بسم الله الرحمن الرحيم

2nd lecture

Carbohydrates

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CARBOHYDRATE

BIOMEDICAL IMPORTANCE:

- Carbohydrates are widely distributed in plants and animals; they have important structural and metabolic roles.
- In plants, glucose is synthesized from carbon dioxide and water by photosynthesis and stored as starch or used to synthesize the cellulose of the plant cell walls.
- Animals can synthesize carbohydrates from amino acids, but most are derived ultimately from plants.
- **Glucose** is the most important carbohydrate; most dietary carbohydrate is absorbed into the bloodstream as glucose formed by hydrolysis of dietary starch and disaccharides, and other sugars are converted to glucose in the liver.

Cont….

- Glucose is the major metabolic fuel of mammals (except ruminants) and a universal fuel of the fetus.
- It is the precursor for synthesis of all the other carbohydrates in the body, including **glycogen** for storage; **ribose** and **deoxyribose** in nucleic acids; **galactose** in lactose of milk, in glycolipids, and in combination with protein in glycoproteins and proteoglycans.
- Diseases associated with carbohydrate metabolism include **diabetes mellitus, galactosemia, glycogen storage diseases,** and **lactose intolerance.**

CARBOHYDRATES ARE ALDEHYDE OR KETONE DERIVATIVES OF POLYHYDRIC ALCOHOLS

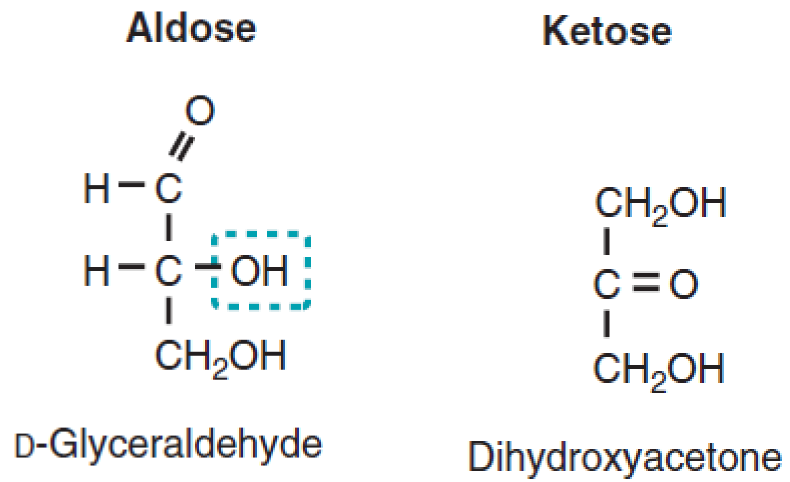
Carbohydrates are classified as follows:

1. **Monosaccharides** are those sugars that cannot be hydrolyzed into simpler carbohydrates

a. The simplest monosaccharides have the formula (CH2O)n.

b. They may be classified as **trioses, tetroses, pentoses, hexoses,** or **heptoses,** depending upon the number of carbon atoms

c. as **aldoses** or **ketoses,** depending upon whether they have an aldehyde or ketone group



	Aldoses	Ketoses
Trioses ($C_3H_6O_3$)	Glycerose (glyceraldehyde)	Dihydroxyacetone
Tetroses($C_4H_8O_4$)	Erythrose	Erythrulose
Pentoses ($C_5H_{10}O_5$)	Ribose	Ribulose
Hexoses ($C_6H_{12}O_6$)	Glucose	Fructose
Heptoses ($C_7H_{14}O_7$)		Sedoheptulose

2. **Disaccharides** are condensation products of two monosaccharide units; examples are maltose, lactose and sucrose.

a. Disaccharides have a formula of $C_n(H_2O)_{n-1}$

b. Such as:

1. Maltose: Glucose + Glucose
2. Lactose: Glucose + Galactose
3. Sucrose: Glucose + Fructose

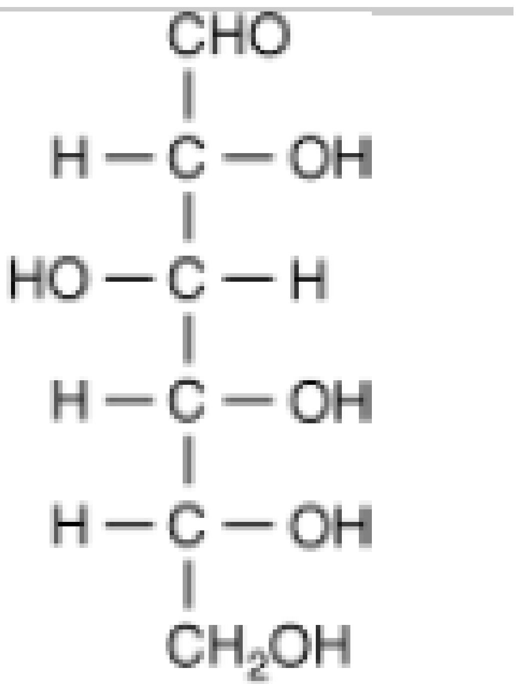
3. **Oligosaccharides** are condensation products of three to ten monosaccharides. such as maltotriose… Most are not digested by human enzymes.

