بسم الله الرحمن الرحيم

BioChemistry | Lecture #6

Carbohydrates Pt.1

Written by : Aziz Lahham
Ibrahim Alzoubi

Reviewed by : Ismail Abu Shaqra

-Our body consists of 4 main Macromolecules : Carbohydrates , Proteins , Lipids , and Nucleic Acids
-Each one of them serves a unique function which the others can't do (That's why we have 4 types).
-Carbohydrates are used as an energy source. However, lipids are a better energy source compared to carbohydrates -All cells in the body accept fat as an energy resource EXCEPT Red Blood Cells(its only source of Energy are carbohydrates)- So what makes carbohydrates unique?: (Next slide)

Why do I need carbohydrates? What is unique about them compared to other macromolecules?

It's **NOT** just about energy. While carbohydrates are a source of energy, all macromolecules—especially lipids—can serve this function. (Although carbohydrates are hydrolyzed quickly, making them the body's *first* source of energy.)

- ❖ What makes carbohydrates special simply is that they are **highly hydrophilic**, which contributes to their **viscous (sticky)** nature.

This hydrophilicity is why carbohydrates are commonly found on cell surfaces, where they play important roles in **cellular and immune recognition**.

Proteins can serve this function too since they are highly soluble.

"Sugars"

Carbohydrates "Saccharides" "Carbo" & "Hydrate"

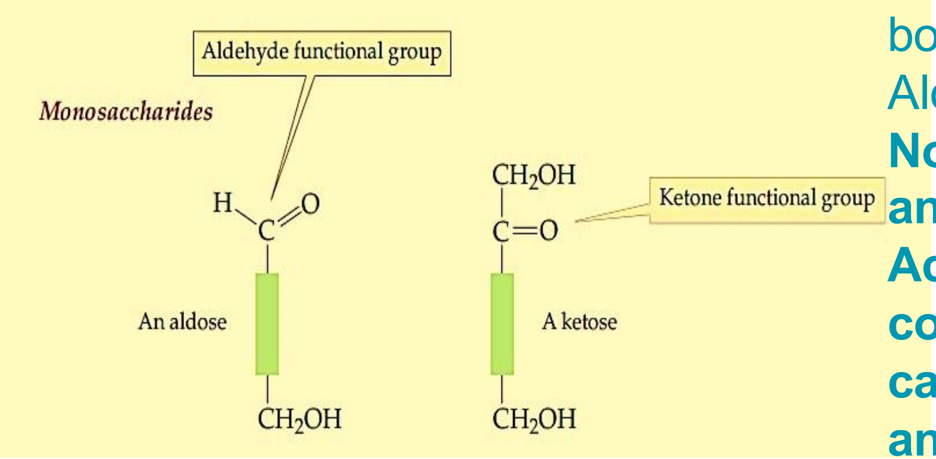
Carbons connected with water(H+OH)

- Glycans with basic formula $(CH_2O)n$ (n varies from 3-8)
- It is a polyhydroxy (aldehyde) or (ketone), or a substance that gives these compounds on hydrolysis

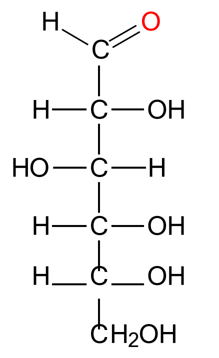
$(CH_2O)_n$ or **H - C - OH**

- Monosaccharide (monomers): a carbohydrate that cannot be hydrolyzed to a simpler one
- Aldoses vs. ketoses: glyceraldehyde(simplest aldose) & dihydroxyacetone(simplest ketose) are the simplest
- In order to be considered a carbohydrate, it **MUST** contain a carbonyl group (the functional group). Carbonyl group is either aldehyde or ketone.

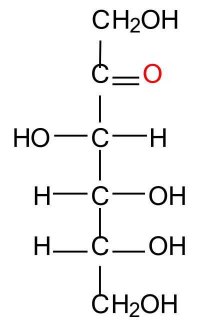
Aldoses (aldehydes) can be oxidized to carboxylic acids (directly)
However Ketoses(ketones) are first converted into Aldehydes and then they are oxidized into carboxylic acids (indirectly)



When they Are reduced they both become Alcohols.
Note that Alcohols and Carboxylic Acids are not considered carbohydrates anymore.



