



# Carbohydrates

Summer semester 2023-2024

• يا إلهي، لا أدنسك استغاثتك، (يا كفا من الضلالين)  
• ربّي لي لي لما أنزلت لي من خير خبير.  
• اللهم صل على سيدنا محمد

# What are they?



- Carbohydrates are polyhydroxy aldehydes or ketones.
- Saccharide is another name for a carbohydrate

- Functions:

- Source of energy (glycogen and starch)
- Structure (cellulose and chitin)
- Building blocks (glycosaminoglycans)
- Cellular recognition (glycoproteins)

جزء  
رئيسي بالبناء

Can make larger Strads

\* Functional group here is Aldehyde  
or  
ketone  
+  
OH<sup>-</sup> group.

\* ترتيب قوسه في functional group  
① keton.  
② Aldehyde.  
③ OH<sup>-</sup>.

# Classification I



عدد جزئیات الی

سکات

- By the number of sugars that constitute the molecule
  - Monosaccharides, Disaccharides, Oligosaccharides, Polysaccharides



monosaccharide



2<sup>nd</sup> disaccharide



oligosaccharide

(chain containing  
3–10 units)



polysaccharide

(long chain with possibly hundreds  
or thousands of units)

# Carbohydrates – natural forms



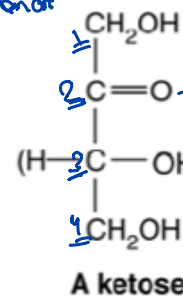
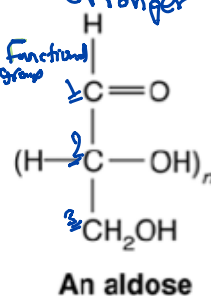
- Most carbohydrates are found naturally in bound form rather than as simple sugars. *ساده شکر به جای شکر پیوسته*
- Polysaccharides (starch, cellulose, inulin, gums)
- Glycoproteins and proteoglycans (hormones, blood group substances, antibodies) *کثیر پروتئین کثیر شکر*
- Glycolipids (cerebrosides, gangliosides) *شکر لیپید*
- Glycosides *sugar molecule + OH molecule*
- Mucopolysaccharides (hyaluronic acid) *large sugar outside the cell.*
- Nucleic acids (DNA, RNA)

# Monosaccharides



- Basic chemical formula:  $(CH_2O)_n$
- They contain at least two or more hydroxyl groups. *because it's poly hydroxyl.*

*Handwritten notes:*  
 as C1 is the stronger donor  
 at the top ← functional group

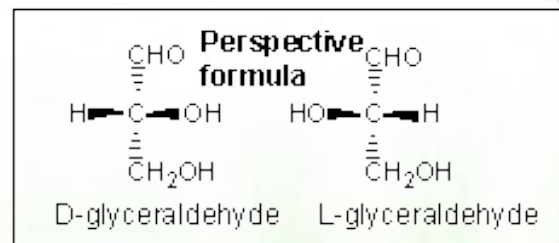
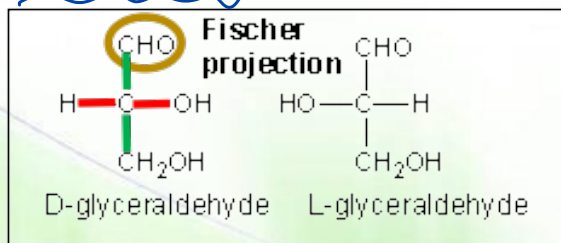


*Handwritten notes:*  
 2 كوك 1/8  
 (منزقة الى يميني)  
 الكيتون الرقم الأول  
 لذلك منزقة من فوقه

ose = sugar.

*2 axis.*

Fisher projections or perspective structural formulas.



**Forward    Backward**

Top (C1): **Most highly oxidized C**

# Classification 2



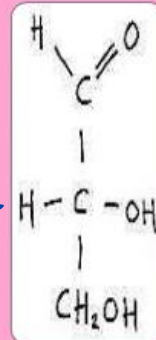
Specific for num of carbon in monosaccharide.

\* Smallest sugar 3 carbon  
3 carbon

- By the number of carbon atoms they contain. في جزى السكر البسيط.

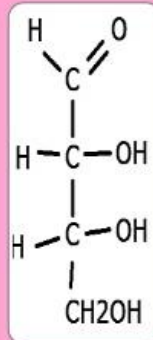
- Triose
- Tetrose
- Pentose
- Hexose
- Heptose
- ...