4. Polysaccharides are condensation products of more than ten monosaccharide units; examples are the starches and dextrins, which may be linear or branched polymers.

Sugars Exhibit Various Forms of Isomerism

- Compounds that have the same chemical formula but have different structures are called isomers.
- Glucose, with four asymmetric carbon atoms, can form 16 isomers.
- The more important types of isomerism found with glucose are as follows:
  - D and L sugar
  - Stereoisomers, enantiomers, and epimers
  - Pyranose and furanose ring structures
  - Anomerism alpha and beta
  - Aldoses and ketoses

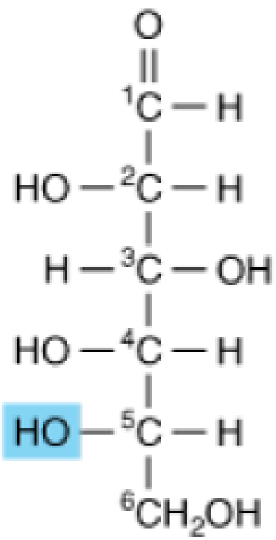
- The numbers of isomers of a monosaccharide is equal to 2 power (n) in which (n) is equal to number of asymmetric carbons for example glucose has 4 asymmetric carbons so according to this formula the number of glucose isomers are equal to 16



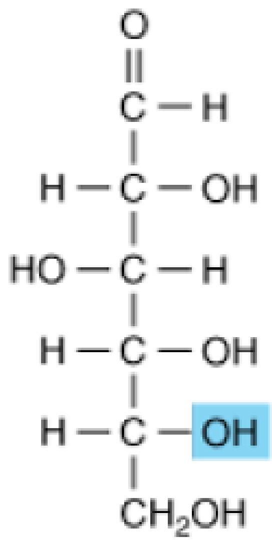
D-Glucose

D and L sugars

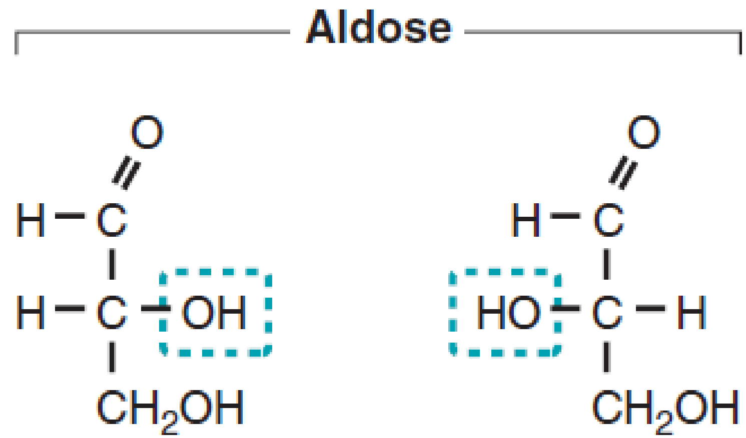
- The configuration of the asymmetric carbon atom farthest from the aldehyde or ketone group determines whether a monosaccharide belongs to the D or L series.
- In the D form, the hydroxyl group is on the right; in the L form, it is on the left
- An asymmetric carbon atom has four different chemical groups attached to it.
- Sugars of the D series, which are related to D-glyceraldehyde, are the most common in nature



L-Glucose



D-Glucose



D-Glyceraldehyde

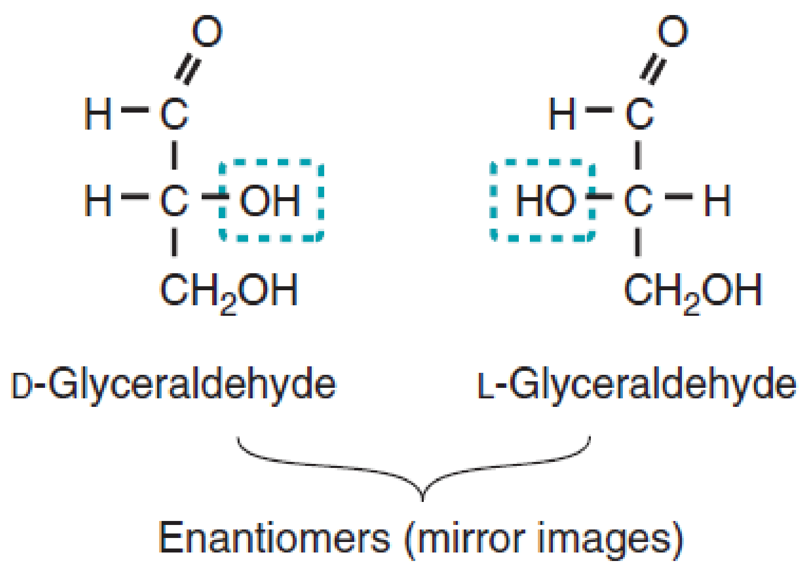
L-Glyceraldehyde

Enantiomers (mirror images)

