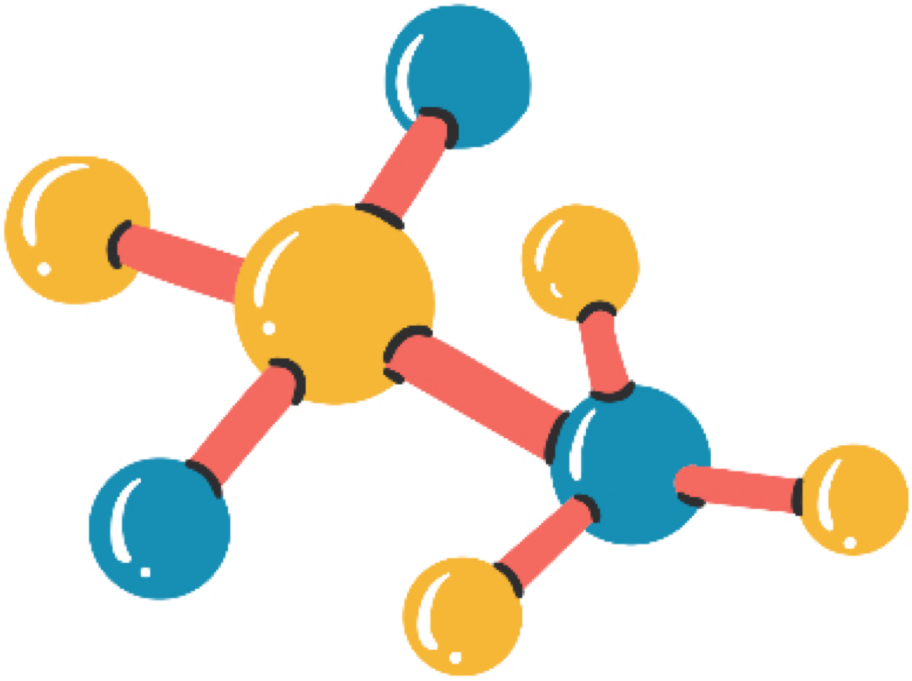
Sheet no. 7

Biochemistry



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Carbohydrates

We will go into many topics:

1- Definition and functions of carbohydrates , the ways we classify it (two ways we have), we would use our info from Ch 5 in organic chem to apply it here

Carbohydrates are organic compounds composed of carbon, hydrogen, and oxygen, They are considered as **polyhdroxyketones** or **polyhydroxyaldehydes**

Polyhydroxy (have more than one hydroxyl group) ketone , aldehyde (the position of carbonyl group)

Saccharide is another name for a carbohydrate.

Functions:

Source of energy (main source of energy , also we have fats- which firstly functions as energy storage)

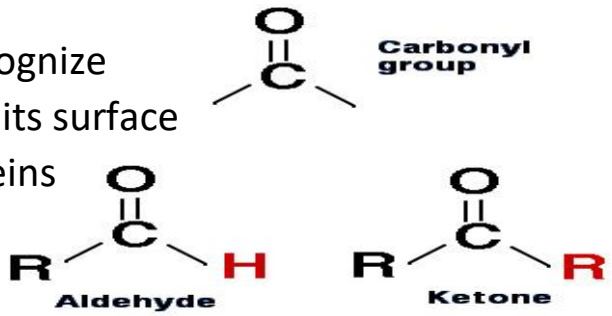
Structure (*cellulose* fibres in plants and *chitin* in exoskeleton in insects as lobster ….etc)

Building blocks

Cellular and immune recognition (cells differs between them by molecules on its surface which are carbohydrates bounded to lipid (glycolipid) or to protein (glycoprotein)

Immune system: the immune cells can recognize the different cells depends on the CHO on its surface so antibodies can binds to it. As glycoproteins because :

1- Its high hydrophilic >>>> increasing The affinity between cells and antibodies.



classification:

as we know, sugars can work as building blocks(monomers) and we can link these monomers by loss of one (H_2O) for each link.

1- Number of sugars that constitute the molecule , we have:

Monosaccharides: contain one sugar unit (can't be hydrolyzed).

Disaccharides: contain two sugar units.

Oligosaccharides: contain 3-10 sugar units.

Polysaccharides: contain more than 10 sugar units.

But carbohydrates have the natural form which is *bounded* mostly , as:

Polysaccharides (starch, cellulose, inulin, gums)

Glycoproteins and proteoglycans (hormones, blood group substances, antibodies)

Glycolipids (cerebrosides, gangliosides) (bad memory for Cyto 🥧) study in details in lipids part

Glycosides

Mucopolysaccharides (hyaluronic acid (used in injection))

Nucleic acids (DNA, RNA) as ribose and deoxyribose -pentose-

Monosaccharides.

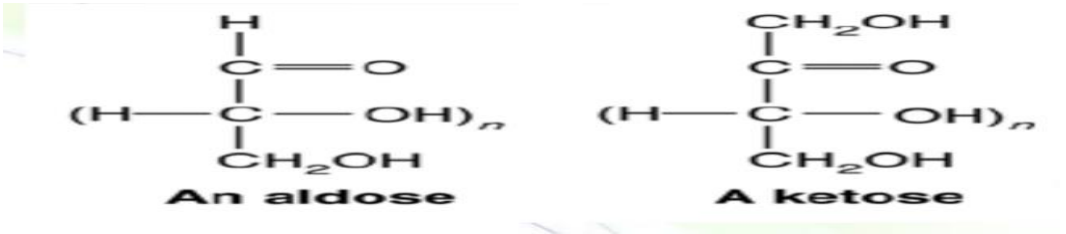
They are the simplest units of carbohydrate containing one sugar unit. General formula is: ***Cn(H2O)n.***

In aldehyde, in a compound of one or two carbons , we can't make sugar.

