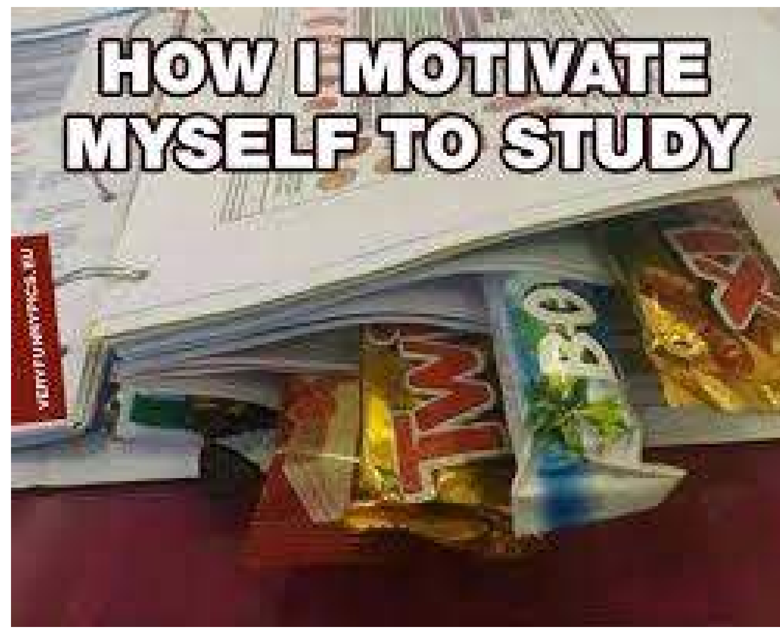
Carbohydrates
السكريات

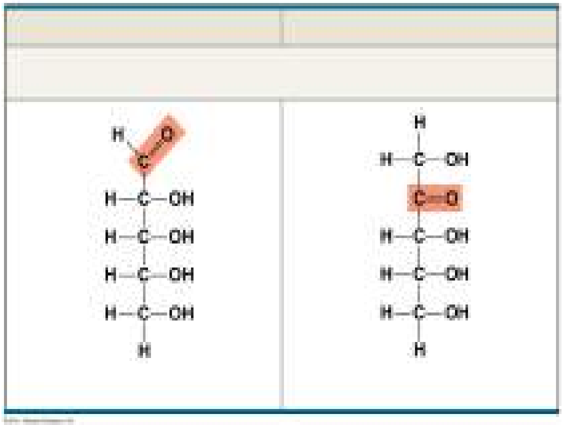


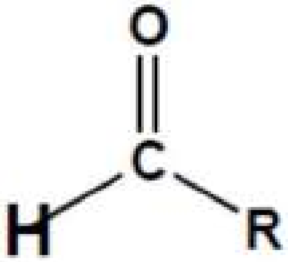
Carbohydrates

- Carbohydrate (or Saccharides) are essential components of all living organisms. Carbs are the most abundant organic compounds in the plant world. They act as storehouses of chemical energy (glucose, starch, glycogen).

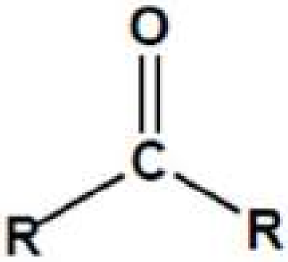
⟶ Carbs are the body's main source of **fuel**, needed for physical activity, brain function and operation of the organs.

- **Carbohydrate:** are polyhydroxyaldehyde or polyhydroxyketone, or a substance that gives these compounds on hydrolysis



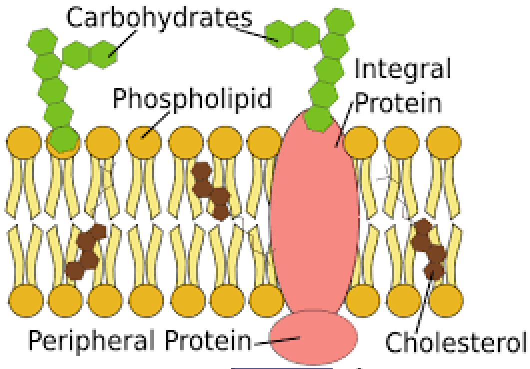


Aldehyde



Ketone

أهمية الكربوهيدرات



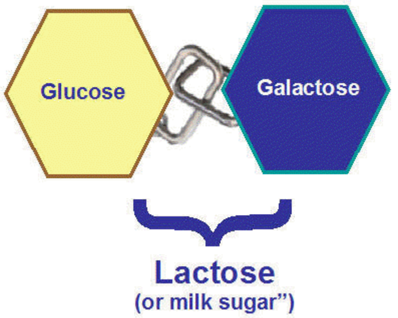
أهمية الكربوهيدرات الفيزيولوجية

- تعمل كمصدر للطاقة في الخلية الحية
- تعمل كوحدات تركيبية لجدار وغشاء الخلية
- تدخل في تركيب الحموض النووية
- تدخل في تركيب حموض أمينية يحتاجها الجسم ولا تكون متوفرة في الغذاء (و ذلك عن طريق إضافة مجموعة أمين للحمض الكيتوني الكربوهيدراتي)
- تكون الغليكوجين الموجود في الكبد والعضلات والذي يستخدم لإنتاج الطاقة عند الحاجة
- الفائض منها يعمل على تكوين شحوم الجسم والذي بدوره يستخدم لإنتاج الطاقة

Classification of Carbohydrates

Carbohydrate may be divided initially into three principal groups:

- sugars: - Monosaccharide: glucose, galactose
  - Disaccharide: sucrose and lactose
- Oligosaccharides: amylose, maltodextrins(3-10)
- Polysaccharides: cellulose, pectins (>10)

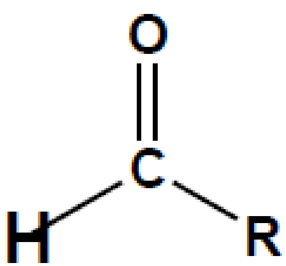


Carbohydrates

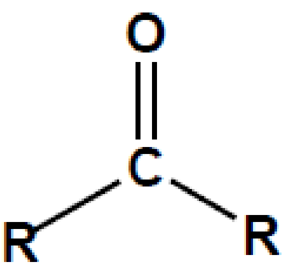
- Building blocks of all carbohydrates are the **Monosaccharide**

They have the general formula $\mathbf{C}n\ (\mathbf{H_2O})n$

- **Aldose :** a monosaccharide containing an aldehyde group
- **Ketose :** a monosaccharide containing a ketone group



