



Cellular and Molecular Biochemistry [FHS1104]

Carbohydrates Chemistry

Lecture {3} section 1

MBCHB/BDS
1ST YEAR SEM.-1
2026

Yasser Khater

Quick review

- ✓ Mention the **physiological** functions of water
- ✓ Explain the concept of **pH** and its importance.
- ✓ What is the normal physiological **pH** of blood
- ✓ Define a buffers and explain their mechanism
- ✓ Mention the **biological buffer system** in the human body.
- ✓ Define Acidosis and Alkalosis

{Lecture 3 Outline}/ Objectives:

- Definition and general formula of carbohydrates
- Functions of Carbohydrates
- Classification of Carbohydrates
- Monosaccharides and their classification
- Disaccharides
- Biomedical concepts/ Clinical correlates

Definition:

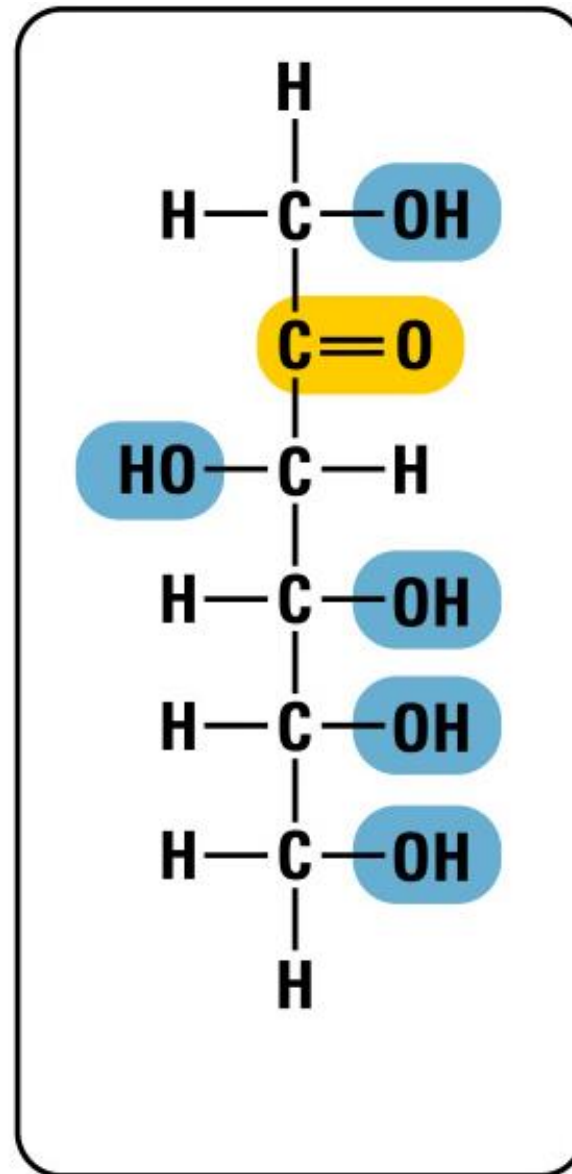
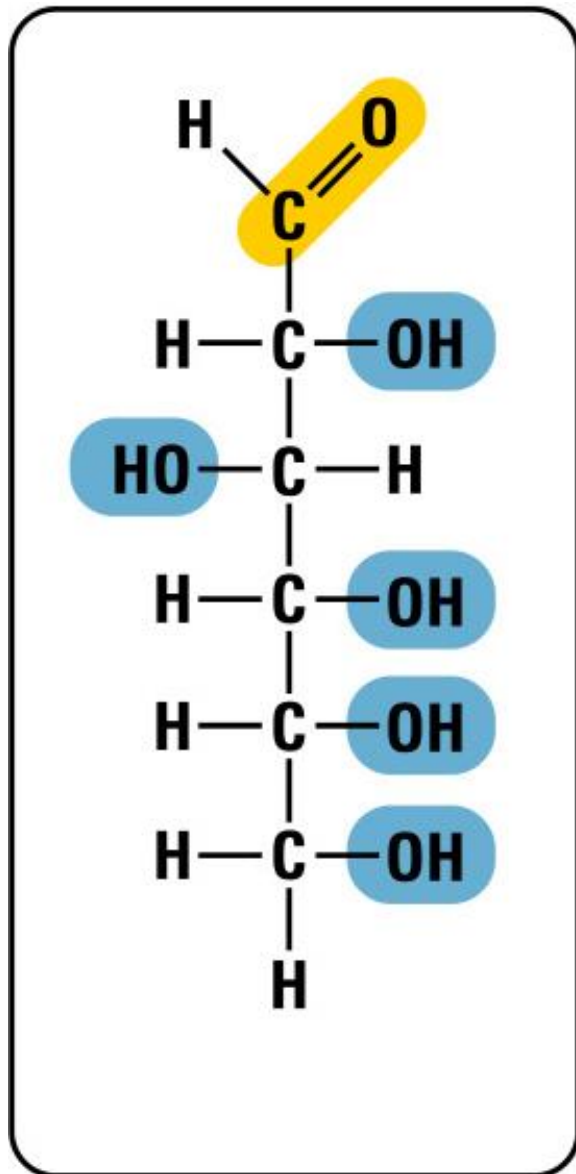


Definition:

Carbohydrates are the most abundant organic molecules in nature. They are primarily made up of carbon, hydrogen and oxygen atoms, C,H and O.

❖ Carbohydrates **are** Polyhydroxy aldehyde **or** polyhydroxy ketone or a substances that can be hydrolyzed to **produce** these elements.

Definition:

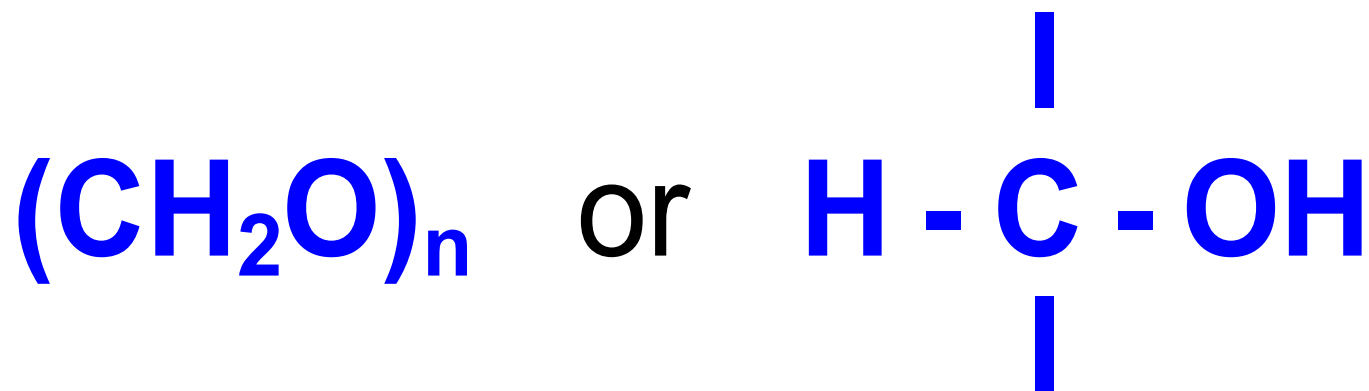


General formula of carbohydrates

Carob (C).....Hydrate

(hydrates of carbon)

Most have general formula $C_nH_{2n}O_n$



What are the physiological functions of Carbohydrates?

Physiological functions of Carbohydrates:

1. **First source of energy** Provide body with **Energy** (especially for glucose dependence cells such as **RBCs**).

Why our body use carbohydrates as primary source of energy ?

- ✓ The metabolism of CHO is easier than fats and proteins.
- ✓ The metabolism of CHO may occur in the presence or absence of oxygen.(very importance for RBCs & Muscles tissues during the exercise).

Physiological functions of Carbohydrates:

- ✓ Carbohydrates are precursors for many organic compounds (**fats, amino acids**).
- ✓ Serve as storage form of energy for future uses (**glycogen**) to meet the immediate energy demands of the body.

Physiological functions of Carbohydrates:

2. Structural role:

- Structural components of many important molecules such as nucleic acids. { DNA, RNA }.
- Participate in the structure of cell membrane and helps in cell-cell communications.(e.g glycoproteins).
- They are structural components of many organisms ,these include the fiber (Cellulose) of plants, exoskeleton of some insects (Chitin).

Classification of Carbohydrates:

Classification of Carbohydrates:

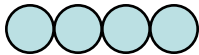
CHO classified according to number of **sugar unit**:



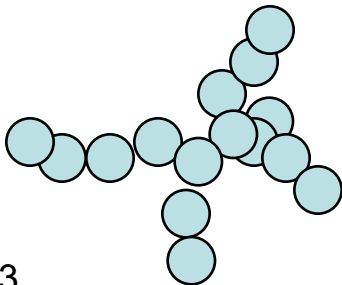
Monosaccharides – simple sugars



Disaccharides – **2**– mono
saccharides covalently linked.

