Bio-Chemistry

Letune 3

L3: Bio-Chemistry of Carbohydrates

28/oct/2024

★ BioChemistry : L3 - Biochemistry of Carbohydrates

- There are 4 Major types of [Macromolecules]
  - ↳ Big / Large molecules
    - Considered to be [Polymers] that Consist of Small units / building blocks Called [Monomers]

1. Proteins
2. Nucleic acids
3. Lipids] - not a polymeric molecule
4. Carbohydrates] - most abundant الموجود بكثرة

- Classification of Carbohydrates -

★ They are [sugars] or [Saccharides]

★ Its Empirical formula is $(CH_2O)n$, where [$n \geq 3$]

- Empirical → before choosing or specifying what n is equal to
- $n \geq 3$ → after deciding what n is equal to then its named a Molecular formula

Carbohydrates ($\sim H_2O$) → Carbon, oxygen, Hydrogen

- [Hydrogen : oxygen] ratio
  2 : 1

Empirical Formula, Molecular formula, structural formula

- Empirical Formula ↓ simplest ratio
- Molecular formula ↓ (Emperical form)n — specify how many atom exactly are there
- structural formula ↓
  - atomic connectivity
  - type of bonds
  - types of functional groups

- Classification of Carbohydrates -

★ **Monosaccharides:** السكريات الأحادية

- Basic units of CHO
- Simplest type of sugars
- __Cannot__ be hydrolyzed into smaller sugars
- They are the building Block's of carbohydrates

Ex: Glucose, Galactose & fructose

★ **Disaccharides:** السكريات الثنائية

- Contain two monosaccharides that are [Covalently] linked by [Glycosidic] Bond

Ex: Sucrose, it consists of:

- Glucose
- fructose

★ **Polysaccharides:** السكريات المتعددة

- Are [Polymeric] molecules
- Composed of long chains of monomers (monosaccharides) that are linked together via: [Glycosidic] Bonds

Ex: Starch, Cellulose, & Glycogen

- Monosaccharides:

* They are Classified according to the [number of Carbon atoms]

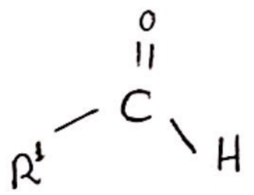
trioses (3), tetroses (4), Pentoses (5), hexoses (6) ... etc

* They are also classified according to:

[The nature of the Carbonyl group] → C=O

Aldoses

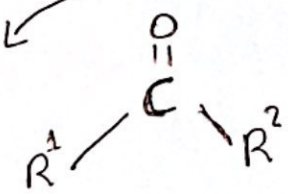
The Carbonyl group is an Aldehyde, } R' = H, alkyl or aryl