Aldehyde



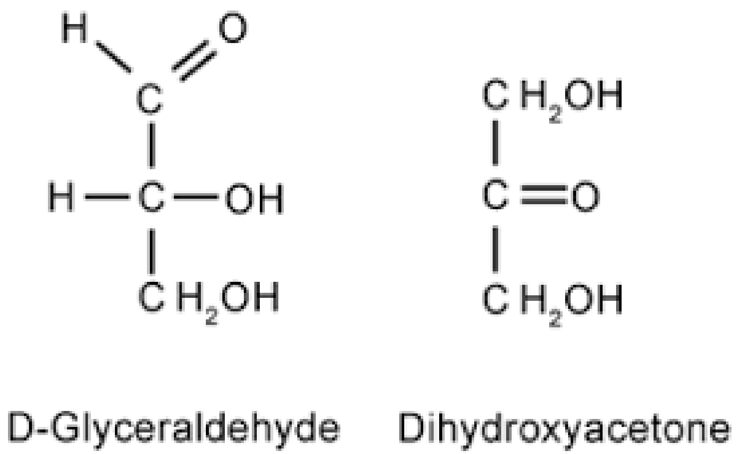
Ketone

Monosaccharides

Monosaccharides are carbohydrates that *cannot be hydrolyzed* to simpler carbohydrate; eg. Glucose or fructose

They are further classified according to:

- The number of carbon atoms in its backbone
- The functioning group (aldehyde or ketone)



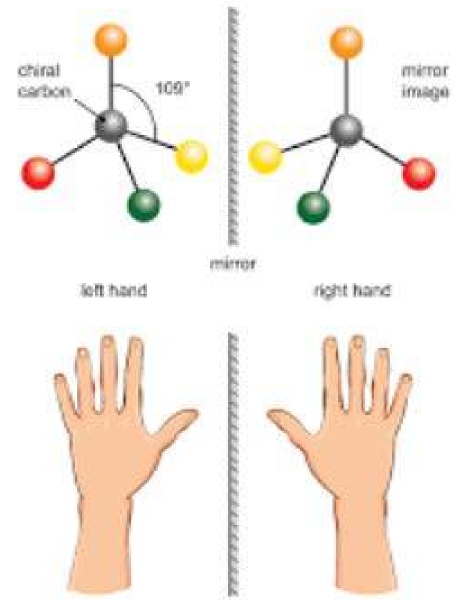
Monosaccharids Classification (by C atoms)

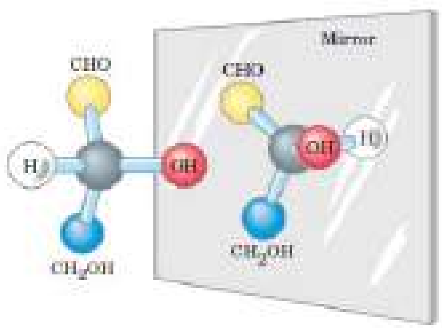
	Sugar	Structure formula	Aldoses	Ketoses
1.	Triose	$C_3H_6O_3$	Glyceraldehydes	Dehydroxy acetone
2.	Tetroses	$C_4H_8O_4$	Erythrose, Threose	Erthrulose
3.	Pentoses	$C_5H_{10}O_5$	Xylose Ribose Arabinose	Ribulose
4.	Hexoses	$C_6H_{12}O_6$	Glucose Galactose Mannose	Fructose

1- Sterioisomerism :خصائص السكريات الأحادية

- Sugars can exhibit isomerism due to the presence of asymetric carbon atom.
- Asymetric C-atom - refers a carbon containing four different atom or group.
- **Isomers** are molecules having same molecular formulas but differ in arrangement of their atoms.

isomers :الزمراء أو المصاوغات





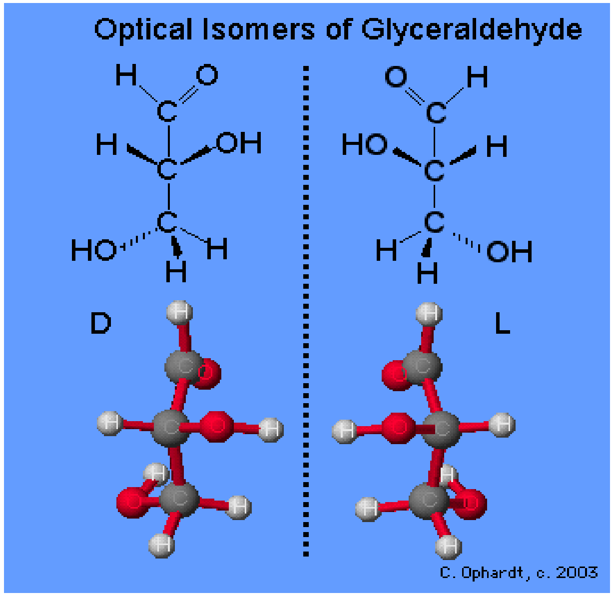
Ball-and-stick models

Monosaccharides

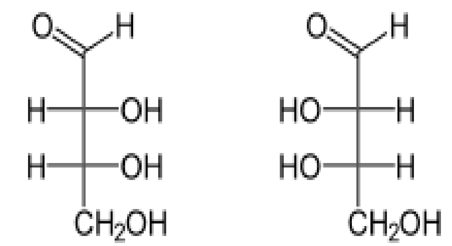
Glyceraldehyde contains a stereocenter مركز فراغي and exists as a pair of *enantiomers* مصاوغات ضوئية *(مشابهات)*

- Mirror-images stereoisomers مصاوغات فراغية

  are called enantiomers

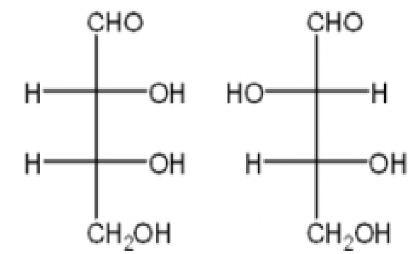


- **Enantiomers:** stereoisomers متزامرات فراغية that are <u>mirror images</u>
  - example: D-erythrose and L-erythrose are enantiomers



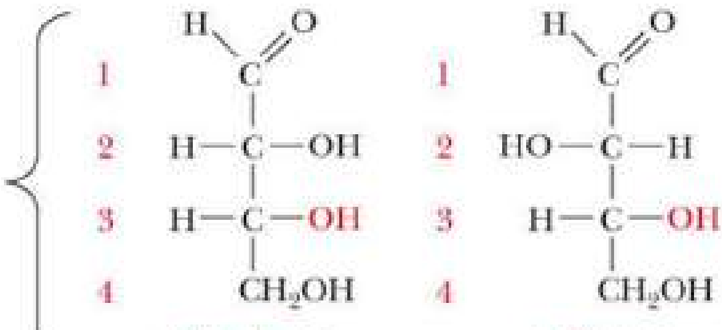
D-Erythrose L-Erythrose

- **Diastereomers:** stereoisomers that are <u>not mirror images</u>
  - example: D-erythrose and D-threose are diastereomers