D-glucose



D-fructose

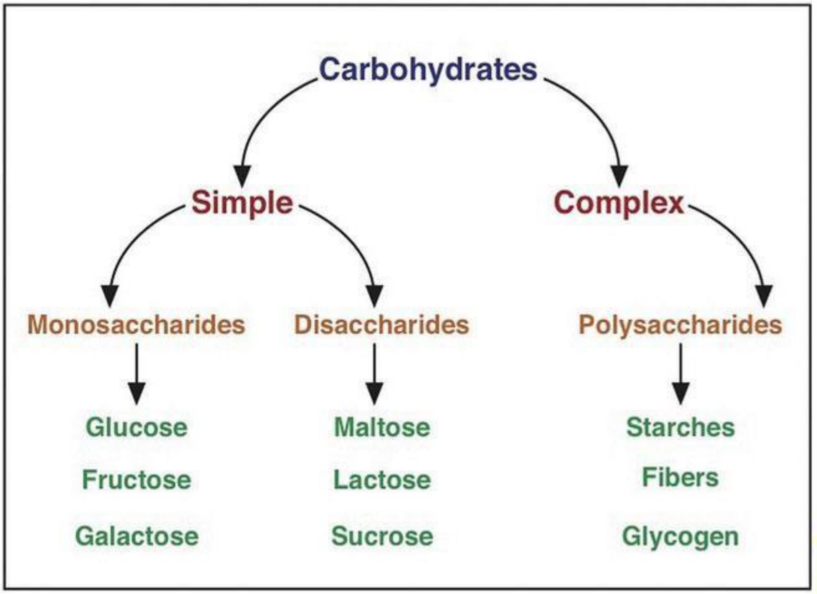
Structural Forms

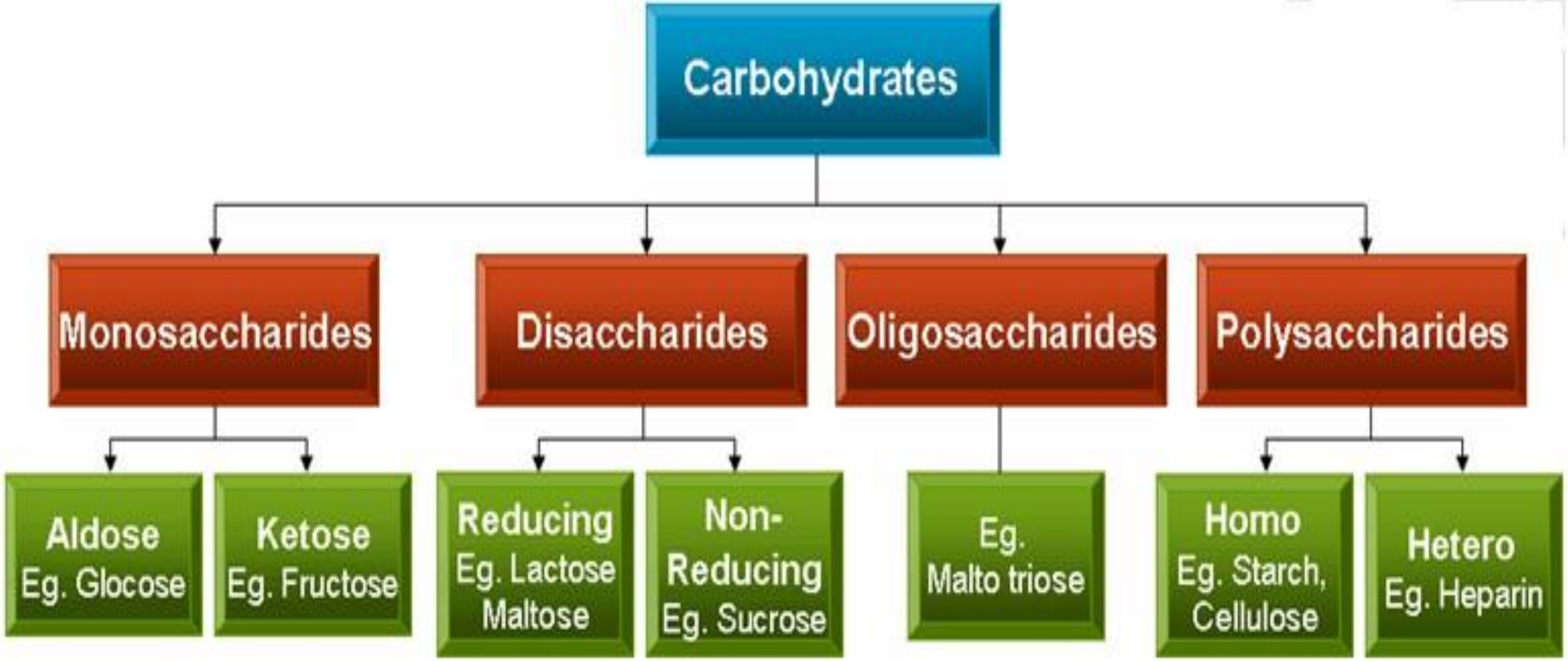
simplest

- Monosaccharides – carbohydrates that cannot be hydrolyzed to simpler carbohydrates (glucose or fructose)
- Disaccharides – carbohydrates that can be hydrolyzed into two monosaccharide units (sucrose → glucose & fructose)
- Oligosaccharides (3 to 10 units) – carbohydrates that can be hydrolyzed into a few monosaccharide units (fructo-oligosaccharides (FOS) found in many vegetables, Raffinose)
- Polysaccharides – carbohydrates that are polymeric sugars (starch or cellulose)