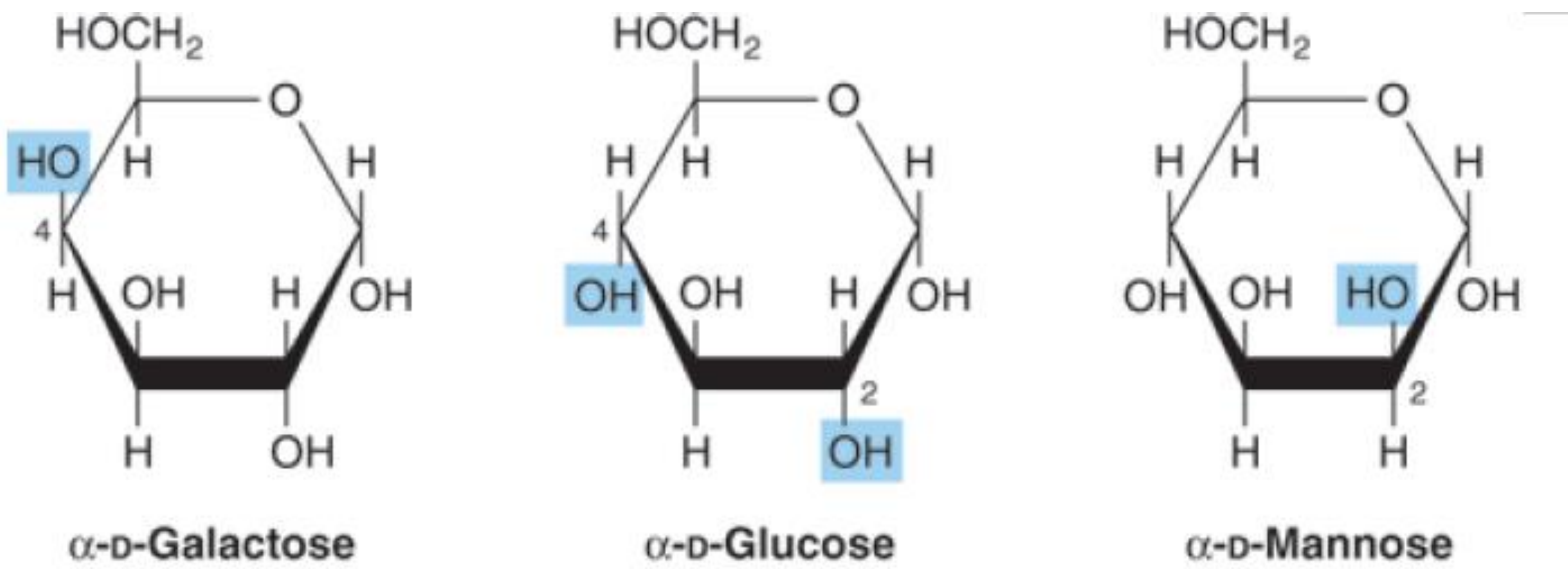
Stereoisomers, enantiomers, and epimers

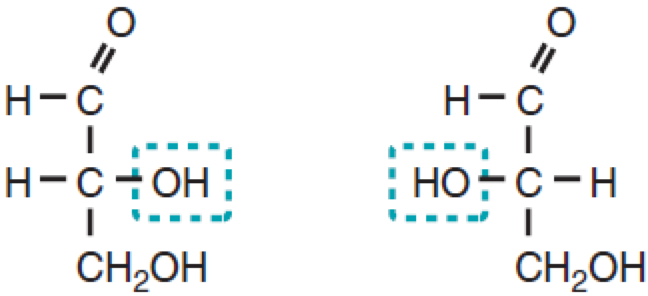
Stereoisomers have the same chemical formula but differ in the position of the hydroxyl groups on one or more of their asymmetric carbons.

a. Enantiomers are stereoisomers that are mirror images of each other.



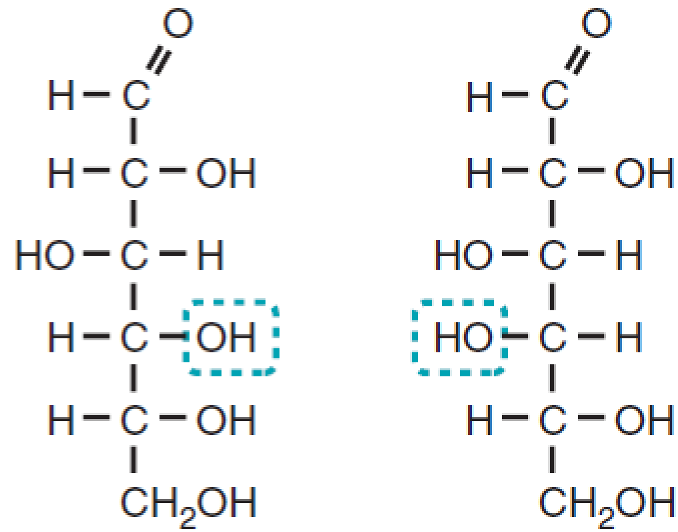
b. Epimers are stereoisomers differing as a result of variations in configuration of the —OH and —H on carbon atoms 2, 3, and 4 of glucose are known as epimers.





