Biochemistry Science

Science asks how the remarkable properties of living organisms arise from the thousands of different lifeless biomolecules. When these molecules are isolated and examined individually, they conform to all the physical and chemical laws that describe the behavior of inanimate matter—as do all the processes occurring in living organisms. The study of biochemistry shows how the collections of inanimate molecules that constitute living organisms interact to maintain and perpetuate life animated solely by the physical and chemical laws that govern the nonliving universe.

The chemistry of living organisms is organized around carbon, which accounts for more than half the dry weight of cells. Carbon can form single bonds with hydrogen atoms, and both single and double bonds with oxygen and nitrogen atoms. Of greatest significance in biology is the ability of carbon atoms to form very stable carbon–carbon single bonds. Each carbon atom can form single bonds with up to four other carbon atoms. Two carbon atoms also can share two (or three) electron pairs, thus forming double (or triple) bonds. Covalently linked carbon atoms in biomolecules can form linear chains, branched chains, and cyclic structures. To these carbon skeletons are added groups of other atoms, called **functional groups,** which confer specific chemical properties on the molecule.

Macromolecules

Many biological molecules are macromolecules, polymers of high molecular weight assembled from relatively simple precursors. ***Proteins***, are long polymers of amino acids, ***Nucleic acids***, DNA and RNA, are polymers of nucleotides ***, Carbohydrates,*** are polymers of simple sugars such as glucose and the ***Lipids,*** are greasy or oily hydrocarbon derivatives.

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CARBOHYDRATES

Occurrence

Most abundant molecules on earth, most are produced by photo-synthesis. They are present in humans, animal tissues, plants and micro-organisms. Carbohydrates are also present in tissue fluids, blood, milk secretions and excretions of animals.

Medical And Biological Importance

1. Carbohydrates are the major source of energy for man. For example, glucose is used in the human body for energy production.

2. Some carbohydrates serves as reserve food material in humans (glycogen) and in plant (starch).

3. Some of carbohydrates are components of cell membrane and nervous tissue.

4. Carbohydrates are components of nucleic acids and blood group substances.

5. Carbohydrates are involved in cell-cell interaction.

6. Derivative of carbohydrates are drugs. For example, streptomycin an antibiotic is a glycoside.

7. Aminosugar, derivatives of carbohydrates are components of antibiotics like erythromycin and carbomycin.

8. Ascorbic acid, a derivative is water-soluble vitamin.

9. Bacterial invasion involves hydrolysis of mucopolysaccharides.

Chemical Nature Of Carbohydrates

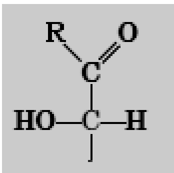
Carbohydrates are polyhydroxy alcohols with a functional aldehyde or keto group. They are represented with general formula $C_{n(}H_2O)_n$. usually the ratio of carbon and water is one in most of the carbohydrates hence the name carbohydrate (carbonhydrate).

Classification of carbohydrates

Carbohydrates are classified into three major classes based on number of carbon chains present. They are:

1. Monosacchrides
2. Oligosacchrides
3. Polysacchrides

All the three classes contain a saccharose group and hence the name saccharides.



Saccharose group

MONOSACCHARIDES

Monosaccharides are those carbohydrates which cannot be hydrolyzed to small compounds. Their general formula is $C_n(H_2O)_n$. They are also called as simple sugars. Monosaccharides containing three to nine carbon atoms occur in nature.

Nomenclature

Monosaccharides have common (trivial) names and systematic names. Systematic name indicates both the number of carbon atoms present and aldehyde or ketone group. For example, glyceraldehyde is a simple sugar containing three carbon atoms and an aldehyde group. Simple sugars containing three carbon atoms are referred as triose. In addition, sugar containing aldehyde group or keto group are called as aldoses or ketoses, respectively. Thus, the systematic name of glyceraldehydes is aldotriose. Similarly, a simple sugar with three carbon atoms and keto group is called ketotriose. Some monosaccharides along with their common and systematic names are shown below

