

Carbohydrate chemistry

الكيمياء الحيوية ١ / المرحلة الثالثة
/ الفصل الأول

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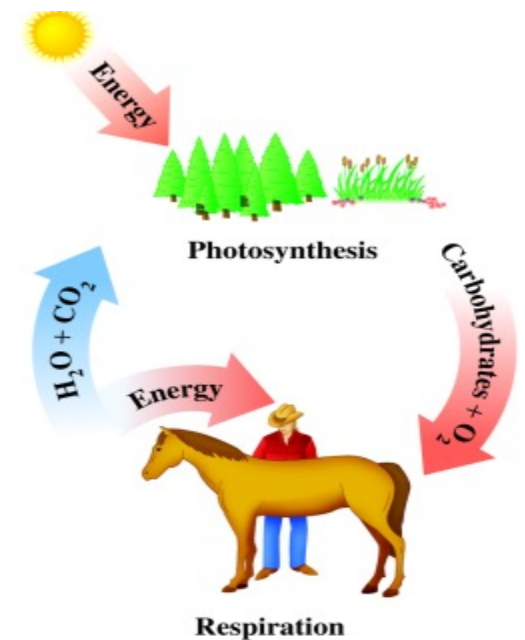
- **INTRODUCTION:DEFINITION, CLASSIFICATION AND FUNCTIONS OF CARBOHYDRATES**

- **Classification**
- **Aldoses , Ketoses**
- **Enantiomers , epimers and anomers**
- **Glycoside Formation**
- **_ Derivatives of Monosaccharides**
- **_ Disaccharides**
- **_ Polysaccharides (Glycans)**
- **_ Glycoproteins**
- **_ Summary**
- **_ Exercise**

Carbohydrates

Carbohydrates are

- A major source of energy from our diet.
- Composed of the elements C, H, and O.
- Also called saccharides, which means “sugars.” Are produced by photosynthesis in plants.
- Such as glucose are synthesized in plants from CO_2 , H_2O , and energy from the sun.
- Are oxidized in living cells (respiratic.., to produce CO_2 , H_2O , and energy



Classification

- **Carbohydrates** – polyhydroxyaldehydes or polyhydroxyketones of formula $(\text{CH}_2\text{O})_n$, or compounds that can be hydrolyzed to them. (sugars or saccharides)
- **Monosaccharides** – carbohydrates that cannot be hydrolyzed to simpler carbohydrates; eg. Glucose or fructose.
- **Disaccharides** – carbohydrates that can be hydrolyzed into two monosaccharide units; eg. Sucrose, which is hydrolyzed into glucose and fructose.
- **Oligosaccharides** – carbohydrates that can be hydrolyzed into a few monosaccharide units. up to 9 or 10
 - **Polysaccharides** – Polysaccharides or glycans
 - Homo and Heteropolysaccharides
 - Complex carbohydrates
- that are are polymeric sugars; eg Starch or cellulose.

- **Aldose** – polyhydroxyaldehyde, eg glucose
- **Ketose** – polyhydroxyketone, eg fructose
- **Triose, tetrose, pentose, hexose**, etc. – carbohydrates that contain three, four, five, six, etc. carbons per molecule (usually five or six); eg. Aldohexose, ketopentose, etc.
- **Reducing sugar** – a carbohydrate that is oxidized by Tollen's, Fehling's or Benedict's solution.
 - Tollen's: $\text{Ag}^+ \rightarrow \text{Ag}$ (silver mirror)
 - Fehling's or Benedict's: Cu^{2+} (blue) \rightarrow Cu^{1+} (red ppt)
- These are reactions of aldehydes and alpha-hydroxyketones.
- **All monosaccharides (both aldoses and ketoses) and most* disaccharides are reducing sugars.**
- *Sucrose (table sugar), a disaccharide, is not a reducing sugar.

Types of Carbohydrates

Monosaccharide + H₂O



no hydrolysis



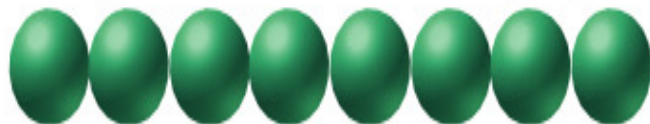
Disaccharide + H₂O



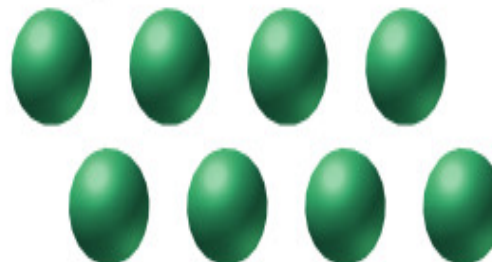
two monosaccharide units



Polysaccharide + many H₂O $\xrightarrow{H^+}$



many monosaccharide units



Monosaccharides

Monosaccharides consist of

- 3 to 6 carbon atoms, typically.
- A carbonyl group (aldehyde or ketone).
- Several hydroxyl groups.
- **also known as simple sugars**
- **classified by 1. the number of carbons and 2. whether aldoses or ketoses**
- **most (99%) are straight chain compounds**
- **D-glyceraldehyde is the simplest of the aldoses (aldotriose)**
- **all other sugars have the ending ose (glucose, galactose, ribose, lactose, etc...)**