1 C >>>>>> can't add OH group

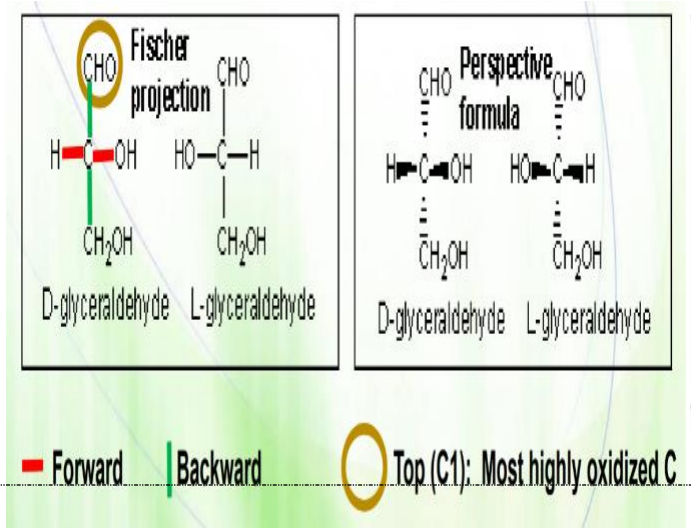
2 C>>>>>> can add ***one*** OH group, but the condition is polyhydroxy (more than one OH group).

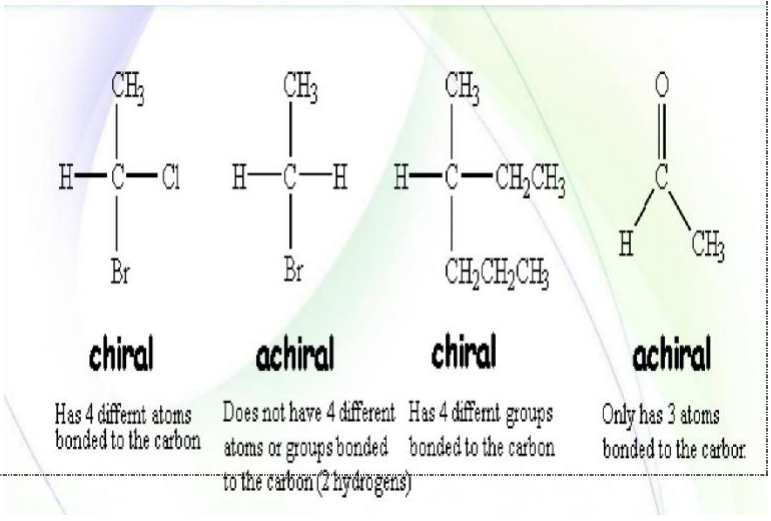
In ketone, the simplest one is acetone (3 C) , if we add two OH groups we get dihydroxyacetone.



Chiral carbon: Is the carbon atom to which 4 different *groups* are attached. Any substance containing asymmetric (chiral)carbon atom shows 2 Properties, Optical activity (D , L) and Optical isomerism(present in more than one form) get clear soon. https://youtu.be/XftIUcLWTEE

E.g., for achiral and chiral





Ok ! we would take D , L and the optical isomers ;

Optical activity.

1- If the substance rotates plane polarized light (PPL) to the right so it is called: dextrorotatory or D or (+)

2- If it rotates it to the left so it is called: levorotatory or L or (-).

How classify sugars into D, L? depending on the furthest carbon from carbonyl group.

Optical isomerism: It is the ability of substance to present in more than one form (isomer). - Substance containing one asymmetric carbon atom has 2 isomers.

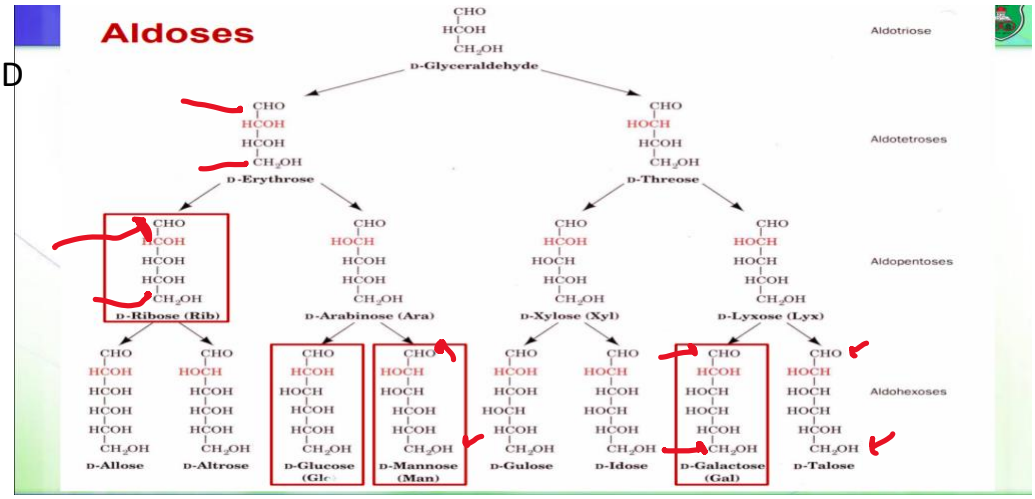
Aldose :

The simplest aldose is Glyceraldehyde (3 C).

Note: we will deal with D compounds

in aldose, number of **chiral carbons** = N – 2 (where N is the **number of carbons**) we delete the first one and the last one in the chain , as marked below