Natural Forms

- Most carbohydrates are found naturally in bound form rather than as simple sugars
  - Polysaccharides (starch, cellulose, inulin, gums)
  - Glycoproteins and proteoglycans (hormones, blood group substances, antibodies)
  - Glycolipids (cerebrosides, gangliosides)
  - Glycosides
  - Mucopolysaccharides (hyaluronic acid)
  - Nucleic acids (DNA, RNA) attatched to nitrogen base





Classification

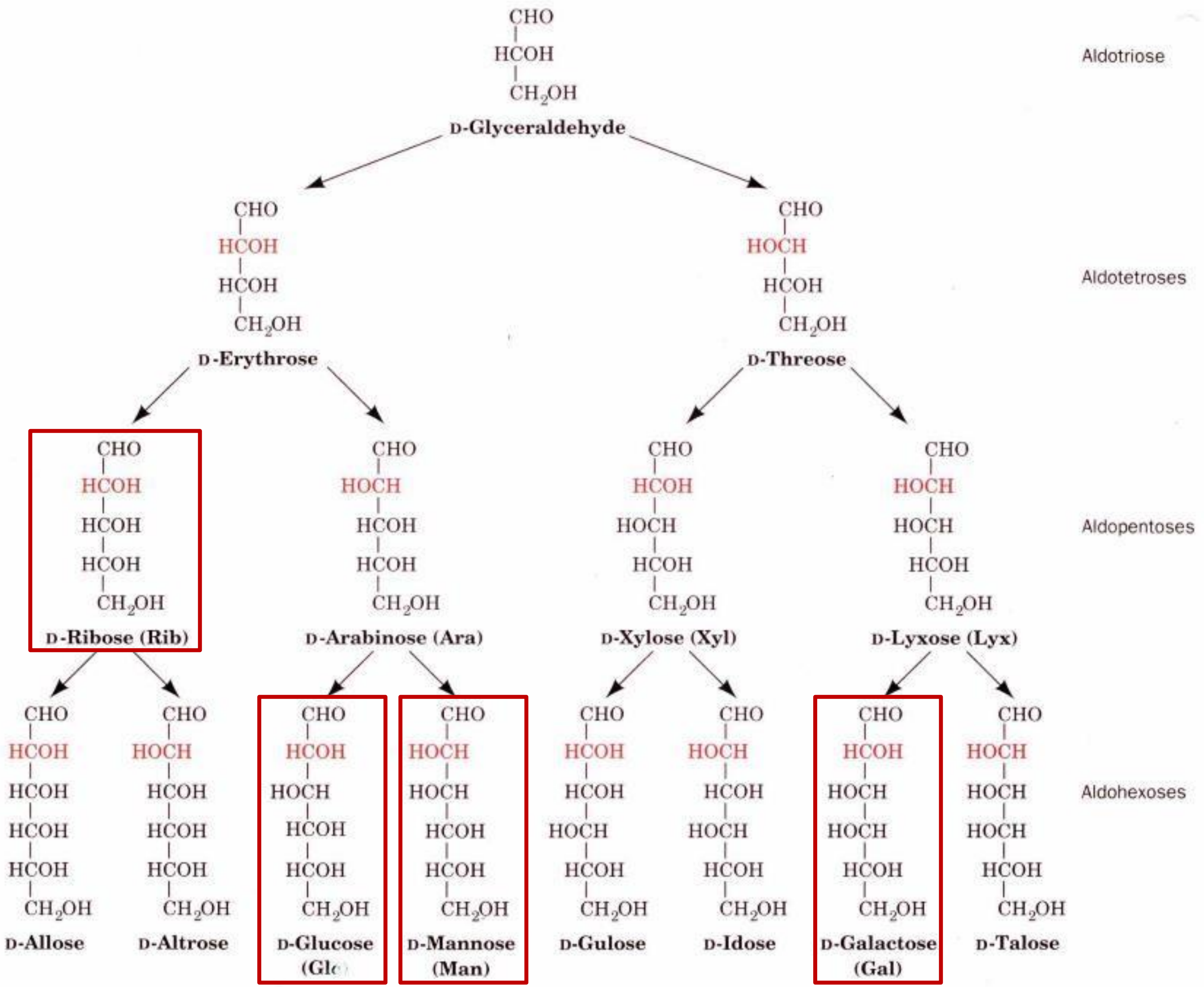
Hexose is the most common Monosaccharide (examples of hexoses are Glucose,fructose ,mannose, galactose)