← كل 3 ذرات  
OH  
و 3 ذرات H



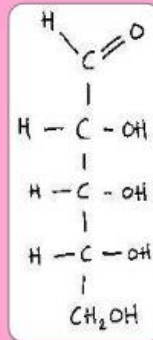
3  
carbon  
atoms

- Triose
- $(\text{CH}_2\text{O})_3$



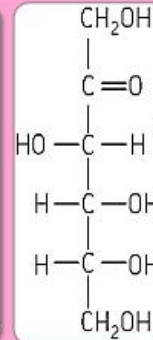
4  
carbon  
atoms

- Tetrose
- $(\text{CH}_2\text{O})_4$



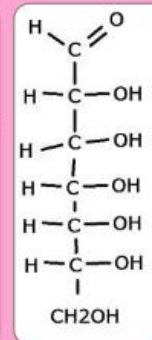
5  
carbon  
atoms

- Pentose
- $(\text{CH}_2\text{O})_5$



6  
carbon  
atoms

- Hexose
- $(\text{CH}_2\text{O})_6$



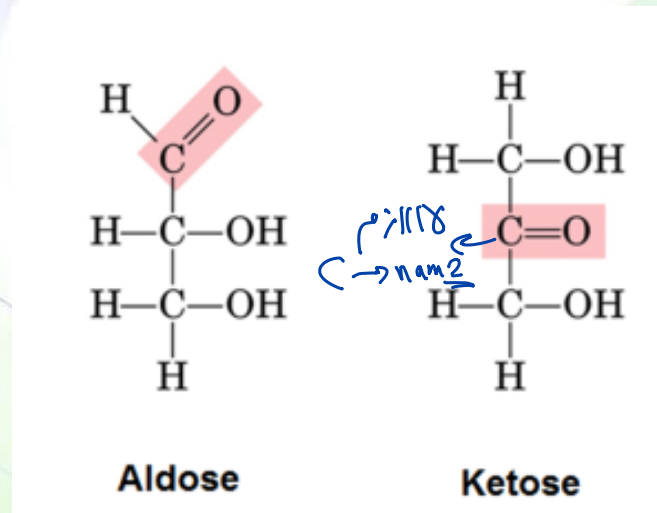
7  
carbon  
atoms

- Heptose
- $(\text{CH}_2\text{O})_7$

# Classification III

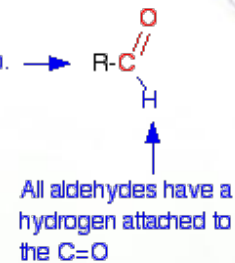


- By the functional group

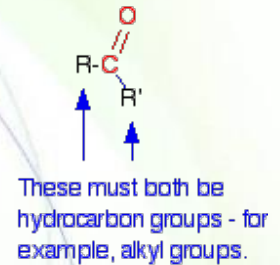


an aldehyde

This can be hydrogen or a hydrocarbon group. →



a ketone

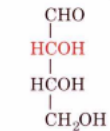


# Aldoses

ایہا بنو کسات حفظ

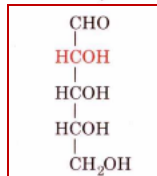


D-Glyceraldehyde

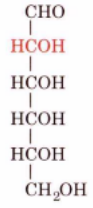


D-Erythrose

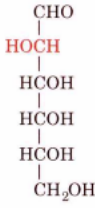
کلی ۵  
یعنی ۵  
یعنی ۵



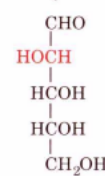
D-Ribose (Rib)



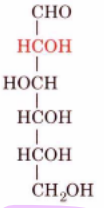
D-Allose



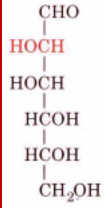
D-Altrose



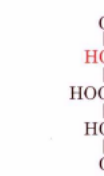
D-Arabinose (Ara)



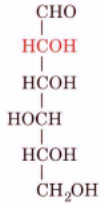
D-Glucose (Glc)



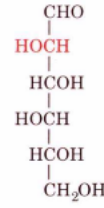
D-Mannose (Man)



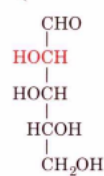
D-Xylose (Xyl)



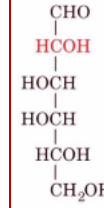
D-Gulose



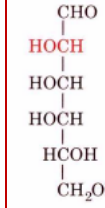
D-Idose



D-Lyxose (Lyx)



D-Galactose (Gal)



D-Talose

Aldotriose

Aldotetroses

Aldopentoses

Aldohexoses

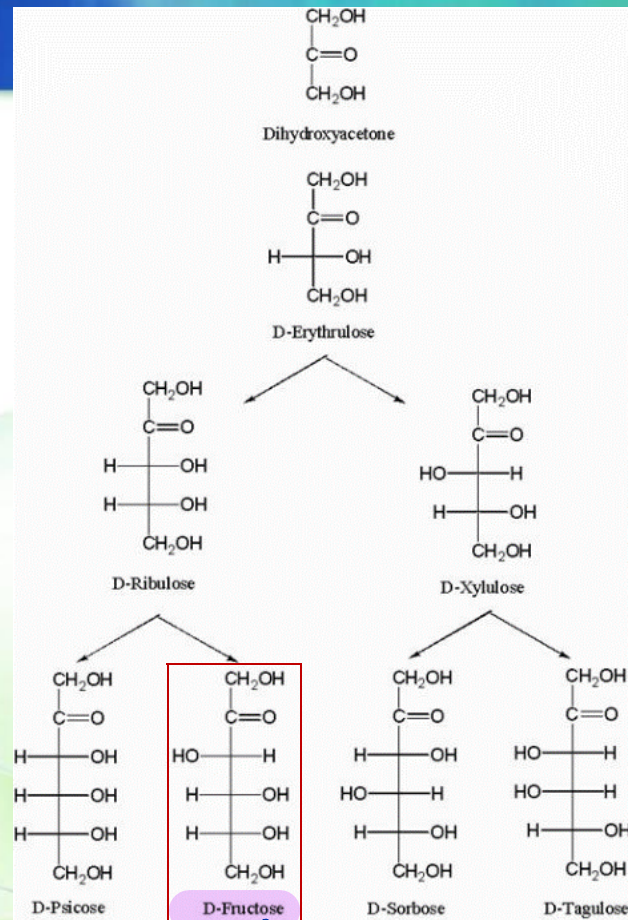
Memorize the ones in boxes.