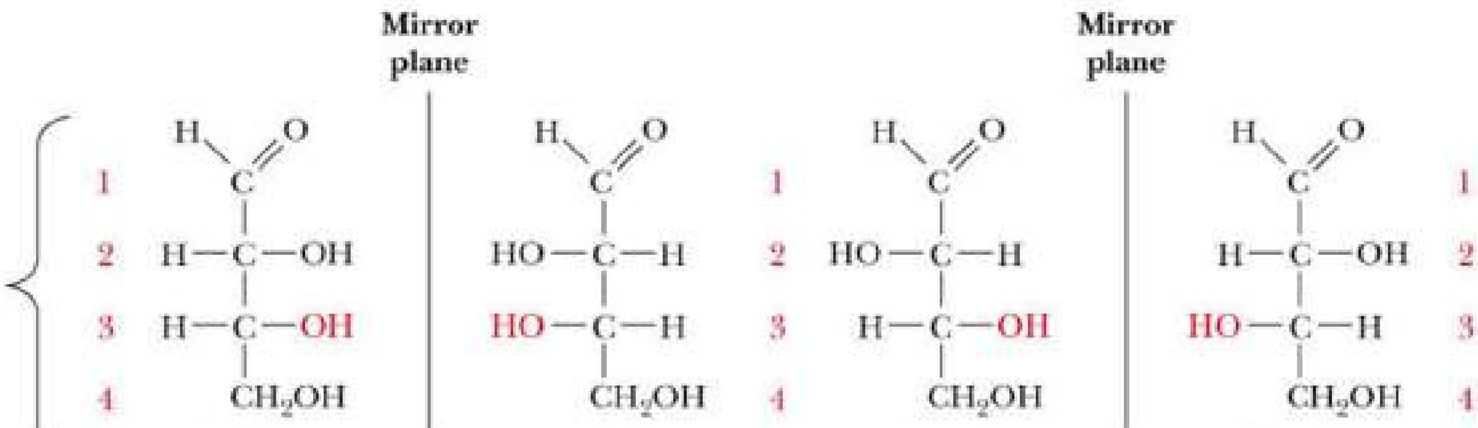
D-Erythrose D-Threose

A Diastereomers D-erythrose and D-threose.

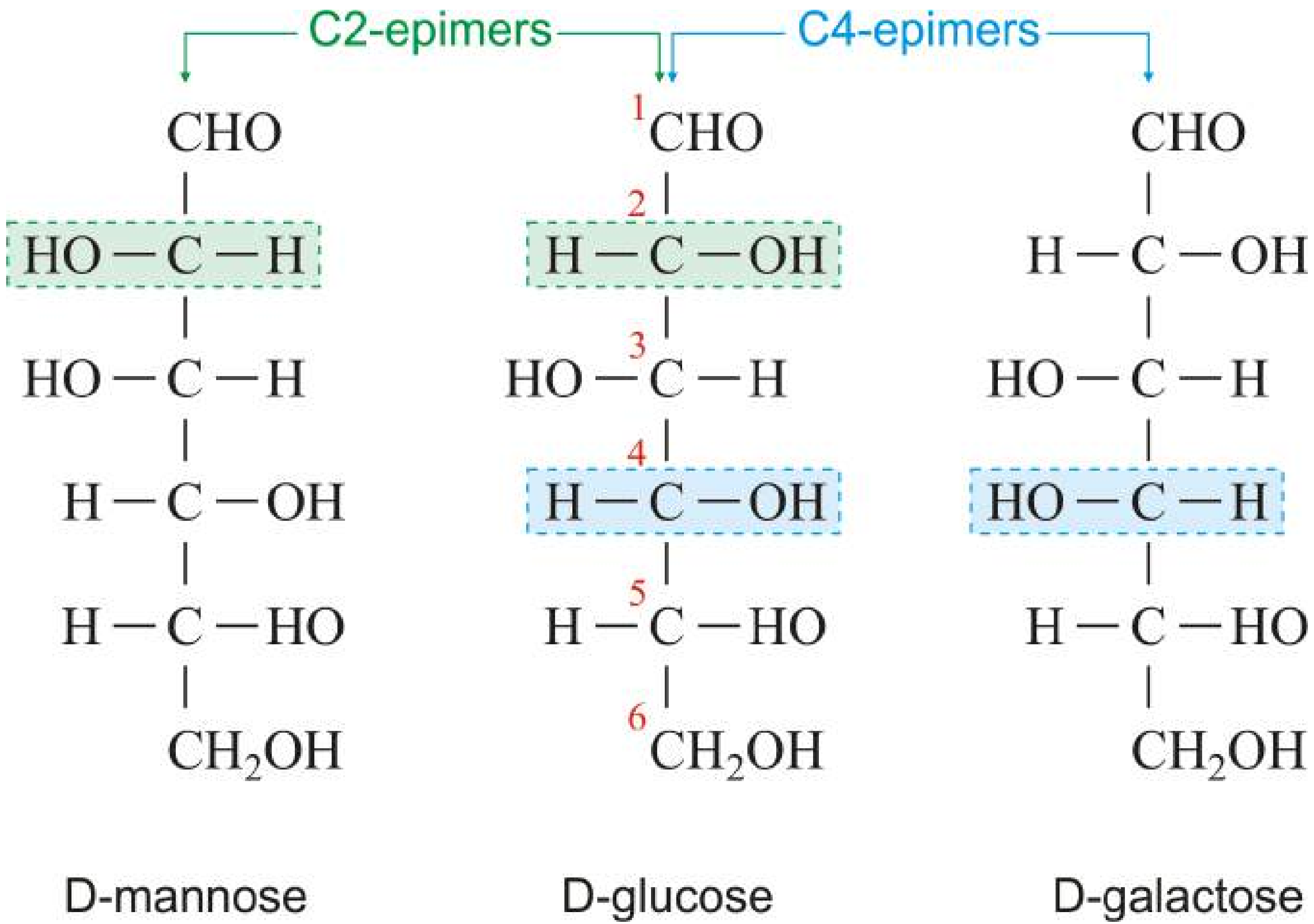


D-Erythrose D-Threose

B Enantiomers D- and L-erythrose and D- and L-threose. The carbons are numbered. The designation of D or L depends on the configuration at the highest-numbered chiral carbon atom.