8 carbon atoms =octose

Carbon Atoms	General terms	Aldehydes	Ketones
3	Triose	Aldotriose	Keto triose
4	Tetrose	Aldotetrose	Ketotetrose
5	Pentose	Aldopentose	Ketopentose
6	Hexose	Aldohexose	Ketohexose
7	Heptose	Aldoheptose	Ketoheptose

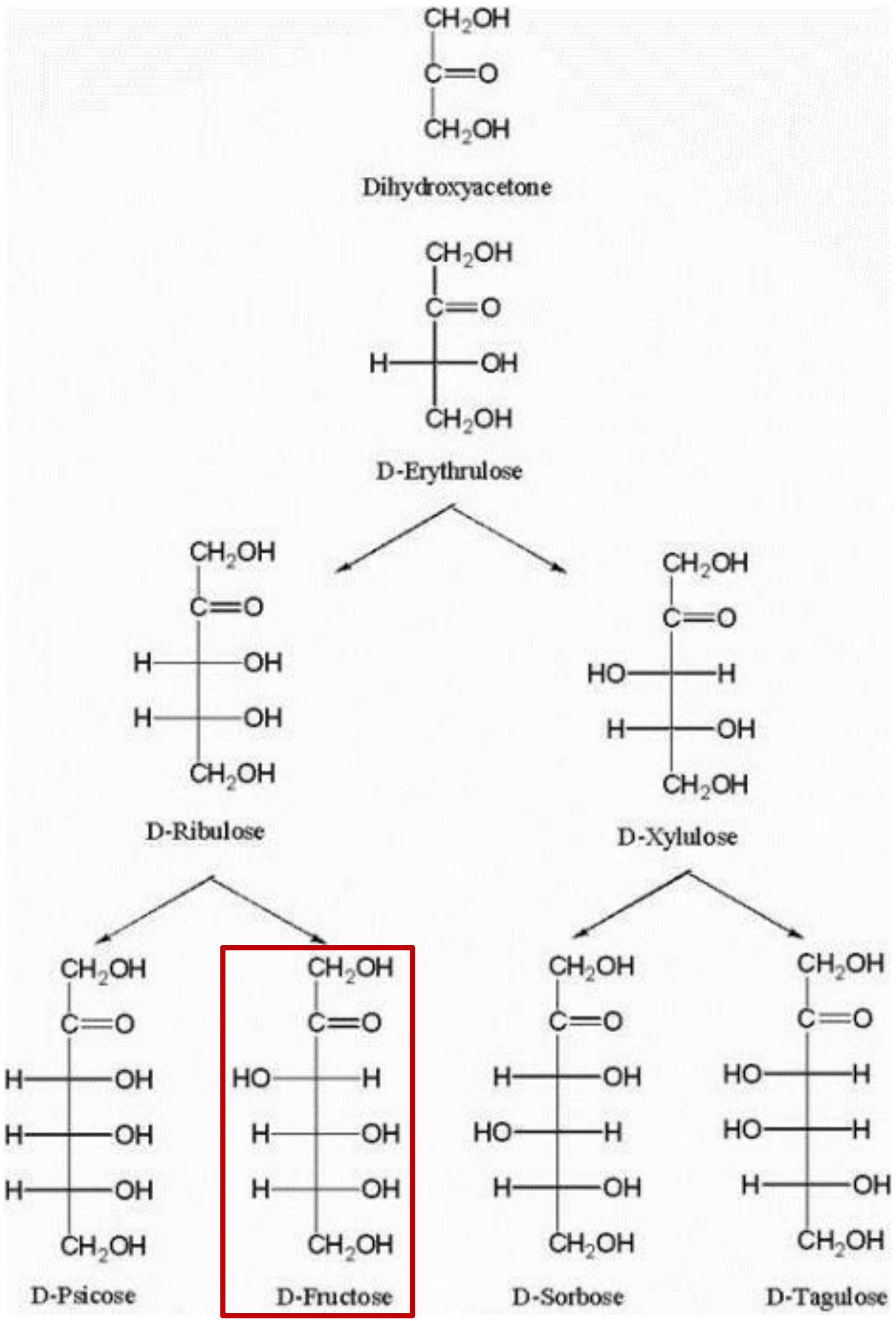
Aldoses

Classification



Classification

Ketoses

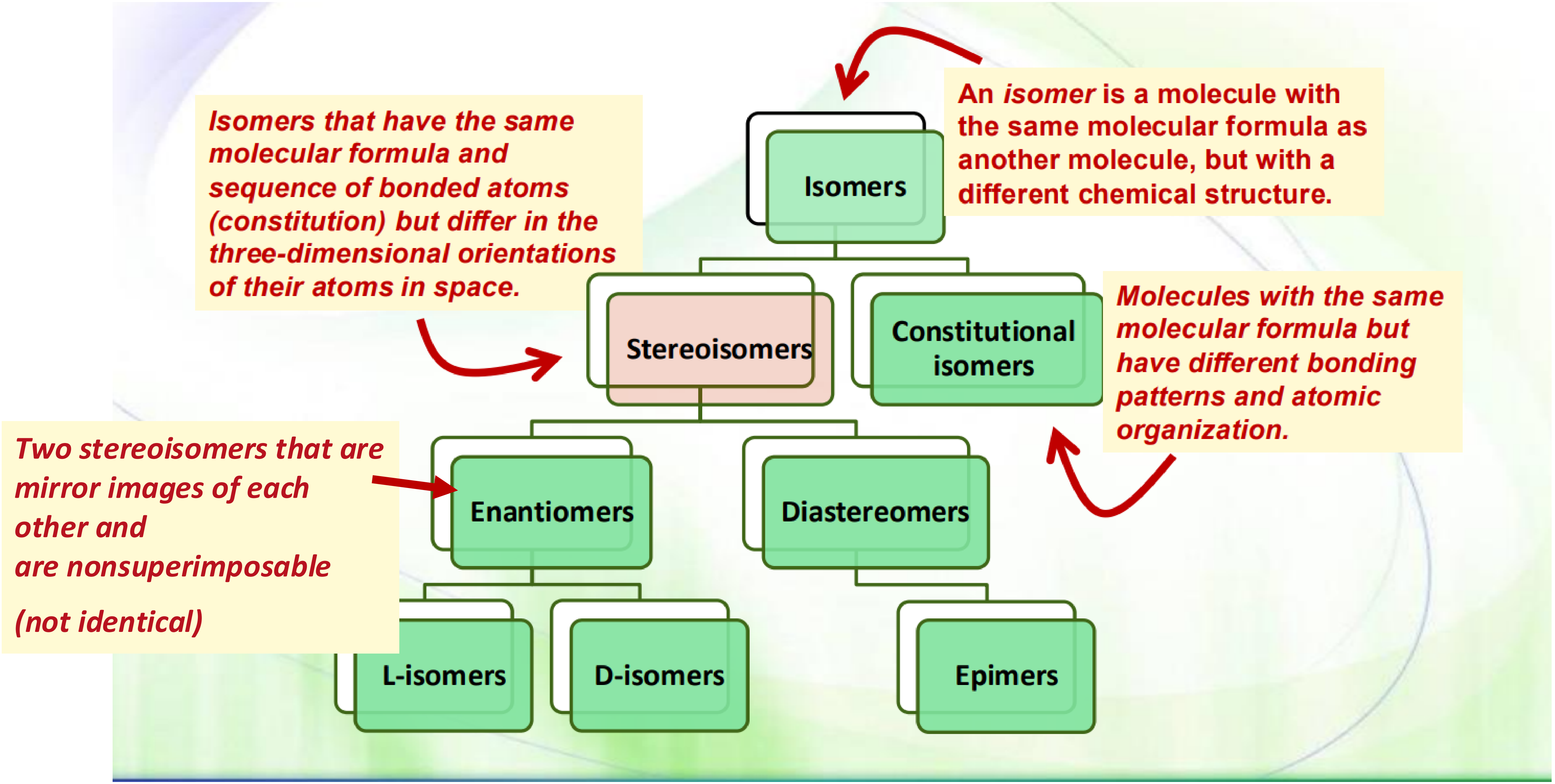


Two important definitions to study carbohydrates (organic chemistry revision)
Chirality and isomerism

- Chiral carbon: a carbon which is connected to **four different** groups.

Otherwise, it's achiral.

- And when we subject that molecule to a light inside a solution it will rotate(clockwise or counterclockwise) , depending on where these functional groups inside the molecule are attached to the carbon.


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.
Isomers