# Ketoses

Memorize the ones in boxes.



الفركتوز

# Common Monosaccharides



- Glucose:

- Mild sweet flavor
- Known as blood sugar هو الذي من خلاله يلامح
- Essential energy source
- Found in every disaccharide and polysaccharide

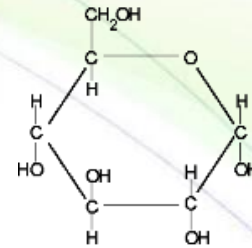
الاعتمادية

- Galactose:

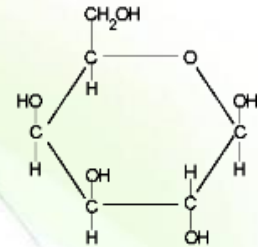
- Hardly tastes sweet & rarely found naturally as a single sugar

- Fructose:

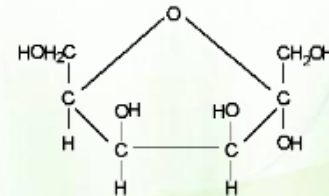
- Sweetest sugar, found in fruits and honey
- Added to soft drinks, cereals, desserts



Glucose



Galactose



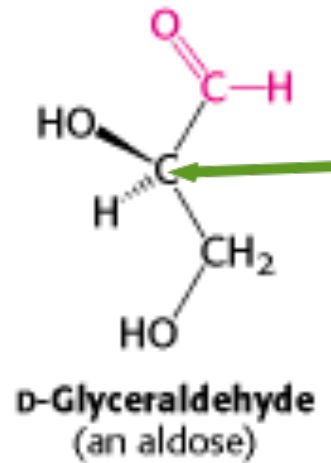
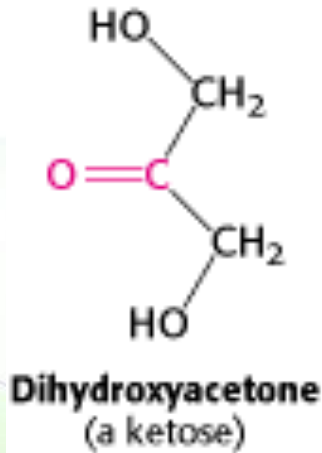
Fructose

# Trioses



**What is a chiral carbon?**

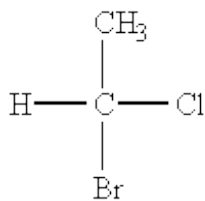
The simplest sugar (tri).  
only



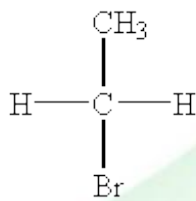
**Chiral carbon** → 4 covalent bond  
4 different groups

ketose

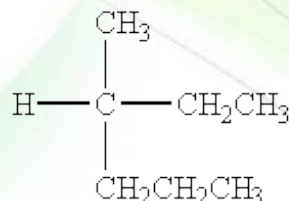
# Note what a chiral carbon is...