D-Glyceraldehyde L-Glyceraldehyde

Enantiomers (mirror images)



D-Glucose **D-Galactose**

Epimers

Ring structures of carbohydrates

a. Although monosaccharides are often drawn as straight chains (Fischer projections), they exist mainly as ring structures in which the aldehyde or ketone group has reacted with a hydroxyl group in the same molecule.

b. **Pyranose and furanose ring structures:** The ring structures of monosaccharides are similar to the ring structures of either pyran (a six-membered ring) or furan (a five-membered ring)

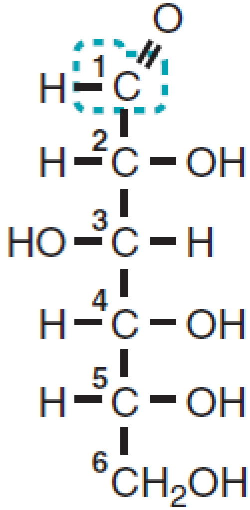
c. The hydroxyl group on the anomeric carbon may be in the a or b configuration.

(1) In the a configuration, the hydroxyl group on the anomeric carbon is on the right in the Fischer projection and below the plane of the ring in the Haworth projection.

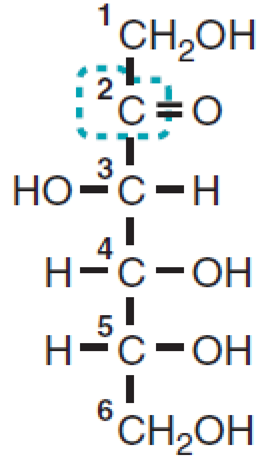
Cont….

(2) In the b configuration, it is on the left in the Fischer projection and above the plane in the Haworth projection.

d. In solution, mutarotation occurs. The a and b forms equilibrate via the straight-chain aldehyde form.

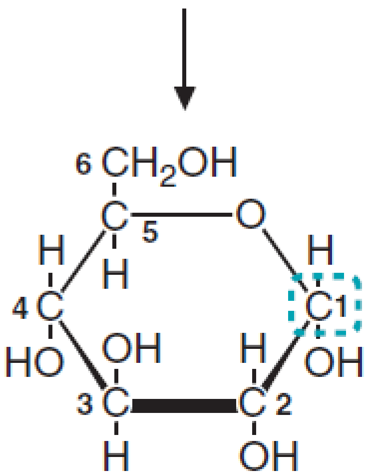


D–Glucose

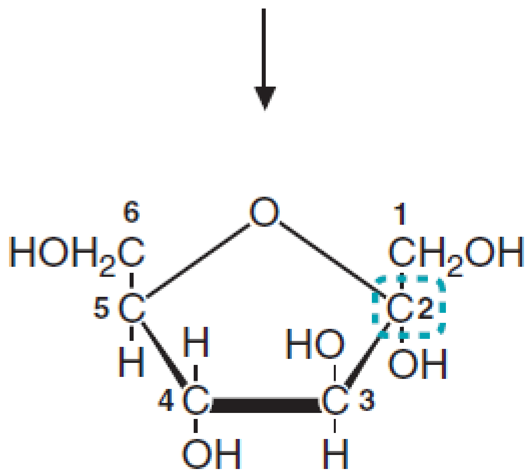


D–Fructose

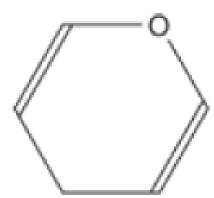
Furanose and pyranose rings formed by glucose and fructose. The anomeric carbons are surrounded by dashed lines



