Carbohydrates

Structure and Functions

Introduction

Carbohydrates are unique in its chemical structure and they are broadly distributed in plant kingdom and animal kingdom.

Carbohydrates have very important roles in human body.
They play:

1- Structural functions.
2- Metabolic roles.

In plants, and by a chemical process called “photosynthesis”, glucose $C_6H_{12}O_6$ is synthesized from carbon dioxide CO_2 and water H_2O. Glucose stored in plant as starch or used to synthesize cellulose.

Animals can gain carbohydrates from eaten plants
They also can synthesize carbohydrate from other sources such as lipid glycerol and amino acids.

Most animal carbohydrate is derived ultimately from plants.

Glucose is the most important carbohydrate.

Most dietary carbohydrate is digested into glucose which absorbed into the bloodstream.
Carbohydrates are converted into glucose in the liver.

Glucose is the major metabolic energy of mammals (except ruminants).
It is a universal energy form of the human fetus.

On the other hand, glucose play a very important role as the precursor for synthesis of all the other types of carbohydrates in the human body.

Glucose is a starting chemical to synthesize:

- **Glycogen** as a for storage form of carbohydrate in the body.
- **Ribose** in RNA and **deoxyribose** in DNA, the nucleic acids.
- **Galactose** in milk, to synthesize lactose the sugar of milk.
- **Glycolipids**, and in combination with lipids.
- **Glycoproteins** in combination with protein.
- **Proteoglycans** in combination with protein.

Many diseases associated with disorder in carbohydrate structure and/or metabolism such as:

- **Diabetes mellitus**
- **Galactosemia**
- **Glycogen storage diseases**
- **Lactose intolerance.**

CARBOHYDRATES ARE ALDEHYDE OR KETONE DERIVATIVES OF POLYHYDRIC ALCOHOLS

(1) Monosaccharides are simple carbohydrates that cannot be hydrolyzed into simpler ones.

Monosaccharides are classified into:

Depending on the number of carbon atoms, they classified into:

- **trioses, tetroses, pentoses, hexoses,** or **heptoses.**
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Depending on aldehyde or ketone group, they classified into:

- **aldoses** or **ketoses.**

Examples are listed in table classification of important sugars.

Name	No. of C	Formula	Aldoses	Ketoses
Trioses	C3	$C_3H_6O_3$	Glycerose	Dihydroxyacetone
Tetroses	C4	$C_4H_8O_4$	Erythrose	Erythrulose
Pentoses	C5	$C_5H_{10}O_5$	Ribose	Ribulose
Hexoses	C6	$C_6H_{12}O_6$	Glucose	Fructose

(2) Disaccharides are condensation products of two monosaccharides, such as maltose and sucrose.

(3) Oligosaccharides are condensation products of 2-10 monosaccharides such as maltotriose.

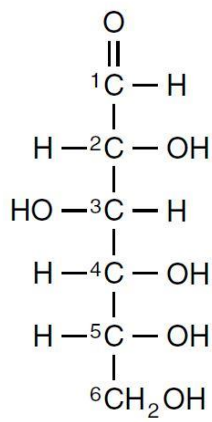
(4) Polysaccharides are condensation products of more than 10 monosaccharids. Examples are the starches and dextrins

Polysaccharides may be linear or branched polymers. Polysaccharides are sometimes classified as hexosans or pentosans, according to monosaccharides' types that involved.

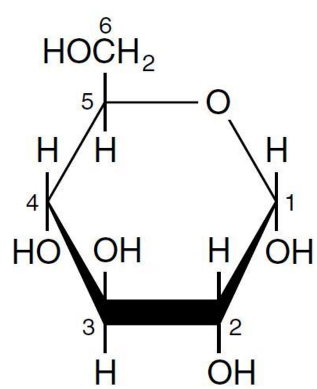
GLUCOSE
THE MOST IMPORTANT MONOSACCHARIDE

The Structure of Glucose Can Be Represented in Three Ways:

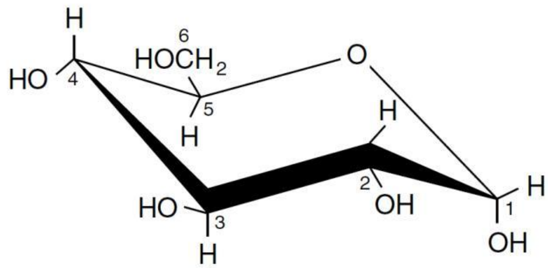
1- The **straight-chain** structural formula (aldohexose) reveals some of the properties of glucose.



1- A **cyclic structure (Haworth projection)**
This drawing is viewed from the side and above the plane of the ring.



3- The **chair form** six-membered ring containing one oxygen atom is in the form of a chair.



Isomerism in Sugars

Glucose, with four asymmetric carbon atoms, can form 16 isomers.

$$\text{No. of isomers} = 2^n = 2^4 = 16$$

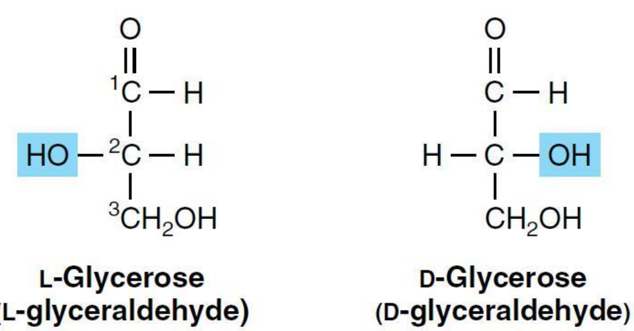
Where n= No. of asymmetric carbon atoms

The more important types of isomerism found with glucose are as follows.

(1) D and L isomerism:

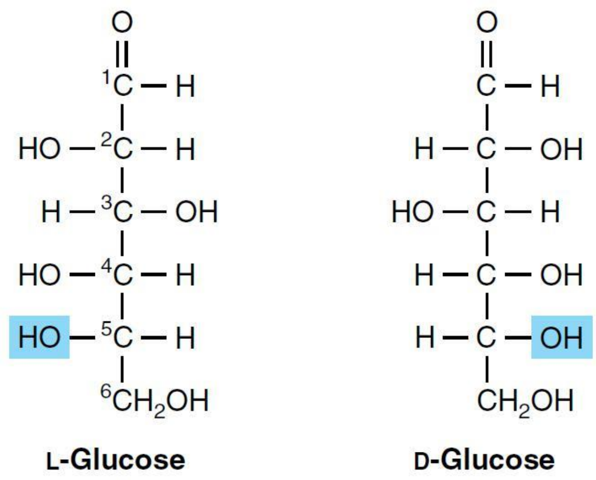
The designation of a sugar isomer as the D form or of its mirror image as the L form,

Example: glycerose (glyceraldehyde).



The orientation of the H and OH groups around the carbon atom adjacent to the terminal primary alcohol carbon (carbon 5 in glucose) determines whether the sugar belongs to the D or L series.

D-isomer: when the OH group on this carbon is on the right the sugar.
L-isomer: when the OH group is on the left.



Most of the monosaccharides occurring in mammals are D sugars, and the enzymes responsible for their metabolism are specific for this configuration.