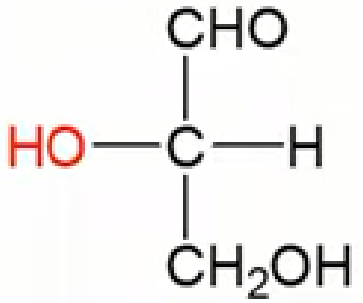
D-glyceraldehyde



L-glyceraldehyde



D-glyceraldehyde

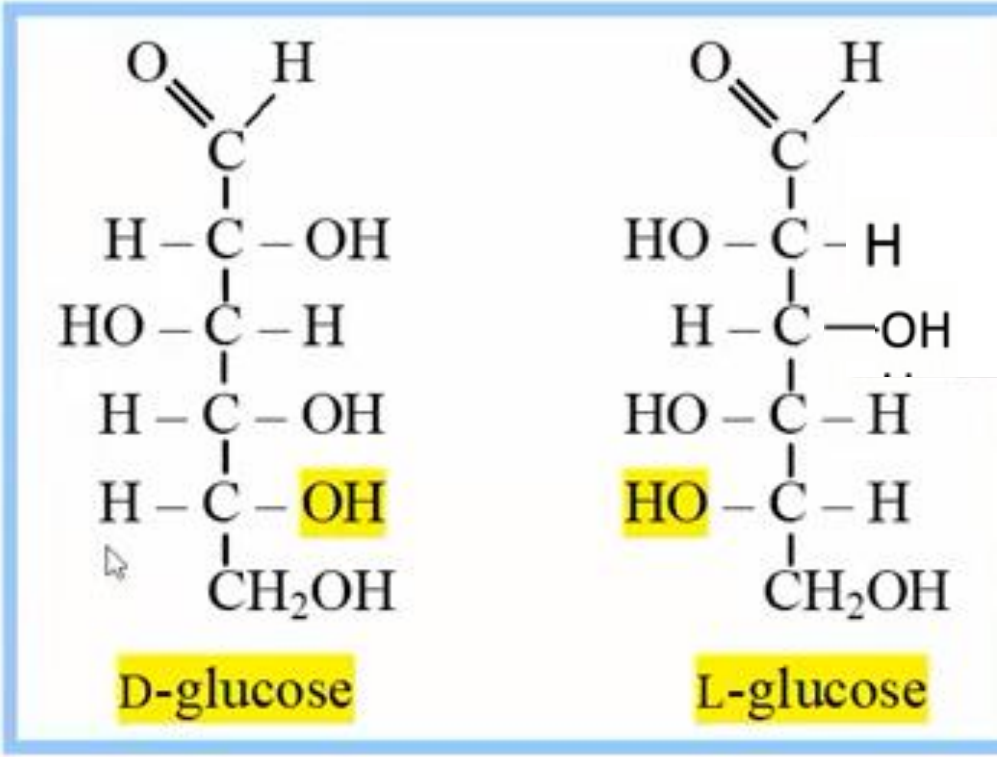


L-glyceraldehyde

D & L sugars are mirror images of one another.

They have the same name, e.g., D-glucose & L-glucose.

Other stereoisomers have unique names, e.g., glucose, mannose, galactose, etc.



The number of stereoisomers is 2^n, where n is the number of asymmetric centers.

The 6-C aldoses have 4 asymmetric centers. Thus there are 16 stereoisomers (8 D-sugars and 8 L-sugars).