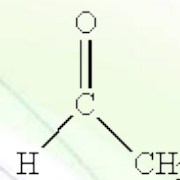
✓



X

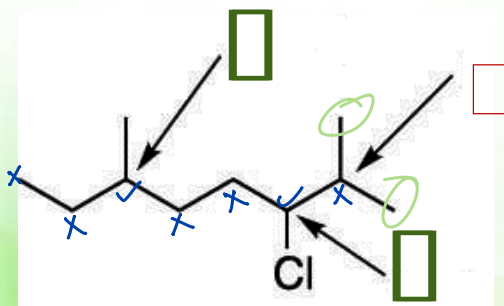


✓



X

2 جهات فقط

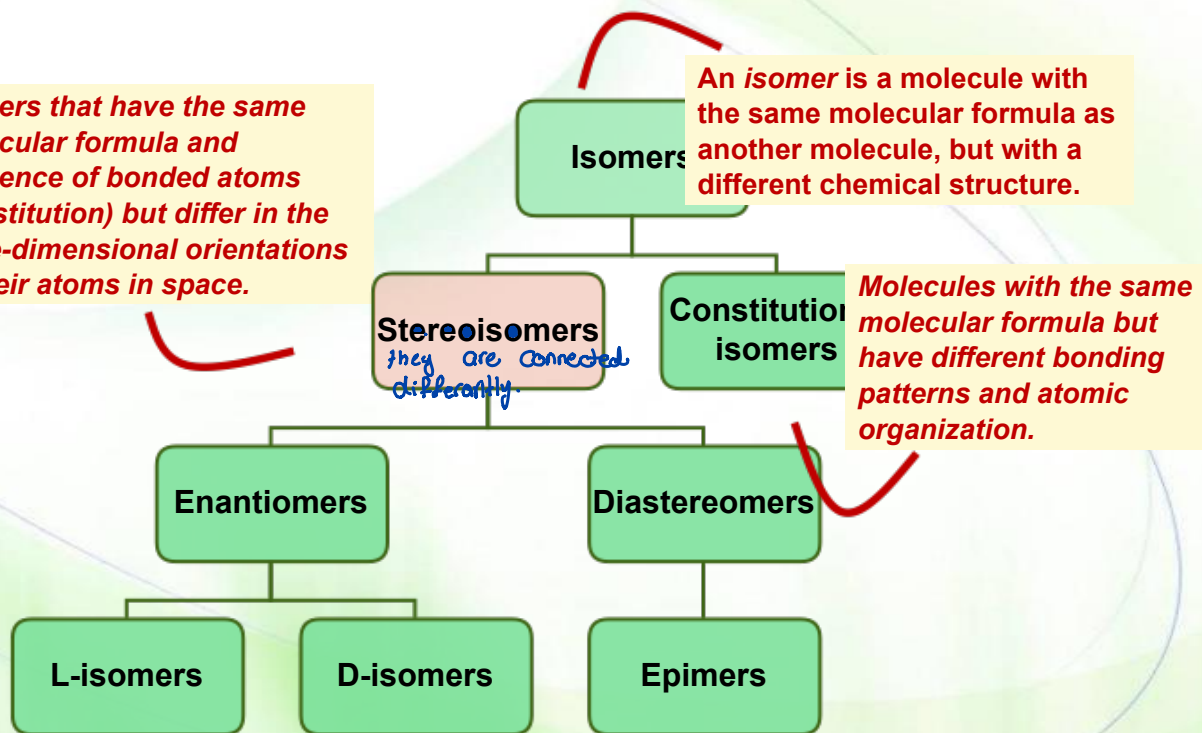


# Isomerism



*Isomers that have the same molecular formula and sequence of bonded atoms (constitution) but differ in the three-dimensional orientations of their atoms in space.*

*An isomer is a molecule with the same molecular formula as another molecule, but with a different chemical structure.*



*في الفضاء C/D*

*in space they are different*

# Isomers of glucose

$2^n$  (n is the number of chiral carbons in a sugar molecule)

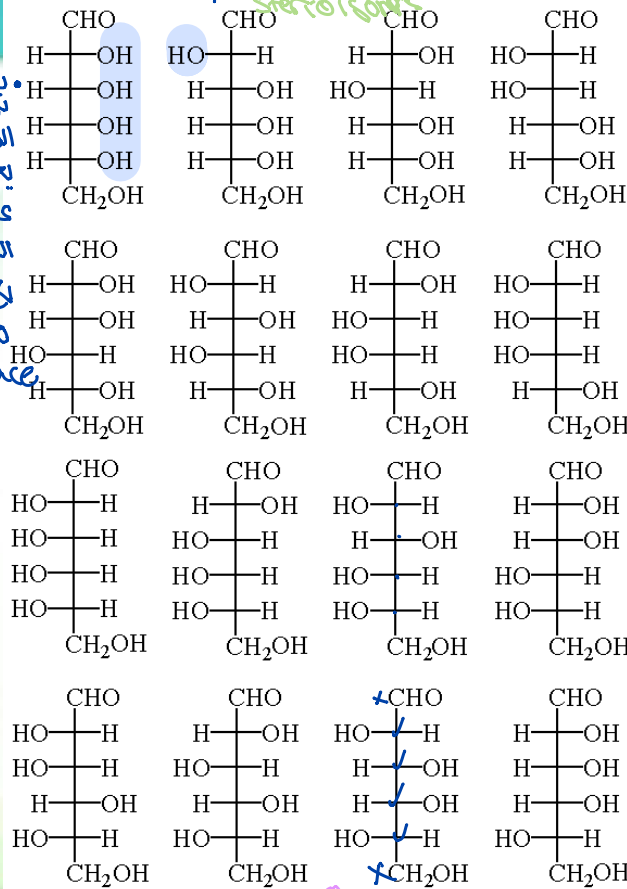
Search for:  
**Glucose,**  
**Galactose**  
**Mannose**

- How do I know the num of stereoisomers of any sugar? depends on num of chiral carbon =  $2^n$

بعض  
الذرات  
يعني  
C  
الثانية في H/OH  
لكن اياها لا علاقة  
ممكن  
So in space  
they are  
different.

