Lecture 24: Carbohydrates 2

Goals:
- Conformation of ring and energy
- Glycosidic bond formation
- Disaccharide nomenclature
- Energy storage polysaccharides
- Structural polysaccharides
- Modified glucose structure
- Bacterial cell walls
- Lysozyme activity.

Conformation of Ring Structures:
The most stable conformations are the "chair" forms. The "boat" form is less stable than either chair form. In the case of glucose, the right chair form is more stable than the left chair form because most of groups are equatorial, reducing unfavorable van der Waals contacts.

Disaccharides: Linkage of the anomic carbon of one monosaccharide to the OH of another monosaccharide via a condensation reaction. The bond is termed a glycosidic bond.
The end of the disaccharide that contains the free anomic carbon is referred to as the reducing end because it is capable of reducing various metal ions, such as Cu²⁺.

Nomenclature: To describe disaccharides you need to specify the following:
1. The names of the two monosaccharides.
2. Their cyclic form:
   a) furanose for 5 membered rings
   b) pyranose for 6 membered rings
3. How they are linked together (one anomeric is always used)
4. The configuration of the anomeric carbons.

The six simple rules for naming disaccharides are as follows:
1. The non-reducing end defines the first sugar, if there is no reducing end, then either end can be used to begin naming.
2. Configuration of the anomic carbon of the 1st sugar (α, β)
3. Name of 1st monosaccharide, root name followed by pyranosyl (6-ring) or furanosyl (5-ring)
4. Atoms which are linked together, 1st sugar then 2nd sugar.
5. Configuration of the anomic carbon of the second sugar (α, β) (often omitted if the anomic carbon is free since α & β forms are in equilibrium.)
6. Name of 2nd monosaccharide, root name followed by pyranose (6-ring) or furanose (5-ring)
   * (If both anomic carbons are involved, then the name ends in "oxide", not "ose")
**Lactose** (milk sugar):

\[ \text{galactose} \text{ and glucose} \]

\[ \beta\text{-galactopyranosyl-(1→4)-}\alpha\text{-glucopyranose} \]

\[ \beta\text{-galactopyranosyl-(1→4)-}\beta\text{-glucopyranose} \]

Lactose is the major sugar in mammalian milk.
- Infants produce the enzyme lactase to hydrolyze the disaccharide to monosaccharides.
- Some adults have low levels of lactase. This leads to lactose intolerance. The ingested lactose is not absorbed in the small intestine, but instead is fermented by bacteria in the large intestine, producing uncomfortable volumes of CO₂.

**Sucrose** (table sugar): The anomic carbon of glucose forms a glycosidic bond to the anomic carbon of fructose.

\[ \alpha\text{-glucopyranosyl-(1-2)-}\beta\text{-fructofuranoside} \]

\[ \beta\text{-fructofuranosyl-(2-1)-}\alpha\text{-glucopyranoside} \]

C. **Polysaccharides**: Many monosaccharides linked by glycosidic bonds. Most poly-saccharides are polymers of either glucose, or modified glucose.

**Short-hand nomenclature**: In the case of homo-polymers, the short-hand notation is to simply describe the linkage between the glucose units: both the conformation of the anomic carbon and the carbons participating in the glycosidic bond, i.e. \( \beta(1\rightarrow4) \) instead of \( \beta\text{-glucopyranosyl (1-4) }\beta \text{ glucopyranose} \).

**Energy Storage Polysaccharides**

1. **Starch** [plants] (mixture of amylose and amylopectin).
   - amylose = \( \alpha(1\rightarrow4) \) glucose.
   - Similar in structure to \( \alpha \)-helix in proteins: forms a helix with extensive hydrogen bonding.

2. **Amylopectin** [plants] = amylose plus \( \alpha(1\rightarrow6) \) branches.

3. **Glycogen** [animals] =
   - more highly branched than amylopectin.

**Release of glucose from glycogen/Starch:**
- glucose units released from non-reducing end by the enzyme glycogen phosphorylase, producing glucose-1-phosphate (G-1-P). G-1-P is used to generate energy in metabolism.