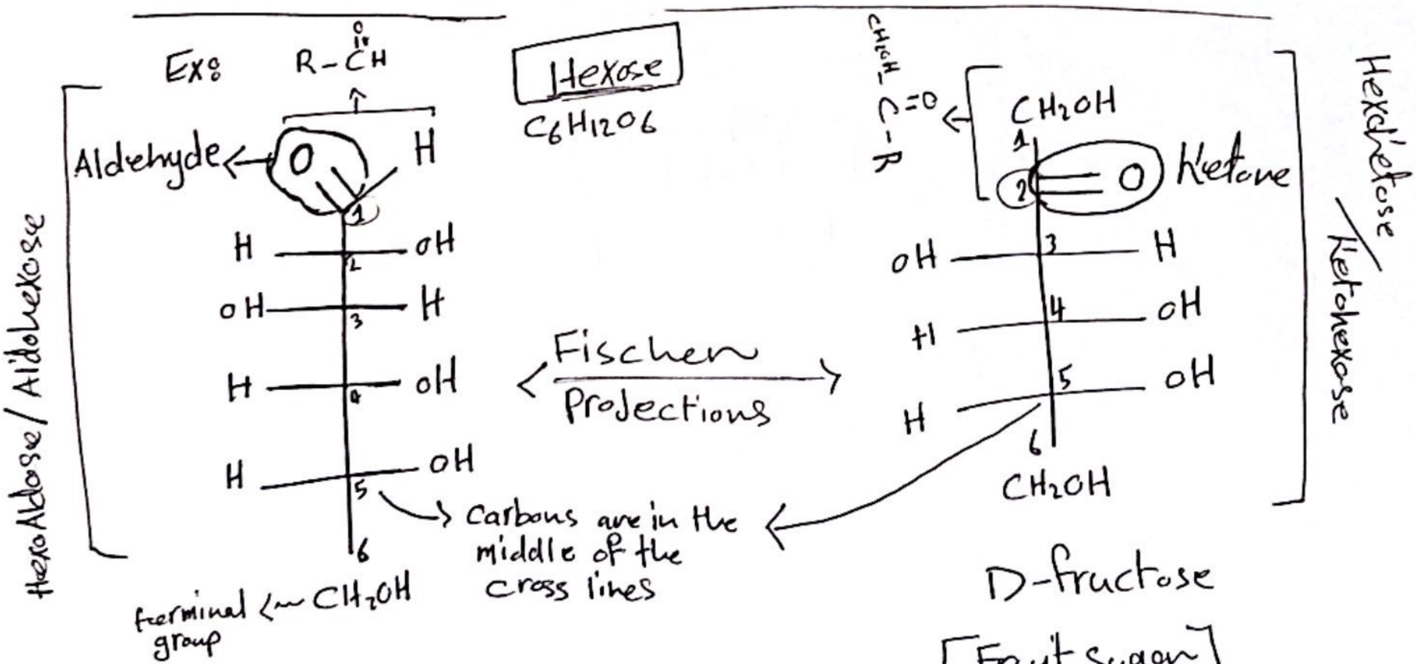


Ketoses

the Carbonyl group is a Ketone

R₁ & R₂ = aryl or alkyl





D-glucose
[grape or Blood sugar]

D-fructose
[Fruit sugar]

★ Isomers & Isomeration ★

صيغة جزيئية

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

① (structual) Constitutional Isomers :

- Atoms & functional groups bind together in different ways . Ex: glucose & fructose

-The past example-
↓
we have seen how the aldehyde & Ketone groups binded to the atoms

② Stereo Isomers (spatial isomers) : الأيزومرات المكانية

- Differ in the configuration of atoms in space rather than the order of atomic connectivity (Just a minor difference)
  - Ls they still have the **same**:
    - Molecular formula
    - Same atomic connectivity
    - types of functional groups
    - types of bonds

Its Just different in:

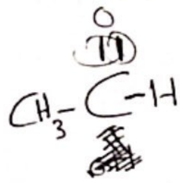
All are the same thing {
- Arrangement of atoms in space
- or in other words (the orientation of the atom)
- or also (the configuration of the atom)
}

- **Chiral Carbon**: asymmetric (غير متطابق) carbon atom attached to 4 different groups of atoms

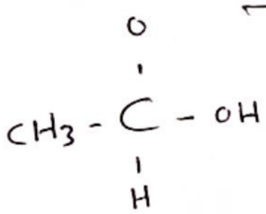
- The number of stereoisomers for any given molecules = 2^n

  n: the number of chiral centers

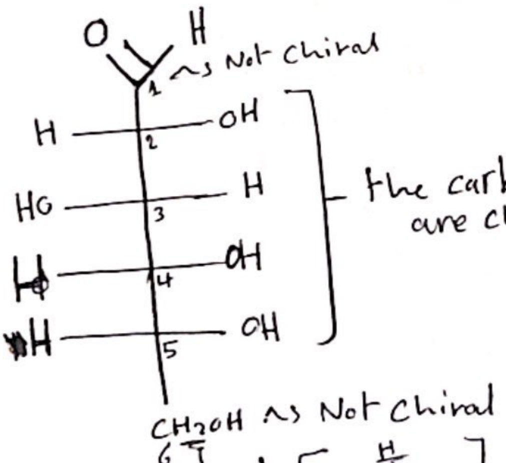
- Ex:



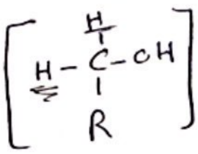
→ Not chiral (it's bound only to 3 different types / groups of atoms)



→ Chiral [bound to 4 different groups of atoms]