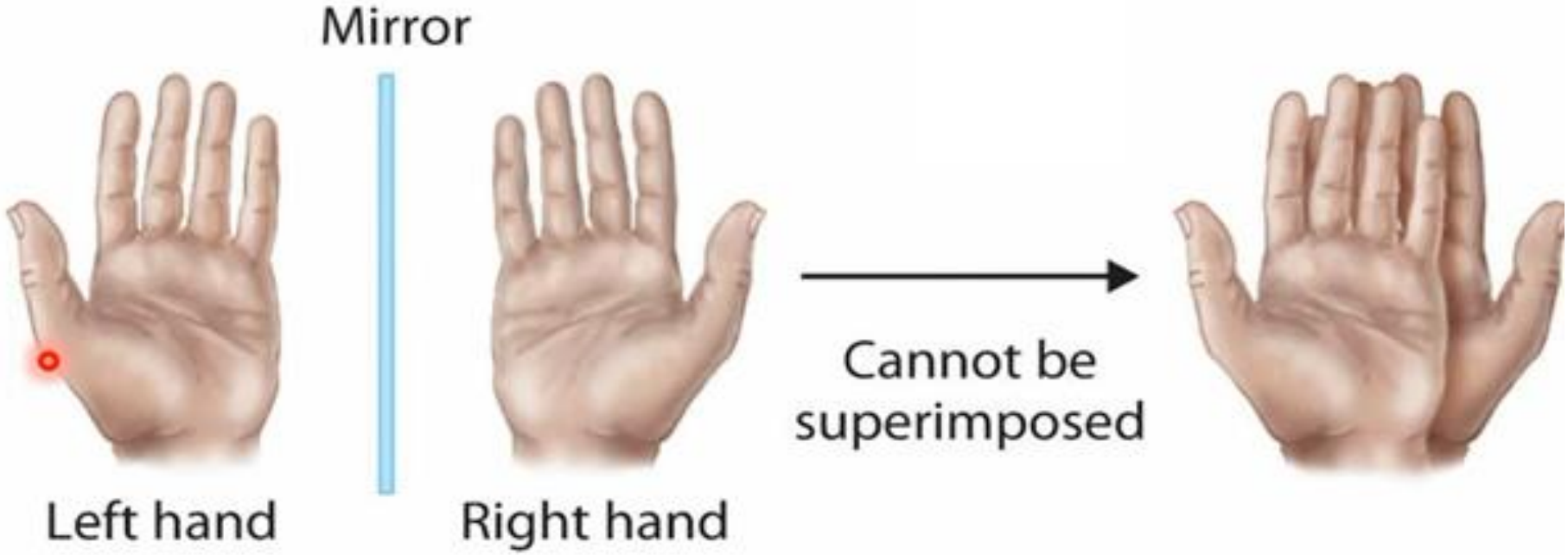
Isomerization

- Isomers: are molecules with same molecular formula but different chemical structures

1. Constitutional (structural) isomers: atoms and functional groups bind together in different ways (e.g. glucose and fructose)
2. Stereroisomers (spatial isomers): differ in the configuration of atoms in space rather than the order of atomic connectivity

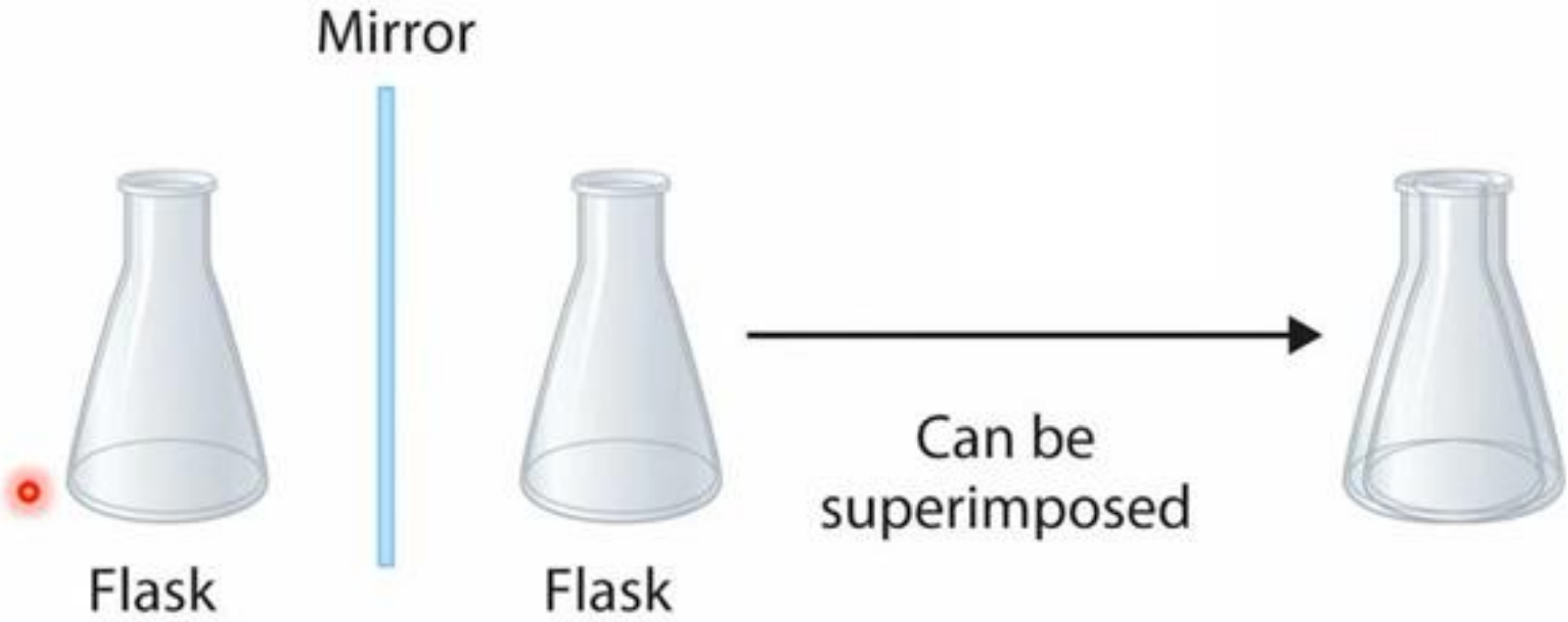
   - Chiral carbon: asymmetric carbon atom attached to 4 different groups of atoms
   - The number of stereoisomers for any given molecules = 2^n where n represents the number of chiral centers