D-Erythrose L-Erythrose D-Threose L-Threose


C2-epimers
C4-epimers
CHO
HO—C—H
HO—C—H
H—C—OH
H—C—HO
CH2OH
1 CHO
2 H—C—OH
3 HO—C—H
4 H—C—OH
5 H—C—HO
6 CH2OH
CHO
H—C—OH
HO—C—H
HO—C—H
H—C—HO
CH2OH
D-mannose
D-glucose
D-galactose

2- Optical Activity

The compounds having asymmetric carbon atoms can rotate the beam of plane polarized light and are said to be optically active فعالة ضوئيا

An isomer which can rotate the plane of polarized light to the right is called as dextrorotatory (+), and is designated as (d)

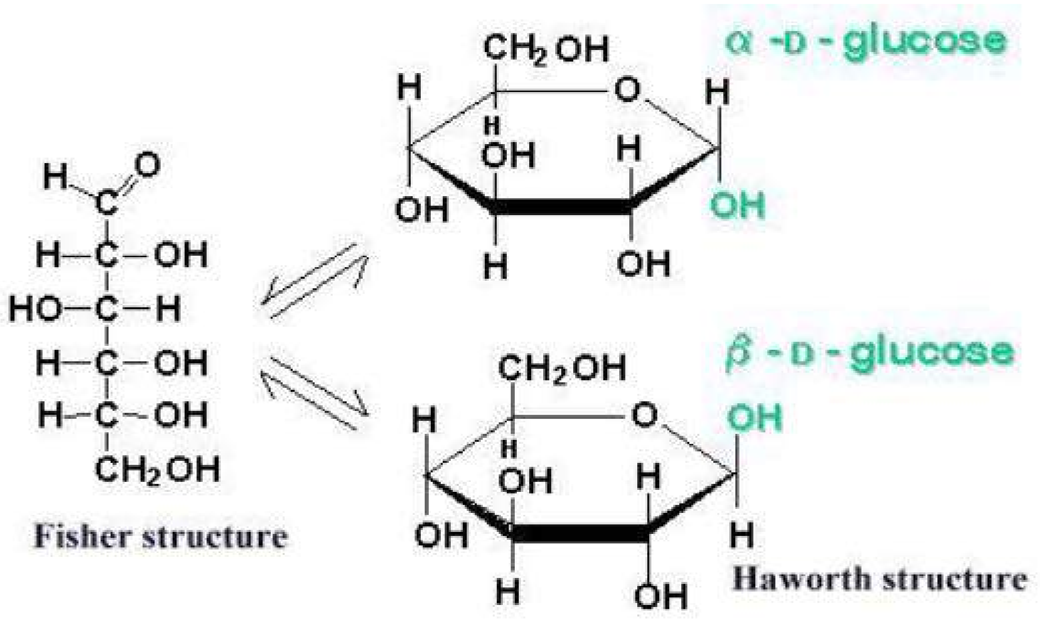
Example: D- (d)-glucose or it is also known as dextrose

While the isomer which rotates the plane of polarized light to left is known as levorotatory (-), and is identified as (l)

Example: D-(l)-fructose

Cyclization of Sugars

In solutions, less than 1% of a sugar will be in the linear form (**Fischer structure)**. Over 99% of the sugar will be in a cyclic ring structure represented by (**Haworth structures)**.



Fischer Projections

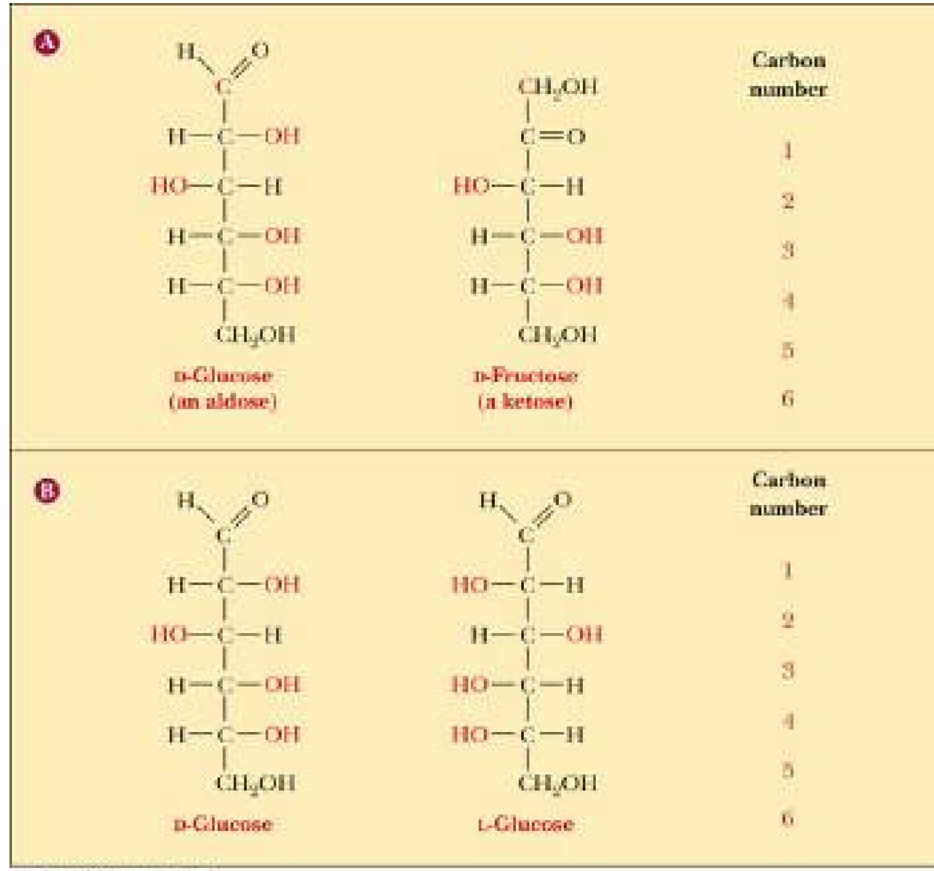
- **Fischer projection:**

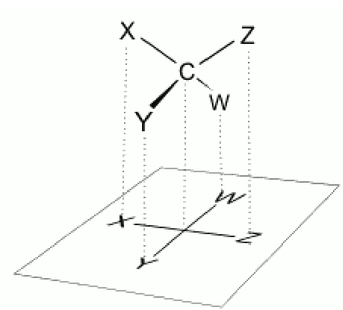
Open chain (in a line)

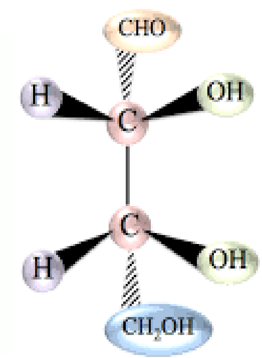
تمثيل ثنائي الأبعاد لمركب عضوي ثلاثي الأبعاد عن طريق الإسقاط:

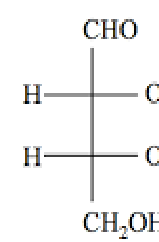
horizontal lines represent bonds projecting forward