D-glucose



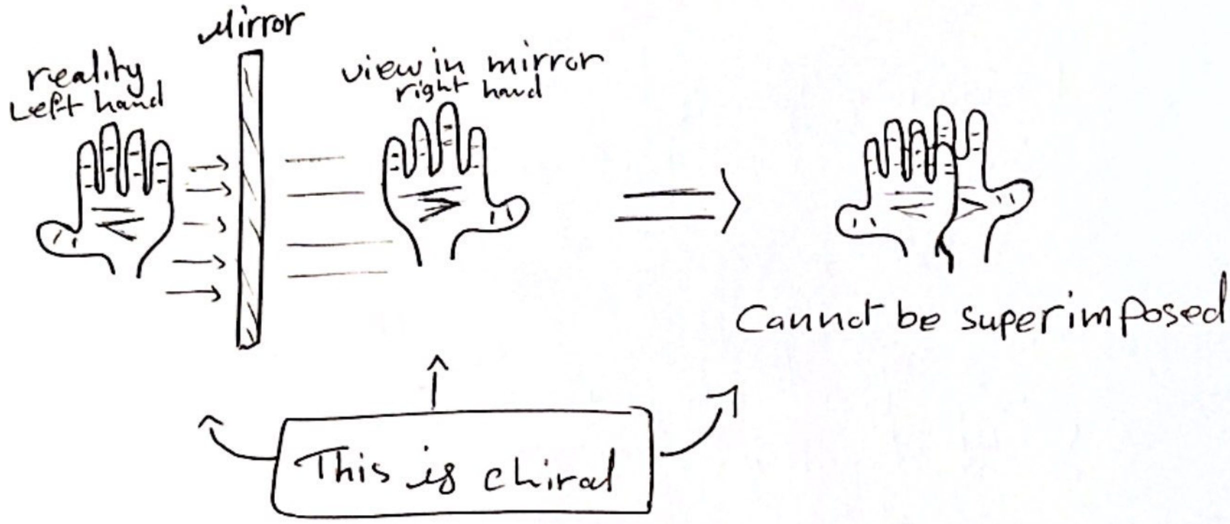
the carbons are chiral → so 4 Chiral Carbons

★ Number of stereoisomers: $2^n = 2^4 = 16$ stereoisomers

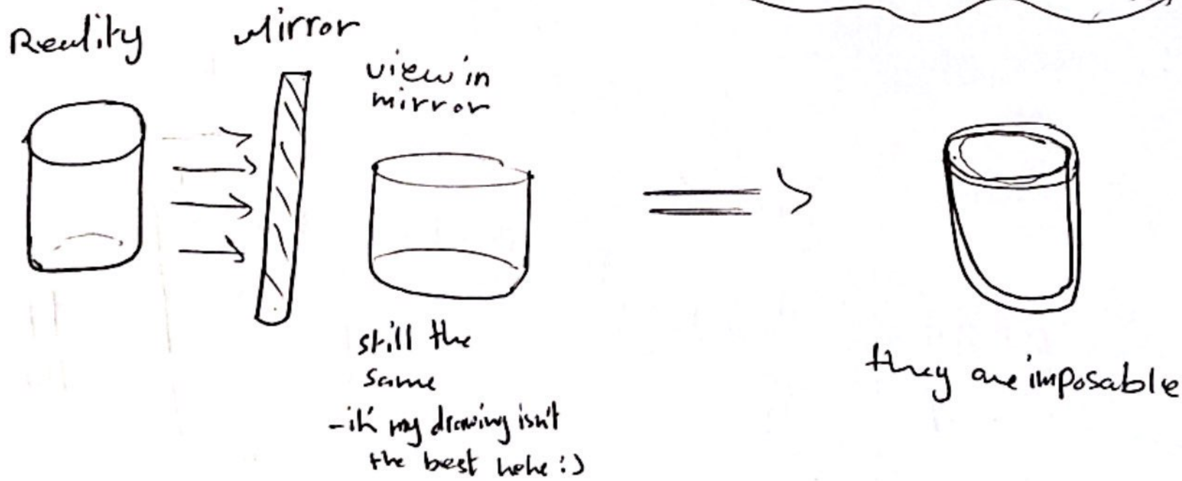
★ Chiral molecules should contain at least One Chiral Center ★ (usually a carbon atom) → Most common

So glucose is a chiral molecule

★ Chirality & Chiral objects ★



Then: <u>Chiral</u> object is: a pair of objects that are mirror images of each other but they aren't superimposable

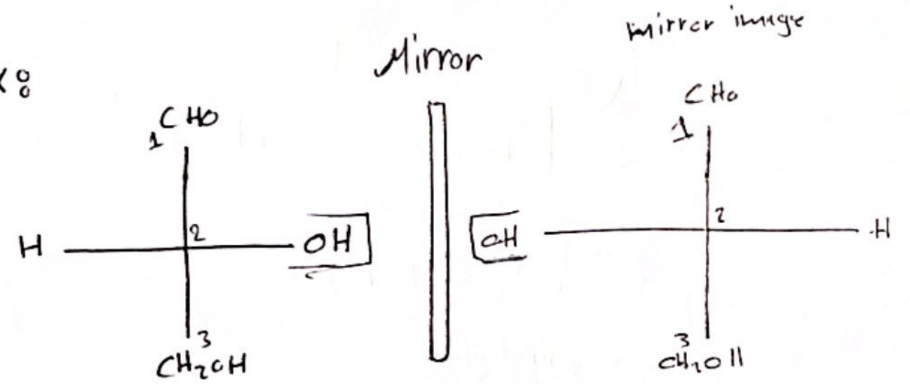


This is NOT chiral so we call it : achiral

★ Types of stereoisomers

□ Enantiomers : they are two stereoisomers that are mirror images to each other but **NOT** superimposable (same as the definition of chiral objects)