Chirality & Chiral Object



(a) Chiral objects

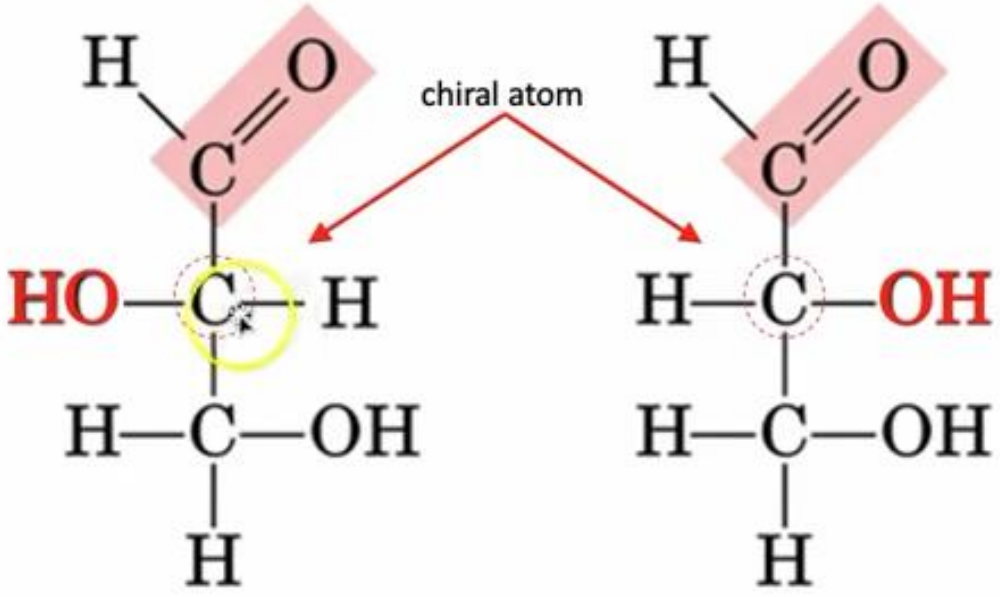
Chirality & Chiral Object



(b) Achiral objects

Chirality and Enantiomers

- Chiral = 4 different bonded groups/atoms
- Thus you can have stereoisomers basically all saccharides
- Enantiomers = mirror images