- vertical lines represent bonds projecting to the rear









D,L Monosaccharides

According to the conventions proposed by Fischer:

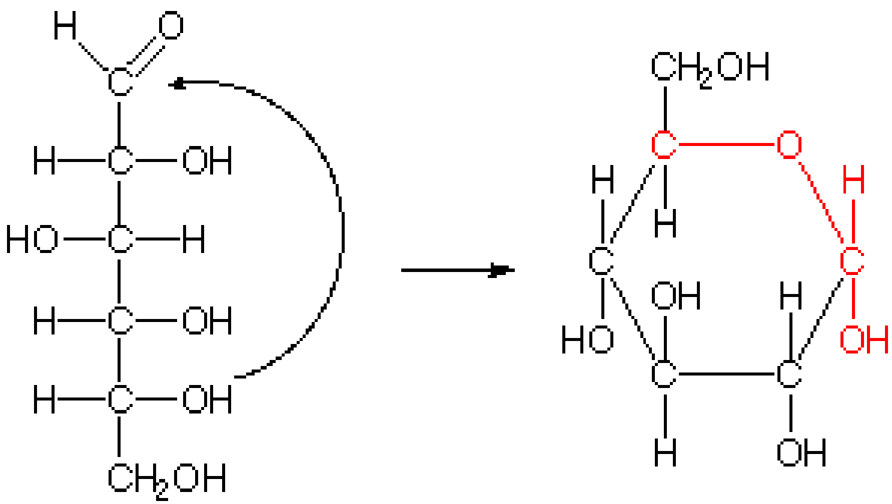
- **D-monosaccharide:** a monosaccharide that, when written as a Fischer projection, has the -OH on its penultimate carbon on the right
- **L-monosaccharide:** a monosaccharide that, when written as a Fischer projection, has the -OH on its penultimate carbon on the left

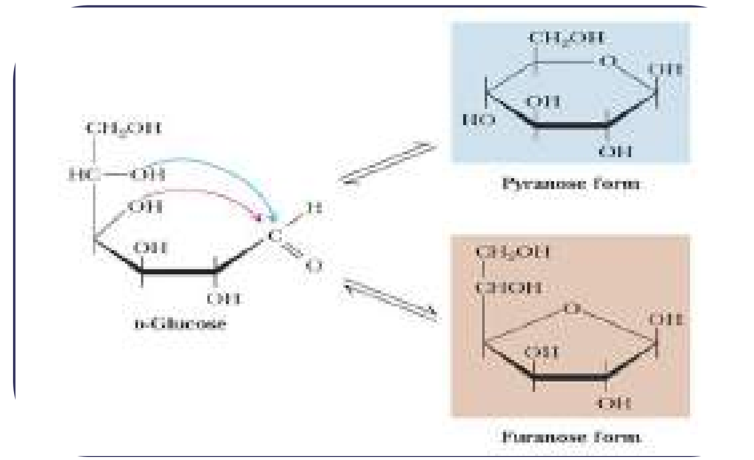
What Happens if a Sugar Forms a Cyclic Molecule?

- Cyclization of sugars takes place due to interaction between functional groups on distant carbons, C1 to C5, to make a cyclic **hemiacetal**
- Cyclization using C2 to C5 results in **hemiketal** formation.
- In both cases, the carbonyl carbon is new chiral center and becomes an **anomeric carbon**

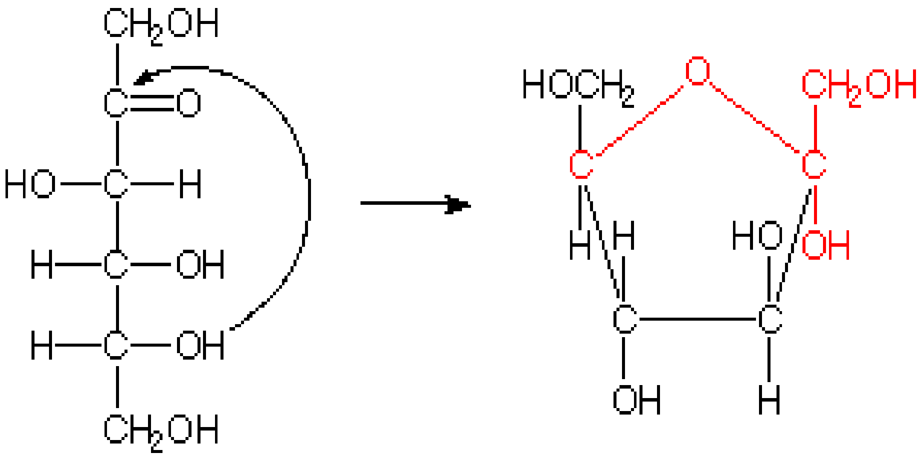
ALDEHYDE sugar or aldoses + alcohol --- hemiacetal (cyclic ring)
KETONE sugar or ketoses + alcohol --- hemiketal (cyclic ring)