Ex:



D-glyceraldehyde L-glyceraldehyde

Not superimposable

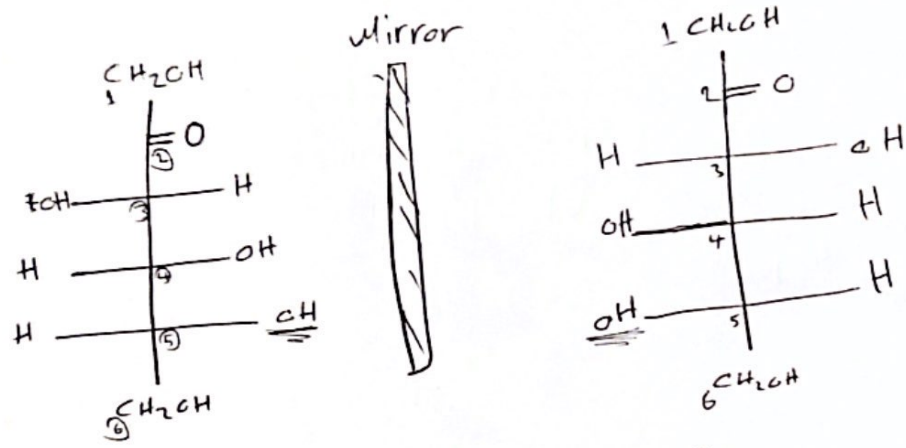
they are called Enantiomers

★ the D in [D-glycer...] comes from the latin word "Dexter" means (on the right)

★ the L in [L-glycer..] comes from the latin word "Laevo" means (on the left)

and its referring to the [OH] group that is on the chiral center
if its on the left we put [L]
if its on the right we put [D]

Ex2: fructose



D-fructose L-fructose

to name and choose which (OH) group to take here because there is multipule of them

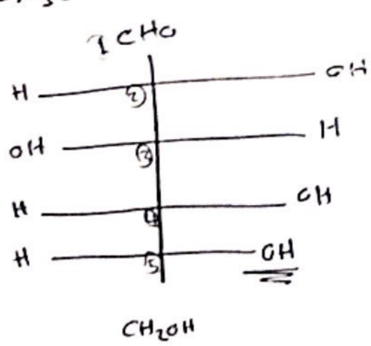
we take the farthest chiral center from the highest oxidised carbon in the molecule

- in this case: the highest oxidized carbon is the one with the functional group C=O which is carbon # 2

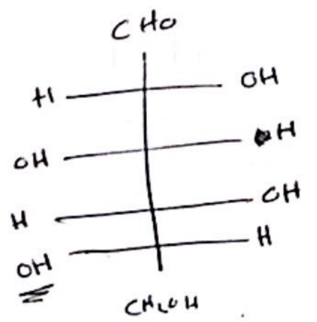
So we take the farthest chiral center from it which happens to be the 5th carbon

Note: in fischer projections the most oxidized carbon is on the top so we take the bottom-most chiral center

Ex3:



D-glucose



L-glucose

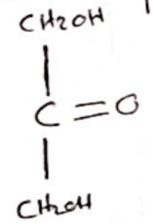
* The most naturally occurring sugars are D-isomers and they are (the biologically active form) *

* our Enzymes are smart, they can distinguish between the D & L isomeric/Enantiomeric Pairs (they are stereo selective)
- the D is biologically active in sugars

- There is NO L-glucose in the body - only D-glucose

Ketotriose or trioketose

Ex:



Dihydroxyacetone

↳ This is not chiral

So: number of stereoisomers = $2^0 = 1$

So not other forms of it such as L or D or anything, Just this Form

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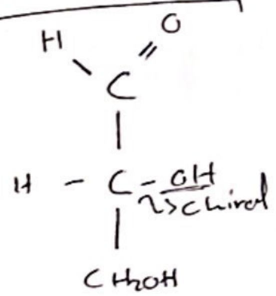
Tricaldose or aldotriose



Glyceraldehyde

↳ There is only ONE chiral Center

So: n of stereoisomers = $2^1 = 2$

D-glyceraldehyde & L-glyceraldehyde

what is the relationship between the two Substances in the example (the Dihydroxyacetone & the glyceraldehyde) ?

