UNIT-I

Carbohydrates are the most abundant biomolecules on earth. Oxidation of carbohydrates is the central energy-yielding pathway in most non-photosynthetic cells.

Definition: Carbohydrates are polyhydroxy aldehydes or ketones, or substances that yield such compounds on hydrolysis.

Carbohydrates have the empirical formula $(CH_2O)_n$.

There are three major classes of carbohydrates:

1. **Monosaccharides**

Monosaccharides, or simple sugars, consist of a single polyhydroxy aldehyde or ketone unit. The most abundant monosaccharide in nature is the six-carbon sugar D-glucose, sometimes referred to as dextrose.

2. **Oligosaccharides**

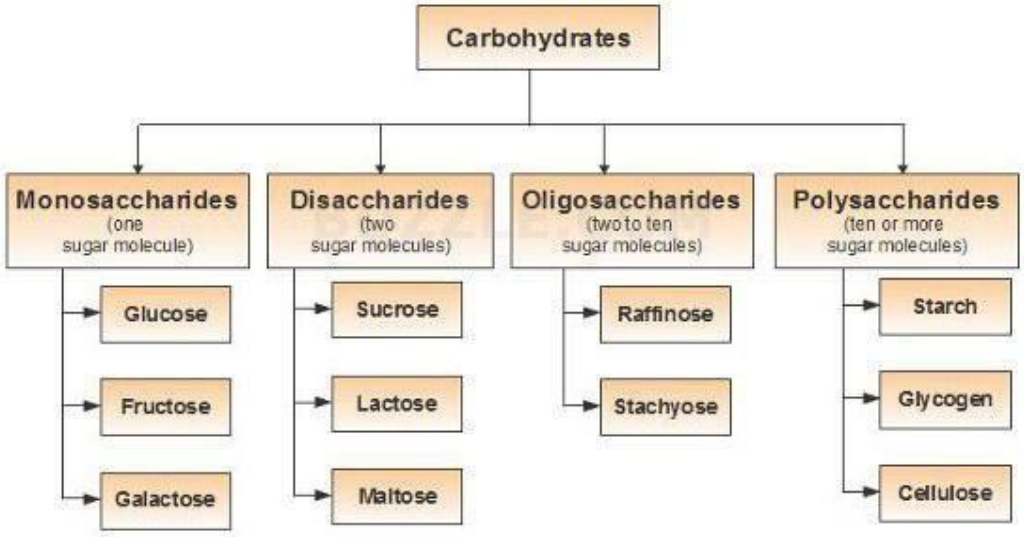
Oligosaccharides consist of short chains of monosaccharide units, or residues, joined by characteristic linkages called glycosidic bonds. The most abundant are the disaccharides, with two monosaccharide units. Example: sucrose (cane sugar).

3. **Polysaccharides**

The polysaccharides are sugar polymers containing more than 20 or so monosaccharide units, and some have hundreds or thousands of units. Example: starch.

Polysaccharides are of two types based on their function and composition. Based on function, polysaccharides are of two types: storage and structural.

A. Storage polysaccharide - starch.
B. Structural polysaccharide - cellulose.



General properties of carbohydrates

- Carbohydrates act as energy reserves, also stores fuels, and metabolic intermediates.
- Ribose and deoxyribose sugars forms the structural frame of the genetic material, RNA and DNA.
- Polysaccharides like cellulose are the structural elements in the cell walls of bacteria and plants.
- Carbohydrates are linked to proteins and lipids that play important roles in cell interactions.
- Carbohydrates are organic compounds, they are aldehydes or ketones with many hydroxyl groups.

Physical Properties of Carbohydrates:

- Stereoisomerism - Compound shaving same structural formula but they differ in spatial configuration. Example: Glucose has two isomers with respect to penultimate carbon atom. They are D-glucose and L-glucose.
- Optical Activity - It is the rotation of plane polarized light forming (+) glucose and (-) glucose.

- Diastereoisomerism - It is the configurational change with respect to C2, C3, or C4 in glucose. Example: Mannose, galactose.
- Anomerism - It is the spatial configuration with respect to the first carbon atom in aldoses and second carbon atom in ketoses.

