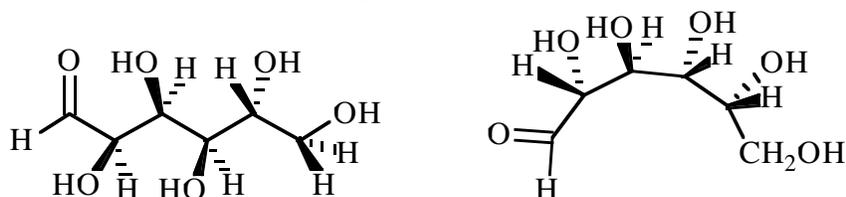


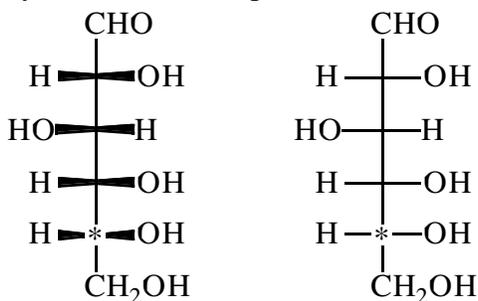
Carbohydrates - The name carbohydrate comes from the words "carbon" and "hydrate", in other words, a carbon atom surrounded by water. In fact, the general formula for most (but not all) **sugars** is $C_n(H_2O)_m$, where n and m are integers. Though the structures of sugars are not carbon surrounded by water, all of them do share certain common features. All sugars have at least two hydroxyl groups (-O-H), and a carbonyl group (>C=O). The carbonyl can be at the end (aldehyde-like) or not (ketone-like). The sugars with the carbonyl at the end are called **aldoses**, and the others are the **ketoses**. The suffix "ose" is used to name the sugar.

Generally speaking, simple sugars fall into five main categories: **trioses**, **tetroses**, **pentoses**, **hexoses**, and **heptoses**. These correspond to having 3, 4, 5, 6, or 7 carbons in the molecule. These molecules tend to be optically active, and the naturally occurring ones are generally **dextrorotary** (i.e. **D-sugars**, as opposed to L-amino acids). The designation of D is based on the enantiomeric carbon furthest from the carbonyl. This point will be repeated once we look at a few sugars.

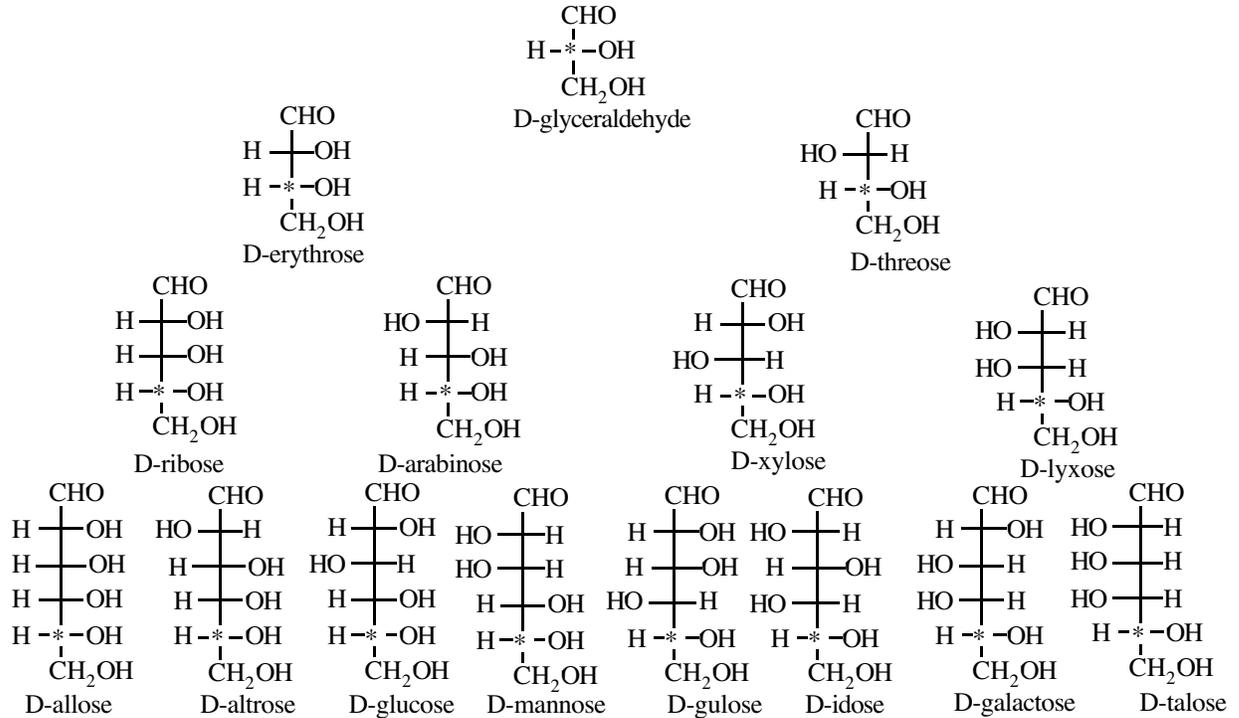
Common Aldoses: The most well known simple sugars (a.k.a **monosaccharides**) are glucose and fructose. Both are hexoses, with glucose being an aldose, and fructose being a ketose. We can draw the structure of glucose as follows:



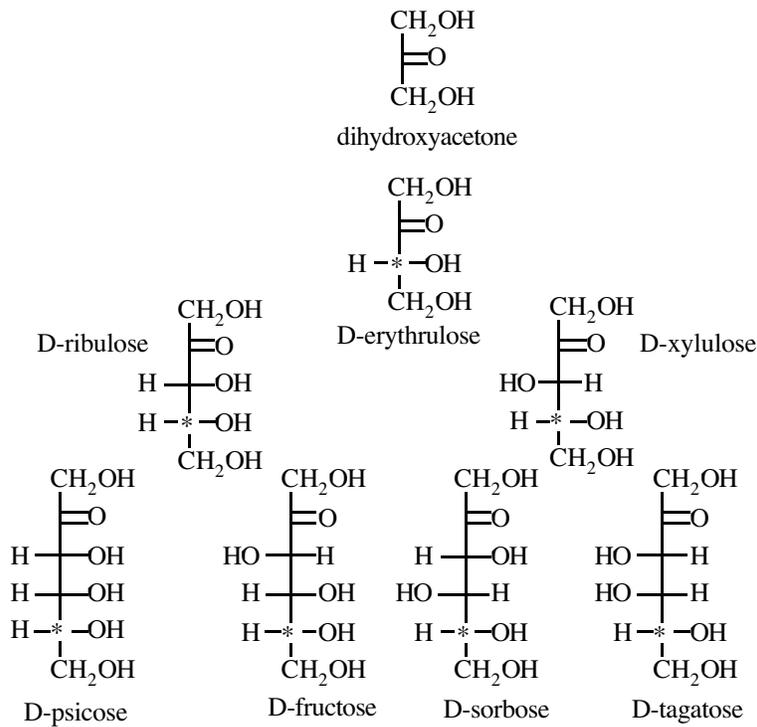
This correctly demonstrates the stereochemistry of each carbon. However, this is rather difficult to draw. Therefore, a fellow by the name of Emil Fischer suggested that we write the structure as a flat, Lewis-type structure, obtained by viewing the molecule from above, assigning the carbonyl end to be the top of the molecule. That is, draw glucose:



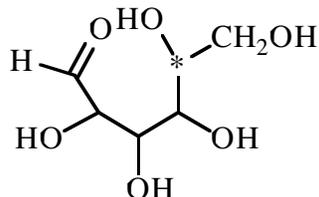
The carbon with the * is the one that designates this as being D-hexose. The relative orientation of the OH groups on the other carbons tell us that this is indeed D-glucose. A sugar that is the same in all orientations except one (i.e. an enantiomer) is called an **epimer**. Ones that differ in more than one are called **diastereomers**. The following is a "family tree" of the common aldoses (the * always shows which carbon corresponds to the D-stereo center):