16 Aldohehexoses

Stereoisomers

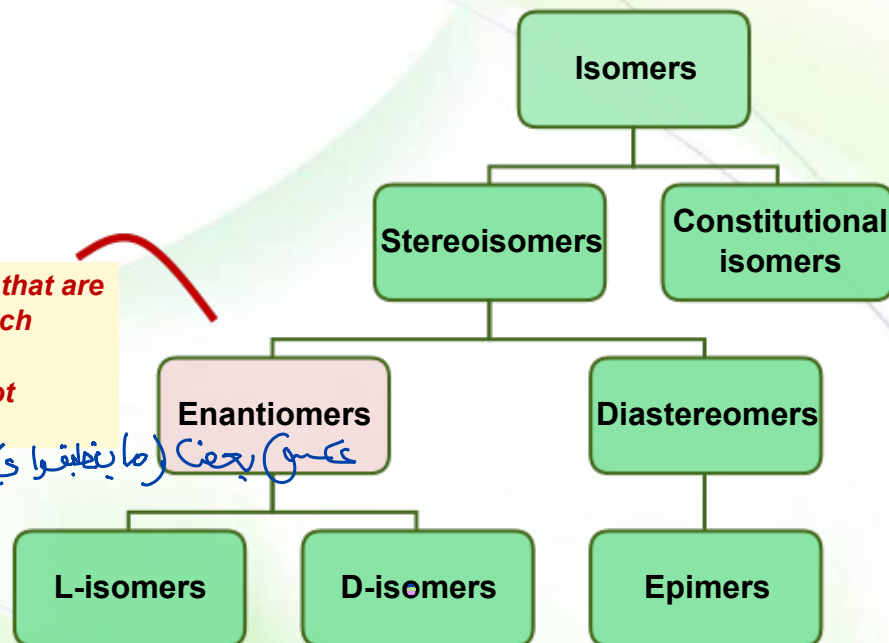


Glucose,  
Galactose  
Mannose

لأنهم ليسوا واحد منهم



# Enantiomers

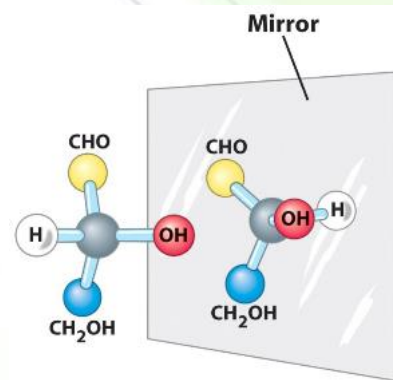
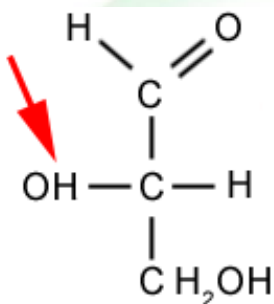
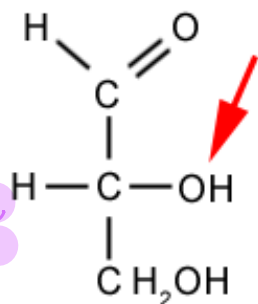


Two stereoisomers that are mirror images of each other and are non-superimposable (not identical)

- How many enantiomers does glucose have?  
only 1  
مركب  
ذائب  
لمرة واحدة فقط.

عكس (مركب) (ما ينفصلوا ي) (مركب)

# Sugar enantiomers (D- vs. L-)



D-Glyceraldehyde

L-Glyceraldehyde

Ball-and-stick models

right.

(left)

\* using D/L depend on position of OH

which is connected to

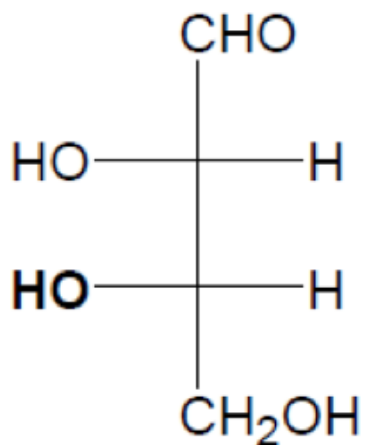
farthest chiral

function/ie  
group.

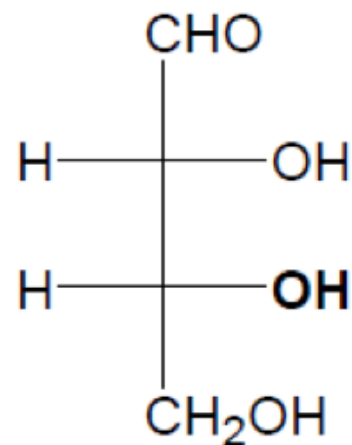
\* for each molecule  
and its mirror  
image → L  
→ D

How many enantiomers?  
Only one.

# Which one(s) is a chiral carbon?



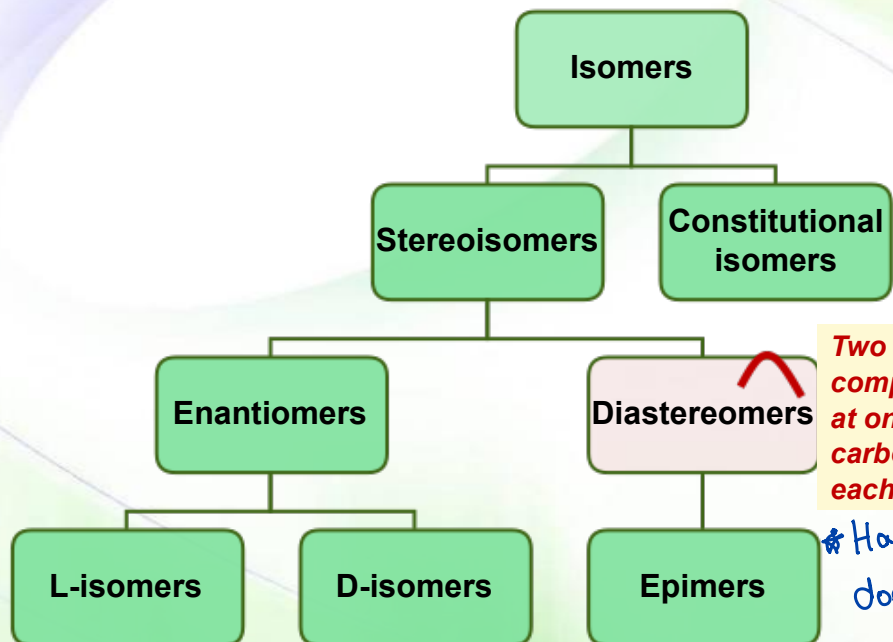
L-erythrose



D-erythrose

Do not memorize  
but study them.