An isomer is a molecule with the same molecular formula as another molecule, but with a different chemical structure.
Stereoisomers
Constitutional isomers
Molecules with the same molecular formula but have different bonding patterns and atomic organization.
Two stereoisomers that are mirror images of each other and are nonsuperimposable (not identical)
Enantiomers
Diastereomers
L-isomers
D-isomers
Epimers

- When we have two stereoisomers, we basically have two different subjects, with different physical and chemical properties.

-An example for stereoisomers (النعنع و الكراوية) they are completely different things (smell, colour, taste) even though the only difference in their structure is that they have different orientation for a functional group.

-Another example, the aldoses(glucose, galactose and mannose) they have the same functional group but different orientation in space.

-And for any of these examples to occur at least one carbon must be chiral(stereogenic center) in the molecule.

-We can predict the number of isomers that a molecule can make using this formula: 2^n (n is the number of chiral carbons in a sugar molecule).

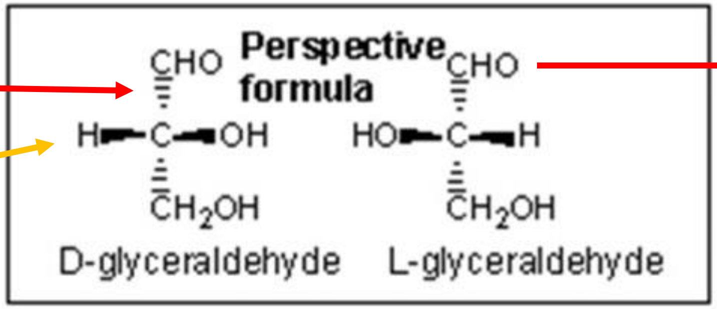
-Glucose has 4 chiral centers →2^4 = 16. So glucose has 16 isomers

To have a better understanding for the geometry of the molecules we have this method of drawing:

- Fischer projection: two-dimensional representation of a three-dimensional organic molecule by projection.
- We draw the molecule as an open chain from up to down, with the functional group located up the chain and the end of the molecule down.
- Longitudinal(vertical) bonds in between the carbon units are going inside the screen, and horizontal bonds are going outside the screen.