Aldoses

Aldoses are monosaccharides

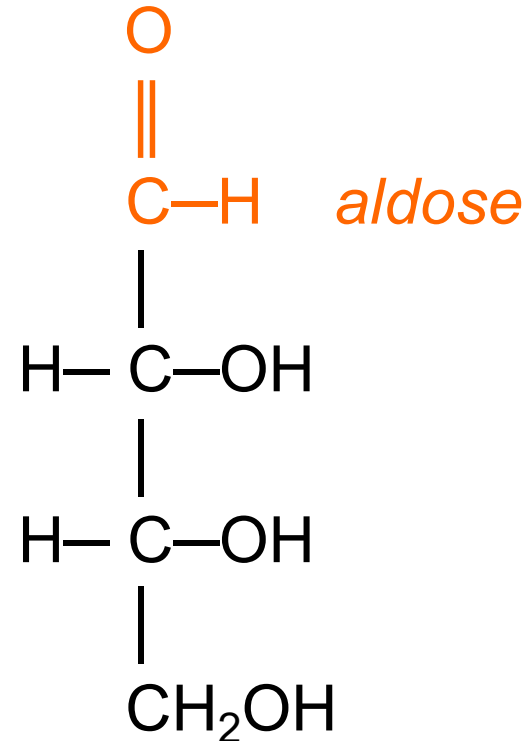
- With an **aldehyde group**.
- With many hydroxyl (-OH) groups.

triose (3 C atoms)

tetrose (4 C atoms)

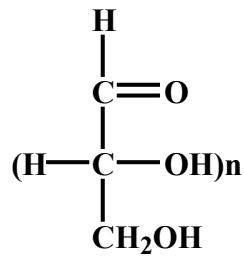
pentose (5 C atoms)

hexose (6 C atoms)