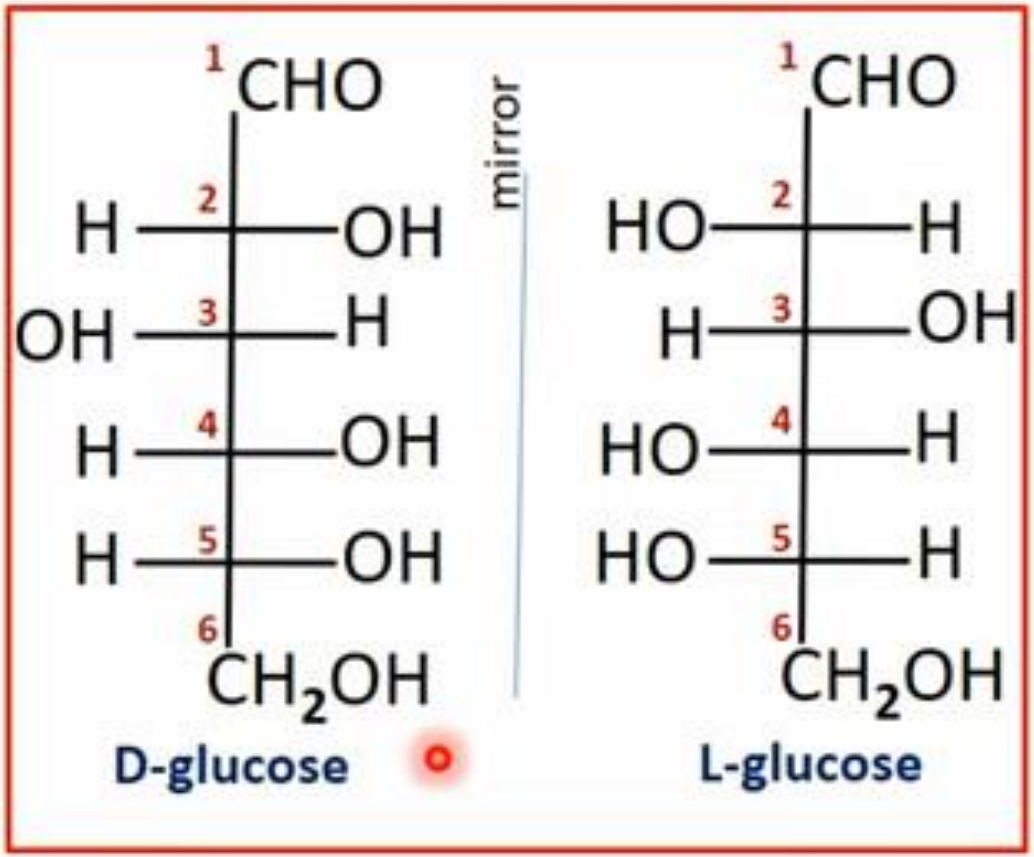
L-Glyceraldehyde

Laevo (-); S

D-Glyceraldehyde

Dextro (+); R

D/L Monosaccharides

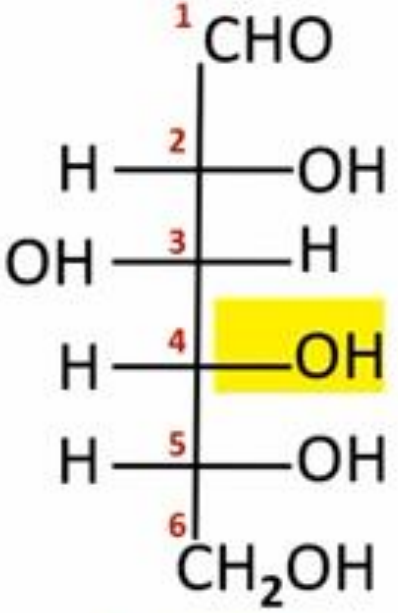


Isomerization

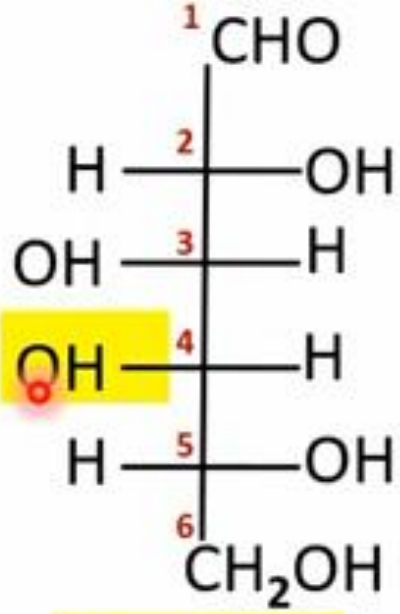
- Enantiomers: are two stereoisomers that are mirror images to each other but not superimposable
- **D-** (dexter)/**L-** (laevus) Nomenclature system: commonly used to assign the configurations in sugars and amino acids
  - As a rule of thumb: if the farthest chiral atom from the highest oxidized carbon (i.e. carbonyl group) has –OH group on the right-hand side, the configuration is assigned as **D** but If it is on the left-hand side, the sugar is designated as **L**
- Most naturally occurring sugars are D-isomers (biologically active form)

Monosaccharides

- Epimers: are stereoisomers that differ in the configurations of atoms at **only** one chiral center (i.e. chiral carbon in CHO). They are not mirror image isomers.

