

Classification and structure of carbohydrates

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This article has been translated from WikiSkripta; ready for the **editor's review**.

Carbohydrates, also called carbohydrates, are the most abundant organic substances on Earth. Their molecules are made up of oxygen, carbon and hydrogen atoms. From a chemical point of view, these are **polyhydroxyaldehydes** and **polyhydroxyketones**. They contain functional aldehyde or keto groups in their molecule, as well as a larger number of hydroxyl groups.

Carbohydrate Classification

'According to the number of units in the molecule, we distinguish:

- **monosaccharides** - cannot be further hydrolyzed into simpler units;
- **oligosaccharides** - they form 2-10 units of monosaccharides by hydrolysis;
- **polysaccharides** - hydrolyzing into more than 10 monosaccharides.

Monosaccharides and oligosaccharides are generally called *sugars*. A synonym for polysaccharide is the word *glycan*.

'Monosaccharides are divided according to:

- Number of C-atoms: trioses, tetroses, pentoses, hexoses.
- Functional groups: aldoses and ketoses.

'Polysaccharides are divided into:

- **Homopolysaccharides**': these are polymers made up of the same type of monosaccharide. Examples are starch, glycogen or cellulose.
- **Heteropolysaccharides**': they are polymers made up of more than one type of monosaccharide. An example is hemicellulose.

Carbohydrate Structure

'The structure of a saccharide molecule can be expressed by different formulas:

- **Linear** (**Fischer**) formula;

File:L-threose formula structure.PNG

- **Cyclic** (*Haworth's*) formula that results from the formation of a heterocyclic structure.

File:Chitosan Haworth.gif

Cycle can be:

six-membered - pyranose - by similarity to six-carbon pyran;
five-membered - furanose - by similarity to five-carbon furan.

- The **Tollens** formula describes the creation of a cyclic structure from a linear formula. It shows the reaction of hydroxyl with a carbonyl group to form a so-called ``semiacetal (hemiacetal) *structure*.

Isomerism

It is a condition where compounds with the **same general formula have a different structural arrangement of atoms in the molecule**. The following types of isomerism are found in carbohydrate molecules.

Template:D- and Template:L- series

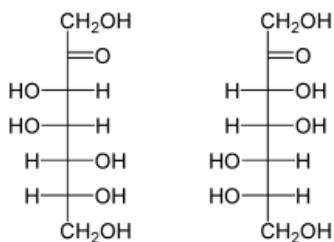
Indicated by the **position of the –OH group** on the last **chiral carbon**. Assignment to the respective series is based on similarity with the starting compound of the carbohydrate series – glyceraldehyde. The –OH group in Fischer's formula is on the right for Template:D- and on the left for Template:L- isomers.

Monosaccharides that normally occur in the body belong to the Template:D- series and the enzymes that catalyze their transformations are *stereospecific* for these isomers.

Template:D- and Template:L- isomers are mirror images of the so-called **enantiomers** - *optical isomers*. They differ in the sign of optical rotation, or the direction in which they rotate the plane of polarized light. However, it is not generally true that the Template:D- series is right-handed and the Template:L- series is left-handed.

Equimolar mixture of enantiomers is called a *racemic mixture*, or Template:DTemplate:L mixture, and it does not show optical activity.

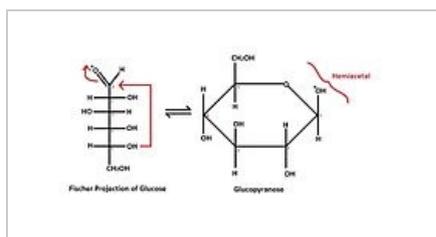
The **Template:D- isomers** are more common in nature.



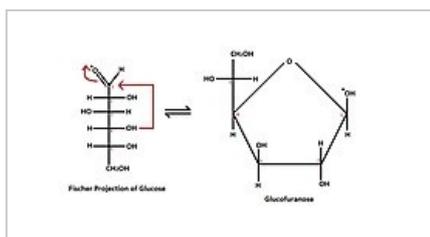
D-Mannoheptulose L-Mannoheptulose

Pyranoses and furanoses

They are designated according to the similarity of the cyclic form of the respective monosaccharide *'with the cycle of pyran or furan'*. Glucose in solution is more than 99% in the form of gluco-pyranose, the rest of the molecules, less than 1%, then appears in the form of gluco-furanose.



An example of pyranose



An example of furanose

α- and β- anomers

They are designated according to the **position of the hemiacetal** or **hemiketal –OH in the cycle**.

"Hemiacetals" are formed by the reaction of aldehyde and alcohol groups, hemiketals by the reaction of keto and alcohol groups.

If the –OH group is oriented to the same side as the –OH group indicating belonging to the Template:D- or Template:L- series, it is an **α-anomer**. If the –OH group is oriented to the opposite side, it is a **β-anomer**'.

In the Template:D- series, therefore, the α-anomer –OH group is oriented *'below the plane of the ring'*.

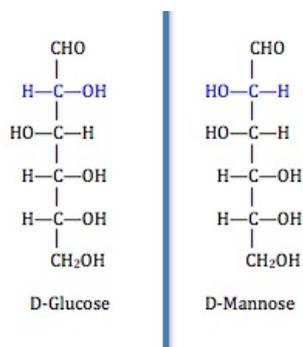
Anomers differ in optical rotation.

For example, when crystalline sugar is dissolved, the equilibrium between the two anomers is stabilized, the optical rotation of the solution changes, a phenomenon called mutarotation.

Epimers

They differ from each other by the position of **one –OH group in the molecule**'.

Examples are **glucose**' and **mannose**'.



Aldoses and ketoses

They are designated by the different functional group on the 1st and 2nd carbons of the molecule.