Traditionally, in carbohydrate chemistry, the furanose rings and the pyranose rings in carbohydrate molecules are shown in the planar conformation, placed on the plane perpendicular to the plane of the paper.

This representation of rings is known as the **Haworth formula**. eg: cyclic forms of D-glucose

To generate the Haworth formulas of the cyclic forms of a monosaccharide, use the following procedure, explained using the pyranoses of D-glucose.

**Step 1:** Draw the Fischer projection of the acyclic form of D-glucose. (See D,L convention)
Step 2: Number the carbon chain in 1 starting at the top.

Step 3: To generate the pyranose ring, the oxygen atom on C-5 in 1 needs to be attached to C-1 by a single bond.
In 1, C-1 is behind the plane of the paper and the hydroxy group on C-5 is in front. For the pyranose ring to be planar, both C-1 and the hydroxy group on C-5 have to be either behind or in front of the plane of the paper. C-5 is a chiral center.

In order to bring the hydroxy group on C-5 to the site occupied by the \( \text{CH}_2\text{OH} \) group without changing the absolute configuration at C-5, rotate the three ligands H, OH, and \( \text{CH}_2\text{OH} \) on C-5 in 1 clockwise without moving the fourth ligand.

(See Fischer projection)

1 and 2 both represent D-glucose, but, in 2, unlike in 1, C-1 and the hydroxy group on C-5 are on the same side of the plane of the paper.

**Step 4**: Ignore that 2 is a Fischer projection and rotate it clockwise by 90°.
Step 5: Redraw the atom chain along the horizontal axis as follows.

Step 6: Add the ligands on C-2 through C-5 in 4. The ligands pointing up in 3 are pointing up in 4; those pointing down in 3 are pointing down in 4.
Step 7: Remove the hydrogen atom and the oxygen atom on C-1 and the hydrogen atom in the hydroxy group on C-5 in 5 and connect the two atoms by a single bond.

Step 8: Add the two remaining bonds to C-1 in 6.
Step 9: Attach a hydrogen atom to the bond pointing up and a hydroxy group to the bond pointing down on C-1 in 7.

Step 10: Interchange the hydrogen atom and the hydroxy group on C-1 in 8.
8 and 9 are the Haworth formulas of the pyranoses of D-glucose. If, in the acyclic form of a monosaccharide, the hydroxy group that reacts with the carbonyl carbon is not on a chiral carbon (eg: D-fructose→pyranoses), skip step 3.

Contributors and Attributions

• Gamini Gunawardena from the OChemPal site (Utah Valley University)