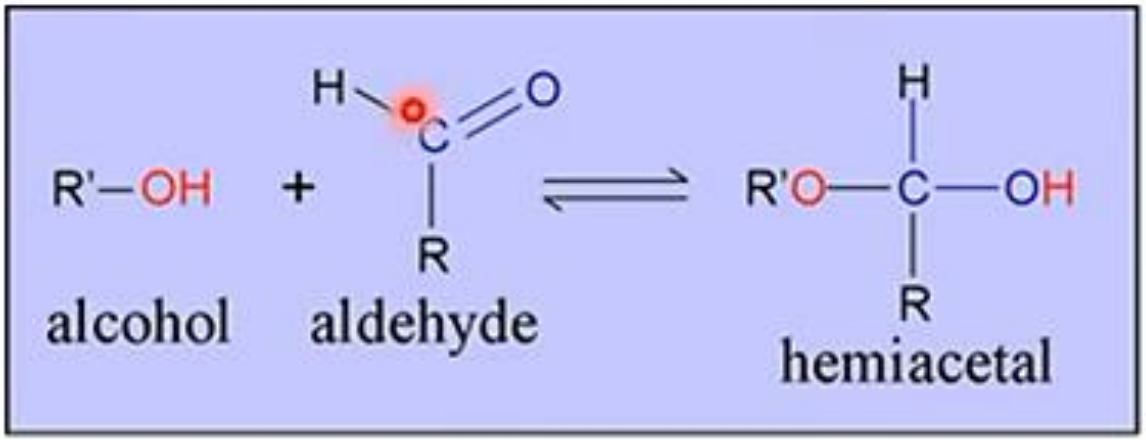


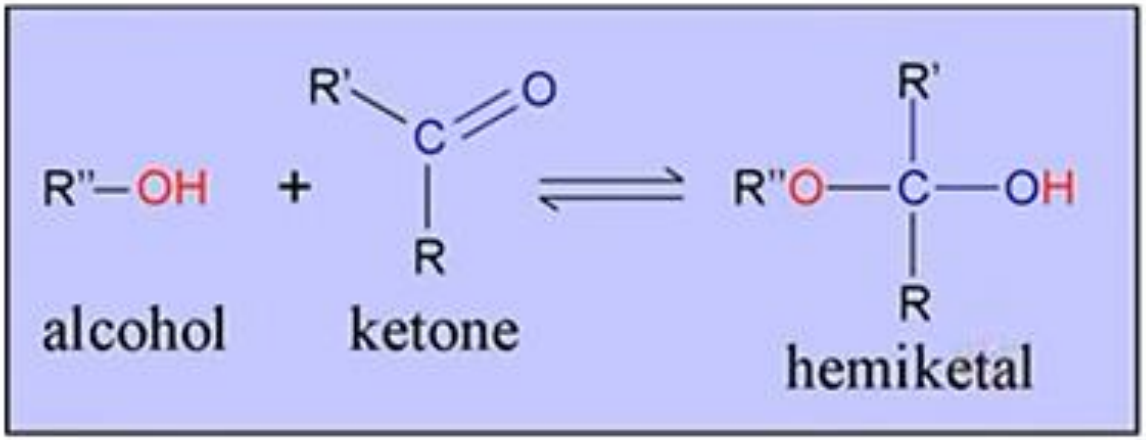
D-glucose



D-galactose

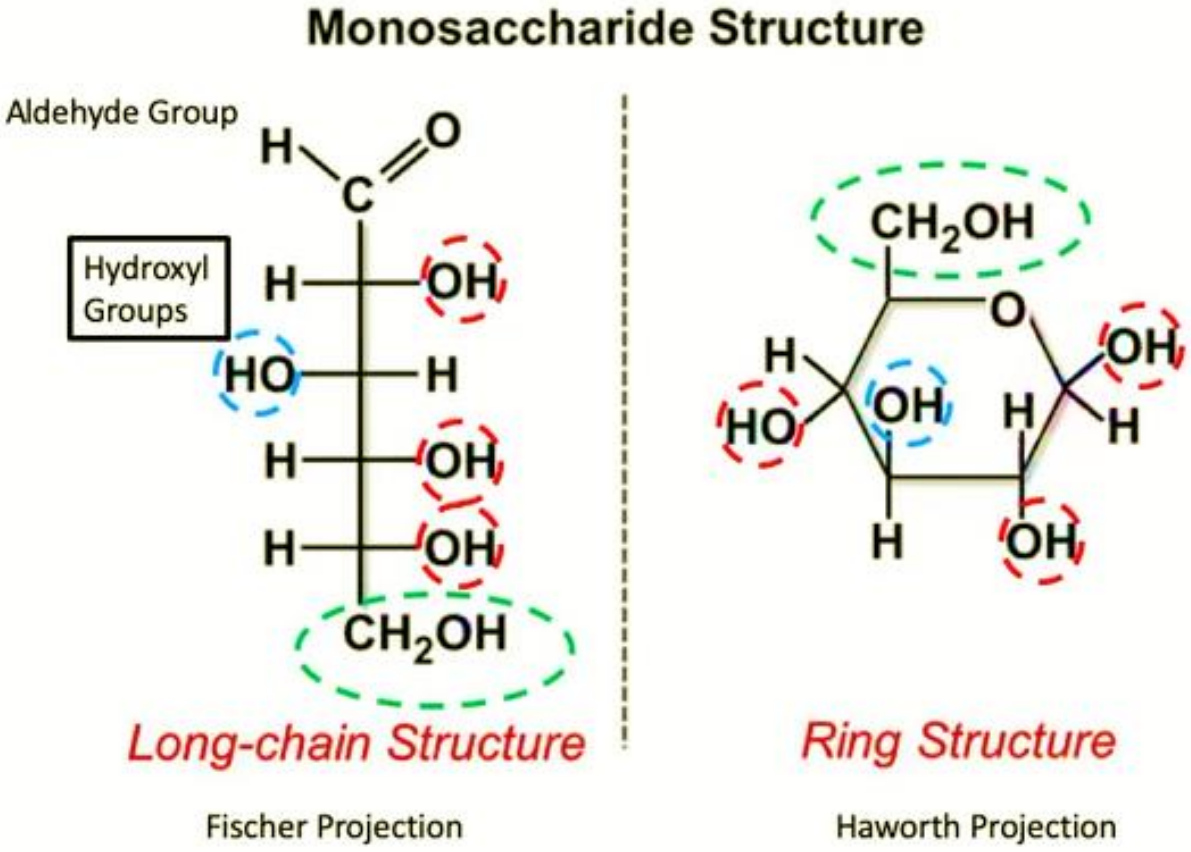
Hemiacetal & Hemiketal



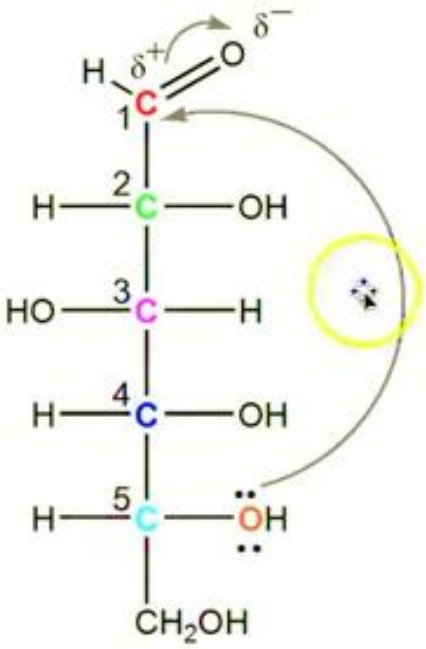