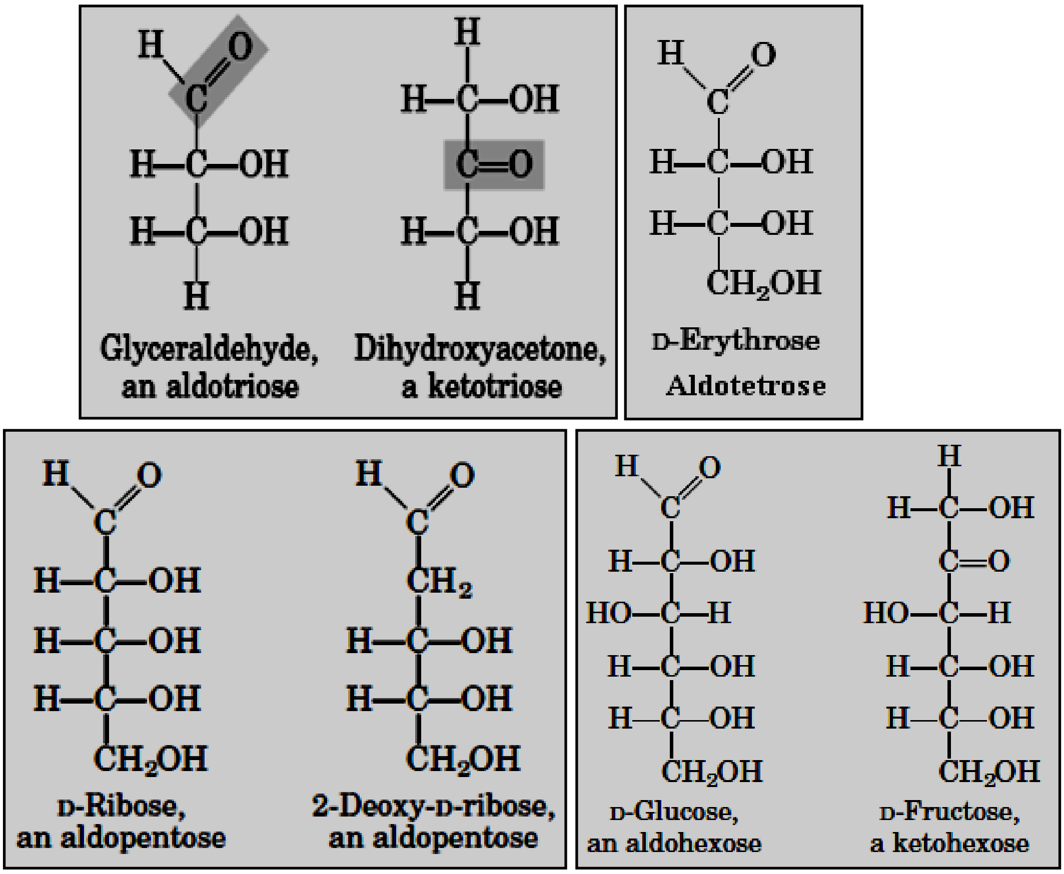


Fig.1.1 Some Important Monosaccharides (Systematic Names Are Given Too)

Name	Formula	Aldoses (*Aldo sugars*)	Ketoses (*Keto sugars*)
Trioses	$C_3H_6O_3$	Glycerose	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	$C_7H_{14}O_7$	Glucoheptose	Sodoheptulose

PROPERTIES OF MONOSACCHARIDES

1. Optical Isomers

All the monosaccharides except dihydroxyacetone contain one or more asymmetric (chiral) carbon atoms and thus occur in optically active isomeric forms. The simplest aldose, glyceraldehyde, contains one chiral center (the middle carbon atom) and therefore has two different optical isomers, or *enantiomers* (Fig. 1.2). By convention, one of these two forms is designated the D isomer, the other the L isomer. To represent three-dimensional sugar structures on paper, we often use **Fischer projection formulas**. In general, a molecule with *n* chiral centers can have 2^n stereoisomers. Glyceraldehyde has $2^1 = 2$; the aldohexoses, with four chiral center has $2^1 = 2$; the aldohexoses, with four centers, have $2^4 = 16$ stereoisomers.