Biological Importance

- Carbohydrates are chief energy source, in many animals, they are instant source of energy. Glucose is broken down by glycolysis/ Kreb's cycle to yield ATP.
- Glucose is the source of storage of energy. It is stored as glycogen in animals and starch in plants.
- Stored carbohydrates act as energy source instead of proteins.
- Carbohydrates are intermediates in biosynthesis of fats and proteins.
- Carbohydrates aid in regulation of nerve tissue and as the energy source for brain.
- Carbohydrates get associated with lipids and proteins to form surface antigens, receptor molecules, vitamins and antibiotics.
- They form structural and protective components, like in cell wall of plants and microorganisms.
- In animals they are important constituent of connective tissues.
- They participate in biological transport, cell-cell communication and activation of growth factors.
- Carbohydrates rich in fibre content help to prevent constipation.
- Also they help in modulation of immune system.

Monosaccharides

- The word “Monosaccharides” derived from the Greek word “Mono” means Single and “saccharide” means sugar
- Monosaccharides are polyhydroxy aldehydes or ketones which cannot be further hydrolysed to simple sugar.
- Monosaccharides are simple sugars. They are sweet in taste. They are soluble

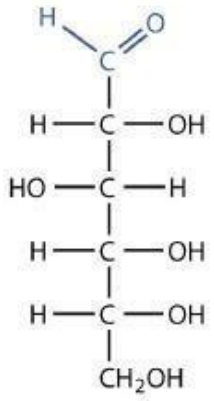
in water. They are crystalline in nature.

- They contain 3 to 10 carbon atoms, 2 or more hydroxyl (OH) groups and one aldehyde (CHO) or one ketone (CO) group.

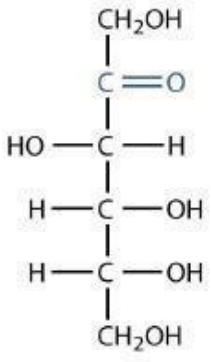
Classification of Monosaccharides

Monosaccharides are classified in two ways. (a) First of all, based on the number of carbon atoms present in them and (b) secondly based on the presence of carbonyl group.

The naturally occurring monosaccharides contain three to seven carbon atoms per molecule. Monosaccharides of specific sizes may be indicated by names composed of a stem denoting the number of carbon atoms and the suffix *-ose*. For example, the terms *triose*, *tetrose*, *pentose*, and *hexose* signify monosaccharides with, respectively, three, four, five, and six carbon atoms. Monosaccharides are also classified as aldoses or ketoses. Those monosaccharides that contain an aldehyde functional group are called aldoses; those containing a ketone functional group on the second carbon atom are ketoses. Combining these classification systems gives general names that indicate both the type of carbonyl group and the number of carbon atoms in a molecule. Thus, monosaccharides are described as aldotetroses, aldopentoses, ketopentoses, ketoheptoses, and so forth. Glucose and fructose are specific examples of an aldohexose and a ketohexose, respectively.



Glucose
(an aldohexose)



Fructose
(a ketohexose)

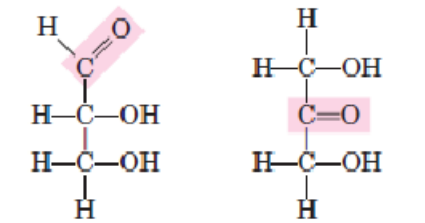
Name	Formula	Aldose	Ketose
Triose	$C_3H_6O_3$	Glycerose	Dihydroxy acetone
Tetrose	$C_4H_8O_4$	Erythrose	Erythrulose
Pentose	$C_5H_{10}O_5$	Ribose	Ribulose
Hexose	$C_6H_{12}O_6$	Glucose	Fructose
Heptose	$C_7H_{14}O_7$	Glucoheptose	Sedo heptulose

Trioses

Trioses are "Monosaccharides" containing 3 carbon atoms. The molecular formula of triose is $C_3H_6O_3$

Characteristics:

- Trioses are simple sugars
- They are soluble in water
- They are sweet in taste.
- The triose may contain an aldehyde group (aldotriose) or a ketone group (ketotriose). Example: Glyceraldehyde and Dehydroxyacetone



