Tutorial 20: Disaccharides and Polysaccharides

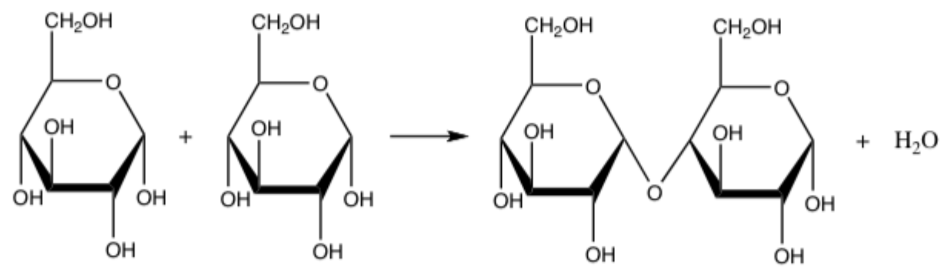
Goals:

- ✓ To understand the structures of common disaccharides and polysaccharides.
- ✓ To understand how monosaccharides link together to form disaccharides and polysaccharides.
- ✓ To be able to recognize and label a glycosidic bond.

Disaccharides

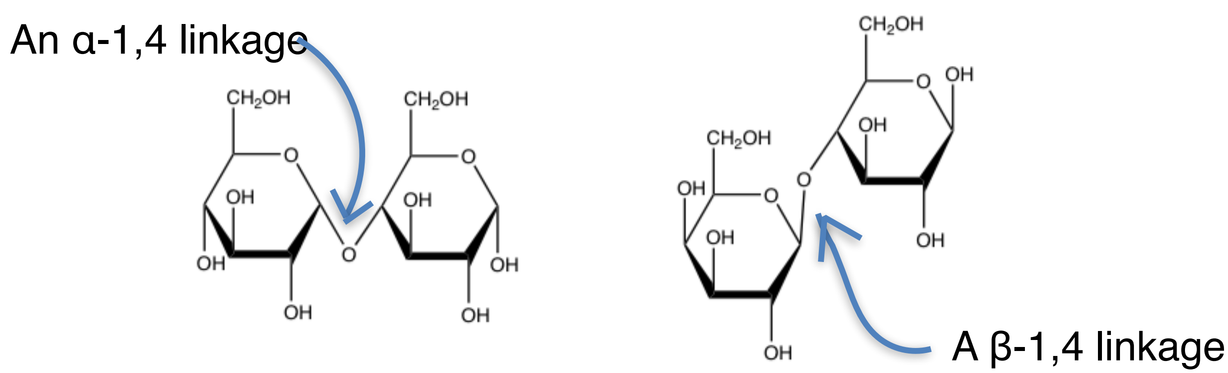
- A hemiacetal can react with an alcohol to form an acetal. An acetal has two -OR groups bonded to the same carbon. This reaction is important in the formation of di- and polysaccharides.

- **Disaccharides:** The hemiacetal of one monosaccharide can react with an alcohol functional group of another monosaccharide to form a disaccharide with an acetal linkage. In sugars, acetals are called glycosides and the acetal linkage is called a glycosidic bond.



alpha-D-glucose alpha-D-glucose disaccharide maltose

- The glycosidic bond can be alpha or beta with respect to the anomeric carbon.

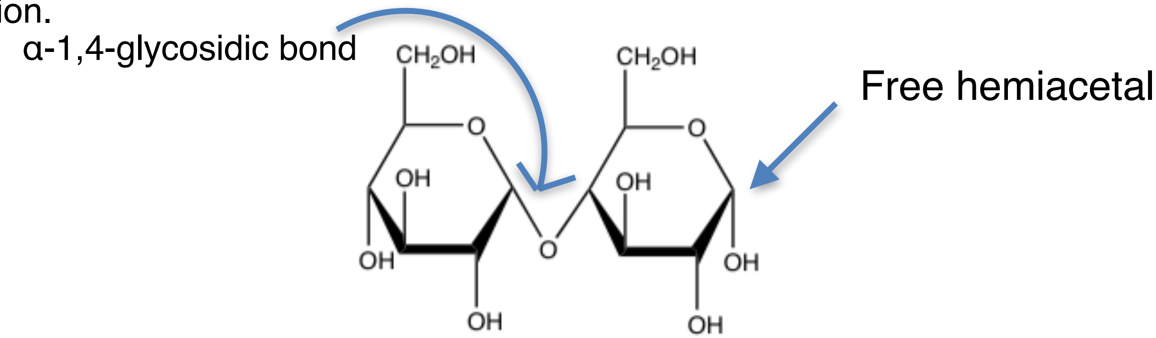


maltose lactose

- Note that formation of a glycoside means that there is no possibility of mutarotation about the anomeric carbon since there is no longer a free hemiacetal there.