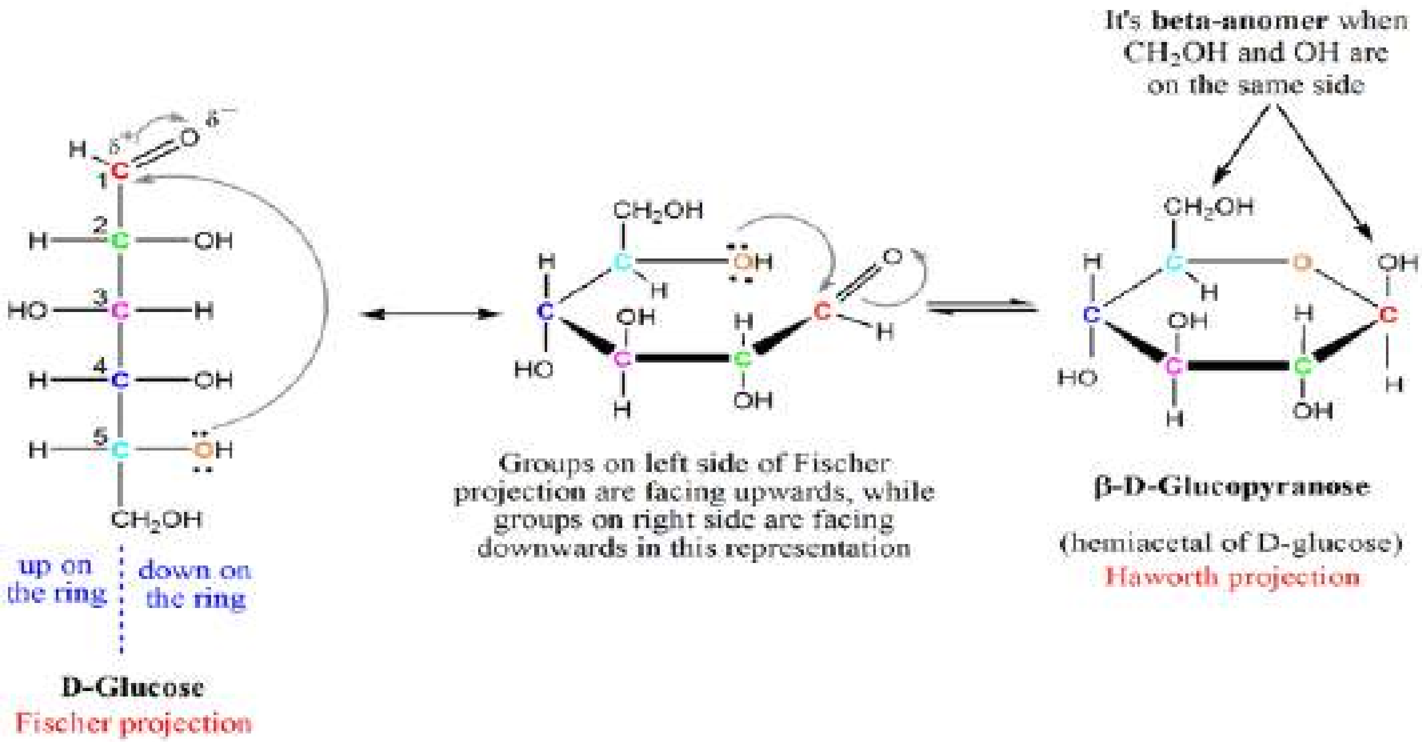
hemiacetal

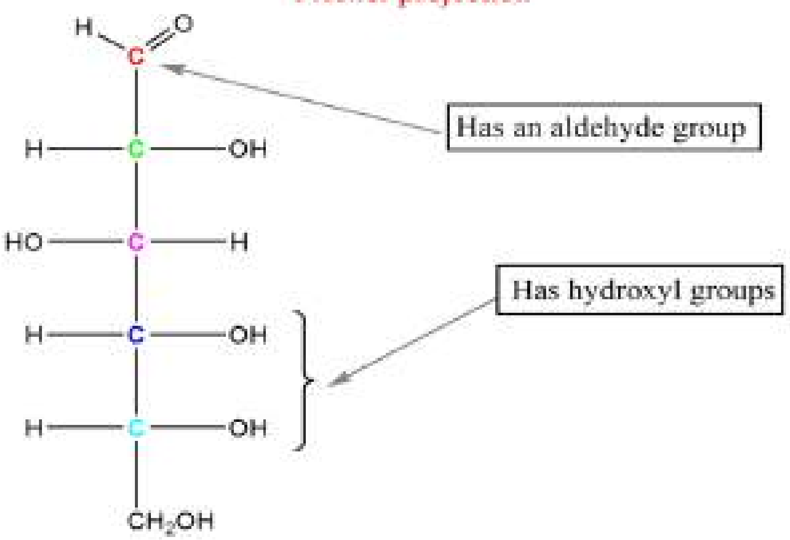




hemiketal







cyclic ***hemiacetals*** ***and*** ***hemiaketals, are formed when an alcohol oxygen atom adds to the carbonyl carbon atom of an aldehyde or a ketone***

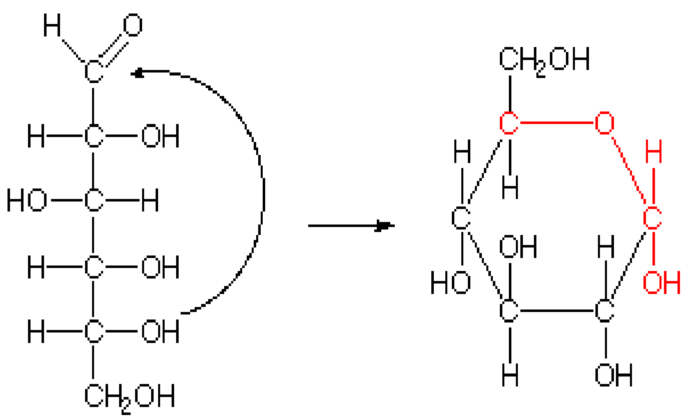
Cyclic Structure

- Monosaccharides have -OH and `C=O groups in the same molecule and exist almost entirely as five- and six-membered cyclic hemiacetals
  - **anomeric carbon الكربونيلي المصاوغ:** the new stereocenter مركز فراغي resulting from cyclic hemiacetal formation
  - **anomers:** carbohydrates that differ in configuration only at their anomeric carbons

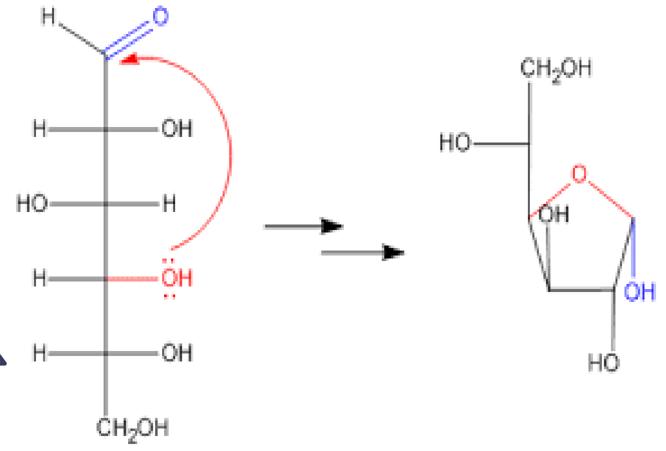
TRADE YOU LUNCHES?