Glyceraldehyde, an aldotriose — Dihydroxyacetone, a ketotriose

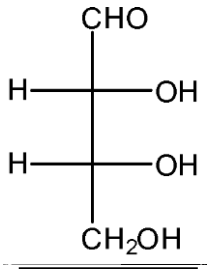
Tetroses

Tetroses are "Monosaccharides" containing 4 carbon atoms. The molecular formula of tetrose is $C_4H_8O_4$

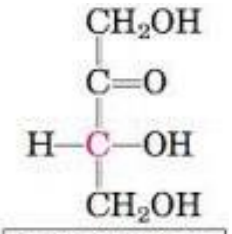
Characteristics:

- Tetroses are simple sugars

- Tetroses are soluble in water
- They are sweet in taste.
- They are crystalline forms.
- The tetroses may contain an aldehyde group (aldotetrose) or a ketone group (ketotetrose).



Erythrose



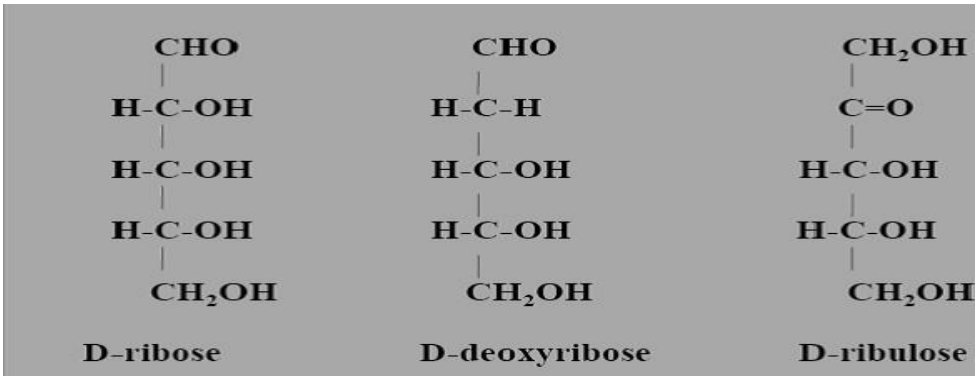
D-Erythrulose

Pentoses

Pentoses are "Monosaccharides" containing 5 carbon atoms. It is an important component of "nucleic acid". The molecular formula of Pentose is $C_5H_{10}O_5$

Characteristics:

- Pentoses are simple sugars
- Pentoses are soluble in water
- They are sweet in taste.
- They are crystalline forms.
- The pentoses may contain aldehyde group (aldopentose) or ketone group (ketopentose).



Hexoses

Hexoses are "Monosaccharides" containing 6 carbon atoms. The molecular formula of Hexose is $C_6H_{12}O_6$

Characteristics:

- Hexoses are simple sugars
- Hexoses are soluble in water
- They are sweet in taste.
- They are crystalline forms.
- The hexoses may contain an aldehyde group (aldohexose) or a ketone group (ketohexose).

Structure of Monosaccharides

1. **Straight or Open Chain Structure**: Here 6 carbon atoms of glucose are arranged in a straight line. It is also called open chain structure because the two ends remain separate and they are not linked. Open chain structures are of two types:

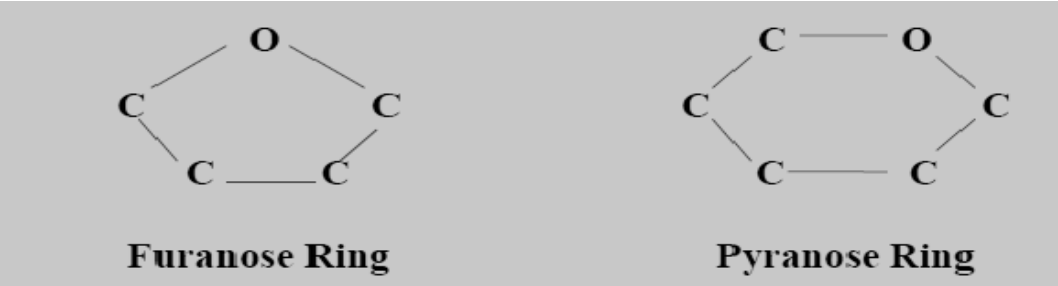
- (a)Structure proposed by Fittig and Baeyer
- (b)Structure proposed by Fischer known as Fischer's Projection Formula.