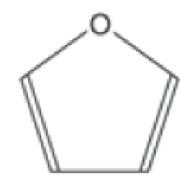
α–D–Glucopyranose



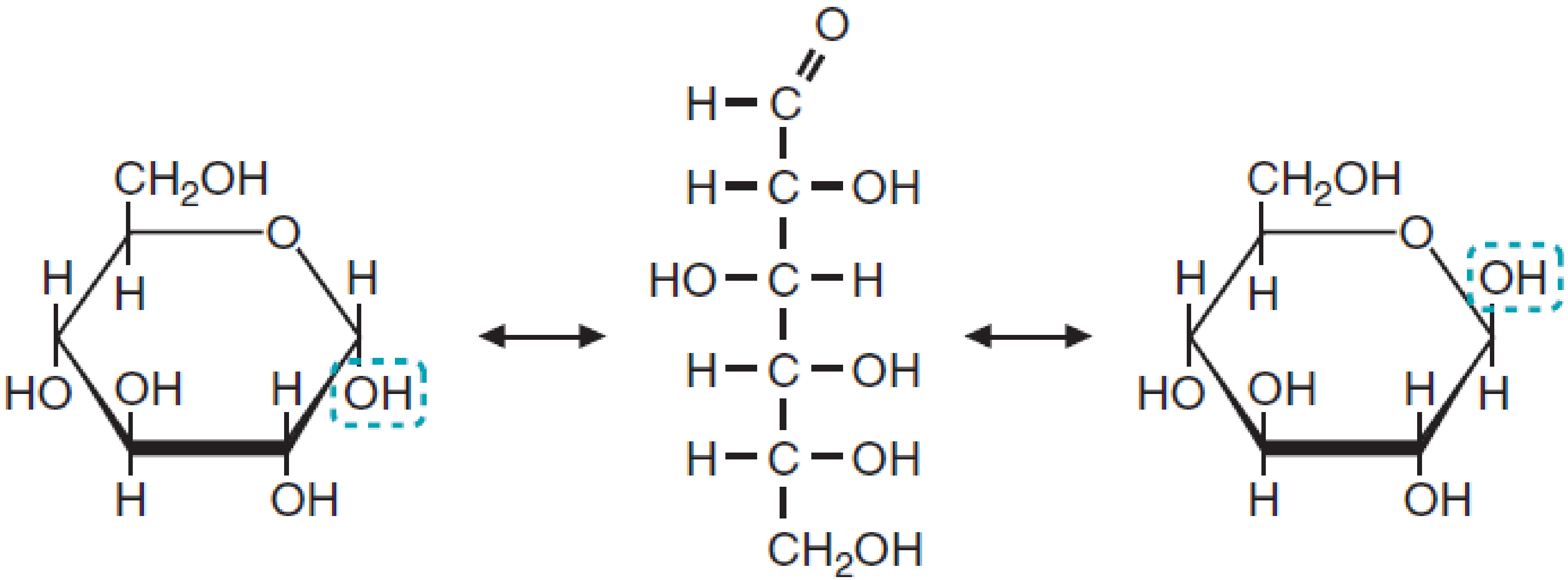
α–D–Fructofuranose



Pyran



Furan

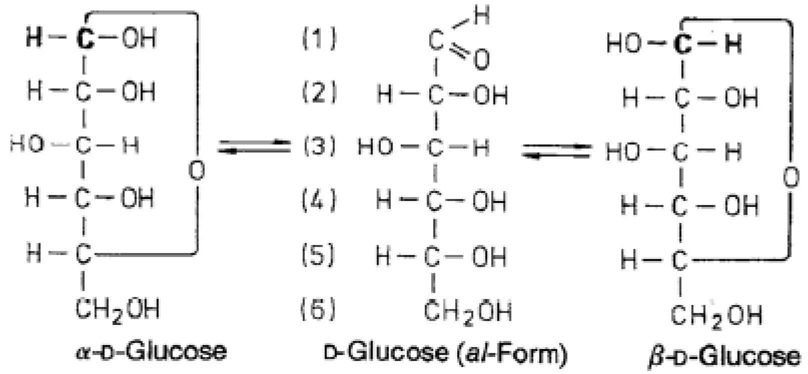


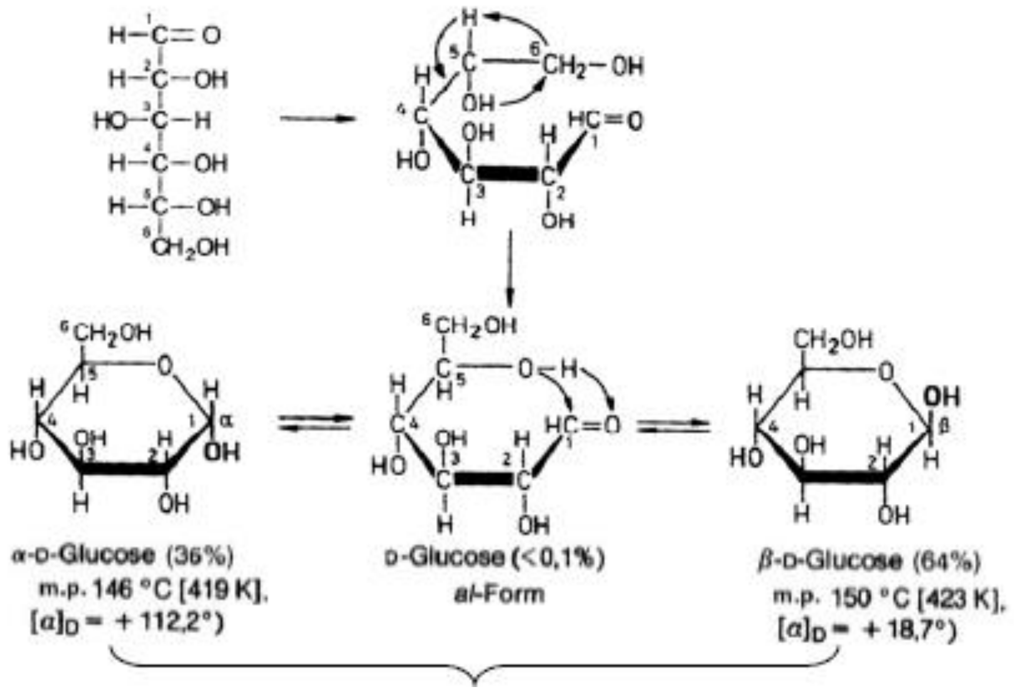
α-D-**Glucopyranose** (36%)