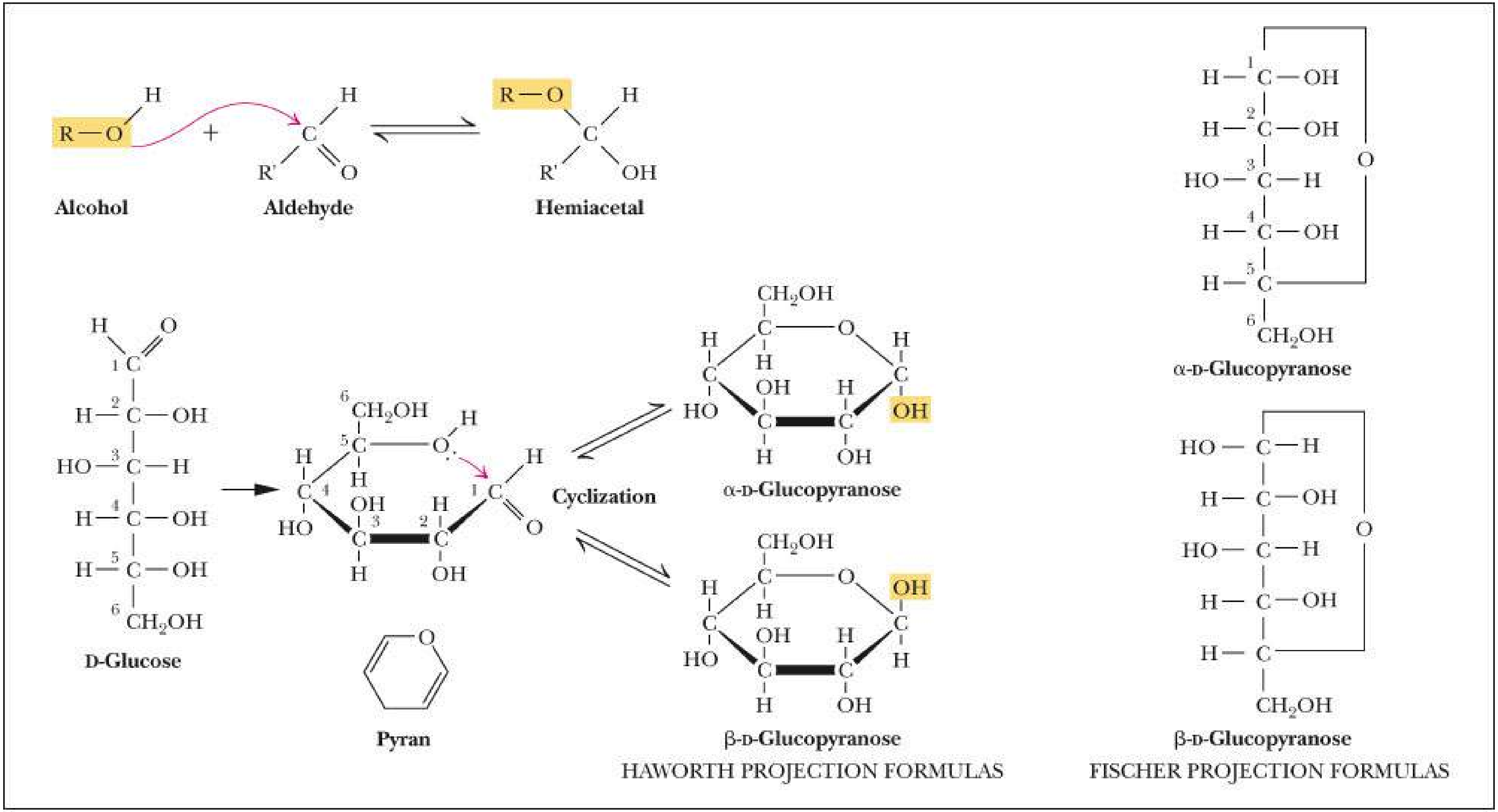
Haworth Projections

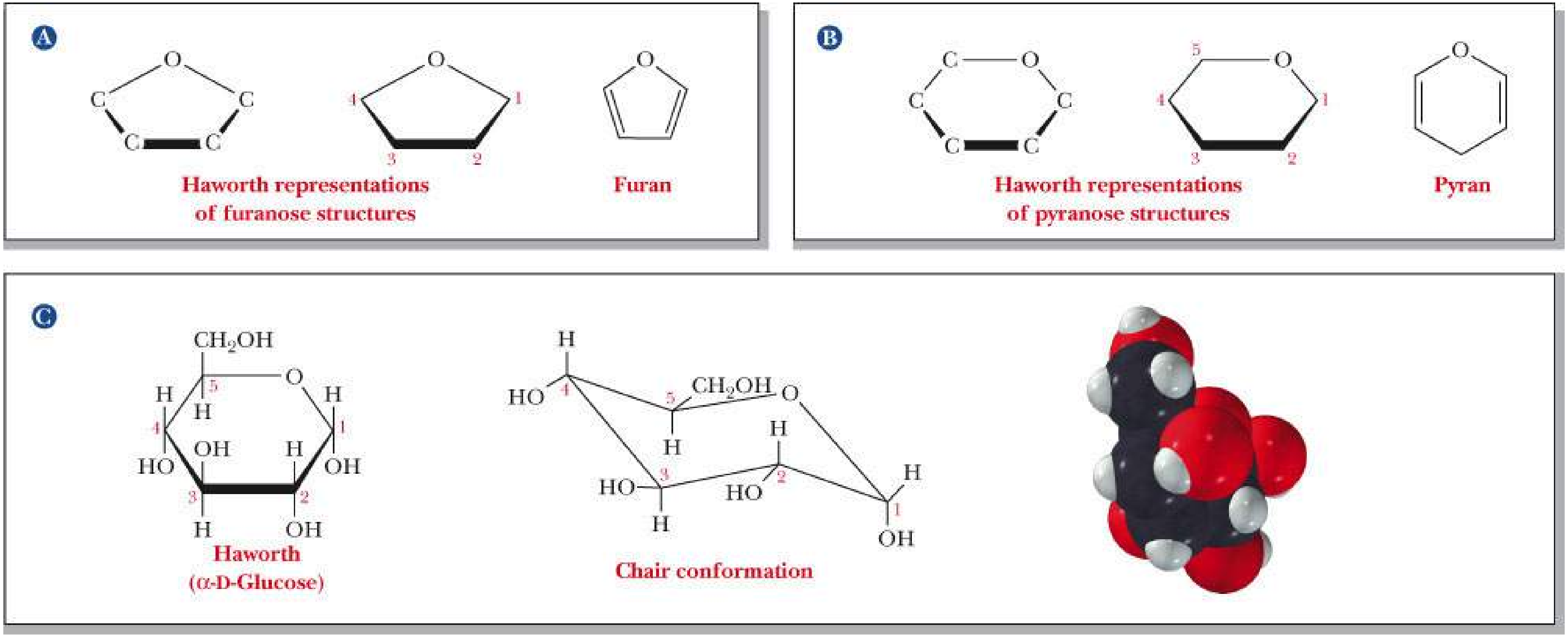
- A six-membered hemiacetal ring is shown by the infix -**pyran**- (pyranose)



- A five-membered hemiacetal ring is shown by the infix -**furan**- (furanose)