Molecular formula	Fittig-Baeyer straight chain	Fischer's straight chain structure
$C_6H_{12}O_6$	CHO | $(CH.OH)_4$ | CH_2OH	CHO | H-C-OH | HO-C-H | H-C-OH | H-C-OH | CH_2OH

2. **Cyclic or Ring Structure:** Here the atoms are arranged in the form of a ring. Haworth (1929) proposed this formula and hence the name Haworth's Projection Formula. The sugar molecules exist in two type of rings which are as follows –

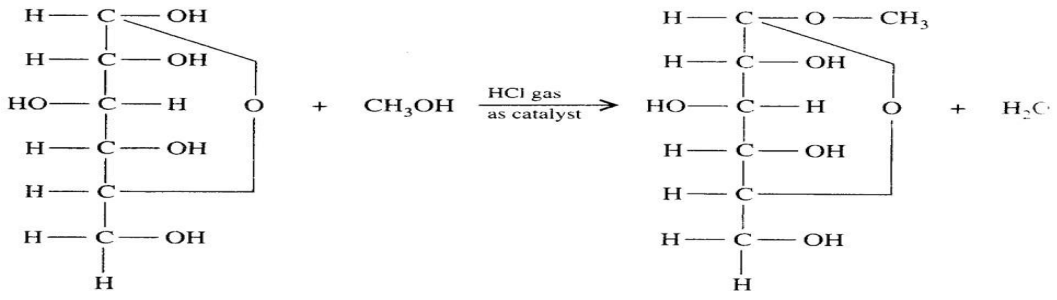
(a)Furanose Ring – 5 membered ring

(b)Pyranose Ring- 6 membered ring



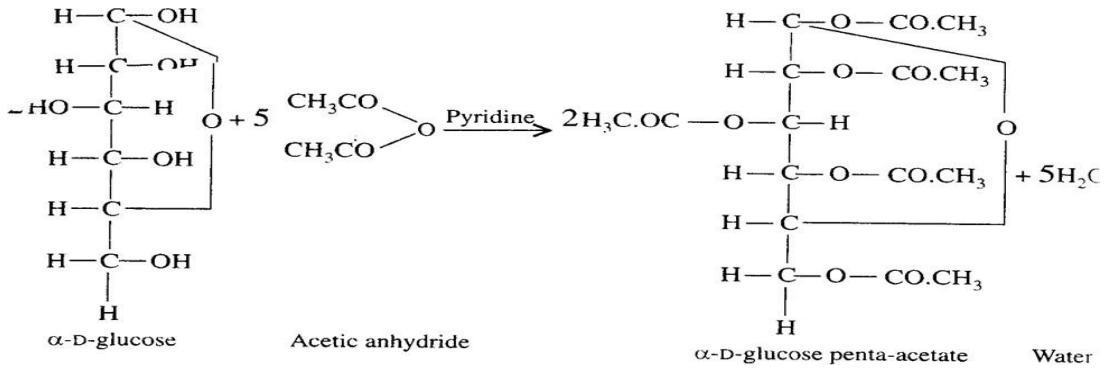
Properties of Monosaccharides

1. Colour - colourless
2. Shape - crystalline
3. Solubility – in Water
4. Taste - sweet
5. Optical activity – Optically active. (a) Dextrorotatory ('d' form) and (b) Levorotatory ('l' form)
6. **Mutarotation** – The change in specific rotation of an optically active compound is called mutarotation. +1120 +52.50 +190 α-D-glucose β -D-glucose
7. **Glucoside formation** -



Glucose + Methyl alcohol = Methyl glucoside

8. Esterification –



9. Reducing agents –

Monosaccharides reduce oxidizing agent such as hydrogen peroxide. In such reaction, sugar is oxidized at the carbonyl group and oxidizing agent becomes reduced.

$C_6H_{12}O_6 + 2\ Cu(OH)_2 \rightarrow C_6H_{12}O_7 + Cu_2O + 2H_2O$

10. Formation of Osazone –