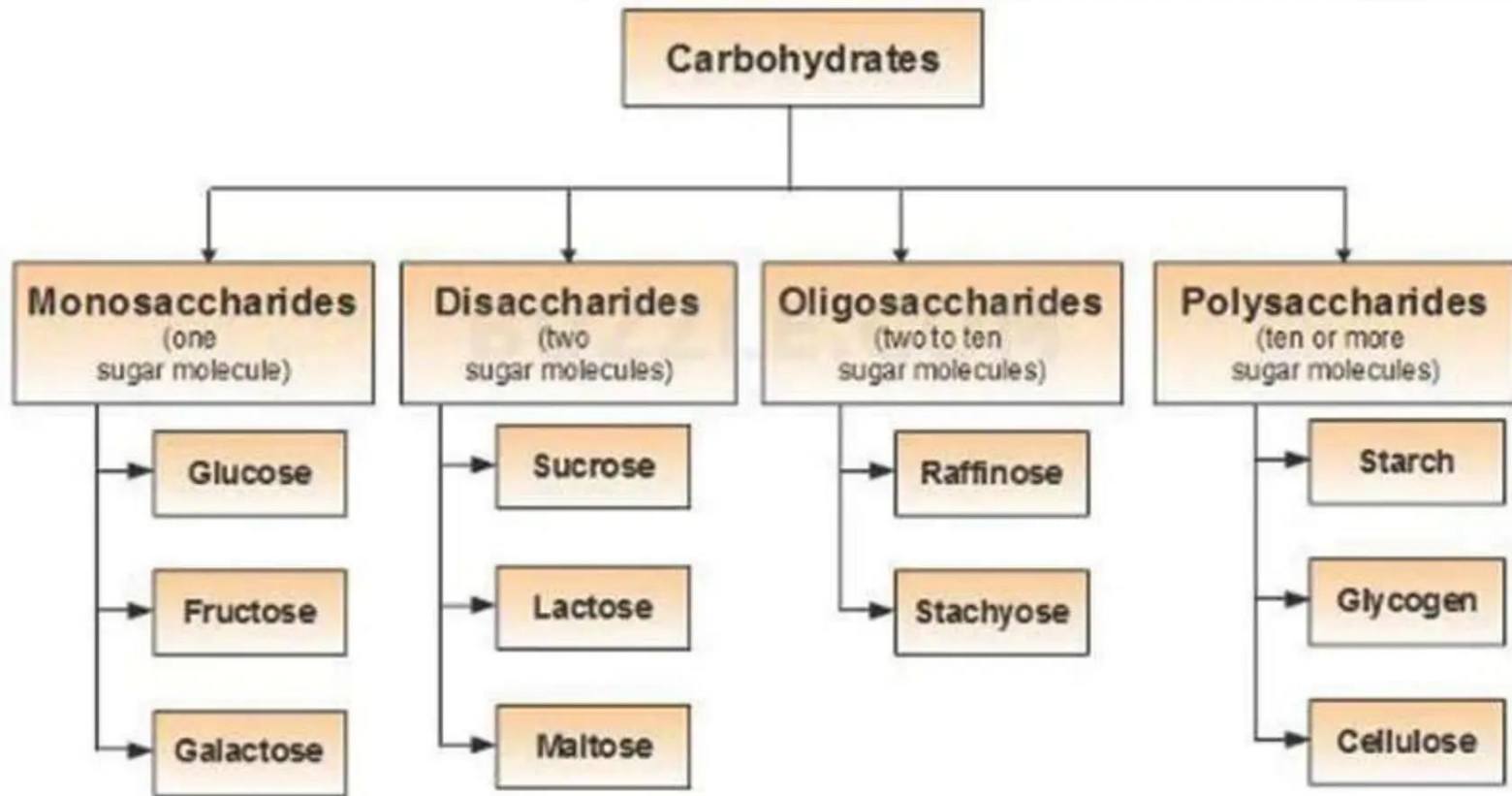


Oligosaccharides – **3** to **10**
monosaccharides covalently linked.



Polysaccharides – more than **10**
monosaccharide units covalently linked.

Classification of Carbohydrates



MONOSACCHARIDES

MONOSACCHARIDES:

A monosaccharide is a carbohydrate that **cannot** be hydrolyzed to a simpler carbohydrate (simple sugar)

Use as building blocks of other sugars (monomers)

Can be classified further base on

- 1– On the basis of the **numbers** of carbon atoms.
- 2– On the basis of the **functional** group.

Classification of Monosaccharide

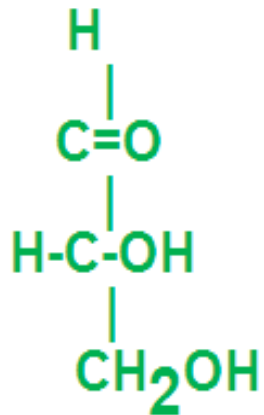
- 1– On the basis of the **numbers** of carbon atoms.
- 2– On the basis of the **functional** group.

No. of 'C' atoms	General term for Monosaccharides	Aldehyde	Ketone
3	Triose	Aldotriose	Ketotriose
4	Tetrose	Aldotetrose	Ketotetrose
5	Pentose	Aldopentose	Ketopentose
6	Hexose	Aldohexose	Ketohexose
7	Heptose	Aldoheptose	Ketoheptose

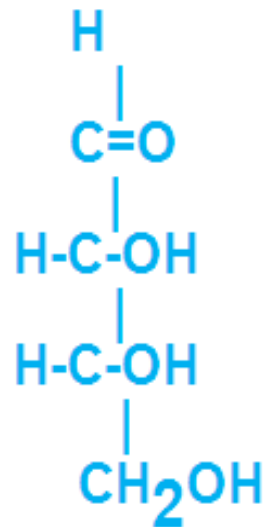
Monosaccharides

Classification of Monosaccharide

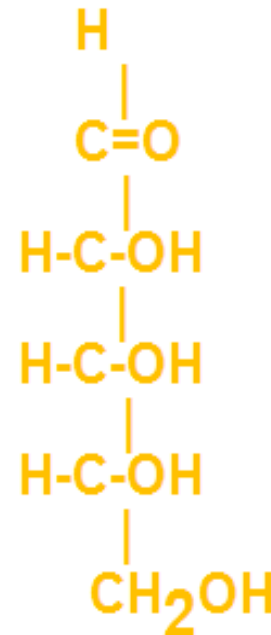
1. According to the **number of carbon atoms**.



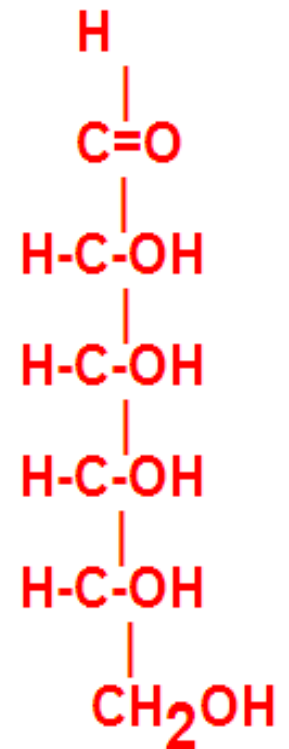
Trioses



Tetrose



Pentoses

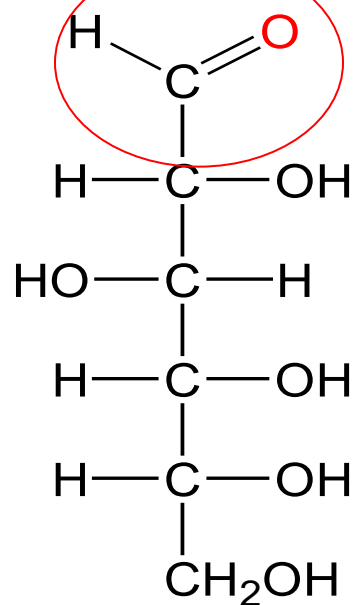


Hexoses

Classification of Monosaccharide

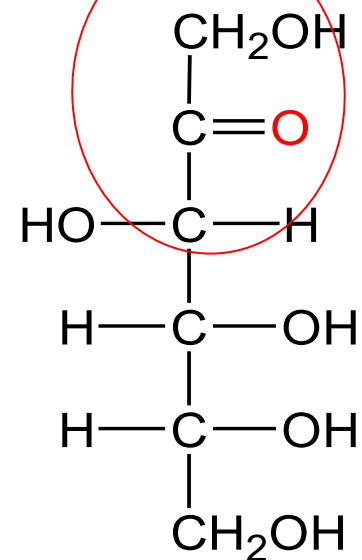
2. According to functional group

Aldoses have an aldehyde group at one end.



D-glucose

Ketoses have a keto group, usually at **C2**.



D-fructose

Examples: According to the **number of carbon atoms & functional group**.

No. of carbon atoms in the chain	Functional group present	Type of sugar	Example
3	Aldehyde	Aldotriose	Glyceraldehyde
3	Ketone	Ketotriose	Dihydroxy acetone
4	Aldehyde	Aldotetrose	Erythrose
4	Ketone	Ketotetrose	Erythrulose
5	Aldehyde	Aldopentose	Ribose
5	Ketone	Ketopentose	Ribulose
6	Aldehyde	Aldohexose	Glucose
6	Ketone	Ketohexose	Fructose