D-**Glucose** (< 0.1%)

β-D-**Glucopyranose** (63%)

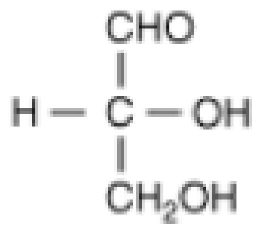
Mutarotation of glucose in solution. The percentage of each form is indicated.


α-D-Glucose
D-Glucose (al-Form)
β-D-Glucose

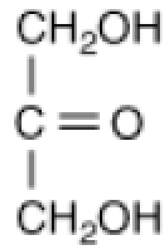

α-D-Glucose (36%)
m.p. 146 °C [419 K],
[α]D = + 112,2°)
D-Glucose (<0,1%)
al-Form
β-D-Glucose (64%)
m.p. 150 °C [423 K],
[α]D = + 18,7°)

Aldoses and ketoses

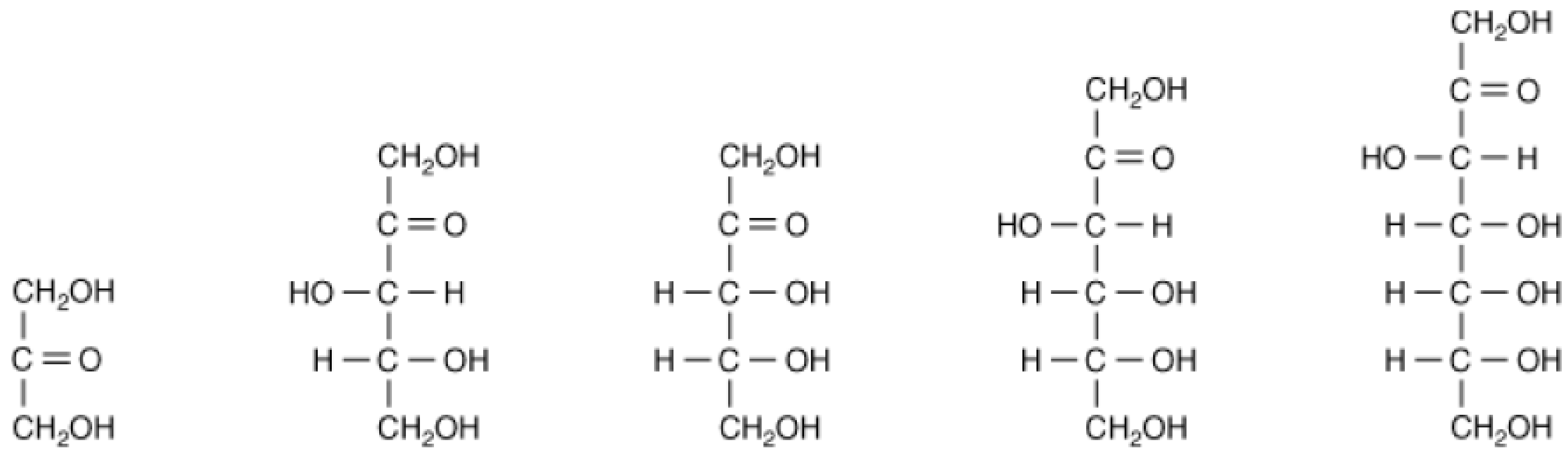
- **aldoses** or **ketoses,** depending upon whether they have an aldehyde or ketone group



D-Glycerose
(D-glyceraldehyde)