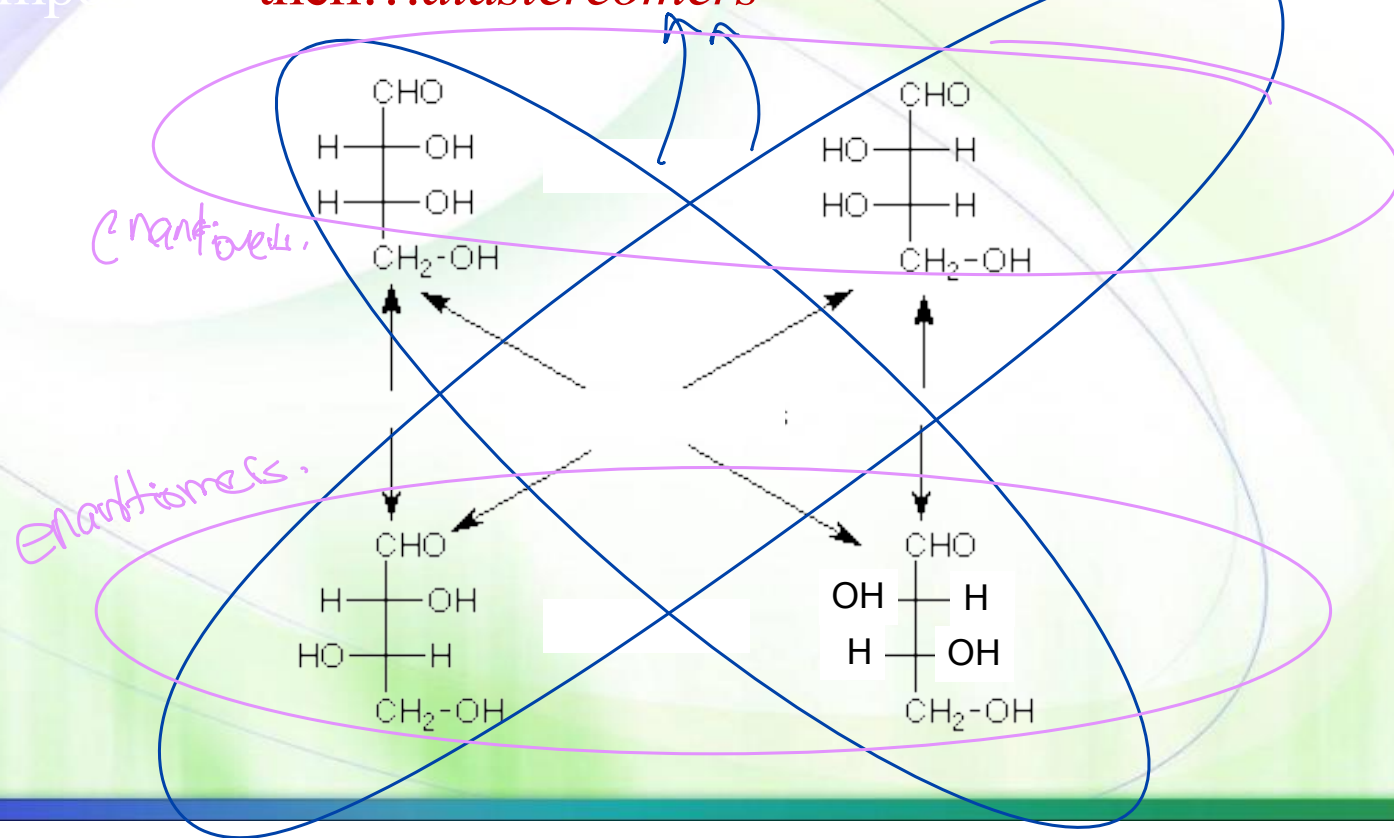
# Isomerism



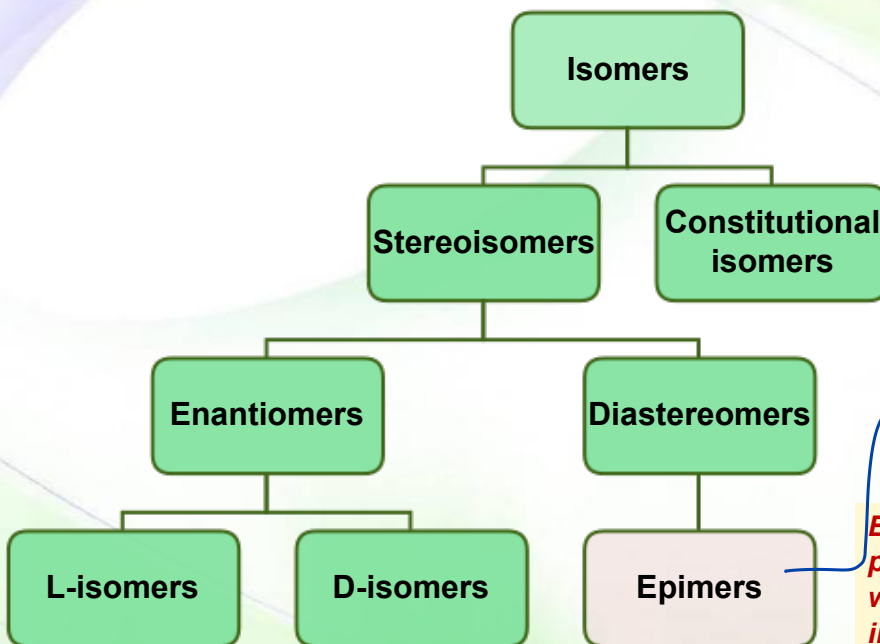
*Two or more stereoisomers of a compound having different configurations at one or more (but not all) of the chiral carbons and are not mirror images of each other.*

\*How many diastereomers does Glucose have? 14  
Sugars 15 119  
enantiomers 16 119

Stereoisomers, but non-mirror images and non-  
superimposable then... *diastereomers*



# Isomerism



difference  
in orientation  
for one OH.

