

5.1: What are carbohydrates

Learning Objectives

- Define carbohydrates, monosaccharides, polysaccharides, and write their general formulas.
- Draw and interpret fisher projections of monosaccharides.

What are carbohydrates

Carbohydrates are primary energy storage compounds, e.g., glucose ($C_6H_{12}O_6$) synthesized by using carbon dioxide (CO_2) from the air, water (H_2O) from the soil, and energy from sunlight, along with the release of oxygen (O_2), as illustrated in Figure 5.1.1.

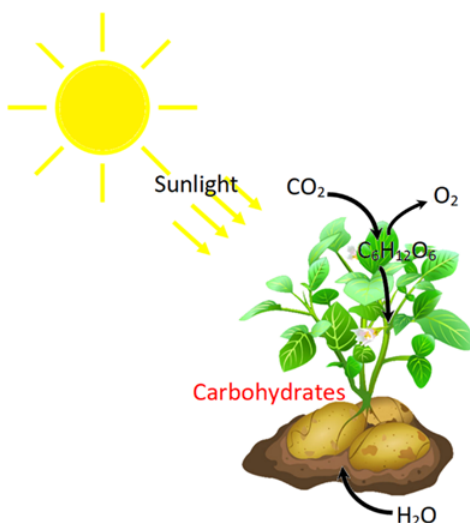


Figure 5.1.1: Illustration of photosynthesis by plants. (Copyright; Public domain)

Oxidation of carbohydrates, e.g., the reverse of the photosynthesis reaction, release energy that plant and animals use for activities. Carbohydrates are the support structure material in plants, e.g., cell-wall and wood, shell material of crustaceans, and connective tissues in animals.

Glucose is a polyhydroxy aldehyde, and fructose, i.e., another carbohydrate found in honey, is a polyhydroxy ketone, as illustrated in Figure 5.1.2.

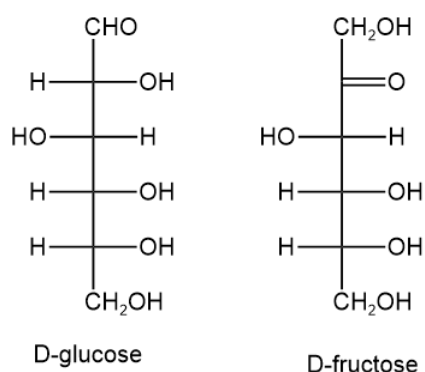


Figure 5.1.2: Fisher projections of D-glucose and D-fructose. (Copyright; Public domain)

Carbohydrates

Carbohydrates are polyhydroxy aldehydes, polyhydroxy ketones, or other compounds that hydrolyze to polyhydroxy aldehydes or polyhydroxy ketones.

The general formula of simple carbohydrates is $C_nH_{2n}O_n$, which can also be written as $C_n \cdot (H_2O)_n$ which is the origin of the name carbohydrates, i.e., hydrates of carbon.

Fisher projections

Fisher projections are two-dimensional representations of molecules for showing the configuration of chiral centers:

- the chiral center is in the plane of the page,
- horizontal lines represent bonds projecting toward the viewers,
- and vertical lines represent bonds projecting away from the viewer.
- The parent C chain is placed on the vertical line, with the most oxidized C, i.e., the $C=O$ in carbohydrates, at the top or near the top end, and the numbering starts from the top most C, as illustrated in Figure 5.1.2.

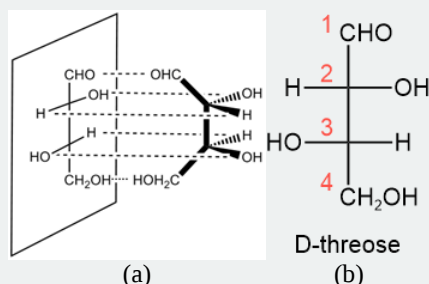


Figure 5.1.2: Illustration of creating a Fisher projection (a) and numbering the C chain of carbohydrates using D-threose as an example. (Copyright: (a) Olion17, Public domain, via Wikimedia Commons, (b) Public domain)

Monosaccharides and polysaccharides

Monosaccharides

Simple carbohydrates that can not be hydrolyzed to more simple ones are called **monosaccharides**. For example, D-glucose, D-fructose, and D-threose shown in previous figures are monosaccharides.

Polysaccharides

Linear or branched chain polymers comprised of monosaccharide repeat units (monomers) are called **polysaccharides**. For example, starch is a polysaccharide with a D-glucose monomer, illustrated in Figure 5.1.3.

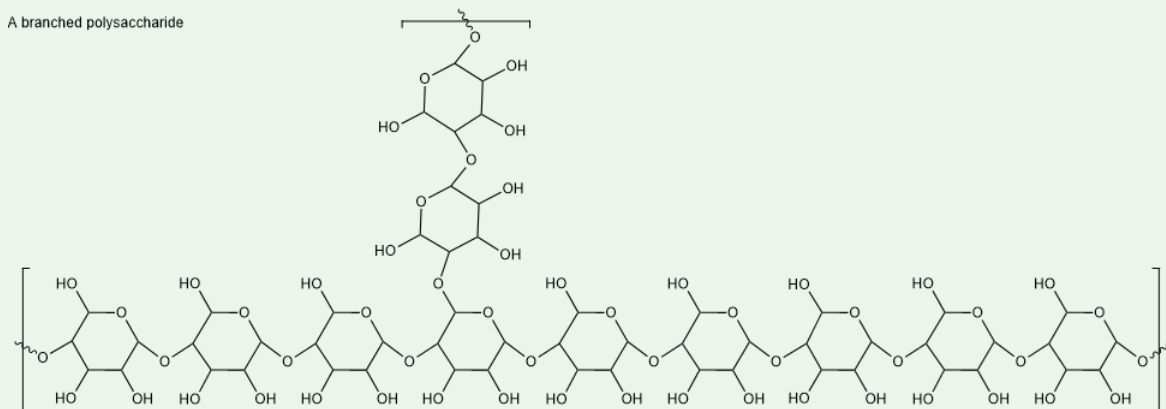
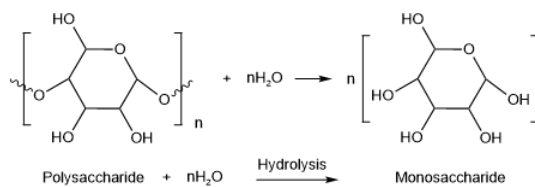


Figure 5.1.3: General structural formula of a starch -a polysaccharide D-glucose. (Copyright; Public domain)

Polysaccharides hydrolyze to monosaccharides, as illustrated in the following general hydrolysis reaction.



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