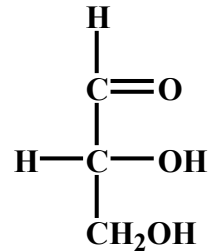


Erythrose, an aldotetrose

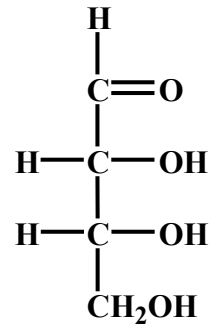
Aldose sugars



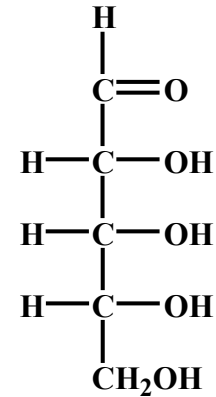
Aldose



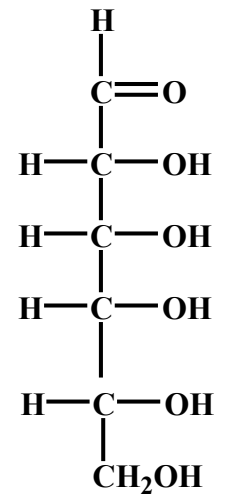
Aldotriose
n = 1



Aldotetrose
n = 2



Aldopentose
n = 3



Aldohexose
n = 4

Ketoses

Ketoses are monosaccharides

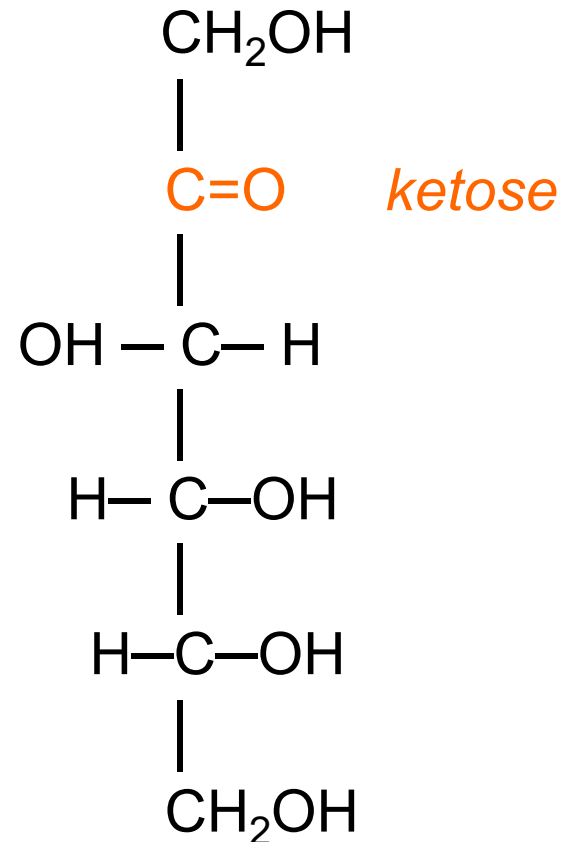
- With a **ketone group**.
- With many hydroxyl (-OH) groups.

triose (3 C atoms)

tetrose (4 C atoms)

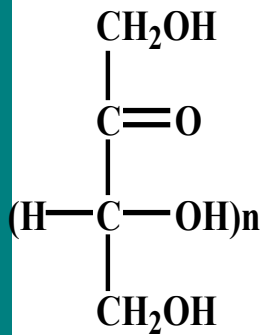
pentose (5 C atoms)

hexose (6 C atoms)