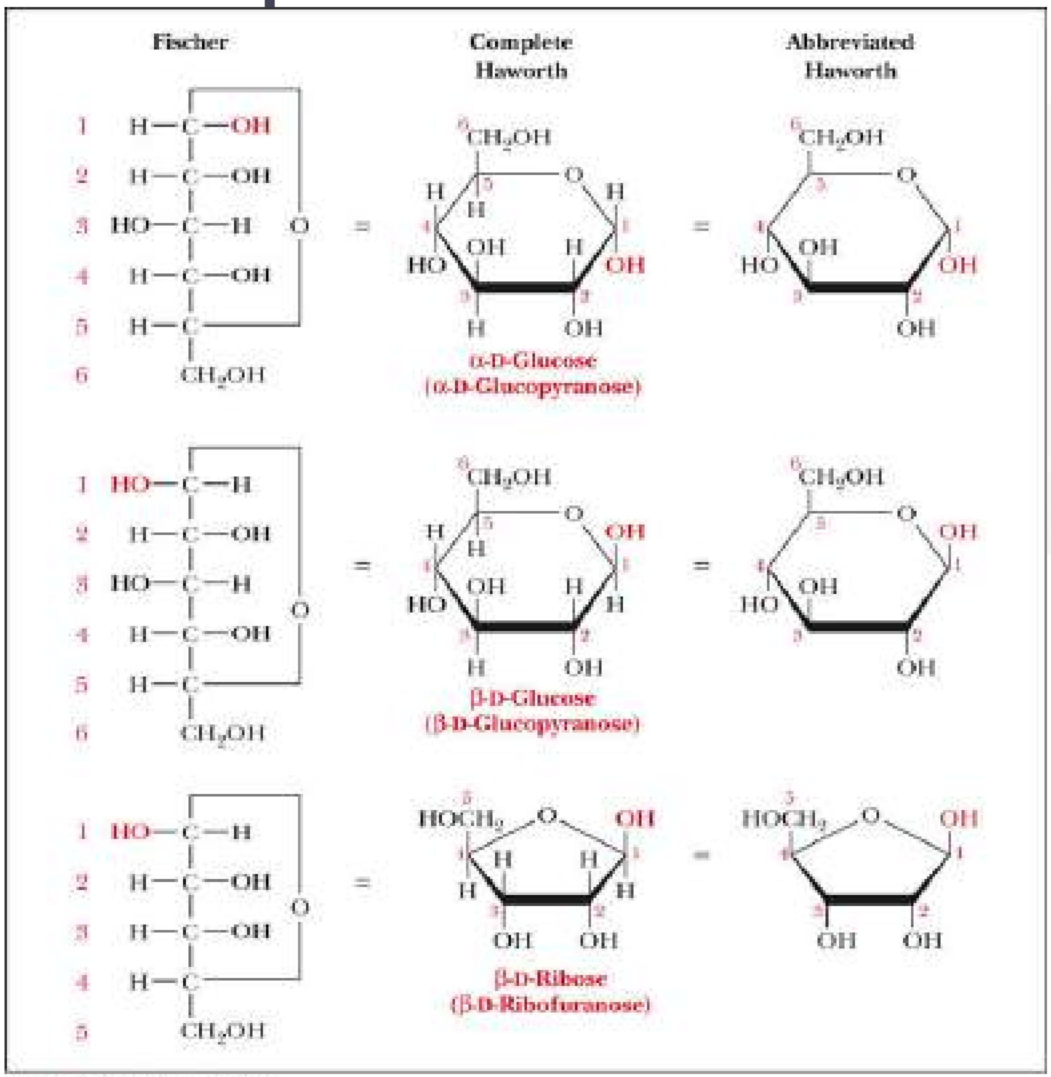


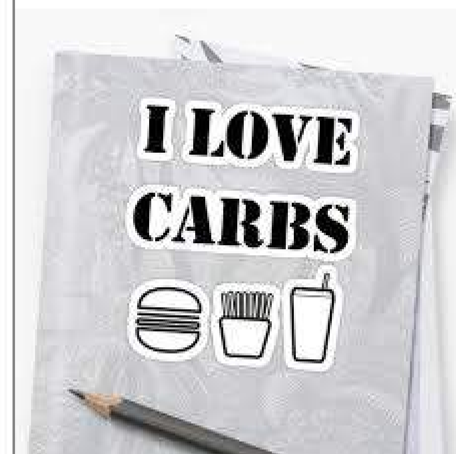

Alcohol
Aldehyde
Hemiacetal
D-Glucose
Pyran
Cyclization
α-D-Glucopyranose
β-D-Glucopyranose
HAWORTH PROJECTION FORMULAS
α-D-Glucopyranose
β-D-Glucopyranose
FISCHER PROJECTION FORMULAS



For pyranoses, the six-membered ring is more accurately represented as a strain-free chair conformation

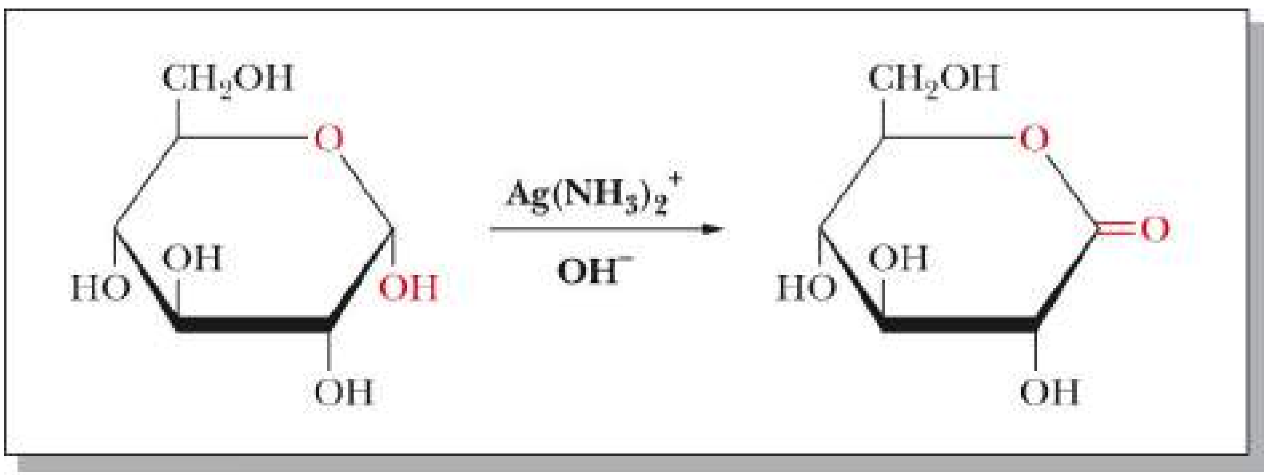
Comparison of the Fischer and Haworth Representations





3-Reactions of Monosaccharides

- **Reducing sugar:** one that reduces an oxidizing agent
  - When the oxidizing agent is Tollens solution (نترات الفضة والأمونيا), silver precipitates as a silver mirror



Reaction of Monosaccharides (Cont'd)

- The carbonyl group of a monosaccharide can be reduced to an hydroxyl group by a variety of reducing agents, such as $NaBH_4$