Chapter 5-2: Carbohydrates

The Wonderful World of the Carbohydrate

- **Carbohydrates** include both sugars and polymers
- The simplest carbohydrates are monosaccharides or simple sugars.
- Disaccharides, double sugars, consist of two monosaccharides joined by a condensation reaction.
- Polysaccharides are polymers of monosaccharides.
- Carbohydrates serve an energy source and provide structure

Sugars, the smallest carbohydrates serve as a source of fuel and carbon sources

- Monosaccharides generally have molecular formulas that are some multiple of $C_xH_{2x}O_x$.
  - For example, glucose has the formula $C_6H_{12}O_6$.
  - Most names for sugars end in *-ose*.
- Monosaccharides have a ***carbonyl group*** and multiple ***hydroxyl groups***.
  - If the carbonyl group is at the **end**, the sugar is an ***aldose***, if not, the sugars is a ***ketose***.
  - Glucose, an aldose, and fructose, a ketose, are structural isomers.
- Monosaccharides are also classified by the number of carbons in the backbone.
  - Glucose and other six carbon sugars are ***hexoses***.
  - Five carbon backbones are ***pentoses*** and three carbon sugars are ***trioses***.
- Monosaccharides may also exist as ***enantiomers***.
- Monosaccharides, particularly glucose, are a major fuel for cellular work.
- They also function as the raw material for the synthesis of other monomers, including those of amino acids and fatty acids.
- Two monosaccharides can join with a **glycosidic linkage,** a type of covalent bond**,** to form a **dissaccharide** via dehydration synthesis (condensation).
  - ***Maltose,*** malt sugar, is formed by joining two glucose molecules.
  - ***Sucrose,*** table sugar, is formed by joining glucose and fructose and is the ***major transport form of sugars in plants.***

Polysaccharides, the polymers of sugars, have storage and structural roles

- **Polysaccharides** are polymers of hundreds to thousands of monosaccharides joined by glycosidic linkages.
- Primary monomer of polysaccharides is glucose.
- Functions:
  - Energy storage
  - Structural
- **Energy Storage Polysaccharides:**
- **Starch** is a storage polysaccharide composed entirely of glucose monomers (alpha glucose ring structure).

- Most monomers are joined by 1-4 linkages between the glucose molecules.
- Form branched and unbranched helices.

- Plants store starch within plastids, including chloroplasts.
- Plants can store surplus glucose in starch and withdraw it when needed for energy or carbon.
- Animals that feed on plants, especially parts rich in starch, can also access this starch to support their own metabolism.
- Animals also store glucose in a polysaccharide called **glycogen**.
  - Highly branched.
  - Humans and other vertebrates store glycogen in the *liver and muscles* but only have about a one day supply.
- One key difference among polysaccharides develops from 2 possible ring structure of glucose.
  - Differ in whether the hydroxyl group attached to the number 1 carbon is fixed ***above (beta glucose***) or ***below (alpha glucose***) the ring plane.
- **Structural Polysaccharides:**
- Structural polysaccharides form strong building materials.
- **Cellulose** is a major component of the tough wall of plant cells.
  - Cellulose, like starch, is a polymer of glucose monomers, but using ***beta rings***.
- Polymers built with beta glucose form ***straight structures***.
- This allows H atoms on one strand to form hydrogen bonds with OH groups on other strands.
  - Groups of polymers form strong strands, ***microfibrils***, that are basic building material for plants (and humans).
- The enzymes that digest starch cannot hydrolyze the beta linkages in cellulose.
  - Cellulose in our food passes through the digestive tract and is eliminated in feces as “insoluble fiber”.
  - As it travels through the digestive tract, it abrades the intestinal walls and stimulates the secretion of mucus.
- Some microbes can digest cellulose to its glucose monomers through the use of cellulase enzymes.
- Many eukaryotic herbivores, like cows and termites, have symbiotic relationships with cellulolytic microbes, allowing them access to this rich source of energy.
- Another important structural polysaccharide is **chitin**.
  - Used in the exoskeletons of arthropods (including insects, spiders, and crustaceans).
  - Forms structural support for cell wall of many fungi
  - Similar to cellulose, except that it contains a nitrogen-containing appendage on each glucose.