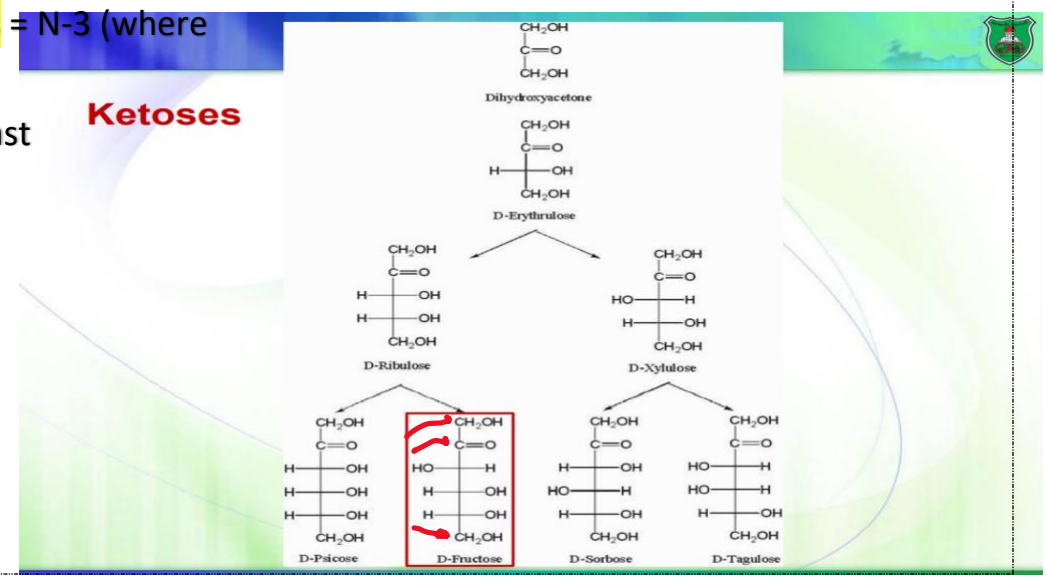
Q) aldose with 9 carbons, how many chiral C we have?



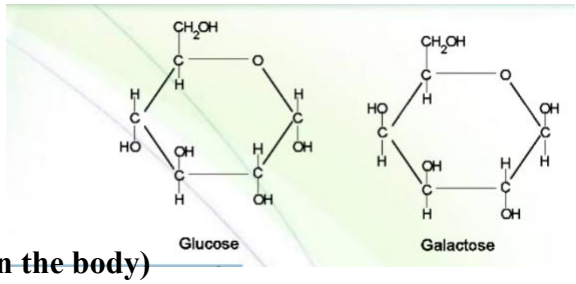
KNOW THE LABELD SUGARS RED

Ketose:

The simplest one is Dihydroxyacetone (3 C) doesn't have D,L, why? . in ketose, number of chiral carbons = N-3 (where N is # of carbons) we delete the first and the last ones. Also, the carbonyl group in the centre as marked by red.



Common Monosaccharides



Glucose – aldohexose-:

1- **Mild sweet flavour**
2- **Known as blood sugar(we use it in blood test mainly)**
3- **Essential energy source (the main source of energy in the body)**
4- **Found in every disaccharide and polysaccharide that get hydrolysed to produce glucose**.

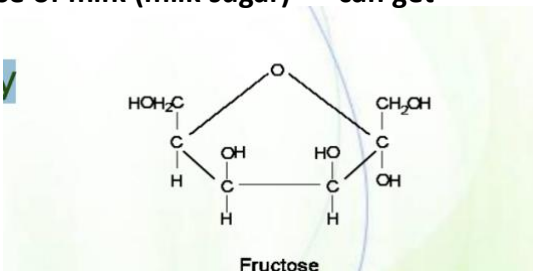
Galactose _aldohexose_:

note: galactose and fructose can Converted into glucose in liver

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

2-**It is synthesized in mammary gland to make the lactose of milk (milk sugar) == can get by hydrolysed of lactose.**

Fructose _ketohexose_:



1-**Sweetest sugar, found in fruits and honey**

2- **Added to soft drinks, cereals, desserts**

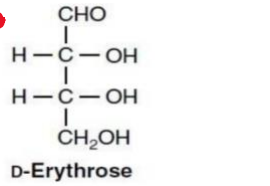
3- **fructose is extracted from corn syrup as a replacement of sucrose which is extracted from sugar cane , known as HFCS (High Fructose corn syrup).**

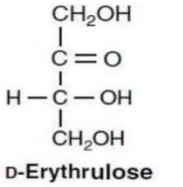
Classification by the number of carbons:

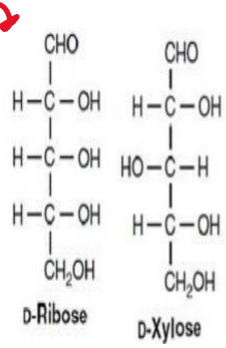
in sweetness :

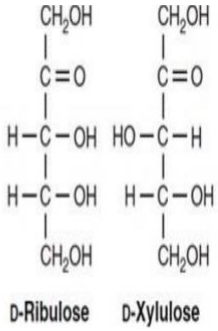
Fructose>glucose>galactose

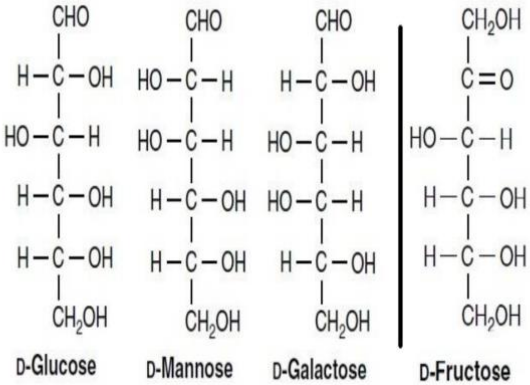
1. ***Trioses:*** containing 3 carbons
   a. Aldotrioses: Glyceraldehyde "glycerose".
   b. Ketotrioses: Dihydroxyacetone.
2. ***Tetroses:*** containing 4 carbon atoms: a.
   Note: The suffix —ulose means Keto group.
3. ***Pentoses***: containing 5 carbon atoms.
   a. Aldopentoses: Ribose, xylose.
   b. Ketopentoses: Ribulose and xylulose.
4. ***Hexoses:*** s containing 6 carbon atoms.
   a. Aldohexoses: glucose, mannose, and galactose.
   b. Ketohexose: fructose