They are structural/Constitutional isomers to each other because they differ in the functional group connected to

★ Enantiomers are **optically active** & can rotate the Polarized light plane either clock or counter clockwise

we Detect this using a Device called a **Polarimeter**

> It has a source of [scribbled out] Polarized light that goes through the sample which changes and rotate the polarized light plane in a certain direction depending on the type of sample (sugar) either clock or counter clockwise

★ the direction of rotation <u>isn't</u> dependent on if the Sugar is D-sugar (it doesn't have to rotate to the right) or is L-sugar (it doesn't have to rotate to the left)

- for example: D-fructose rotates to the <u>left</u> so its [levorotatory]
  and L-fructose rotates to the <u>Right</u> so [dextrorotatory]

- if it rotates to the right its labeled with: (+) (dextrorotatory) and if to the left: (−) (Levorotatory)

- the old way was to label it with:
  [d] → small itallic <u>d</u> if to the right
  & [l] → small itallic <u>l</u> if to the left

Ex: D-glucose rotates to the right so:

either: (d) D-glucose
or (+) D-glucose

★ <u>By chance</u> also it was found that D-glyceraldehyde is dextrorotatory as well

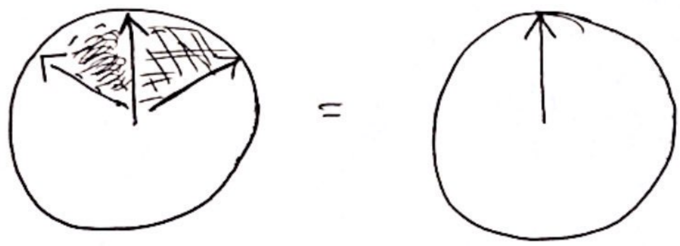
★ Dextrose is the commerical name / trade name of **D-glucose**

★ Laevulose is the Commerical / trade name of **D-fructose**

- Racemic mixture -

- its a mixture that contains same amounts of each enantiomer
- therefore the net rotation of ligh is **zero** ↷

[The **NET** Rotation]

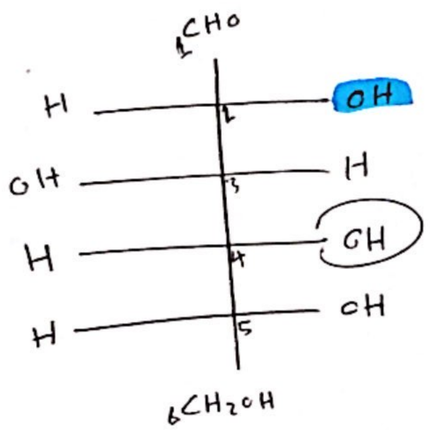


50:50 %

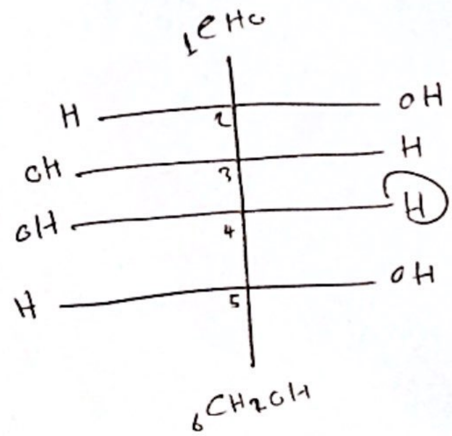
★ Epimers :

- They are stereoisomers that differ in the Configuration of atoms at only ONE chiral Center
- They aren't mirror images of each other

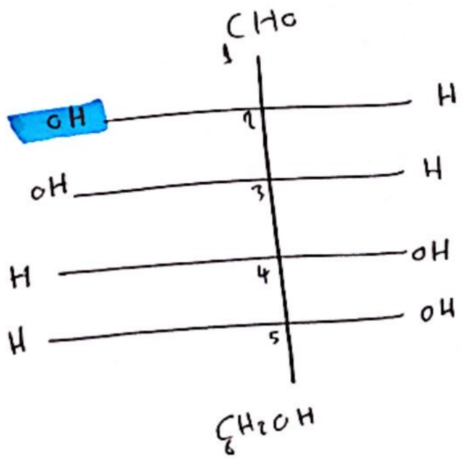
Ex:



D-glucose



D-galactose



D-Mannose

- glucose & galactose are C4 Epimers
- glucose & mannose are C2 Epimers

★ Memmorize how glucose look's ★