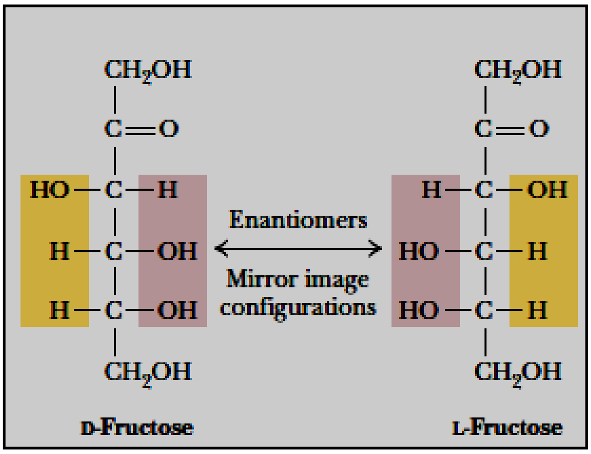
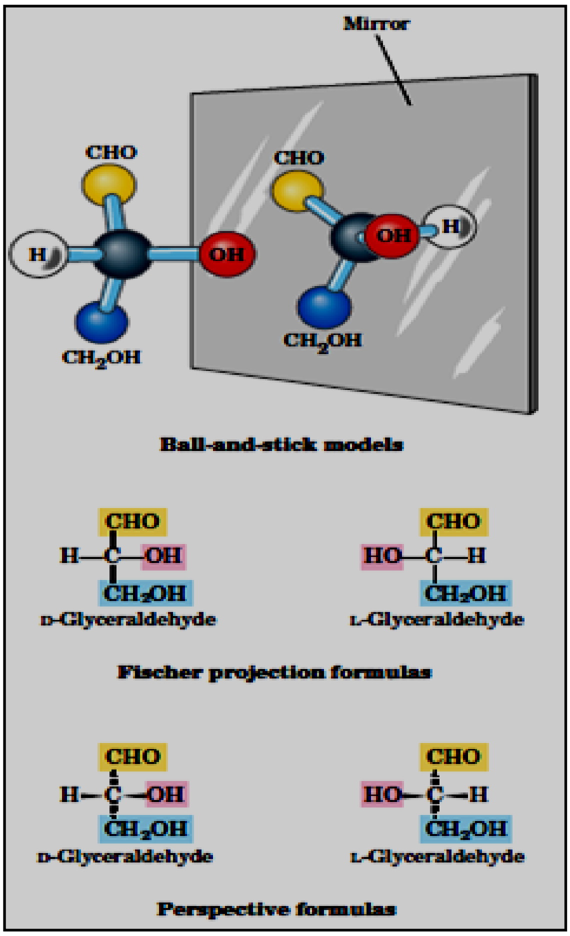


FIGURE 1–2 Three ways to represent the two stereoisomers of glyceraldehyde. The stereo-isomers are mirror images of each other. Ball-and- stick models show the actual configuration of molecules. By convention، in Fischer projection formulas, horizontal bonds project out of the plane of the paper, toward the reader; vertical bonds project behind the plane of the paper, away from the reader.



The stereoisomers of monosaccharides of each carbon-chain length can be divided into two groups that differ in the configuration about the chiral center *most distant* from the carbonyl carbon. Of the 16 possible aldohexoses, eight are D forms and eight are L. Most of the hexoses of living organisms are D isomers.

2. Optical Activity

Monosaccharides except dihydroxy acetone exhibit optical activity because of the presence of asymmetric carbon atom. If a sugar rotates plane polarized light to the right then it called as dextrorotatory and if a sugar rotates plane polarized light to left then it called the levorotatory. Usually '+' sign or 'd' indicates dextrorotation and ' - ' or ' l ' indicates levorotatory. For example, D-glucose which is dextrorotatory is designated as D(+) glucose and D-fructose, which is levorotatory is designated as D(-)fructose.

3. Epimers

Are those monosaccharides that differs in the configuration of -OH group on 2nd, 3rd and 4th carbon atoms. Epimers are also called *diasterioisomers*. Glucose, galactose and mannose are examples for epimers. Galactose is an epimer of glucose because, configuration of hydroxyl group on 4th carbon atom of galactose is different from glucose. Similarly, mannose is an epimers of glucose because configuration of hydroxyl group on 2nd carbon atom of mannose is different from glucose (Fig.1.3). Ribulose and xylulose (both are ketoses) are also epimers. They are differ in configuration of -OH group on third carbon atom (Fig. 1.4).