Sugars: Monosaccharide

- Any sugar that cannot be hydrolyzed to simpler sugars



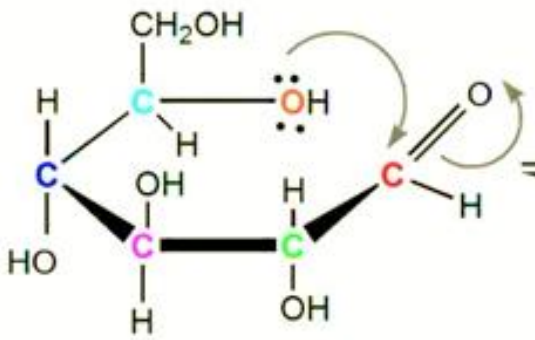
Formation of D-Glucose



up on the ring | down on the ring

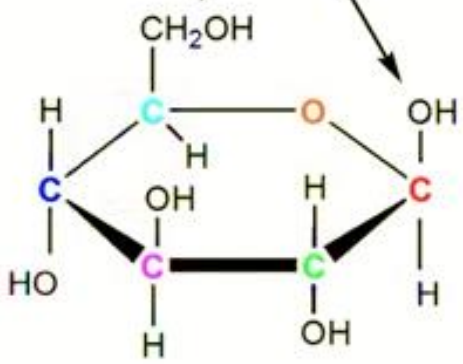