MONOSACCHARIDES

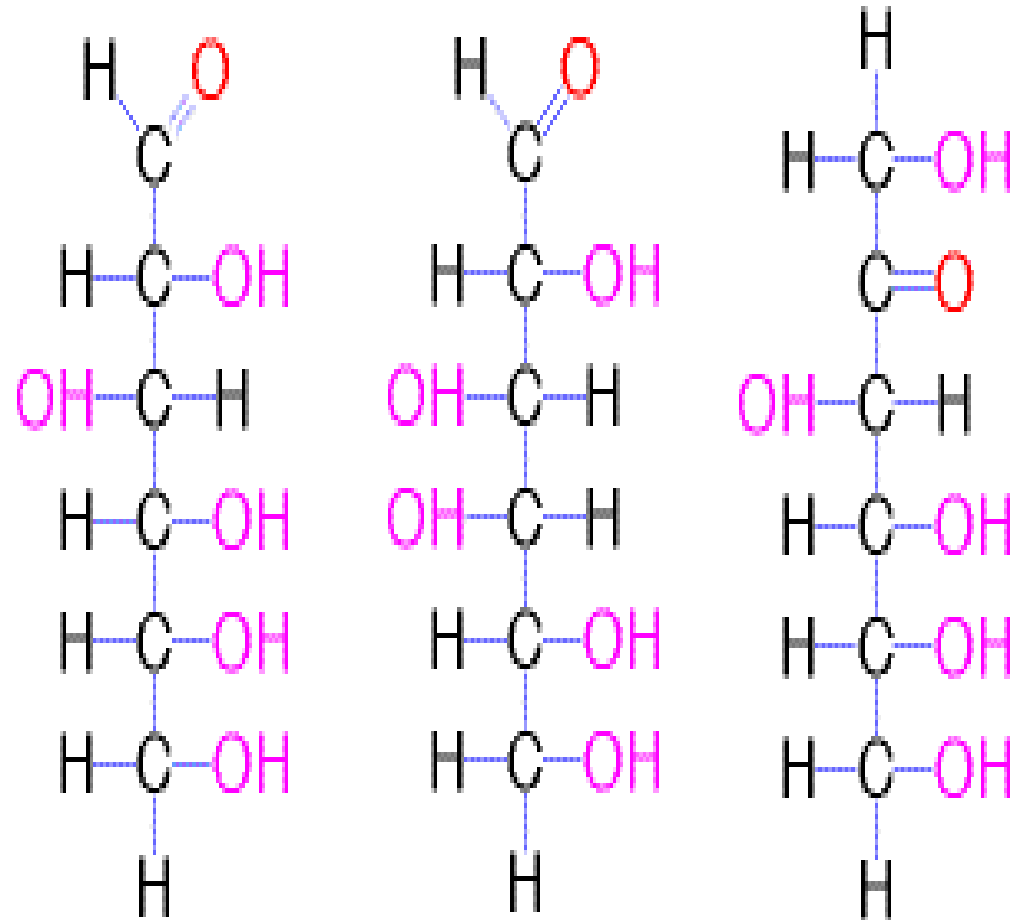
Hexoses

Monosaccharides:

Have the same chemical formulas, but **different** structural (isomers)



Hexose Sugars



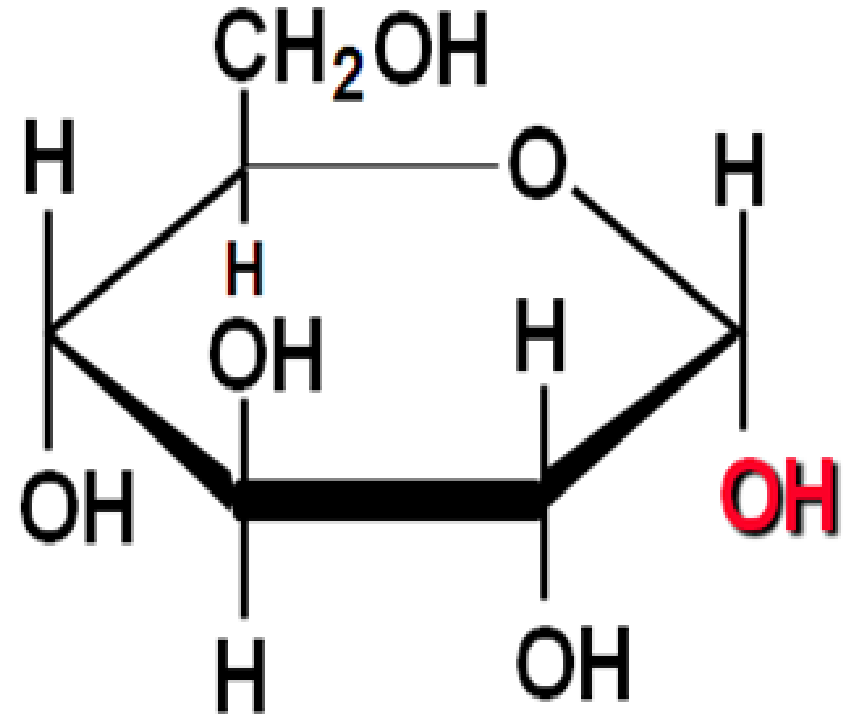
Glucose

Galactose

Fructose

Important monosaccharides: **Glucose**

- Is the most important monosaccharide:
- known as **blood** sugar.
- Essential energy source.
- Found in **every** disaccharide and polysaccharide

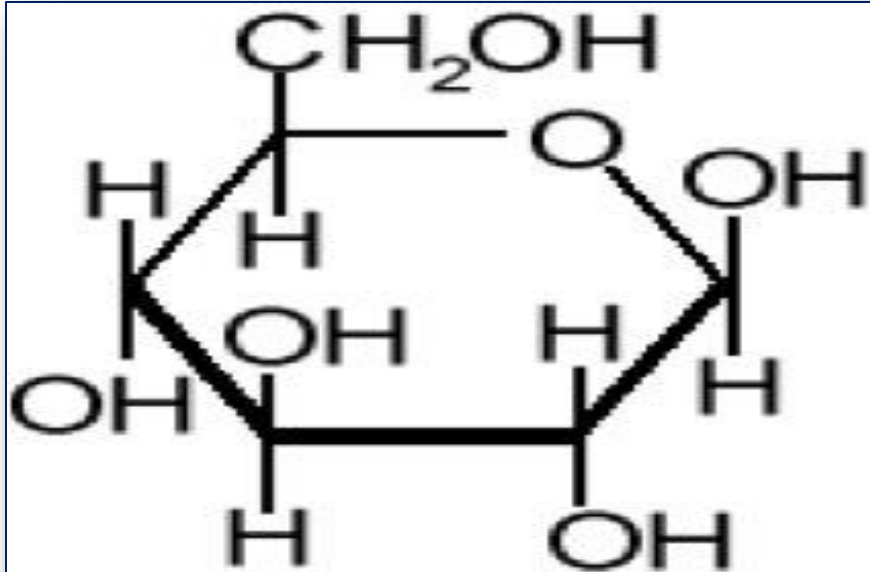


α -D - glucose

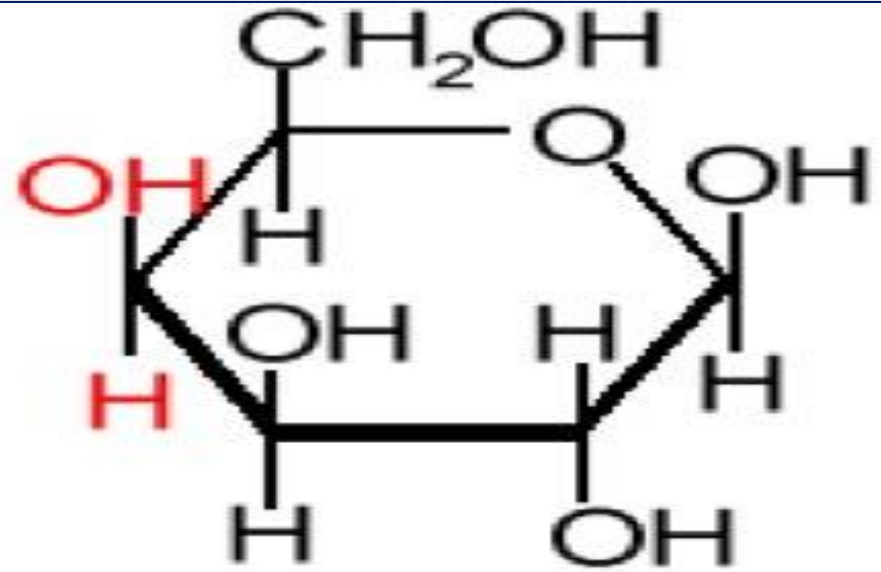
Important monosaccharides: **Galactose**

Rarely found naturally as a single sugar.

Common **part** of lactose – disaccharide.



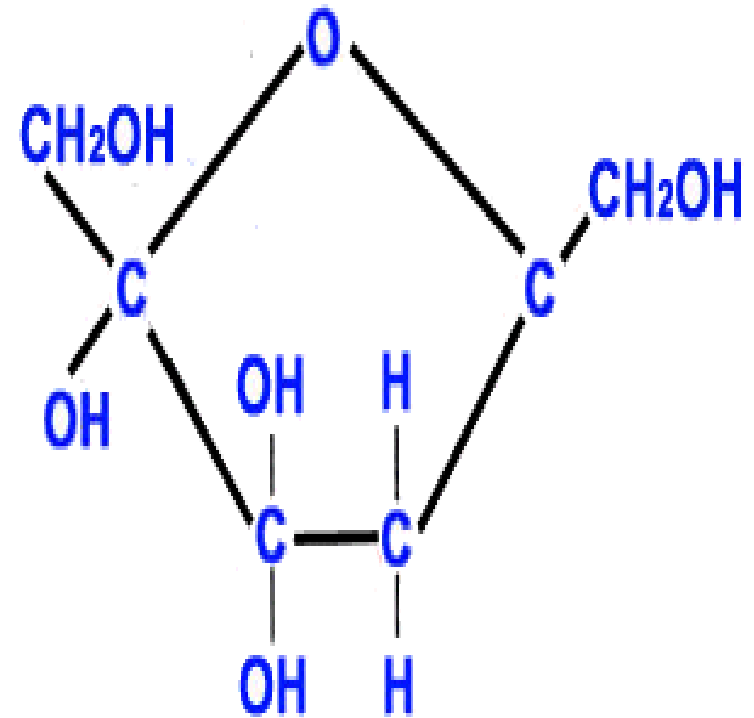
Glucose



Galactose

Important monosaccharides: **Fructose**

- **Sweetest** sugar.
- Found in **fruits**
- Rarely found naturally as a single sugar.