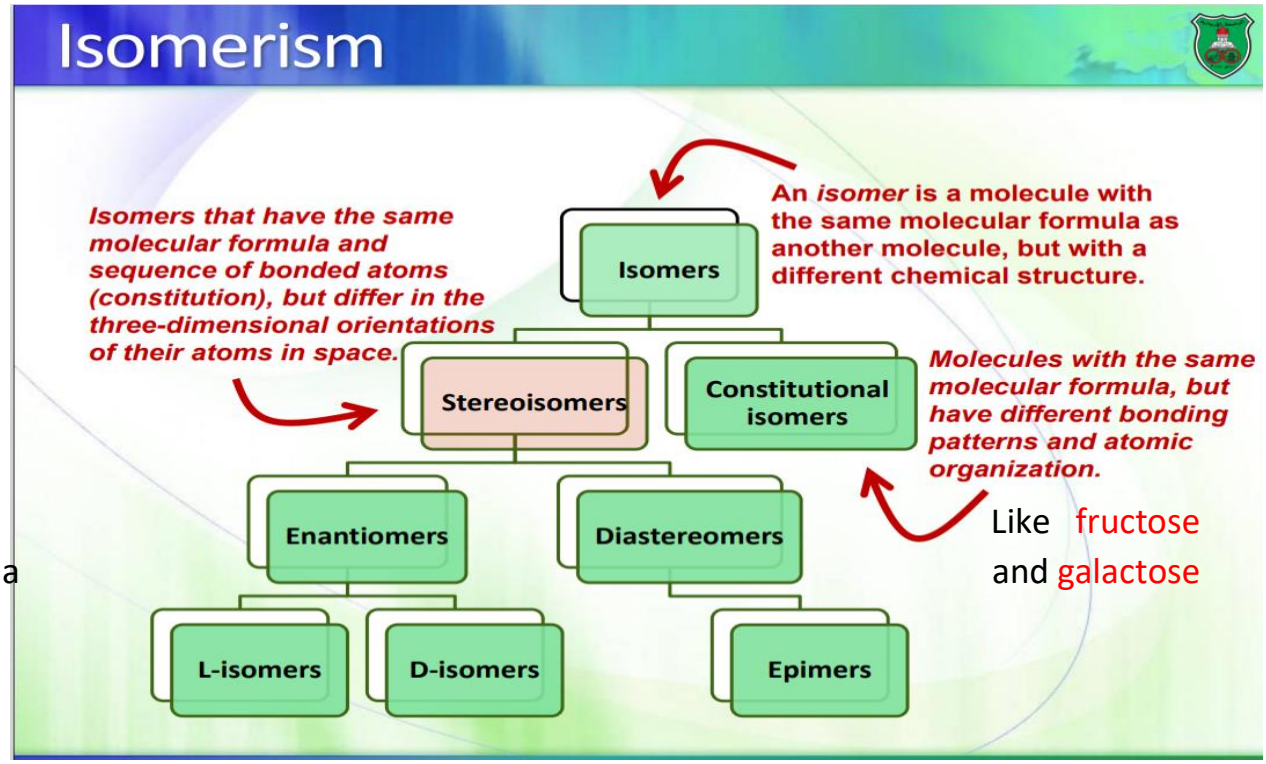








optical isomerism: It is the ability of substance to present in more than one form (isomer) – here we describe the relationship between two compounds-.



a Like fructose and galactose

Isomers of *glucose*:

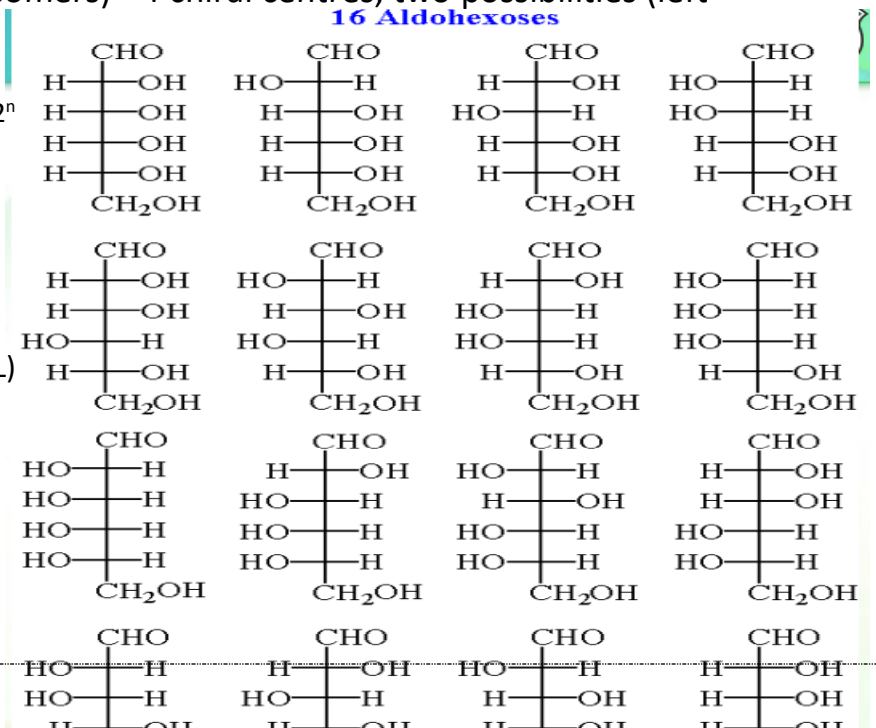
Glucose has 6 carbons, 4 chiral centres. it can be rearranged in space to form stereoisomers (not constitutional isomers) - 4 chiral centres, two possibilities (left and right) for each ,

