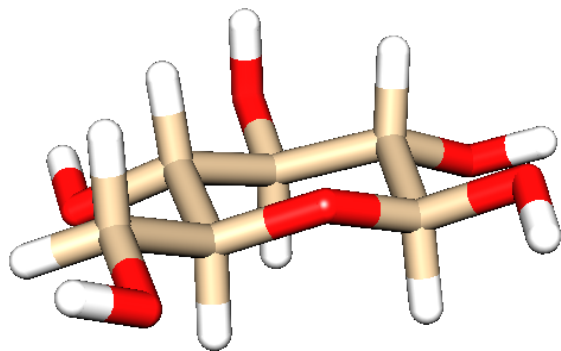
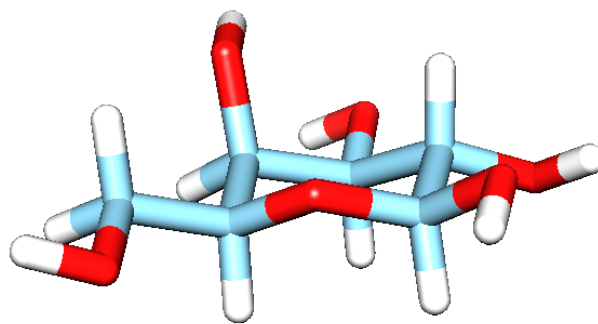


Carbohydrates

1. The 3D structure of glucose and galactose are shown.



D-glucose

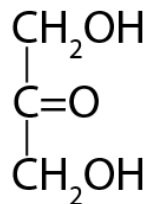
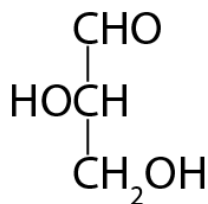


D-galactose

- Is the axial or equatorial position more stable in the chair conformation?
- What do you notice about the orientation of the OH and H groups in glucose? Are they in the axial or equatorial position?
- How does this differ from galactose?
- Which monosaccharide do you think is more stable? Briefly justify your answer.
- Based on your answer, why do you think that sugars with more than one stereoisomer away from glucose are not very common?

2. Glyceraldehyde and dihydroxy acetone are shown.

- Are these carbohydrates? How do you know?



- What is the main difference between glyceraldehyde and dihydroxy acetone? Be specific – use chemical terms (i.e. think functional groups).

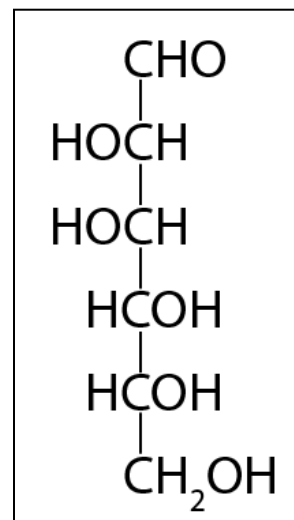
c. What is the difference between an aldose and a ketose?

3. The Hawthorn projection (linear form) of D-mannose is shown.

a. How do you know that this is the D isomer of mannose?

b. Is mannose an aldose or a ketose?

c. Draw the Hawthorn projection of D-glucose (the C2 epimer of mannose).



d. The cyclical form of glucose and mannose.

e. Fructose is the ketose equivalent of glucose. Draw the linear and cyclical form of fructose.