**Epimer** refers to one of a pair of stereoisomers whereby two isomers differ in configuration at only one chiral carbons.



# Diastereomers with different orientation of one chiral carbonm then... *epimers*



Memorize and study them.

isomers ✓

stere ✓

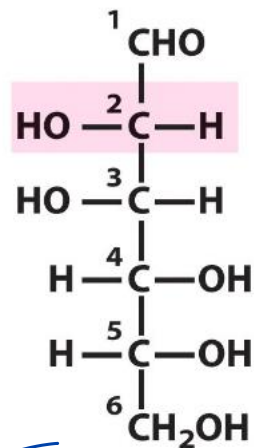
enantiomers? ✗

المتكافئة البصرية عكس البعد  
لأنهما لهما صور مرآتية متطابقة  
mirror image (Gluco)

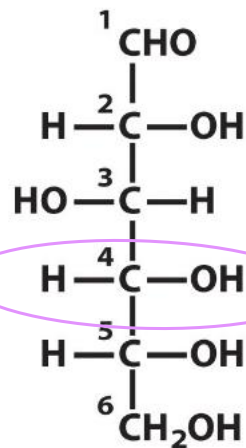
Diastereo ✓

المتكافئة البصرية عكس البعد  
epimers.

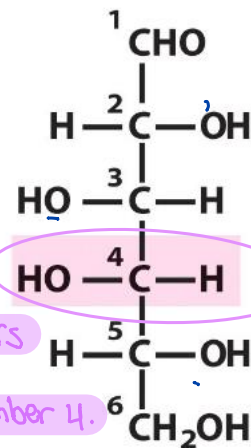
اختلاف اتجاه OH في مركزين  
Chiral



D-Mannose  
(epimer at C-2)



D-Glucose



D-Galactose  
(epimer at C-4)

epimers

at

number 4.

Is L-glucose an epimer with D-mannose and D-galactose?

Diastere  
but  
not

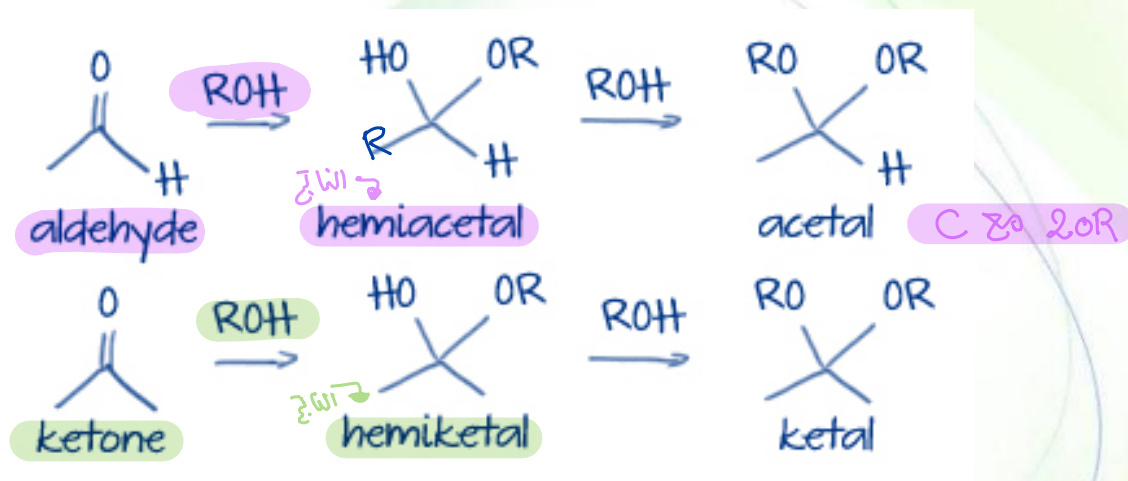
epimer (اختلاف اتجاه OH في مركزين)