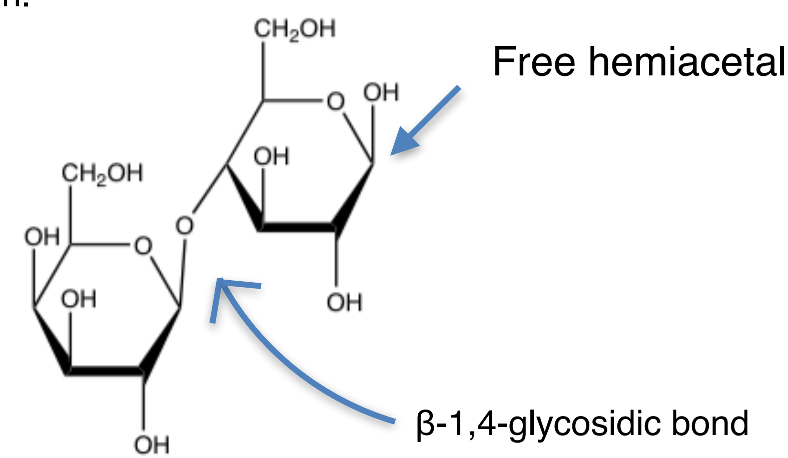
Common Disaccharides

- **Maltose:** Forms in nature when starch is broken down in germinating grains (particularly barley), or when starch is digested by animals. Forms when the anomeric carbon of one D-glucose reacts with the alcohol off of the 4th carbon of another D-glucose forming an α-1,4-glycosidic bond. Note that there is a free hemiacetal which can undergo mutarotation.



maltose

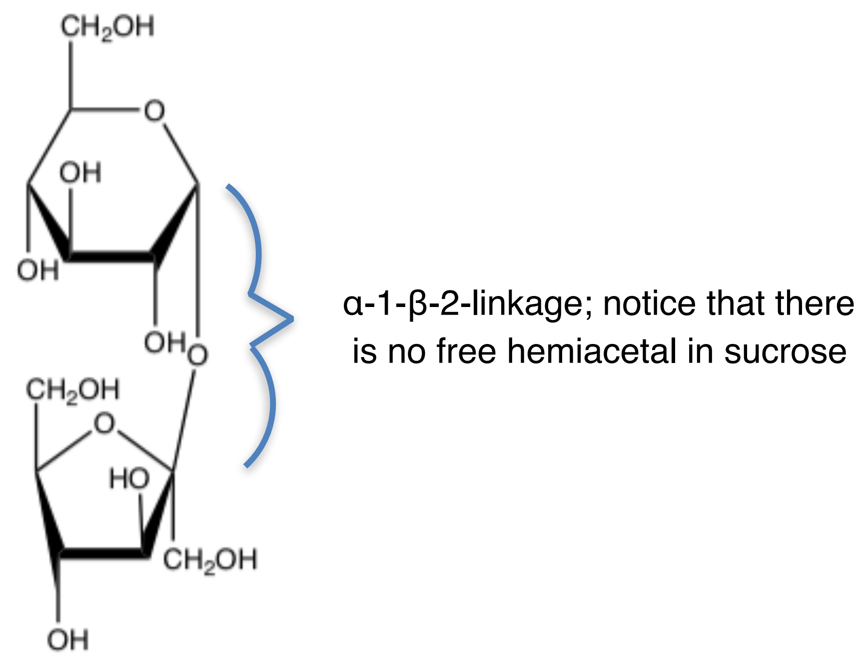
- **Lactose:** Major carbohydrate of mammalian milk. Forms when the anomeric carbon of D-galactose reacts with the alcohol off of the 4th carbon of D-glucose forming a β-1,4-glycosidic bond. An individual who is lactose intolerant is deficient in the enzyme necessary to hydrolyze the β-1,4-glycosidic bond in lactose. Note that there is a free hemiacetal which can undergo mutarotation.



lactose

Common Disaccharides Continued

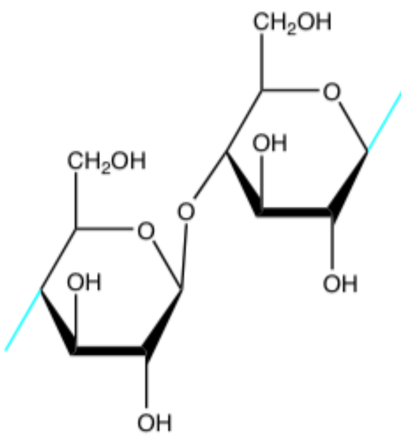
- **Sucrose**: Table sugar, commonly just called sugar. Forms when the anomeric carbon of D-glucose reacts with the –OH of the anomeric carbon in D-fructose forming an α-1-β-2-glycosidic bond. Sucrose is a non-reducing sugar since it contains no free hemiacetals. This makes sucrose less susceptible to oxidation and a great choice for use in preserved foods.