D-Glucose

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

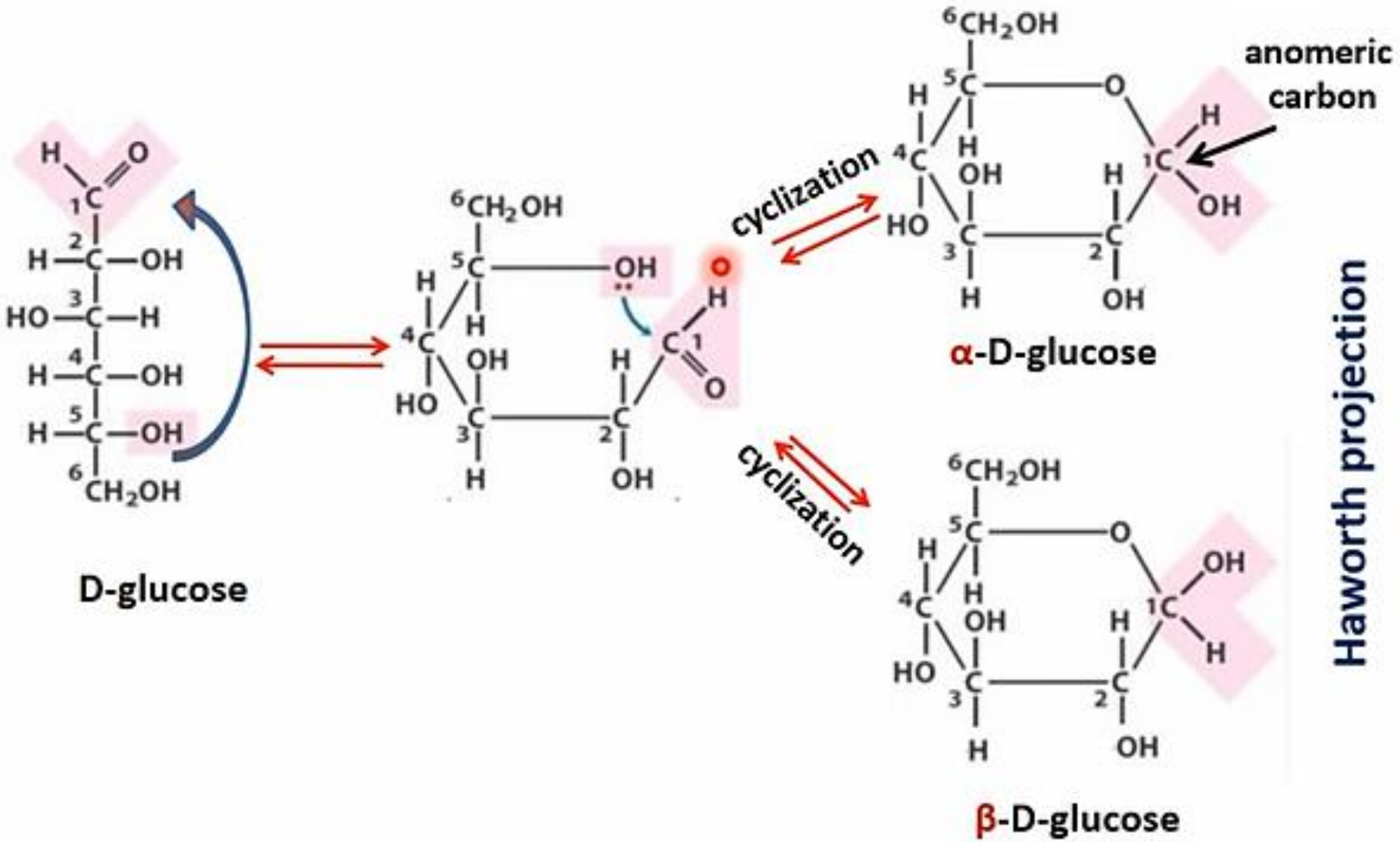


β-D-Glucopyranose

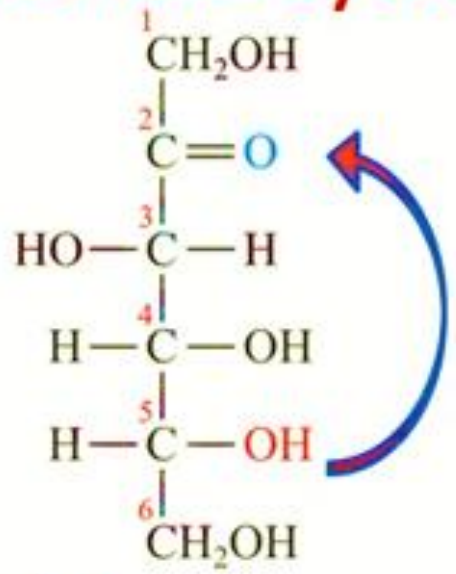
(hemiacetal of D-glucose)

Haworth projection