Inside the page
(-)z axis

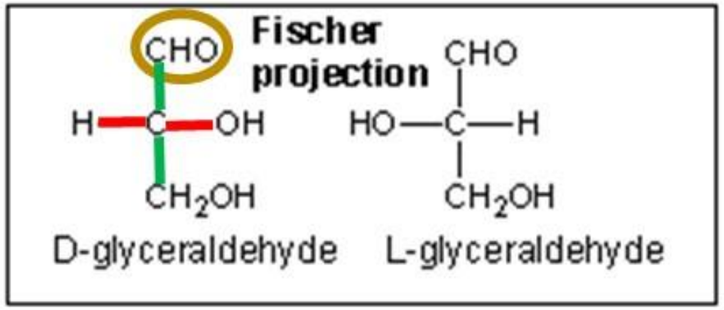
Outside the page
(+)z axis

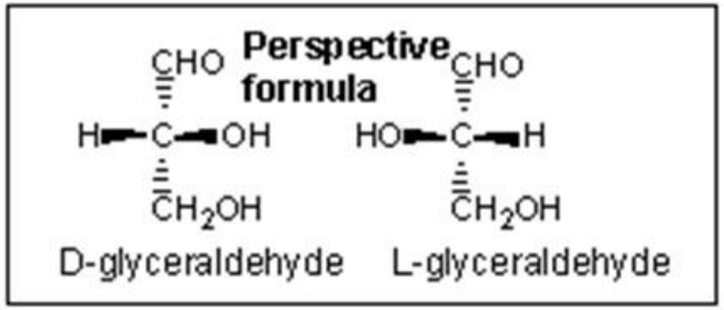


Functional group

Fischer projection

Monosaccharides



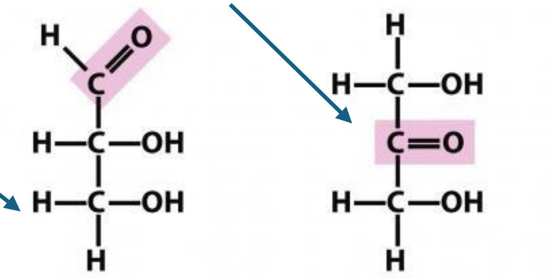


- Basic chemical formula: $(CH_2O)n$
- Stereocenters
- D or L
- D sugars predominate in nature
- The 2-D representation (Fischer Projections)

The last carbon in every monosaccharaide is achiral

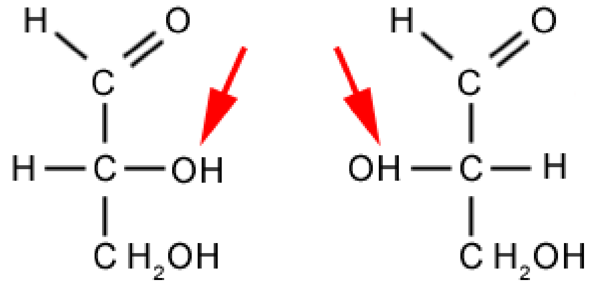
Forward Backward Top (C1): Most highly oxidized C

Ketotriose is an achiral molecule



Glyceraldehyde, an aldotriose

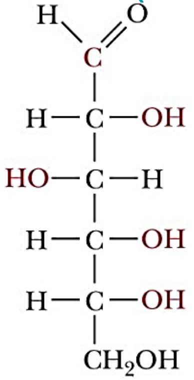
Dihydroxyacetone, a ketotriose



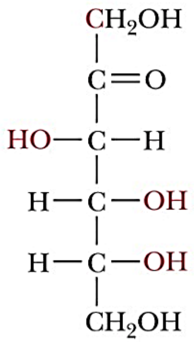
D-Glyceraldehyde L-Glyceraldehyde

▪The simplest monosaccharaide contains 3 carbon(triose)