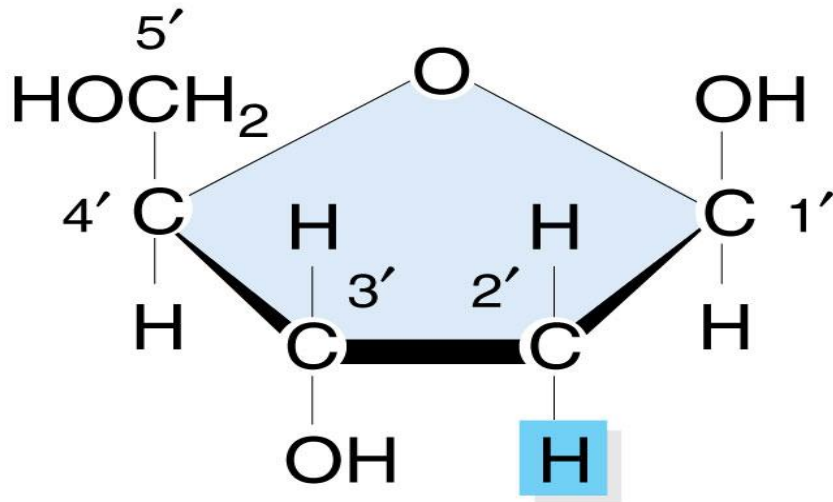


fructose

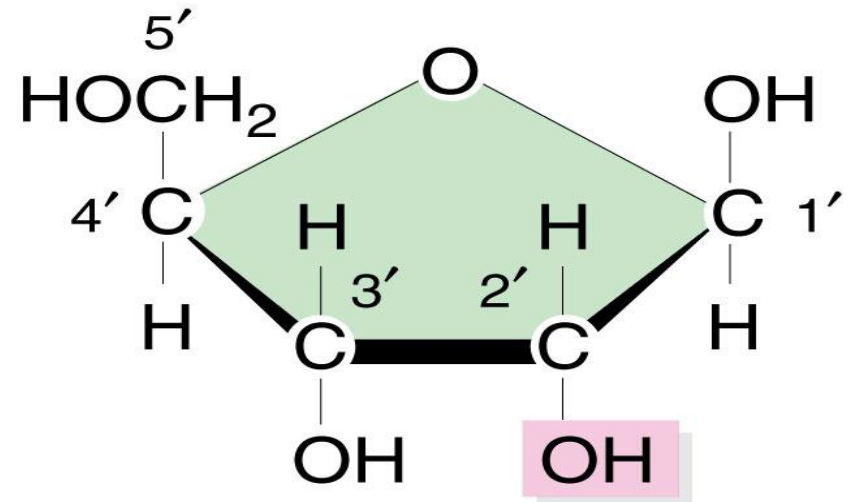
Pentoses (5C)

Important monosaccharides: **Ribose**

- An important sugar in **genetic material** (**DNA** and **RNA**).
- In DNA the **O-** of **C-2** removed from the **Ribose**, and the sugar becomes deoxyribose.



Deoxyribose



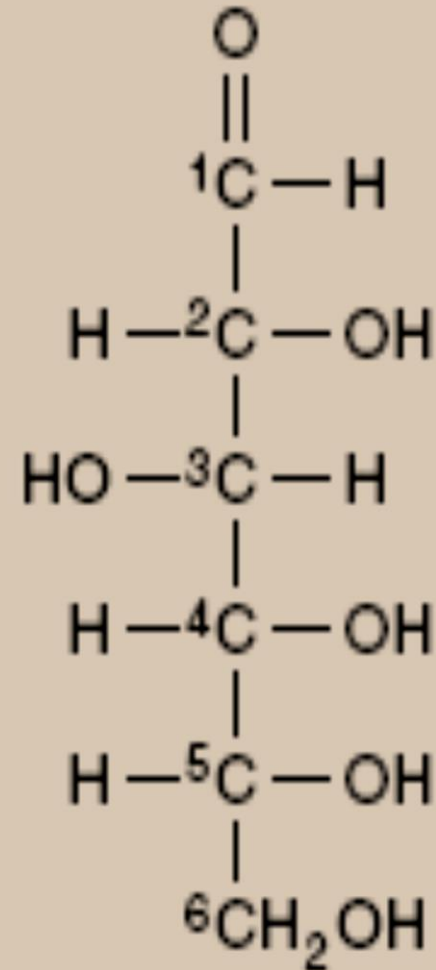
Ribose

Structure of sugars:

Structure of sugars:

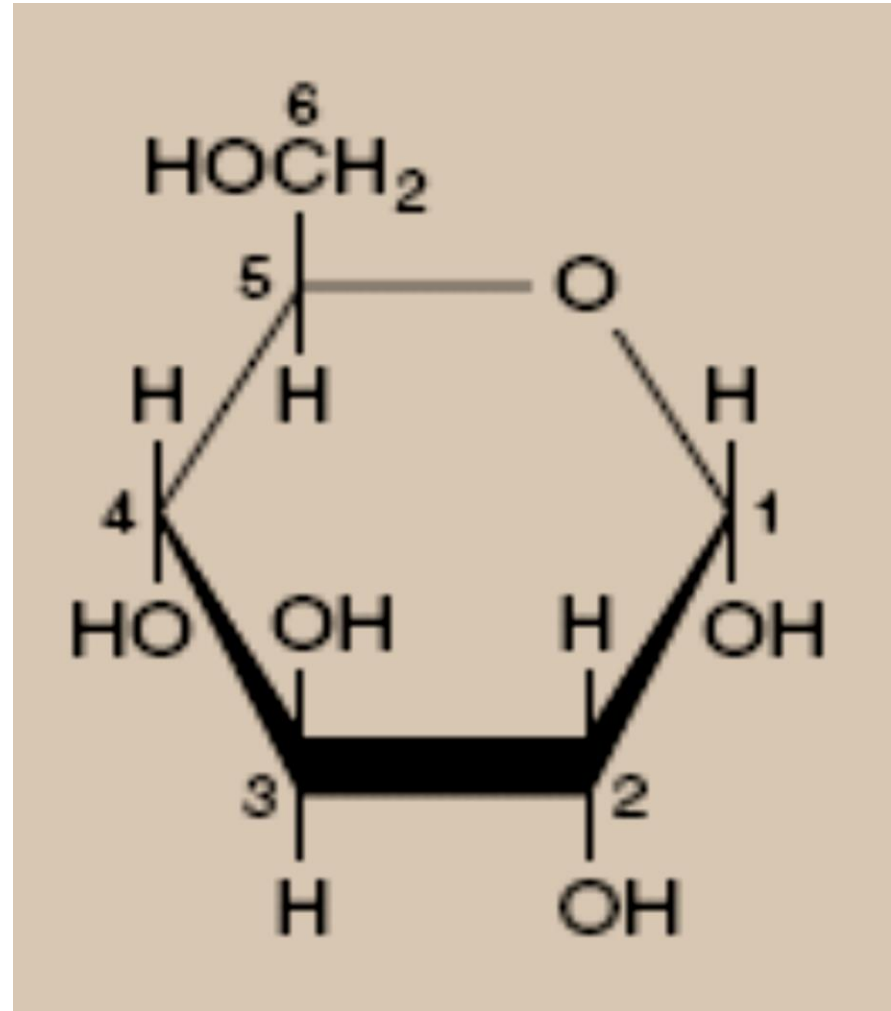
The term "**sugar**" is applied to carbohydrates soluble in **water** and sweet to taste.

1- **Fischer shape** : **straight chain**



Structure of sugars:

2- Haworth shape: ring structure:



Furan(ose) and Pyran (ose) rings

- **Pyranose**

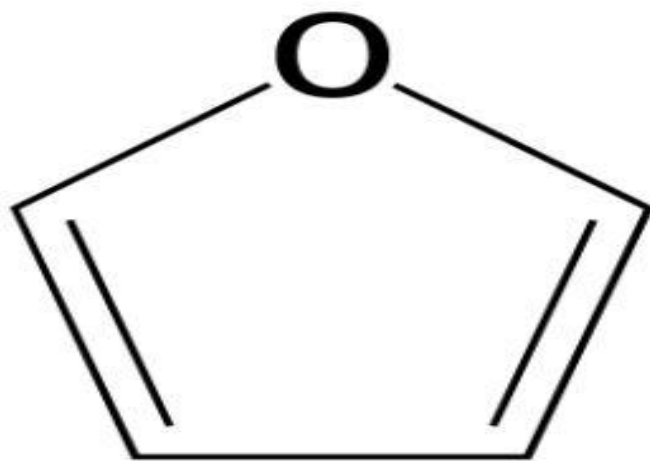
- **6-member** ring, **C1** or **C2** reacts with the OH on **C6**.
(e.g hexoses sugars)

- **Furanose**

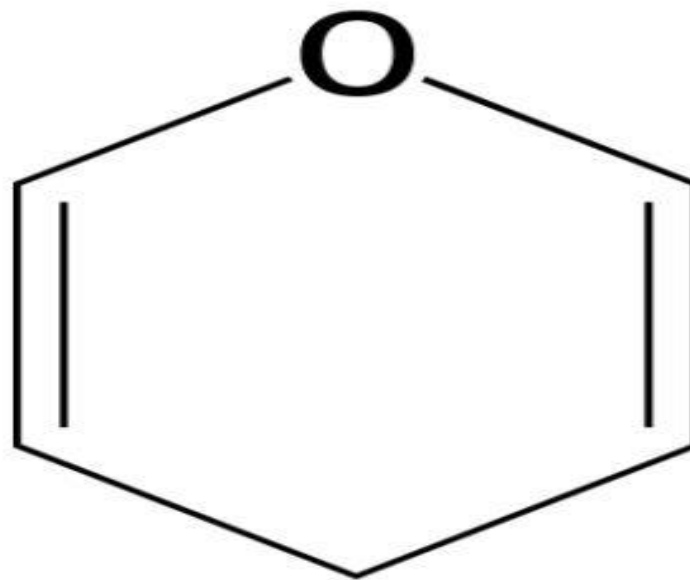
- **5-member** ring, **C1** or **C2** reacts with the OH on **C5**.
(e.g pentoses sugars)

pyranoses and furanoses

Sugars Prefer To Be **Cyclic** in water solutions



Furan



Pyran

ISOMERS OF MONOSACCHARIDES

ISOMERS OF MONOSACCHARIDES

1) D- and L- isomers

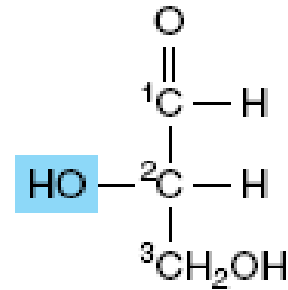


= mirror images of each other

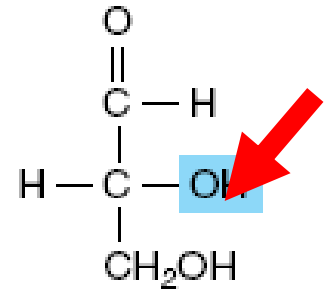
nature important:

D-monosaccharides).