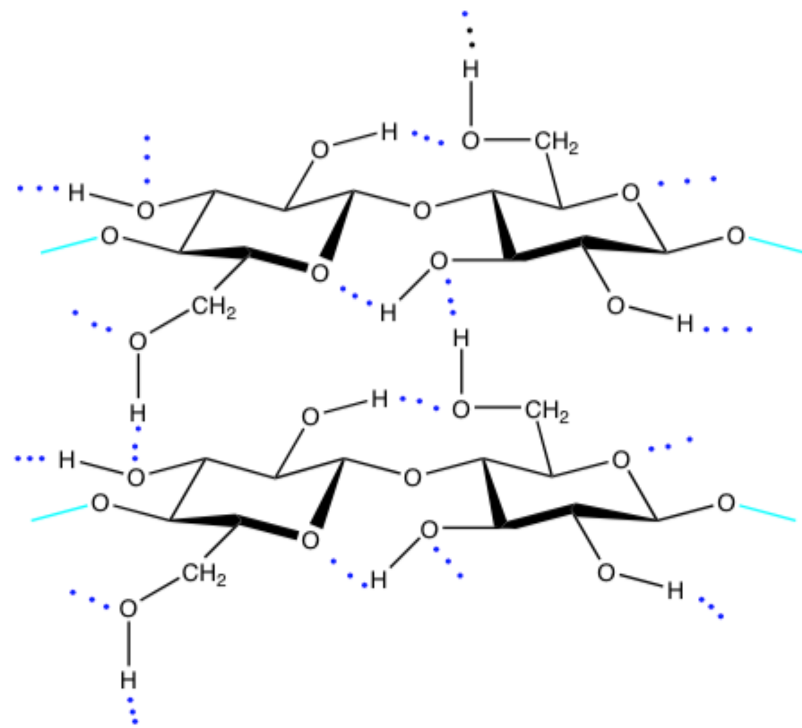
sucrose

Polysaccharides

- **Polysaccharides:** Polymers of monosaccharides connected by glycosidic linkages.
  - Cellulose: Consists of numerous D-glucose units connected by β-1,4-linkages. The orientation of the glucose units results in a high number of hydrogen bonds that form a strong fibrous material.



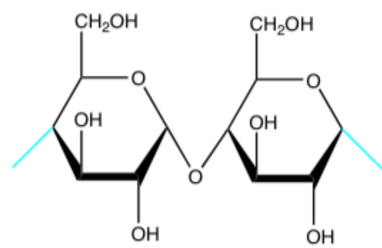
repeating unit of cellulose



cellulose

Polysaccharides Continued

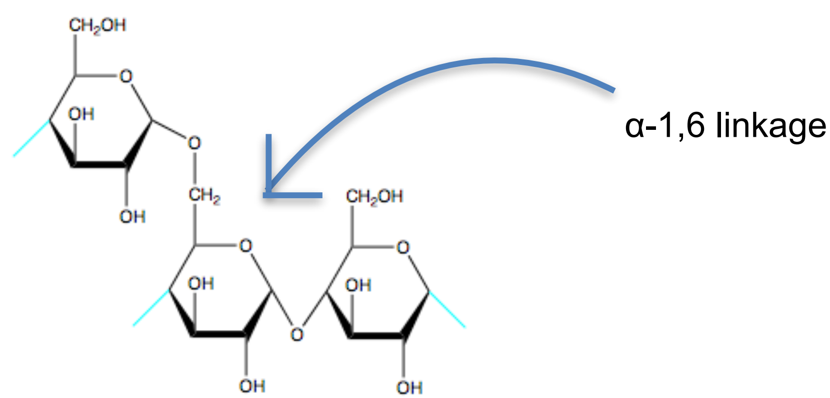
- Starch: Consists of numerous D-glucose units linked by glycosidic bonds. Consists of amylose (20%) and amylopectin (80%). Plants use starch for carbohydrate storage. They break starch down into glucose monomers for energy.
    - Amylose: consists of hundreds to thousands of D-glucose units connected by α-1,4 glycosidic bonds. The chain forms a coiled structure.



repeating unit of amylose

    - Amylopectin: Has thousands of D-glucose units connected by α-1,4- linkages with branching D-glucoses approximately every 25 units along the chain. Branched units are linked by α-1,6 glycosidic bonds.

- Glycogen: Structure is the same as amylopectin, but with more frequent branching (every 8-12 glucose units is branched). Serves as the source of carbohydrate energy storage in animals.



α-1,4 and α-1,6 linkage in amylopectin and glycogen