Monosaccharide cyclization



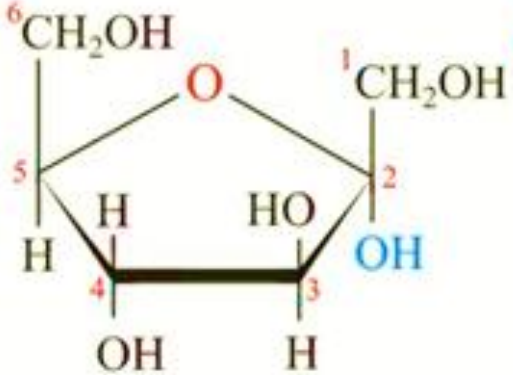
Monosaccharide cyclization



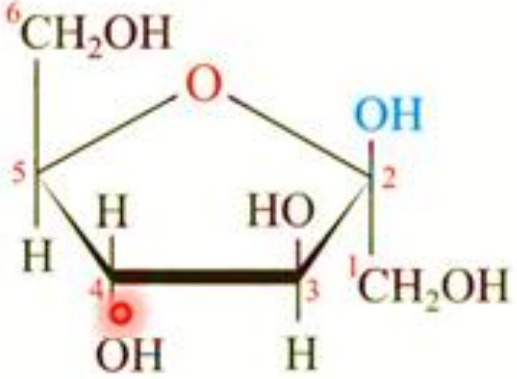
D-fructose
Linear form

cyclization

cyclization



α-D-fructose



β-D-fructose