# Acetal/ketal vs. hemiacetal/hemiketal



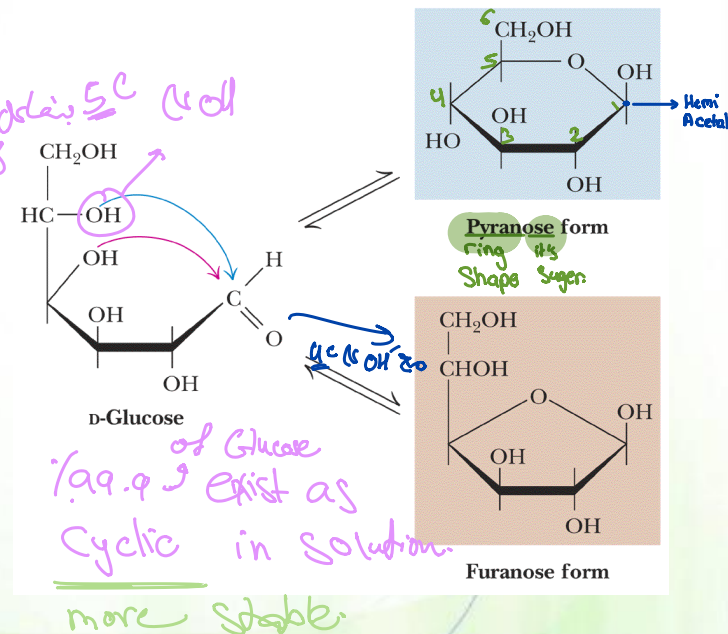
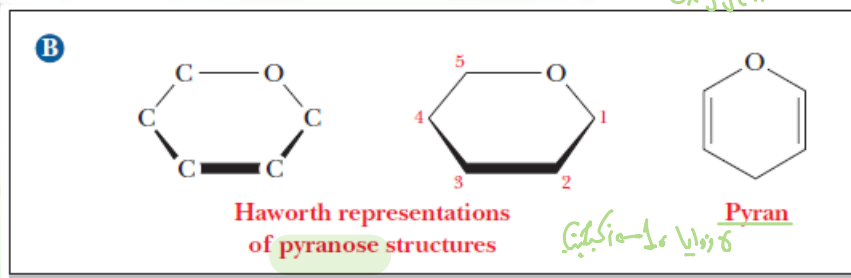
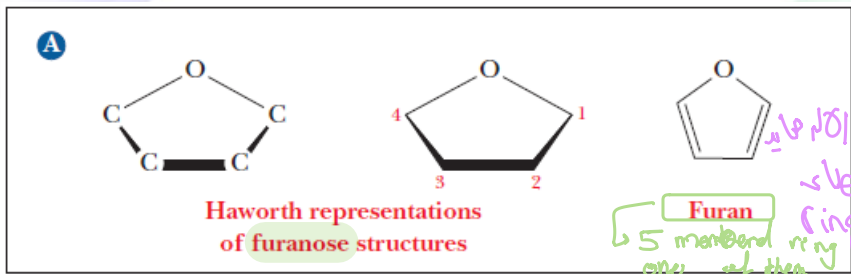
Hemiacetal and hemiketal: ether and alcohol on same carbon

Acetal and ketal: two ethers on same carbon



*What is the difference between hemiacetal and hemiketal and the difference between acetal and ketal?*

# Formation of a ring structure



• furan and pyran → name of rings

• Puranose more stable than furanose

لشوي اند تفت ٧

# Anomers



In rings form, All groups are stable  
So the positions don't change.

Except the group (أي فوق بفلخوف)  
on carbon num 1. (أي تحت بفلخوف)  
أي كانت بأعلى أو أسفل.

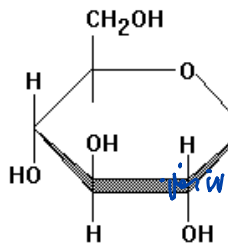
فأي الـ OH متحركة  
لذا كانت:

up the ring  $\rightarrow$  beta  
below the ring  $\rightarrow$  alpha

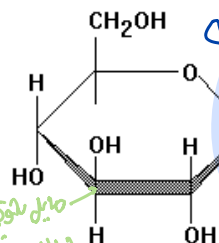
Anomers: Sugar molecule  
that differ in orientation  
of position of OH that's  
connected to Anomeric Carbon.

أه شكلها زي للسكك  
ويش بتتبع للسكك  
بالبحر تحت أو فوق

β مع كلمة بيت والبيت  
فوق أو تحت أو باعلى



alpha-D-glucose



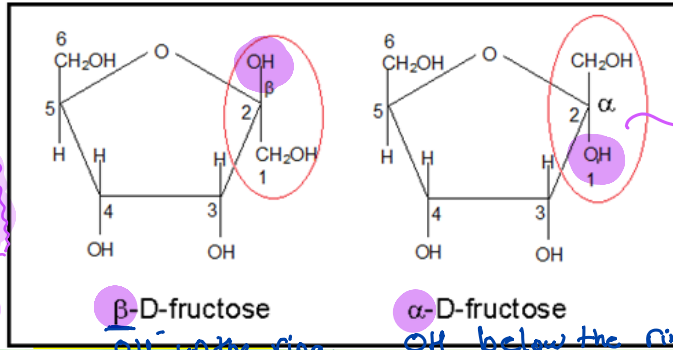
beta-D-glucose

draw

بالأعلى كانت  
functional group.

C (أي فوق أو تحت)  $\rightarrow$  Anomeric Carbon  
تحت أو أعلى

المركب انومري



β-D-fructose

α-D-fructose

OH up the ring.

OH below the ring.

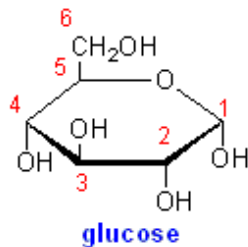
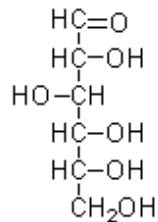
Anomeric Carbon (أي فوق أو تحت)  
which was (كيتون)  $\rightarrow$  C num 2  
keton

2C فركتوز منطوق

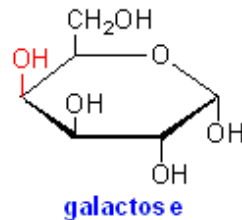
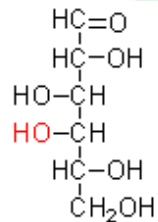
# Chain to ring

## Left-up, right-down

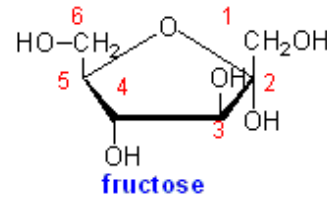
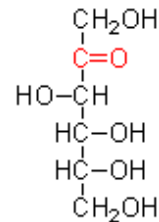
Face the  
sugar and go  
down to  
**YOUR right**



glucose



galactose



fructose