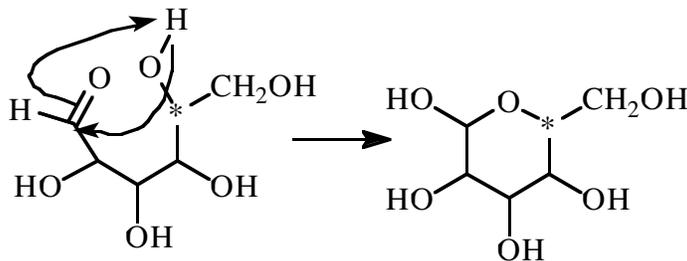
Ketoses: The common ketoses have the carbonyl only one carbon away from the end. The simplest of these sugars (dihydroxy acetone) is the only one that does not get the D-designation, since it is not optically active (why?). The following sugars are the common ketoses:



Hemi-acetals - The hexoses and pentoses are large enough that the chains can get twisted in such a way as to place the carbonyl next to the *ed hydroxyl. For example, the generic hexa-aldose below shows the correct orientation:

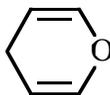


In this situation, a hemi-acetal can form:



Depending on whether the -OH formed by the C=O is twisted up or down relative to the plane of the hexagon, the resulting hemi-acetal is designated as either α or β , with α being down and β being up. These two stereo-isomers are called **anomers**.

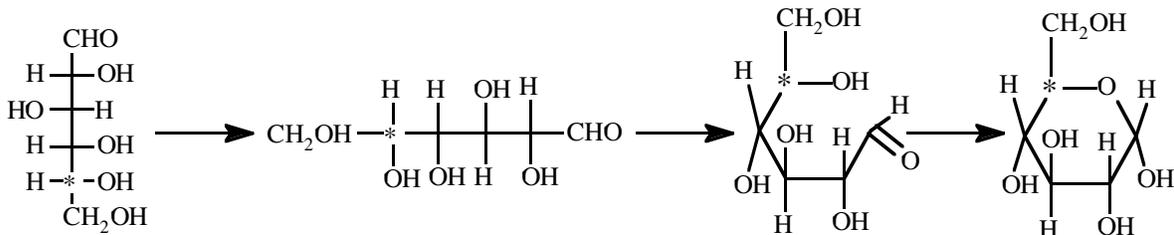
The ring size (i.e. 5 or 6 members in the ring) are given certain designations. The six-membered rings are called **pyranoses**, because they resemble the molecule **pyran**:



The five membered rings are called **furanoses**, as they look like on **furan**:



The representation of the ring structures as flat rings are called Haworth structures, and, as always, there are certain rules that must be obeyed to use them. If we rotated the Fischer projection to the right by 90° , the orientation of the OH groups shows how they will appear on the ring. The CH_2OH that is not included in the ring is always pointed upwards, i.e. using glucose as an example:



The product in this example is α -D-glucopyranose. The three dimensional structure of the pyranose family is the chair form we saw in cyclohexane. For furanoses, the structure is sometimes called an "envelope".

Disaccharides and Polysaccharides: Acetals - When two or more simple sugars (mono-saccharides) bind, they form new molecules called **polysaccharides**. The process can be described as a dehydration, since the resulting molecule is one water molecule smaller than the sum of the two original sugars. The bond takes place between the "carbonyl hydroxide" of one ring, and another hydroxide from the next ring. Depending on which carbon it is bound to, the product has different characteristics and a different name. The common disaccharides that we encounter everyday (e.g. **sucrose**, **lactose**, **maltose**) are all said to be **α -1,4-disaccharides**, where the 1 corresponds to the carbonyl carbon, and the 4 is the fourth carbon in the chain. This type of bond is also called an α -glucosidic bond, and represents an **acetal** formed when the intra-molecular hemi-acetal makes a bond to an external hydroxyl group. (Cellulose, which is also a polyglucose molecule, is made up of β -1,4-glucosidic bonds).