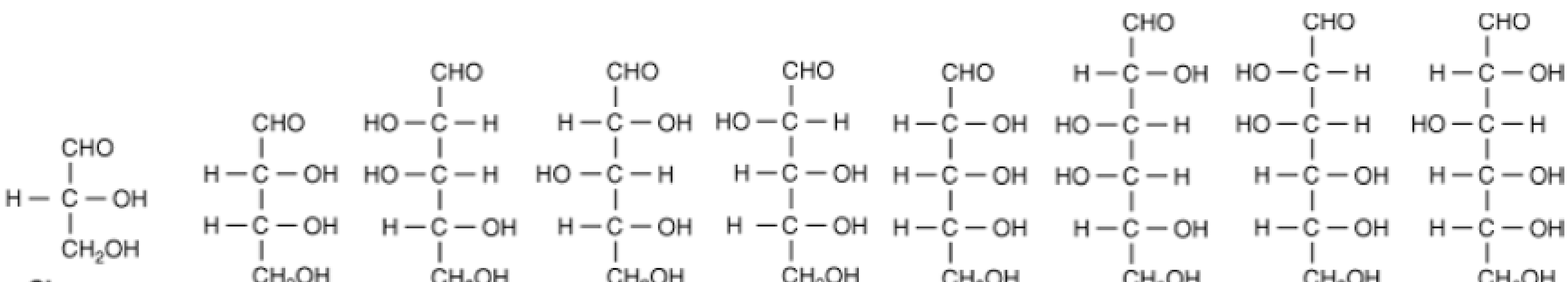


Dihydroxyacetone



Dihydroxyacetone | D-Xylulose | D-Ribulose | D-Fructose | D-Sedoheptulose

Examples of ketoses of physiologic significance.

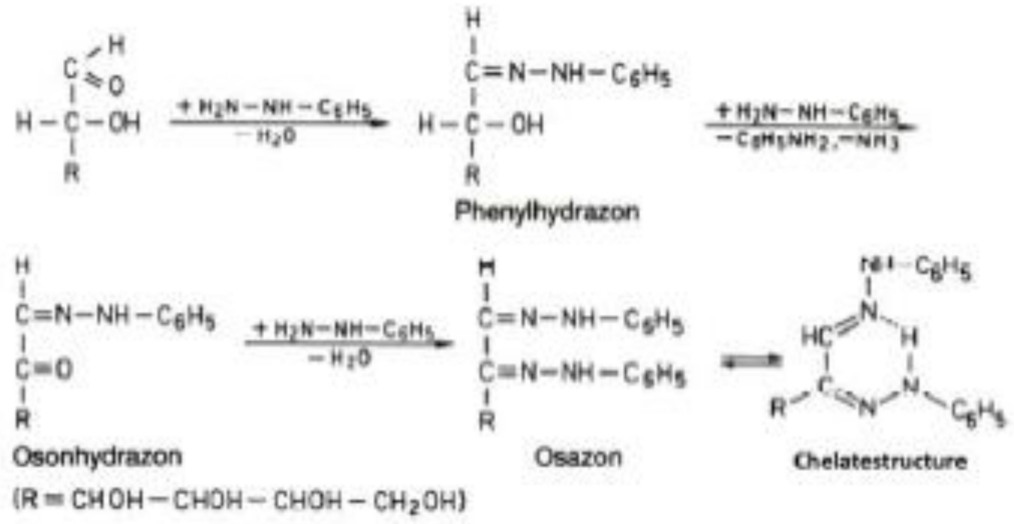


D-Glycerose (D-glyceraldehyde) | D-Erythrose | D-Lyxose | D-Xylose | D-Arabinose | D-Ribose | D-Galactose | D-Mannose | D-Glucose

Examples of aldoses of physiologic significance.