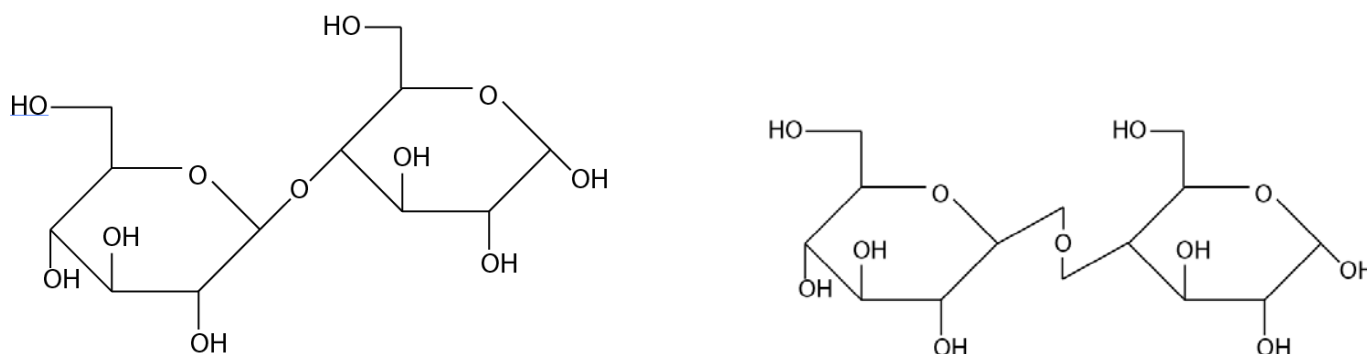
f. Circle the anomeric carbons on each of the cyclical forms of the sugars that you drew in parts a and f and label each as alpha or beta. Now circle the carbon on the Hawthorn projections. What do you notice? Which carbon in the linear form ends up as the anomeric carbon?

- g. The 3D structure of galactose is shown in problem 2. Galactose is a C_____ epimer of glucose.
- h. Sometimes you will need to be able to draw the anomeric carbon pointed left instead of right. To accomplish this, you need to draw the ring in reverse, but you also need to “flip” each OH group (what was up now goes down). Draw glucose and fructose with the anomeric carbon pointing left.

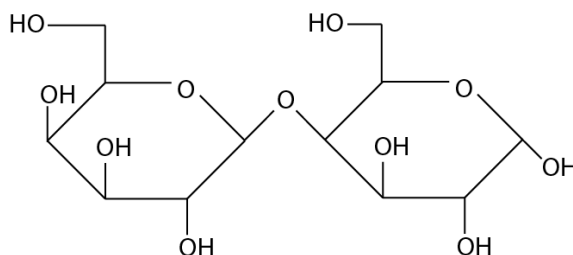
4. Carbohydrate monomers link together through glycosidic bonds. These bonds are the product of a condensation reaction between two alcohols.

a. What is the product of a condensation reaction between ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) and methanol (CH_3OH)?

b. Disaccharide names tell you everything that you need to know about how they are linked together. α -D-glucose (1 \rightarrow 4) β -D-glucose means that a glycosidic bond is linking the anomeric carbon (C1) of β -D-glucose to C4 of α -D-glucose. This molecule is drawn below in two ways: on the left, the glycosidic linkage is drawn directly and the right image is a common representation of the glycosidic bond that allows the saccharide polymers to be drawn in a linear way while retaining the ability to identify the stereochemistry of the C1 and C4 carbons.



- c. Circle the anomeric carbons in the two structures above.
- d. Name the disaccharide shown here



e. Sketch each of the following disaccharides:

α -D-glucose (1 \rightarrow 6) β -D-glucose (this is part of the branching that occurs in starch and cellulose)

β -D-galactose (1 \rightarrow 4) β -D-glucose (lactose)

α -D-glucose (1 \rightarrow 2) β -D-fructose (sucrose – so table sugar)

5. Monosaccharides are incredibly soluble in water (2.1 kg of sucrose will dissolve in 1L of water!). However, most polysaccharides are sparingly or not at all soluble in water. Why do you think this is?

Based on your answer, propose a reason that corn starch can be used as a thickening agent in stew. It may help you to think about what happens to Jell-O (yep, a polysaccharide) when it gets heated up and then cooled back down.

6. Sugar modifications are an incredibly important part of sugar chemistry. For example, chitin, the principle component in the exoskeleton of crustaceans, insects, and spiders, is made from repeating units of β -N-acetylglucosamine linked through a (1 \rightarrow 4) glycosidic bond.
- Glucosamine (yep, the glucosamine that you hear about when you hear ads about joint health) is a glucose molecule with an amine group substituted at the C2 carbon. Draw glucosamine.
 - N-acetylglucosamine (NAcGlc) is formed when glucosamine is condensed with acetic acid. Draw NAcGlc.
 - Draw the repeating disaccharide of chitin.