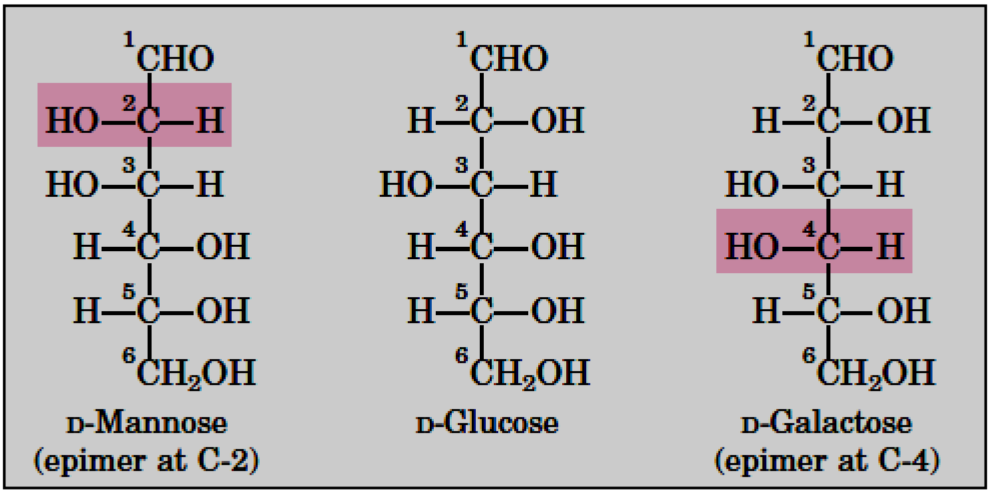


FIGURE 1–3 Epimers. D-Glucose and two of its epimers are shown as projection formulas. Each epimer differs from D-glucose in the configuration at one chiral center

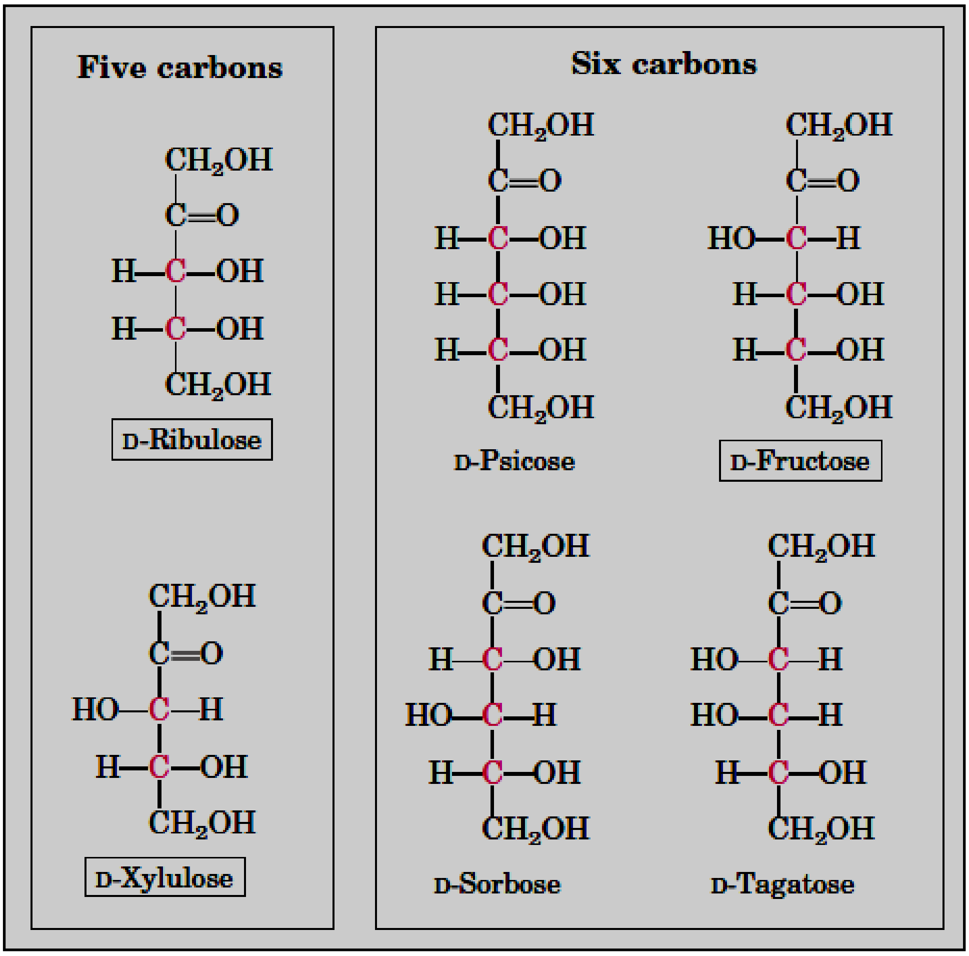


Figure 1-4 Epimers of some ketoses