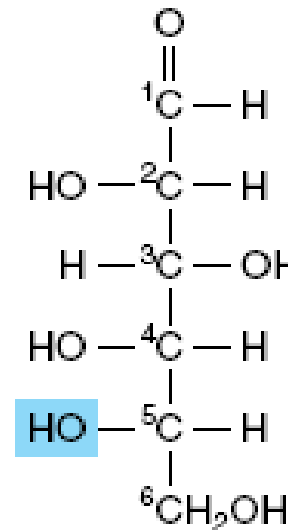
the D and L refer to the configuration of the asymmetric carbon atom furthest from the aldehyde or ketone group.



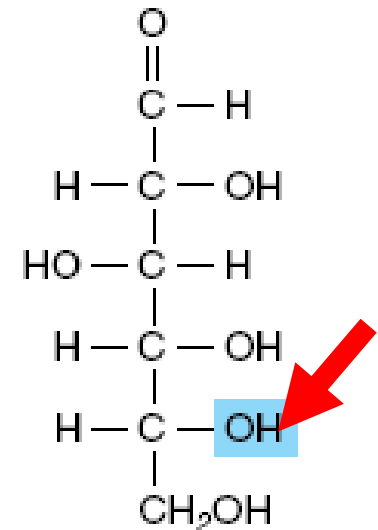
L-Glyceraldehyde
(L-glyceraldehyde)



D-Glyceraldehyde
(D-glyceraldehyde)



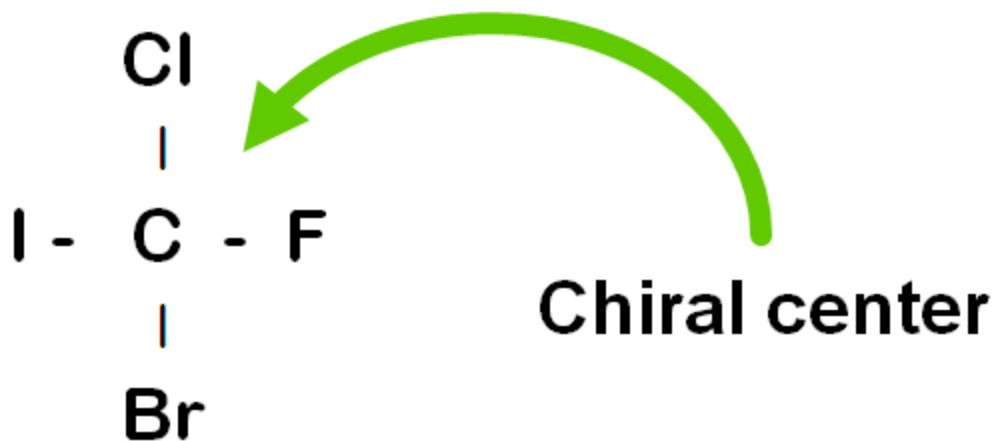
L-Glucose



D-Glucose

Chiral carbon

- **Chiral center** is an **asymmetric carbon** with **4 different** group are attached to it.



Optical activity

- Optical activity

- Ability to rotate plane polarized light:

- To the right (**Dextrorotatory**)

- usually **D isomers**, use **(+)** symbol.

- or to the left (**Levorotatory**)

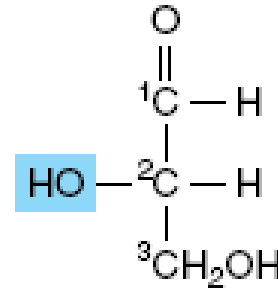
- Usually **L isomers**, Use **(-)** symbol

ISOMERS OF MONOSACCHARIDES

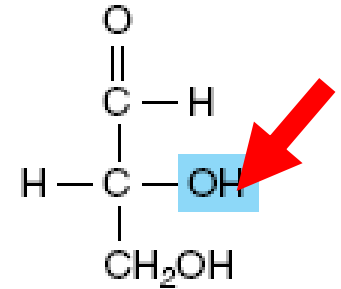
1) D- and L- isomers



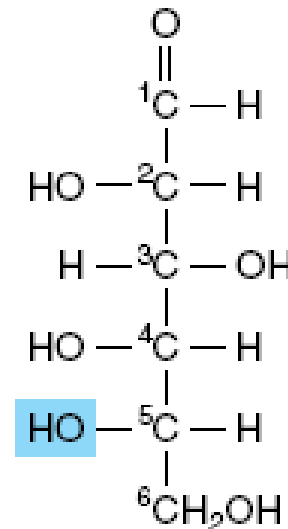
the **naturally occurring** monosaccharides in the mammalian tissue are **mostly** of D-configuration. The **enzyme machinery** of cell is specific to metabolize **D-** form of monosaccharides.



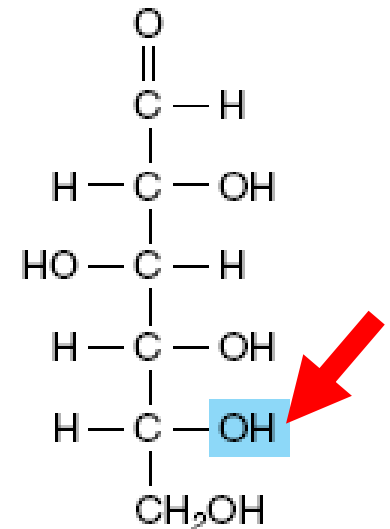
L-Glycerose
(L-glyceraldehyde)



D-Glycerose
(D-glyceraldehyde)

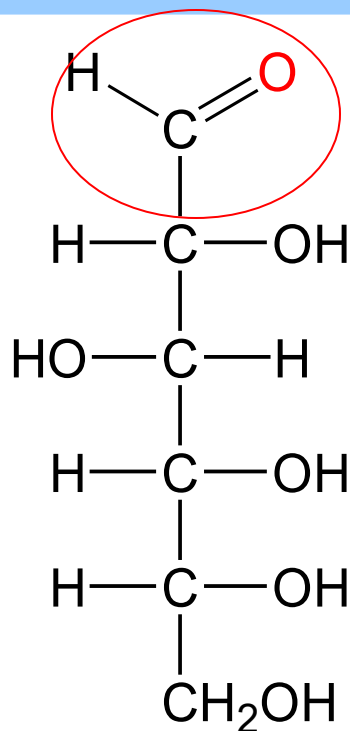


L-Glucose

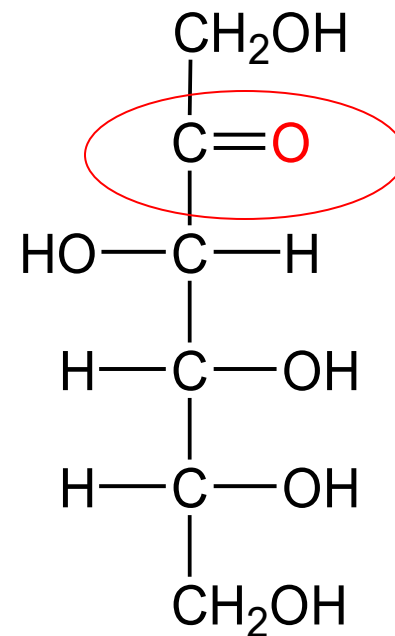


D-Glucose

2) functional isomerization Aldoses and Ketoses



D-glucose

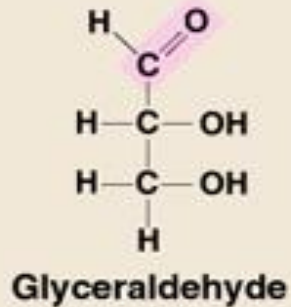


D-fructose

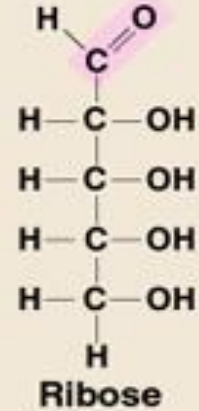
functional isomerization

TRIOSE SUGARS ($C_3H_6O_3$)

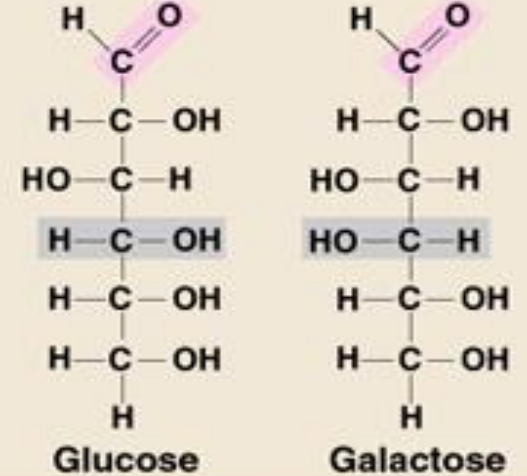
ALDOSES



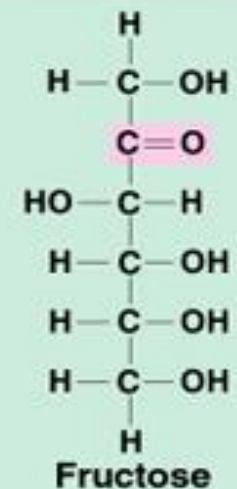
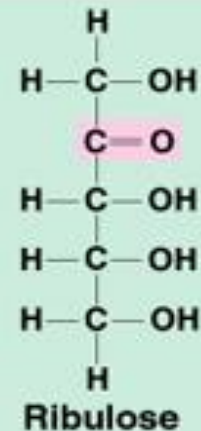
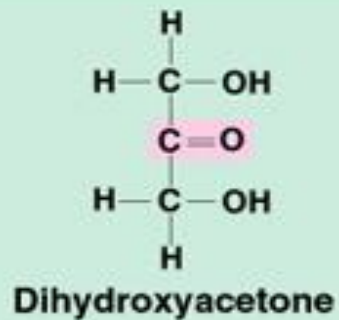
PENTOSE SUGARS ($C_5H_{10}O_5$)



HEXOSE SUGARS ($C_6H_{12}O_6$)



KETOSES



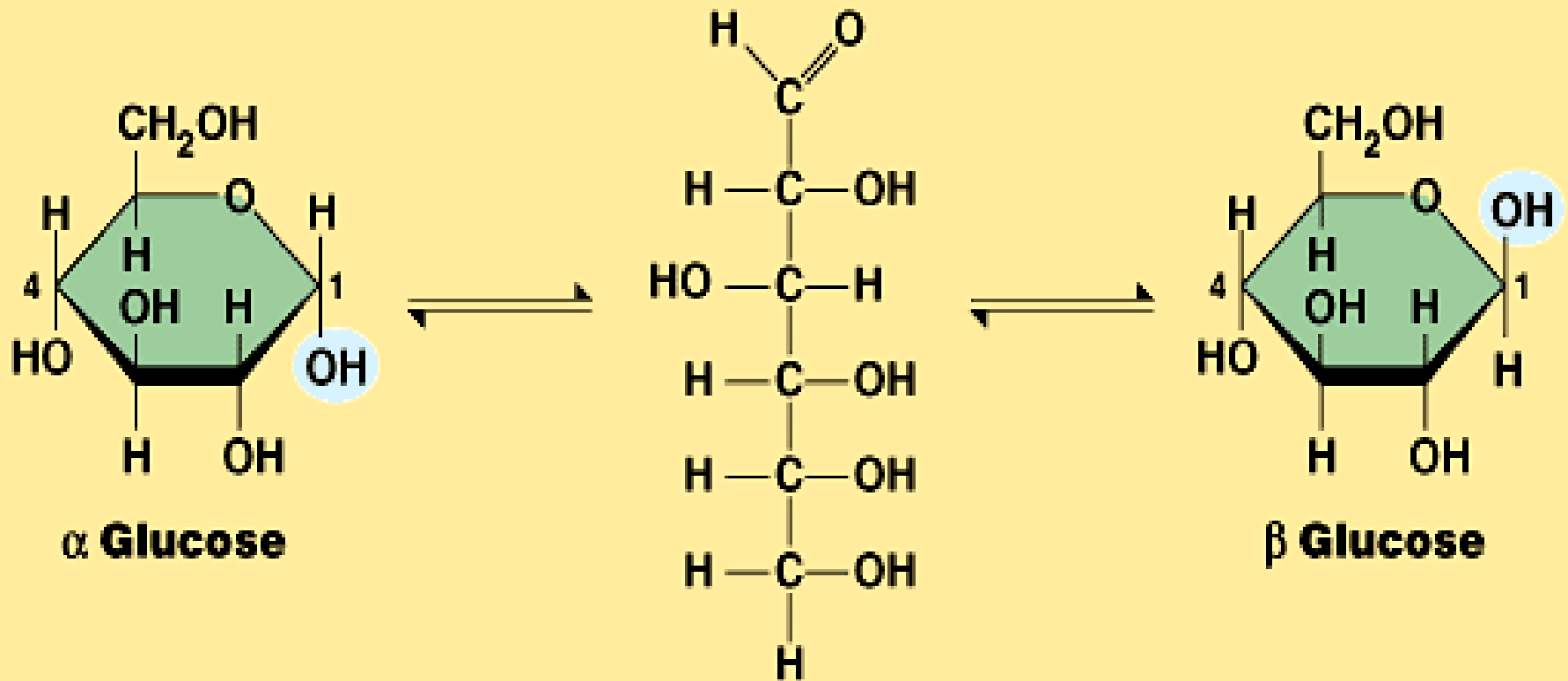
3) α and β Forms in the Rings form of Sugars:

- The **-OH** group that forms can be **above** or **below** the ring resulting in two forms.
- **α -form**
 - OH group is **down**.
- **β -form**
 - OH group is **up**.

3) α and β



only cyclic molecules



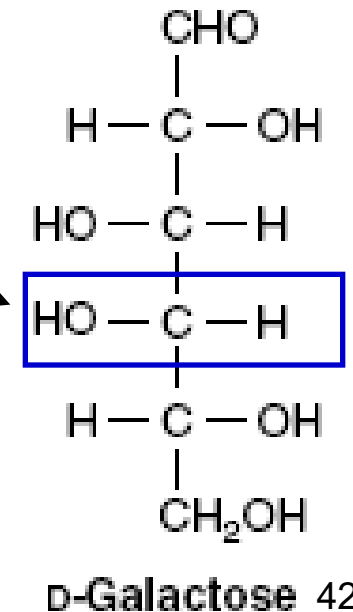
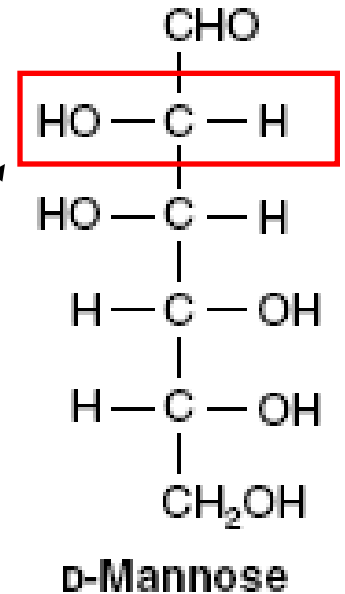
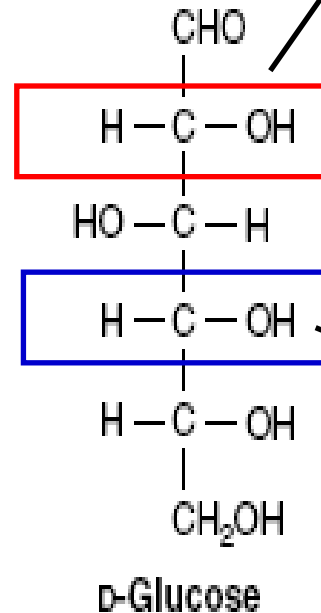
(a) α and β glucose ring structures

4) Epimers

EPIMERS : **two**
monosaccharide **differ**
in OH Position in **ONE**
carbon

Mannose = epimer of
Glucose (C2)

Galactose = epimer of
Glucose (C4)



Epimers:

C2-epimers

C4-epimers

CHO



HO — C — H



HO — C — H



H — C — OH



H — C — HO



CH₂OH

D-mannose

1

CHO



H — C — OH



HO — C — H



H — C — OH



H — C — HO



CH₂OH

D-glucose

CHO



H — C — OH



HO — C — H



HO — C — H



H — C — HO



CH₂OH

D-galactose

Disaccharides

Disaccharides:

Disaccharides are sugars composed of two monosaccharides linked by type of bond called **glycosidic** bond.

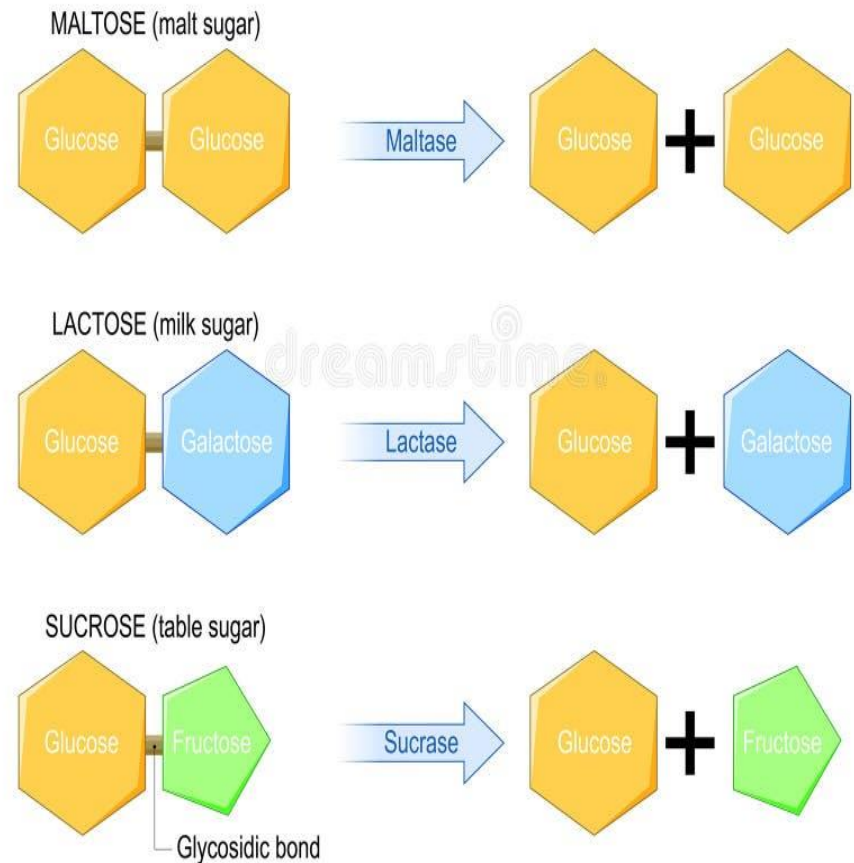
Disaccharides are formed by a **condensation reaction** where one molecule of **water** is released during the joining of two monosaccharides.

Disaccharides

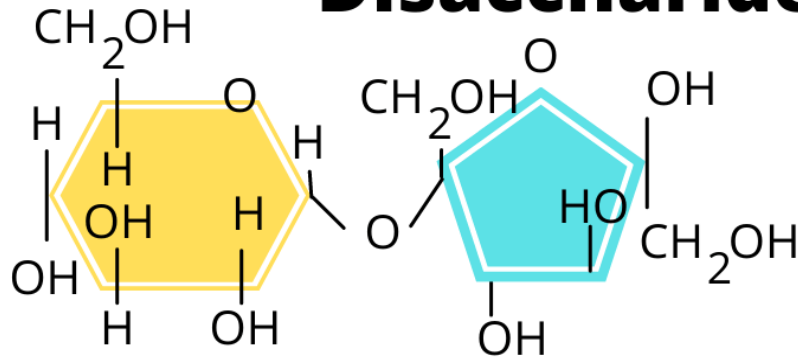
On hydrolysis (digestion) yield **two** monosaccharides' examples are:

- Maltose (**2** glucose moieties)
- Lactose (glucose and galactose)
- Sucrose (glucose and fructose)

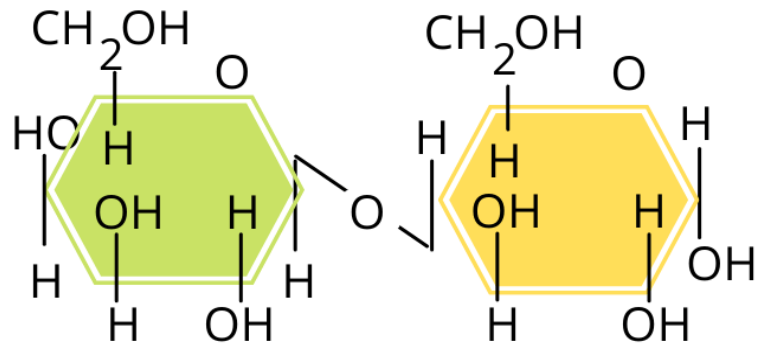
Disaccharides digestion



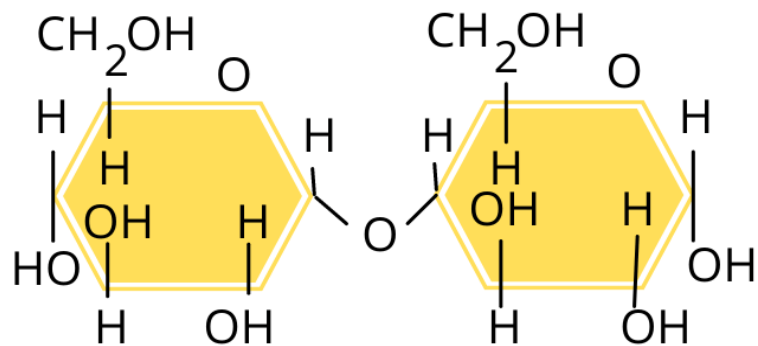
Disaccharide Examples



Sucrose
glucose + fructose



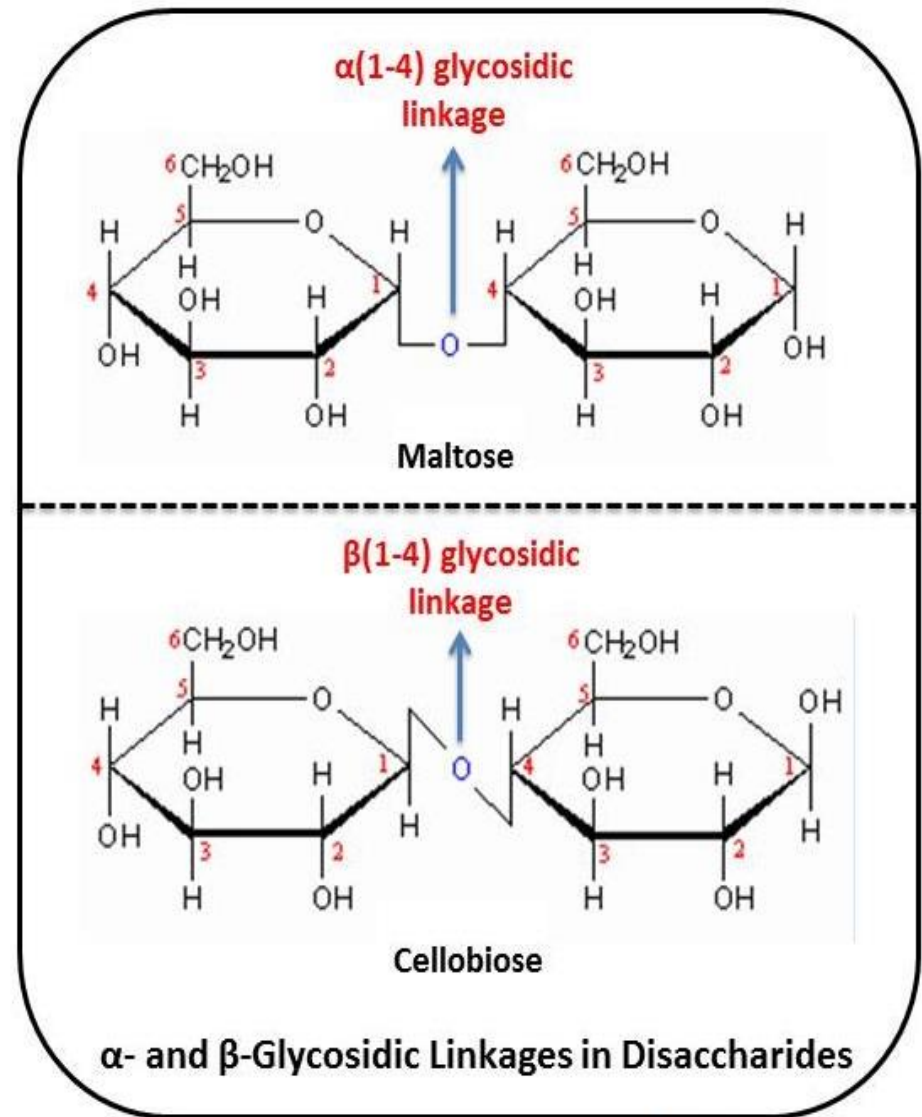
Lactose
galactose + glucose



Maltose
glucose + glucose

Glycosidic bonds

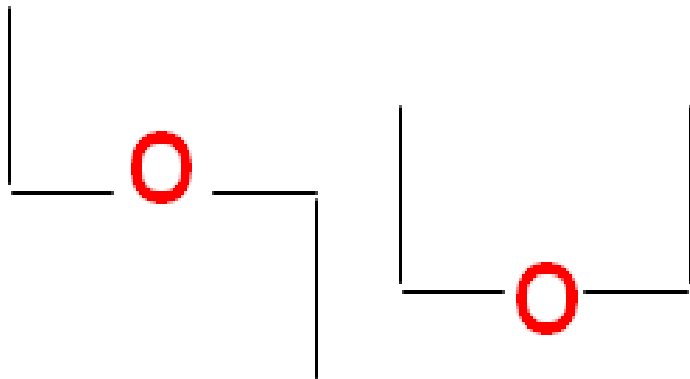
- α or β -OH group of cyclic monosaccharide can form link with another one forming oxygen bridge (**glycosidic bond**)
- sugar-O-sugar



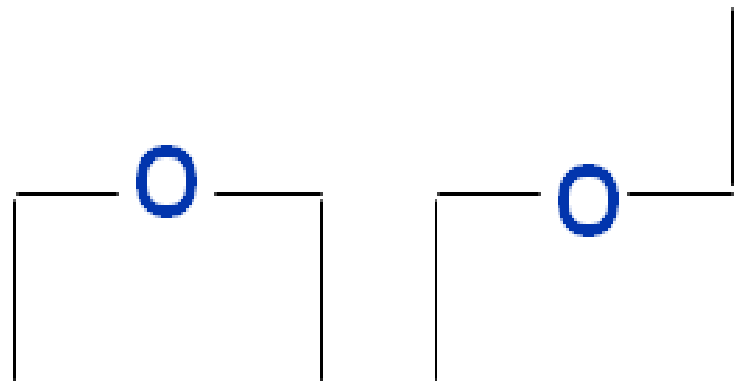
Type of Glycosidic bonds

Type is based on the position of the **OH** at **C-1**.

α -bonds

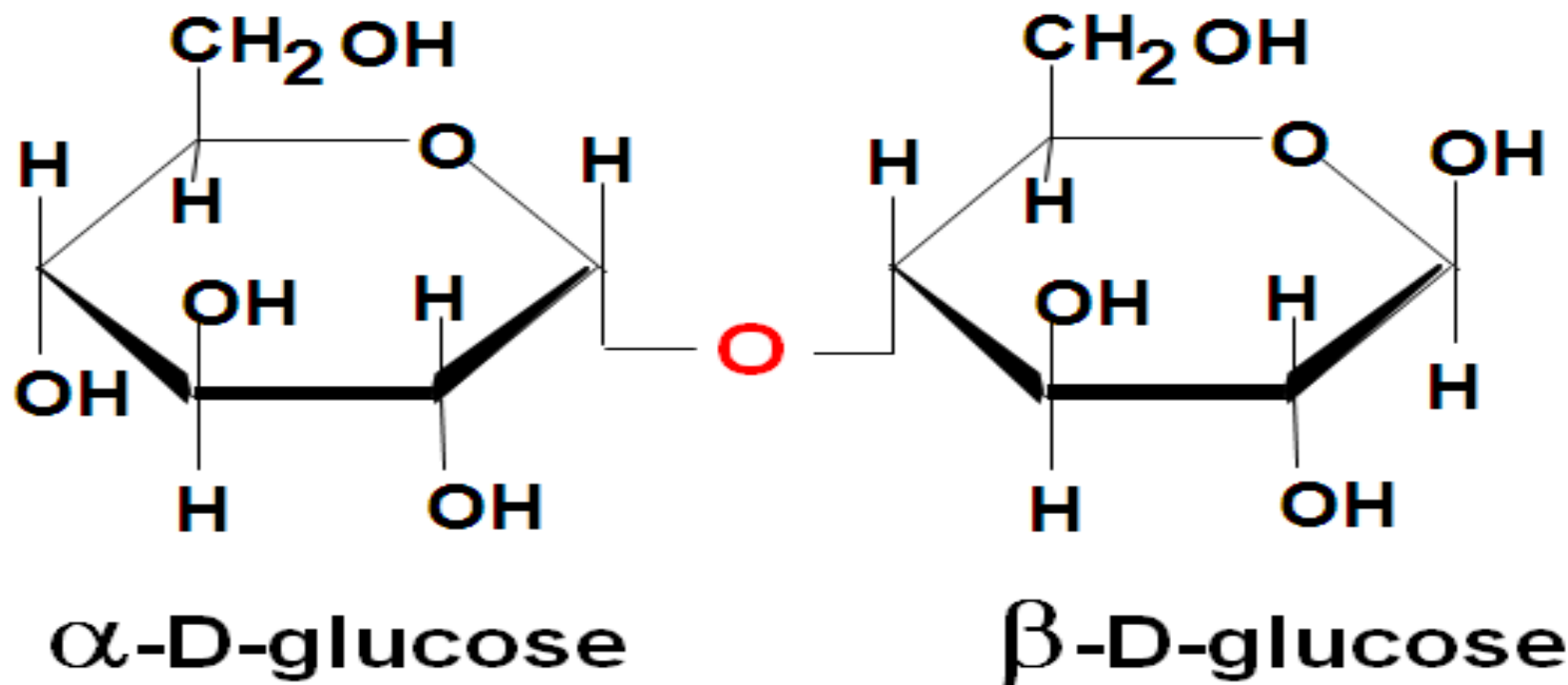


β -bonds



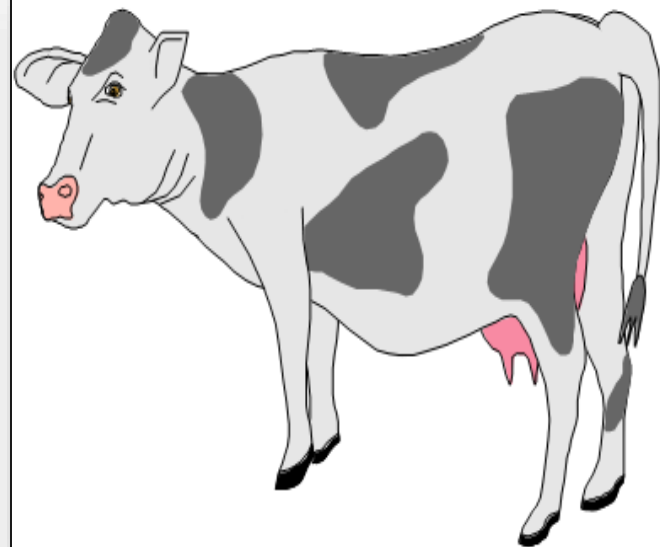
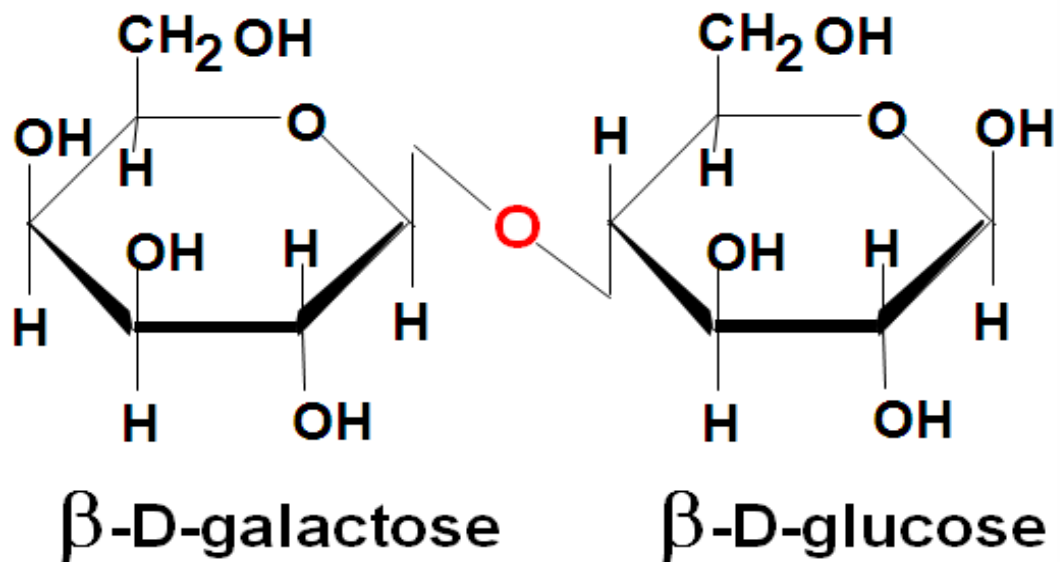
Important Disaccharides: Maltose

- **Malt** Sugar.
- α -D-glucose and β -D-glucose, $\alpha(1\rightarrow4)$ linkage.



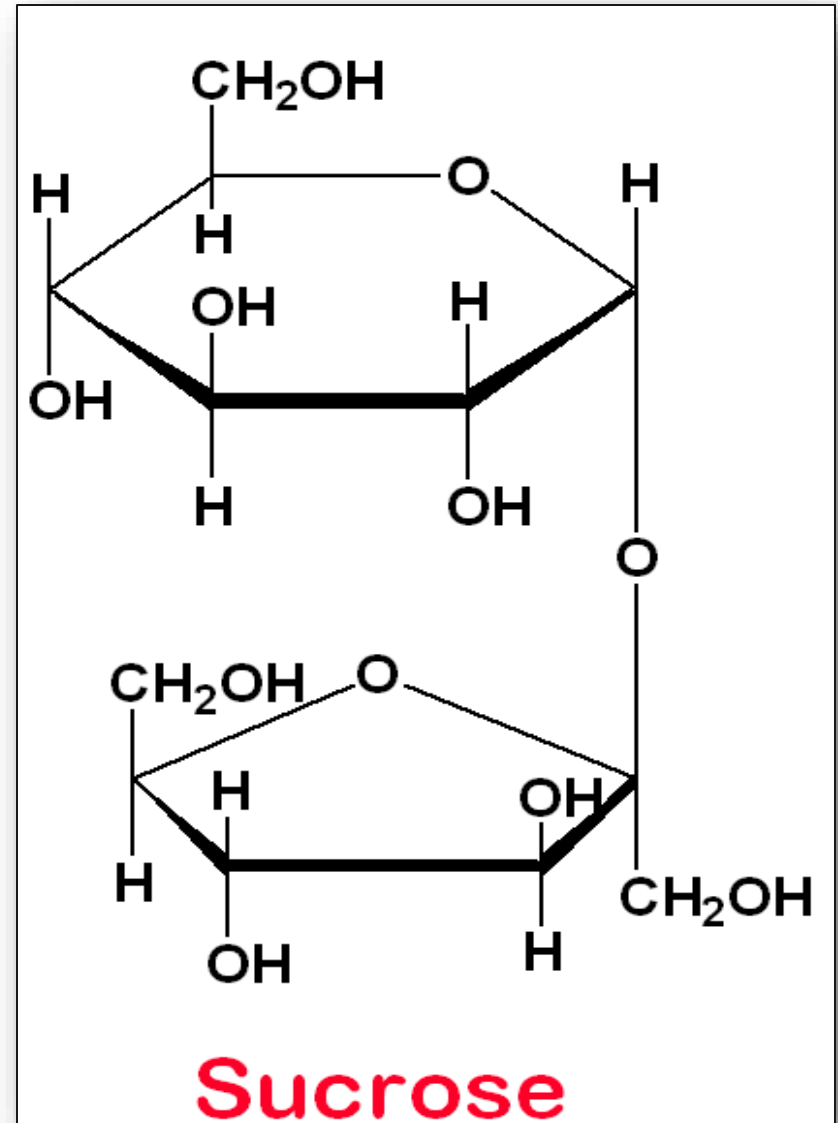
Important Disaccharides: **Lactose**

- **Milk** Sugar.
- β -D-galactose and β -D-glucose, **$\beta(1\rightarrow4)$** linkage.



Important Disaccharides: **Sucrose**

- Sugar **cane**.
- Disaccharide of α -glucose and β -fructose.
- $\alpha \beta(1 \rightarrow 2)$ linkage



Biomedical concepts/ clinical correlates

- Glucose is the most important **energy source** of carbohydrates.
- The bulk of dietary carbohydrates [starch] is **digested** and finally **absorbed as** glucose into the body
- Dextrose [glucose] in solution in dextrorotatory form] is frequently **used in medical practice**
- Several **diseases** are associated with carbohydrates e.g.. Diabetes mellitus, glycogen storage diseases and lactose intolerance.

References:

- 1-lipincotts biochemistry 8th edition 2022**
- 2. Harpers 25th , 27th and 32nd edition 2023**
- 3- Lehninger principles biochemistry 8th edition 2021**
- 4- Medical biochemistry 6th edition 2023**
- 5- Mark Basic Medical biochemistry 6th edition 2023**
- 6- Stryer biochemistry**