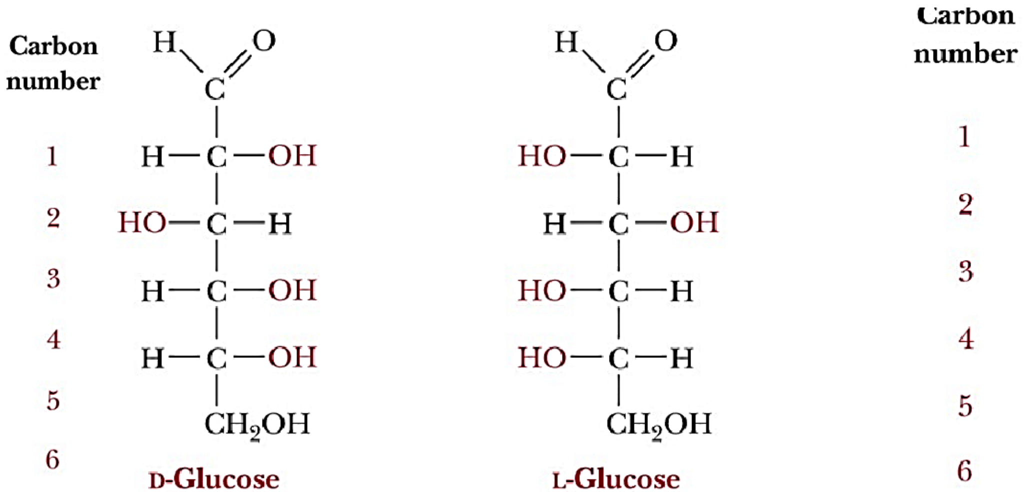
Chiral molecule



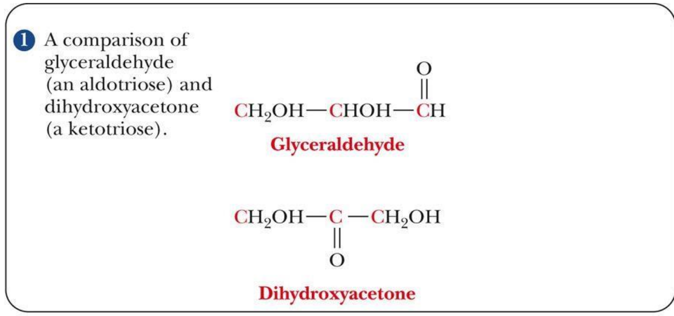
D-Glucose (an aldose)



D-Fructose (a ketose)



D-Glucose L-Glucose



How to determine whether the monosaccharaide is D or L (شرح الدكتور نافذ)

Every monosaccharaide with at least one chiral centre has two enatiomers, D and L.

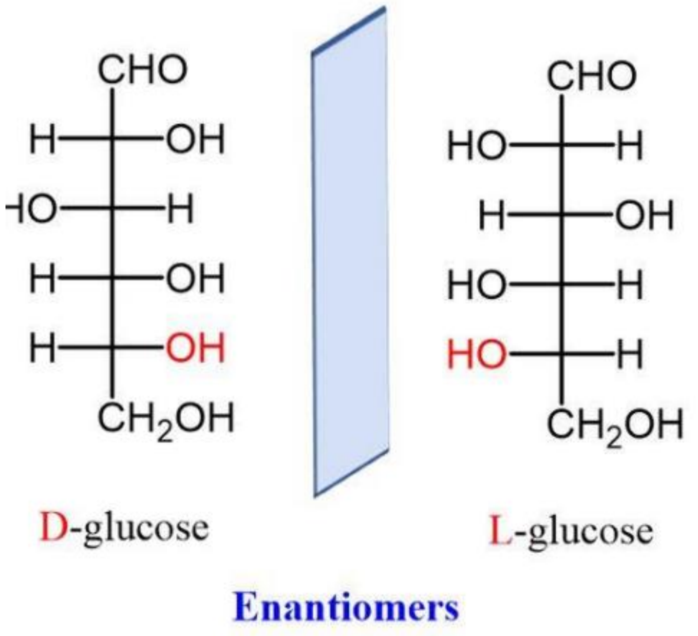
First, we must find the chiral centre, but we have agreed that the last carbon in every monosaccharaide is achiral, so we look at the carbon before the last one since it is always chiral unless the whole molecule is achiral of course, if the group was to the right of the carbon we call it D, if it was to the left, we call it L.

Next slide إضافي من الدكتور مأمون شرح

D : Dextro (right in latin)
L : Levo (left in latin)

What does the D / L designation depend on?

- The hydroxyl (OH) group attached to the chiral carbon that is the furthest from the functional group.
- • EXAMPLE...



We are looking at the OH group at the furthest carbon from the functional group (that is C#5) : On the right the OH group is to the left therefore L- glucose. AND on the left the OH is to the right therefore D – glucose.

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			

رسالة من الفريق العلمي:

في ازدياد العلمِ إرغامُ العدى

و جمالُ العلم إصلاح العمل

ابن الوردي

Additional sources:
2023 Modified for slide 17.