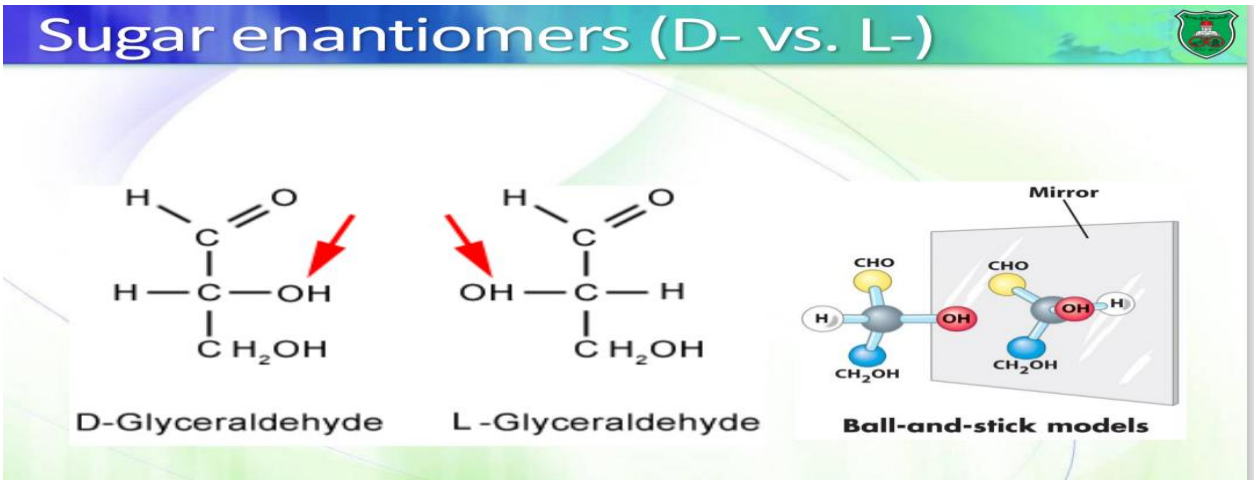
the number of these compounds = 2^n

(n = is the number of chiral carbons in a sugar molecule).

L , D related to what?

We decide the configuration of sugar (D,L) depending on the farthest chiral carbon from carbonyl group.



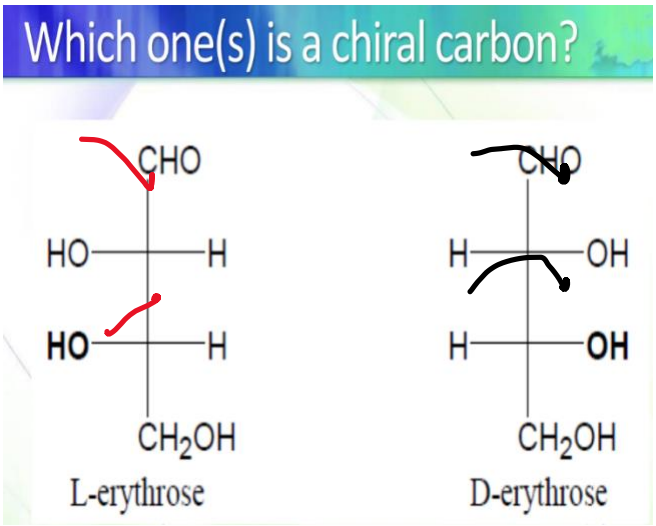


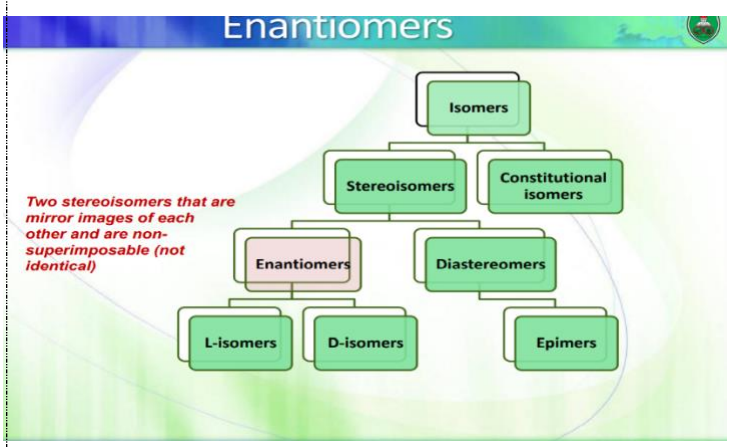
Glyceraldehyde has one chiral carbon, so it has the choice of D , L . the feature of enantiomers is clear from the mirror (mirror plane) .

2 chiral carbons in each sugar,

The left is L, and the right is D = enantiomers

(completely different sugars)





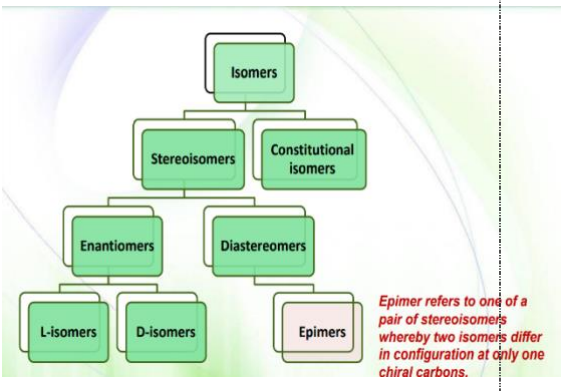
Diastereomers :

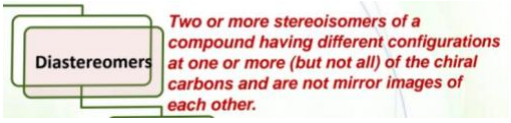
two compounds have different chiral configuration

, but in one or more they are ***similar***.