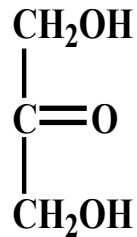


Fructose, a ketohexose

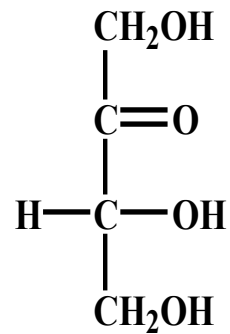
Ketose sugars



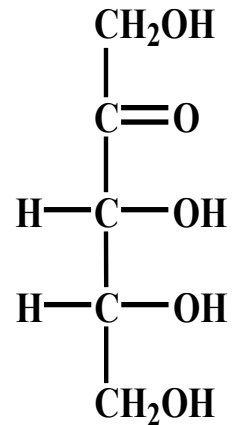
Ketose



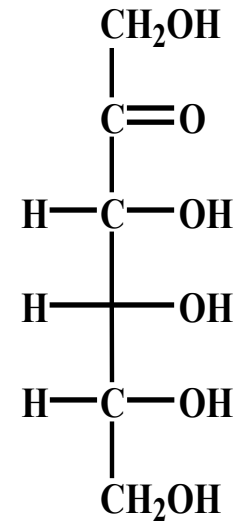
Ketotriose
 $n = 0$



Ketotetrose
 $n = 1$



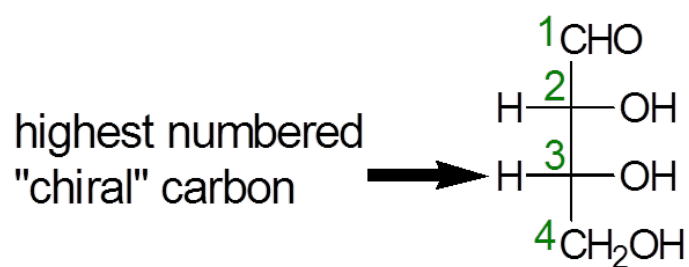
Ketopentose
 $n = 2$



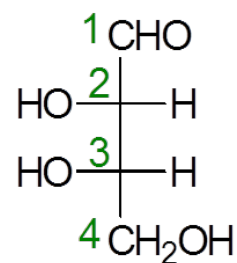
Ketohexose
 $n = 3$

Aldotetrose

aldotetroses

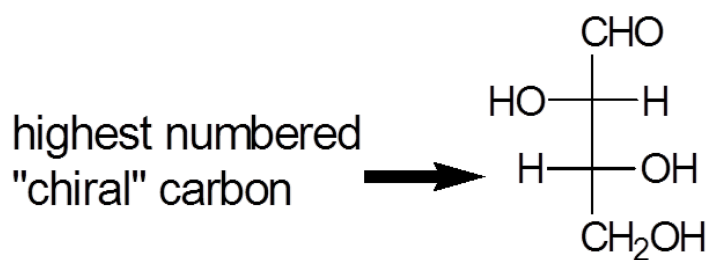


D-erythrose

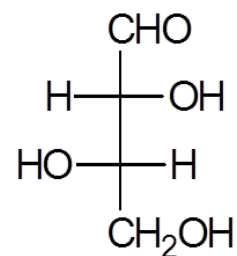


L-erythrose

← highest numbered
"chiral" carbon



D-threose

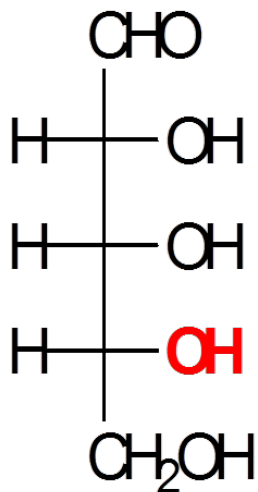


L-threose

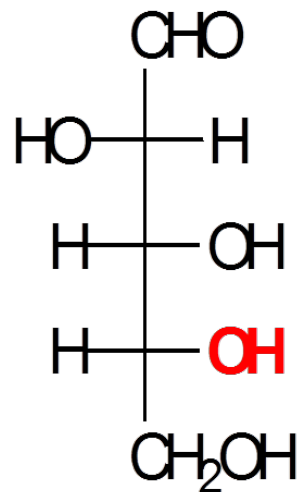
← highest numbered
"chiral" carbon

Aldopentoses:

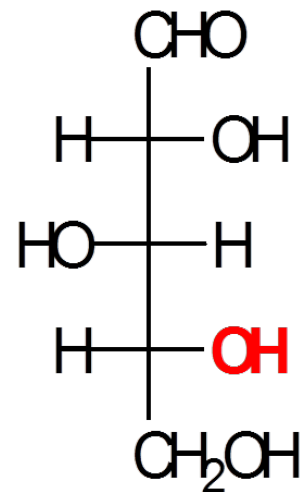
C5, three chiral carbons, eight stereoisomers



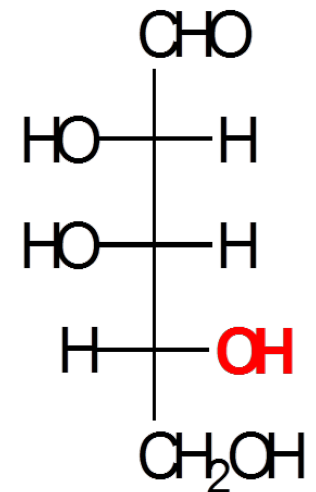
D-ribose



D-arabinose

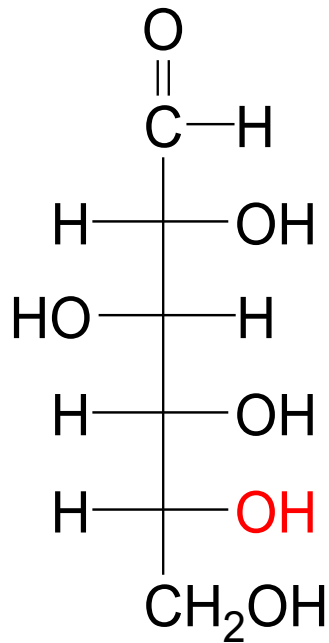


D-xylose

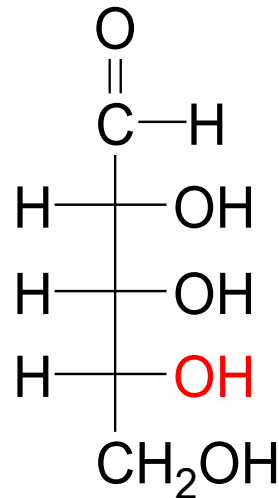


D-lyxose

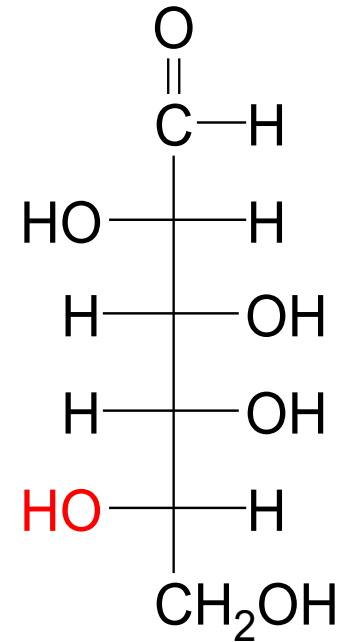
Examples of D and L Isomers of Monosaccharides



D-glucose



D-ribose



L-galactose

Optical isomerism

- Asymmetric compounds rotate plane polarized light

POLARIMETRY

Measurement of optical activity in chiral or asymmetric molecules using plane polarized light
Molecules may be chiral because of certain atoms or because of chiral axes or chiral planes
Measurement uses an instrument called a polarimeter
Rotation is either (+) dextrorotatory or (-) levorotatory

POLARIMETER



Learning Check

Identify each as aldo- or keto- and as tetrose, pentose, or hexose:

