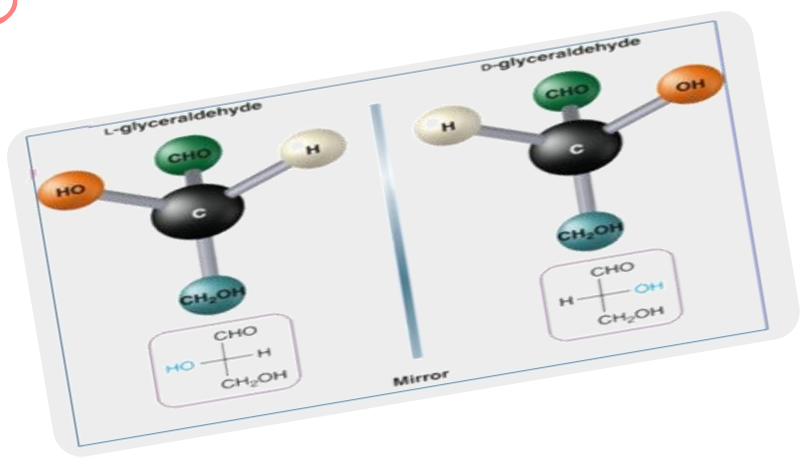
Chapter Outline

Chapter 1 Instructional Goals

- Define the terms carbohydrate, and saccharides .
- Describe the chemical structure of carbohydrates.
- We will learn the biological important of carbohydrate such as glucose, starch, glycogen and cellulose.
- Next we will see how classified the carbohydrates and monosaccharides.
- How to distinguish between D and L- Monosaccharides
- Will be learning how to writing the Haworth Projections .
- Describe the physiological important of monosaccharides .



Lect. 1

Carbohydrates

1-1 Introduction:

Carbohydrates: are the most abundant biomolecules, distributed widely in plants and animals where, they perform structural and functional roles. **They are hydrated carbon molecules**. Generally the **hydrogen** and **oxygen** will be present in the proprotion of 2:1.

Carbohydrates may be defined as **polyhydroxy aldehydes or ketones, or any substances that yield one of these compounds on hydrolysis**.

Many carbohydrates have the empirical formula $\mathbf{(CH_2O)_n}$, where n is 3 or larger.

1-2 Biological importance of carbohydrates:

[1] Carbohydrates provide the **majority of energy in most organisms**.

[2] Glucose is **stored as glycogen in liver and muscle**.

[3] Carbohydrates (e.g. cellulose) give **structure to cell walls** (in plants) and **cell membranes**.

[4] Carbohydrates **serve as metabolic intermediates** (e.g. glucose 6- phosphate, fructose–1,6–bisphosphate).The metabolic intermediates derived from glucose are **used for the biosynthesis of amino acids, nucleic acid and nucleotides**.

[5] Carbohydrates (e.g. ribose, deoxyribose) comprise **large portions of the nucleotides that form DNA and RNA**.

[6] Carbohydrates **also play a role in lubrication, cellular intercommunication and immunity**.

[7] It plays an important role in the **metabolism of proteins and fatty acids**.

1-3 Classification of carbohydrates

Based on the sugar units they contain, carbohydrates are classified into four groups, as

[1] Monosaccharides (Simple sugar, consist of single unit of sugar)

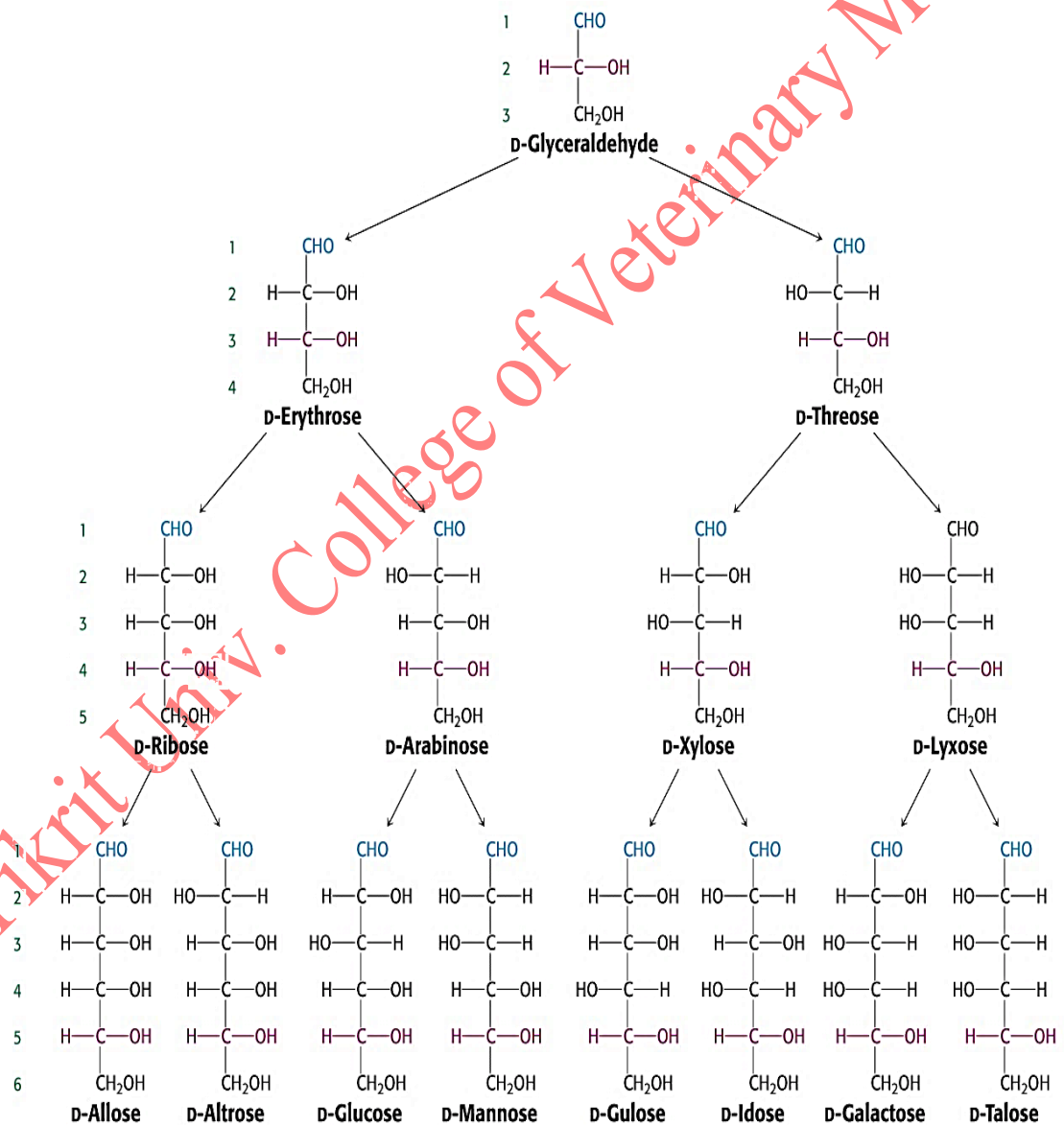
[2] Disaccharides (Two units of monosaccharide)

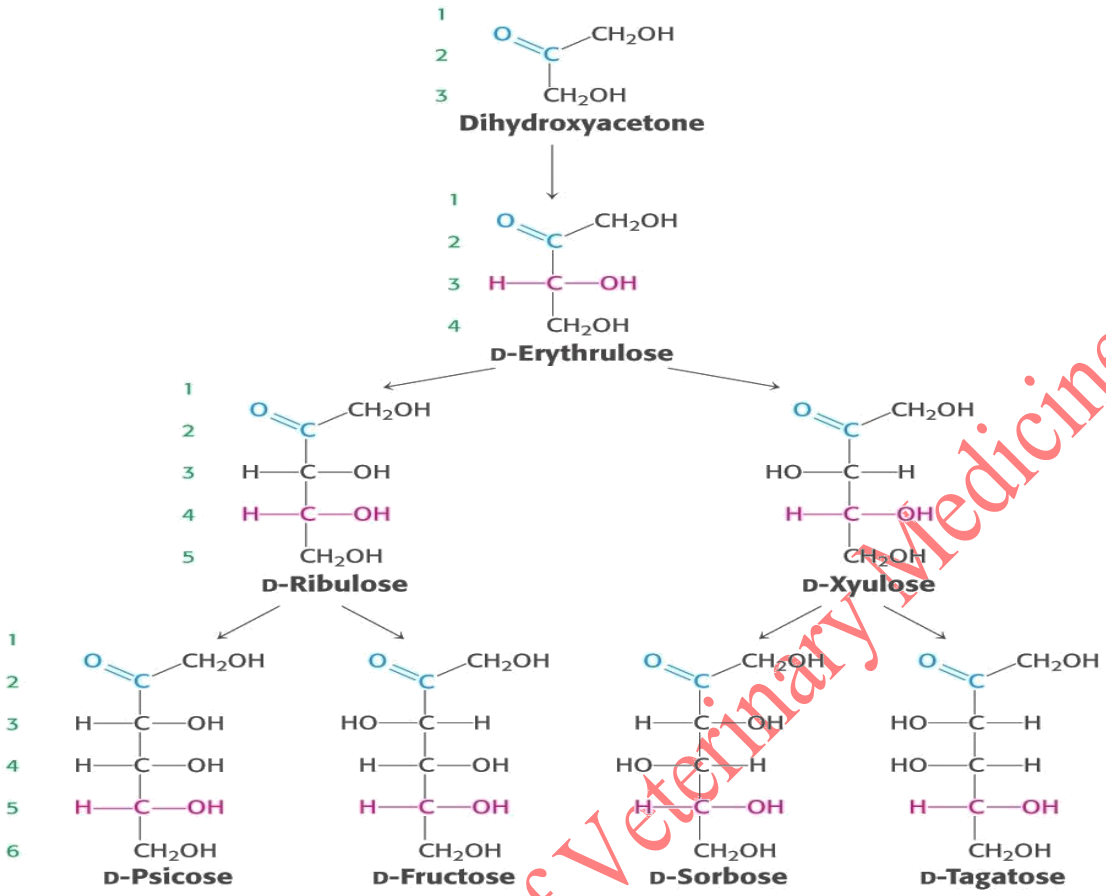
[3] Oligosaccharides (a small polymer of sugar) (3 to 10 units of monosaccharide)

[4] Polysaccharides

[1] Monosaccharides are simple sugars, consisting of **single polyhydroxy aldehyde or ketone unit. They cannot be hydrolyzed to yield simpler forms of sugar**.

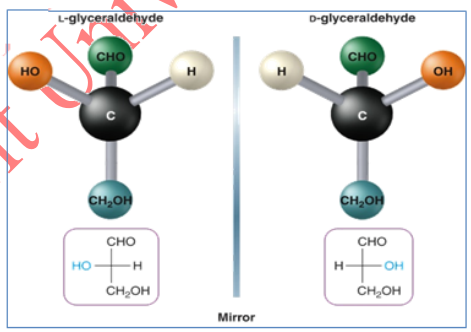
- ❖ They can be subdivided depending upon the **number of carbon atoms** to trioses, tetroses, pentoses, hexoses, heptoses and octoses.
- ❖ Carbohydrates with an **aldehyde as their functional group are called as Aldoses**. Those with **keto as functional group are called as ketoses**. (According to the C=O position)

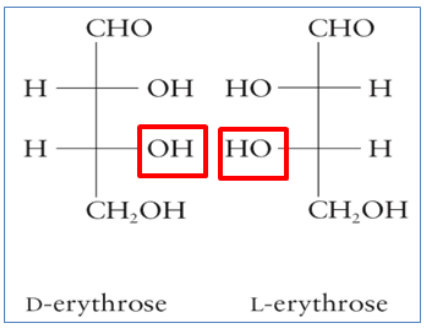




1-4 Fischer projections (D vs L Designation)

The hydroxyl group on the chiral carbon farthest from the C=O group determines whether the carbohydrate is **D (OH on right)** or **L (OH on left)**. The two horizontal bonds are coming toward the viewer out of the plane in which they are drawn. And these **two isomers called Enantiomers**

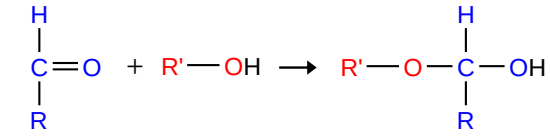


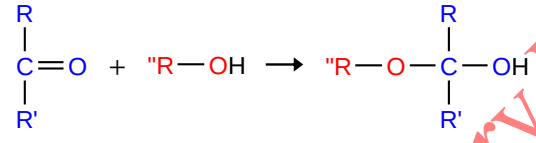


Anomer (Haworth Projections)

All monosaccharides with at least five carbon atoms exist predominantly as **cyclic hemiacetals and hemiketals**.

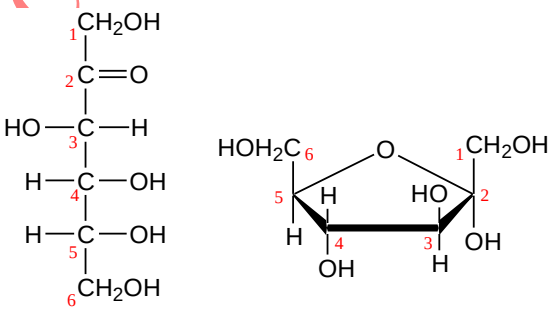
- An aldehyde can react with an alcohol to form a hemiacetal.
- A ketone can react with an alcohol to form a hemiketal.





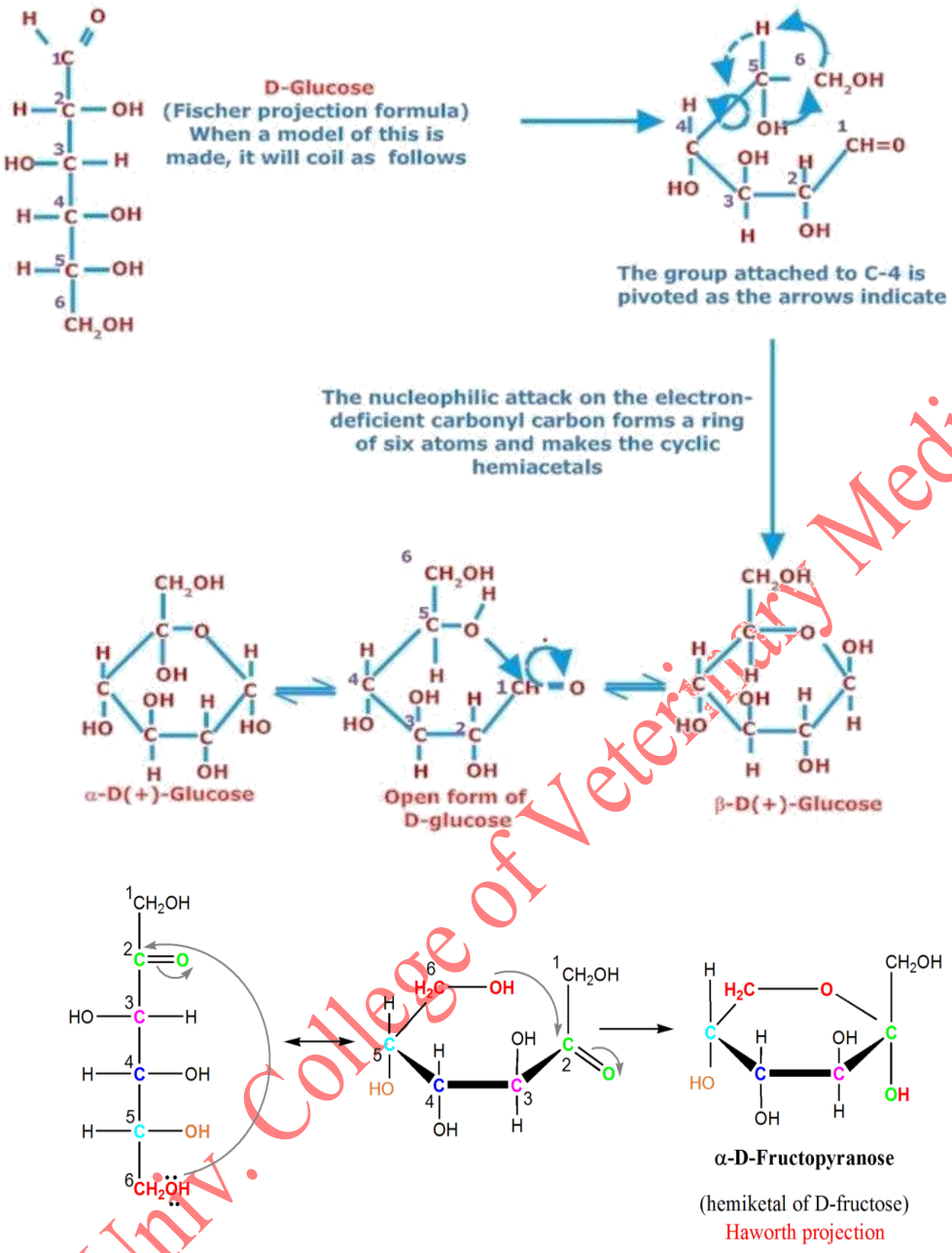
1-5 Cyclic structure of pentoses and hexoses

- Pentoses and hexoses can cyclize as the ketone or aldehyde reacts with a distal OH.
- Glucose forms an intra-molecular hemiacetal, as the C1 aldehyde & C5 OH react, to form a 6-member pyranose ring, named after pyrane. **These representations of the cyclic sugars are called Haworth projections**.
- **Fructose forms either a 6-member pyranose ring, by reaction of the C2 keto group with the OH on C6**, or a **5-member furanose ring, by reaction of the C2 keto group with the OH on C5**



D-fructose (linear) α-D-fructofuranose

A Haworth structure can be used to depict the three-dimensional cyclic carbohydrate structures.



[2] Disaccharides: Yield two molecules of the same or different monosaccharides when hydrolyzed. Examples are sucrose, lactose, and maltose.

[3] Oligosaccharides: Yield 3–6 monosaccharide units on hydrolysis. Eg. maltotriose and raffinose

[4] Polysaccharides: Yield more than 6 molecules of monosaccharide on hydrolysis. Examples of polysaccharides are starch, cellulose, glycogen and dextrins.

The polysaccharides may be **linear or branched** eg. **Cellulose is a linear polysaccharide** and **starch is a branched polysaccharide**.

1-6 Physiological important of monosaccharides

Some of physiological functions of common monosaccharides are listed in Table 2.

Table 2: Physiological important of common monosaccharides

Sugars	Occurrence	Functions
Pentoses		
D-Ribose	Nucleic acids	As an important component of DNA, RNA and also in NAD+, NADP+, FAD +and ATP Ribose phosphates are intermediates in HMP pathway (HMP : hexose monophosphate or The pentose phosphate pathway)
D-Ribulose	Formed in metabolic processes	It is an intermediate in the HMP pathway
D-Arabinose	In wood gums	Constituent of glycoproteins
D-Xylose	Wood gums, proteoglycans and glycosaminoglycans	Constituent of glycoproteins
D-Lyxose	Heart muscle	A constituent of lyxoflavin isolated from human heart muscle
L- Xylulose	Intermediate in uronic acid pathway	-
Hexoses		
D- Glucose (Blood sugar)	Fruit juice, hydrolysis of starch, cane sugar, maltose and lactose	The sugar of the body. The glucose is transported in the blood and oxidized in the cells to produce energy In diabetes the glucose is present in the urine
D-Fructose (Fruit sugar)	Found in fruit and honey	It is the sweetest of all the sugars. In seminal fluid it provides the energy source for the spermatozoa. It can be changed to glucose in the liver In some hereditary disorder fructose is accumulated causing hypoglycemia
D- Galactose (Brain sugar)	Hydrolysis of lactose	It can be changed to glucose in the liver. It is used to synthesize lactose in the mammary gland. A constituent of glycolipids and glycoproteins Failure in the metabolism leads to galactosemia and cataract
D-Mannose	Hydrolysis of plant mannans and gums	A constituent of many glycoproteins