A special type of diastereomers is

Epimers: are isomers having more than asymmetric carbon

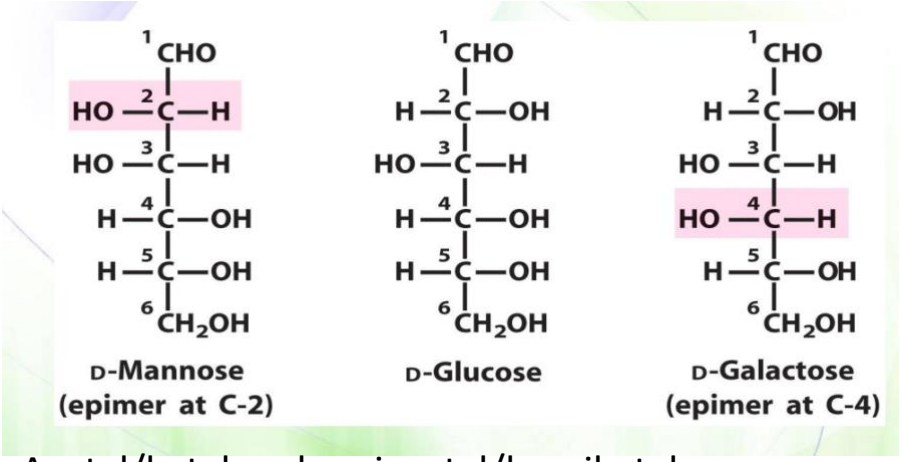




, all are same ***except only one is different***

a. ***Glucose & Mannose*** are epimers at carbons2.

b. ***Glucose & Galactose*** are epimers at carbons 4.



Galactose and mannose

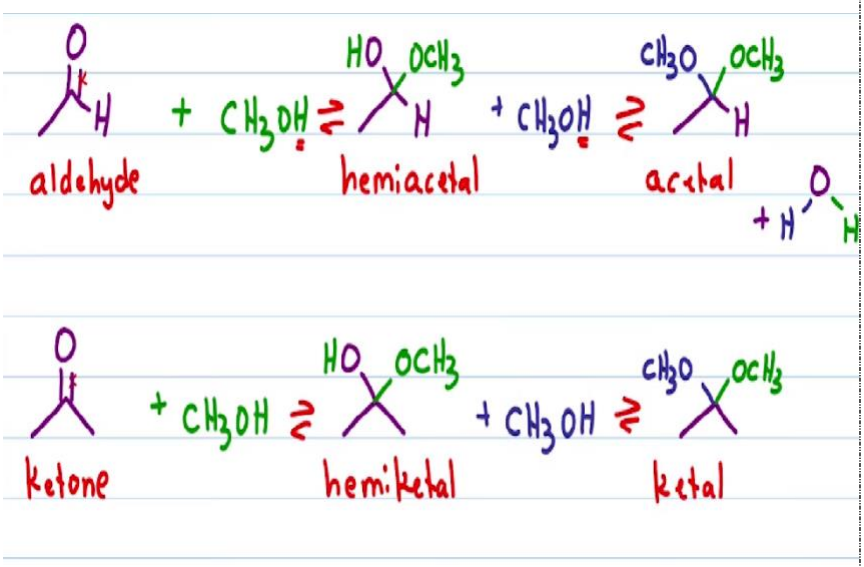
Diastereomers not epimers

Acetal/ketal vs. hemiacetal/hemiketal

Hemiacetal and hemiketal: ether and alcohol on same carbon

Acetal and ketal: two ethers on same carbon.

We see these when we react sugar with each others. As one reacts as aldehyde and the other reacts as alcohol.



Hemiacetal and hemiketal differ in the source of the molecule . As shown right.

#Hemiacetal has H atom

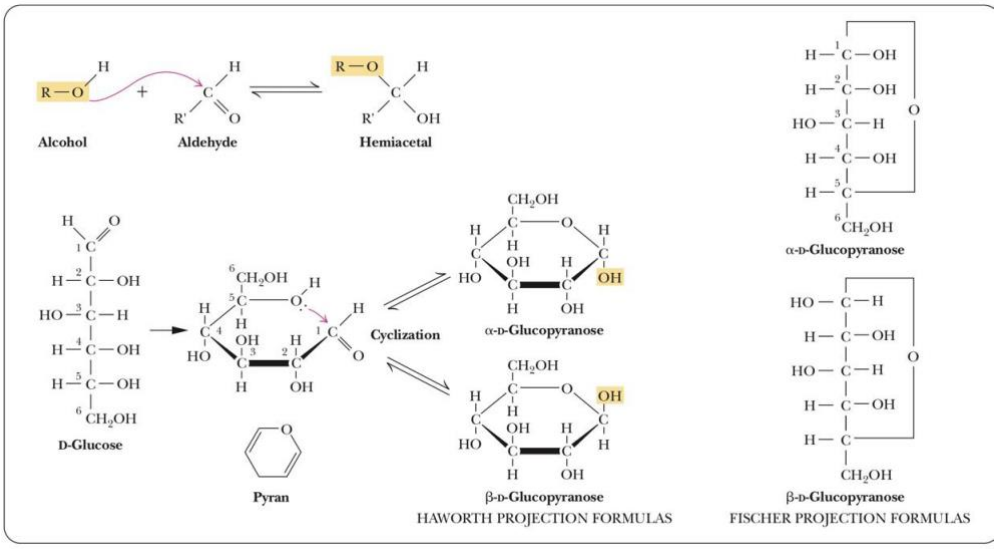
Hemiketal doesn't have it.

that's the only difference between them.

In sugars,

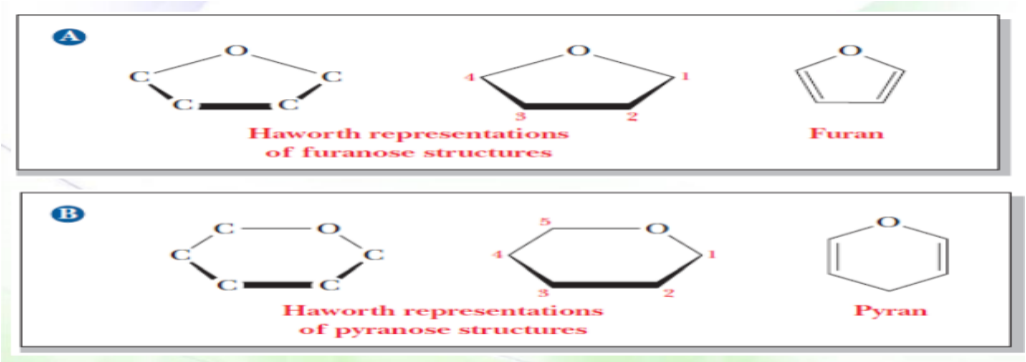
Functional groups in the same compound react with each other == hemiacetal/ hemiketal forming.