Chemical properties of monosaccharides

1. Reaction with hydrazine and preparation of osazone:

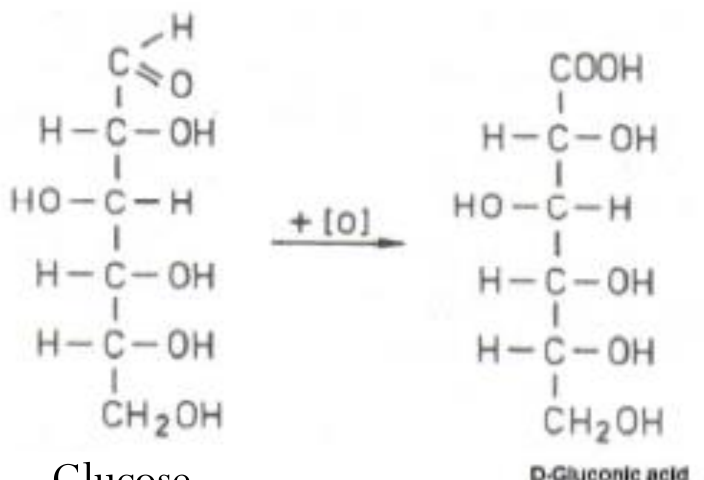


Glucose and fructose → needle shape crystal

Lactose and galactose → fluffy ball shape crystal

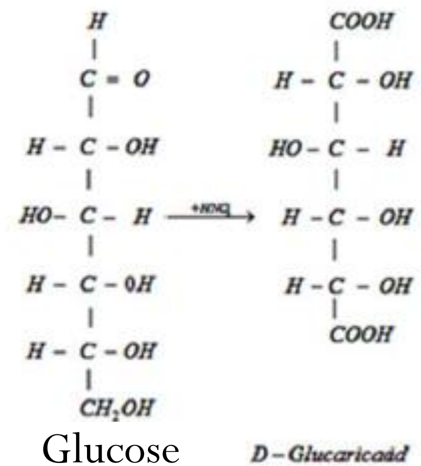
Maltose → sunflower shape crystal

2. Oxidation



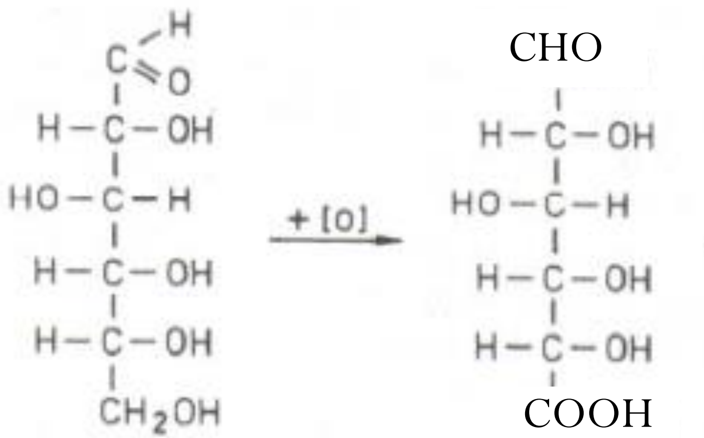
Glucose

D- Gluconic acid (aldonic acid)



Glucose

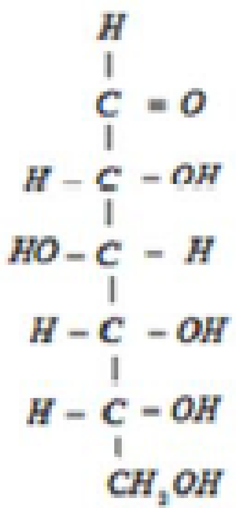
D- Glucaric acid (aldaric acid)



Glucose

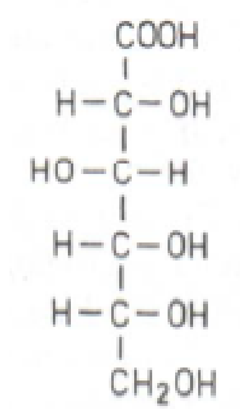
D- glucuronic acid
(uronic acid)

3. Reducing property of carbohydrates: (benedict and fehling)



D-Glucose

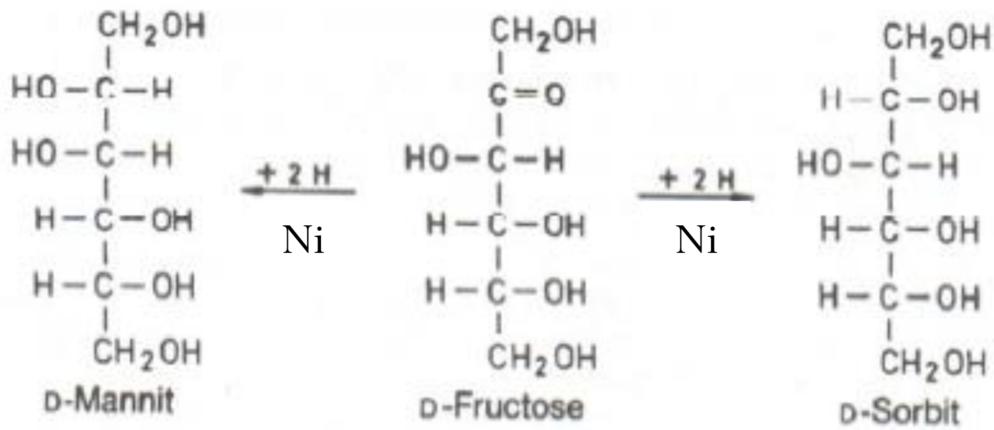
$+ 2Cu(OH)_2 \longrightarrow$

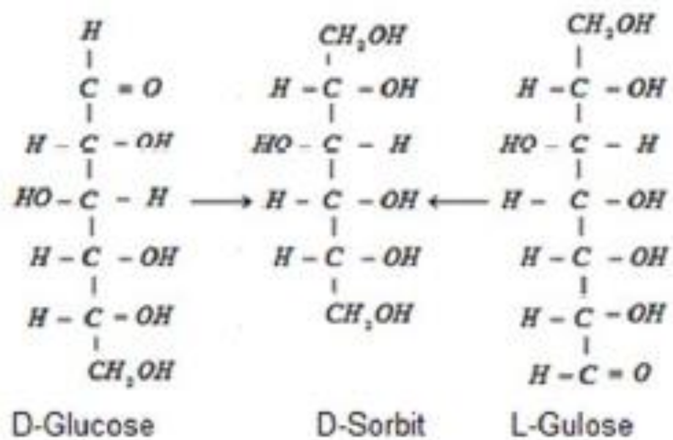


D-Gluconic acid

$+ Cu_2O + 2H_2O$

4. Reduction of carbohydrates





THANK YOU !