Functional groups from different sugar compounds react together = acetal and ketal forming .



Glucose is found in the ring structure 99% of the time, and 1% in the chain structure (for reaction) Because its more stable in ring structure.

A reaction between C 1 and C 5 to form the ring which is considered hemiacetal.



A five-membered ring is called *a furanose* because of its resemblance to furan; a six-membered ring is called *a pyranose* because of its resemblance to pyran

Furan : carbon number 1 with carbon number 4.

Pyran : carbon number 1 with carbon number 5.

Note: any group that is written to the *right* of the carbon in a Fischer projection has a *downward* direction in a Haworth projection; any group that is written to the left in a Fischer projection has an *upward* direction in a Haworth projection. carbonyl carbon can be upward or downward (alpha and beta) and shift between them

From the book:

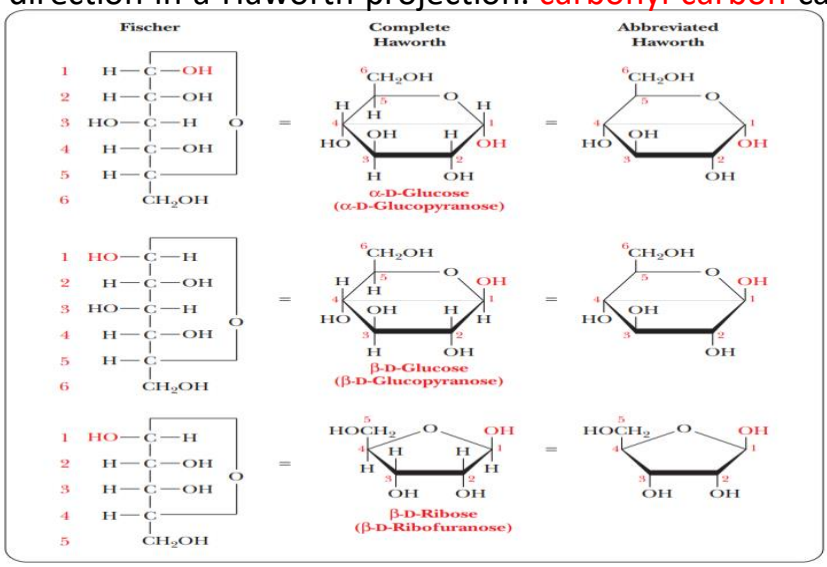
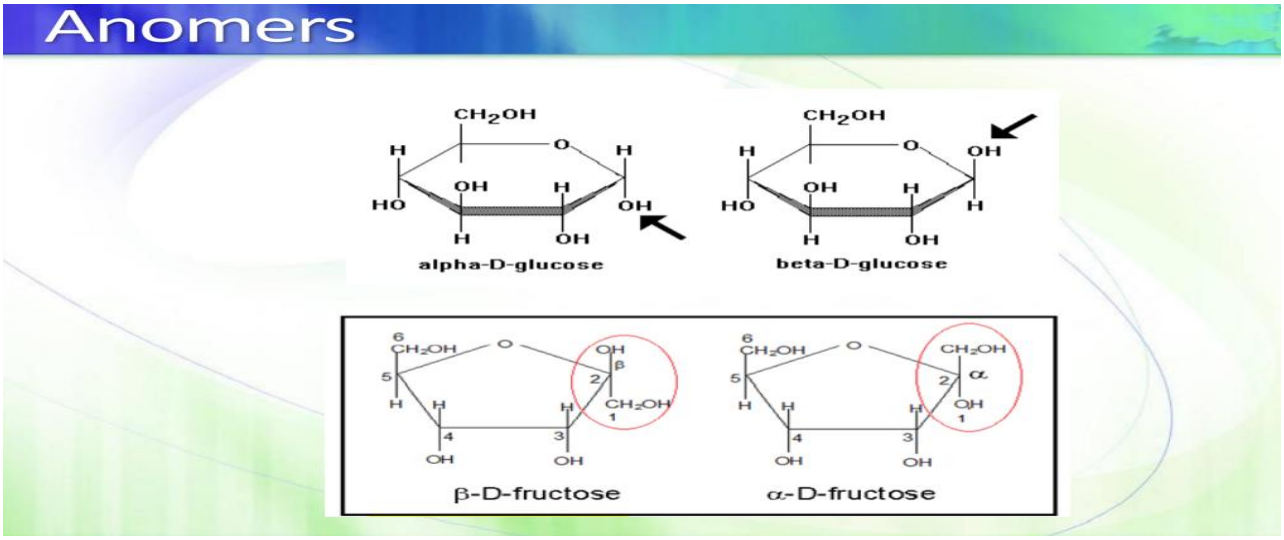


FIGURE 16.8 A comparison of the Fischer, complete Haworth, and abbreviated Haworth representations of α- and β-D-glucose (glucopyranose) and β-D-ribose (ribofuranose). In the Haworth representation, the α-anomer is represented with the OH group (red) downward, and the β-anomer is represented with the OH group (red) upward.

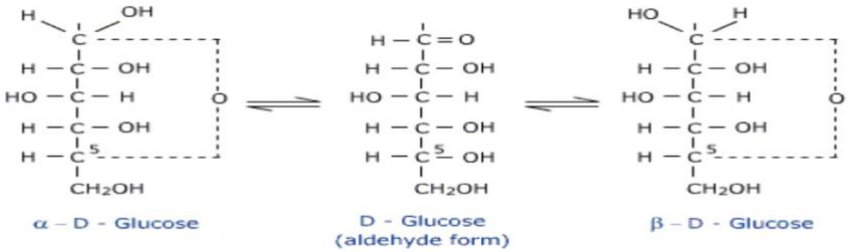


Anomers: These are isomers obtained from the change of position of hydroxyl group attached to the anomeric carbon.

e.g. α and β glucose are 2 anomers. Also α and β fructose are 2 anomers.

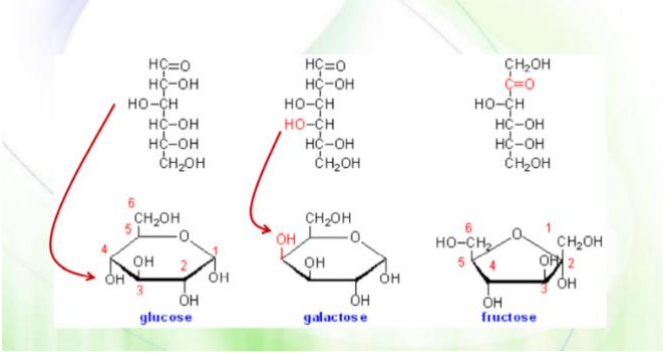
Anomeric carbon: is the asymmetric carbon atom obtained from active carbonyl sugar group

C1 in aldoses and C2 in ketoses

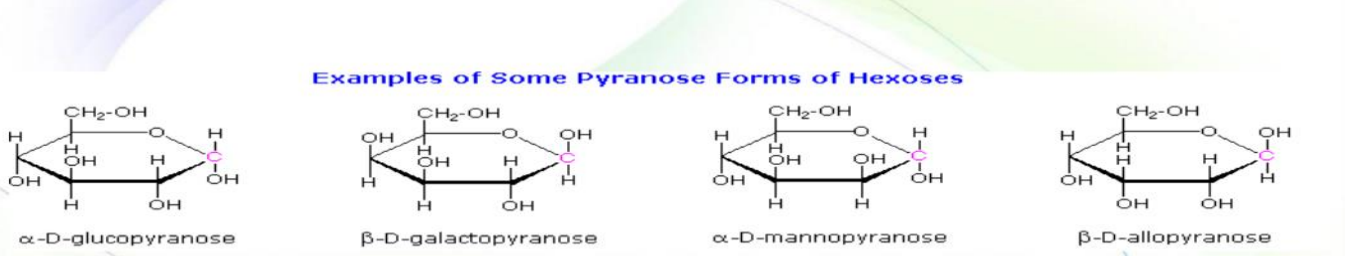


The molecule (glucose) is alternating between these 3 structures, but it stays in beta more long as mentioned above

the relationship here is anomers



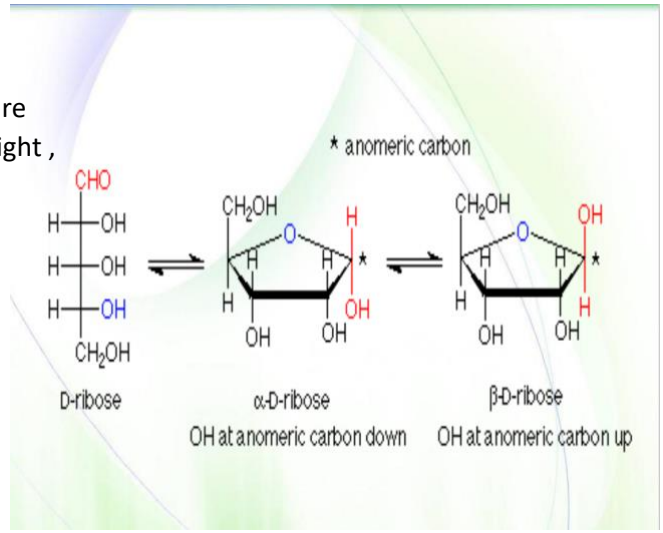
Cyclic Aldohexoses



This is called an alpha sugar because the anomeric carbon marked in PINK has the OH below the ring , it is also a D sugar (carbon) number 6)	Same the previous one, the only Difference in carbon number 1 …….. here its beta not alpha	Carbon number 2 , OH is upward so its mannose. related to Sugar 1, they are epimer OH on carbon 1 is down ==== alpha	This is called a beta sugar because the anomeric carbon marked in PINK has the OH above the ring , it is also a D sugar (carbon 6)

Cyclic ribofuranose

This is a ribose that can only form a furanose as a ring structure . All of the hydroxyl groups in the ribose are oriented to the right , so if the sugar forms a ring it rotates to YOUR right , and all of the hydroxyl groups will become below the ring (as shown in the second structure).
We can have two forms of the ribose (alpha or beta)



Glucose molecule,

Its alpha or bata?
in a time, the OH group on carbon 1 may be upward or downward . for a short time it becomes straight chain ***in order to react*** , so we have the three conformation.
64% of time be beta (OH up)
36% of time be alpha (OH downward).
So, Beta glucose is more stable than alpha. But in fructose alpha is more stable.
It depends on the most relaxed orientation of huge groups.

How can we decide if its D , L from the ring form?
We use carbon number 6 as an indicator, if its up >>> D configuration
If its down >>> L configuration.

In our bodies, it doesn't matter whether the glucose is alpha or beta for reactions, but in some cases such as DNA or RNA it differs because of the right condensation in the first place.

Quick Q

1. for a compound to be optically active it must be:
   A) Coloured B) A protein C) Symmetric D) Asymmetric E) Plant in nature

2. Glucose and galactose are epimers. This means that:

A) They are mirror images of each other.

B) One is pyranose and the other is furanose.

C) They rotate plane polarized light in opposite directions.

D) They differ only in the configuration about carbon atom number 2.

E) They differ only in the configuration about carbon atom number 4

3. Rotation of the plane of polarized light is caused by solutions of all the following monosaccharides, Except:

(a) Glucose (b) Glyceraldehyde (c) Fructose (d) Dihydroxyacetone (e) None of the above:

4-Which of the following are Aldohexoses:

a- Ribose, fructose and erythrose.
b- b- Fructose, ribose, and ribulose.
c- c- Lactose, sucrose, and maltose.
d- d- Glucose, mannose, and galactose.

5- Which of the following is a ketose?
   A) Galactose B) Fructose C) Fucose D) Mannose E) Xylose

Good luck