Carbohydrates

In many ways, our bodies can be thought of as chemical processing plants. Chemicals are taken in, processed through various types of reactions and then distributed throughout the body to be used immediately or stored for later use. The chemicals that are used by the body can be divided into two broad categories: macronutrients, those substances that we need to eat regularly in fairly large quantities, and micronutrients, those substances that we need only in small amounts. There are 3 major classes of macronutrients that are essential to living organisms: carbohydrates, fats and proteins. In this lesson, we will discuss the carbohydrates; fats and proteins are discussed in another lesson.

Carbohydrates

Carbohydrates are the main energy source for the human body. Chemically, carbohydrates are organic molecules in which carbon, hydrogen and oxygen bond together in the ratio: \( C_x(H_2O)_y \) where \( x \) and \( y \) are whole numbers that differ depending on the specific carbohydrate to which we are referring. Animals (including humans) break down carbohydrates during the process of metabolism to release energy. For example, the chemical metabolism of the sugar glucose is shown below:

\[
C_6H_{12}O_6 + 6 O_2 \rightarrow 6 CO_2 + 6 H_2O + \text{energy}
\]

Animals obtain carbohydrates by eating foods that contain them, for example potatoes, rice, breads, etc. These carbohydrates are manufactured by plants during the process of photosynthesis. Plants harvest energy from sunlight to run the reaction described above in reverse:

\[
6 CO_2 + 6 H_2O + \text{energy (from sunlight)} \rightarrow C_6H_{12}O_6 + 6 O_2
\]

A potato, for example, is primarily a chemical storage system containing glucose molecules manufactured during photosynthesis. In a potato, however, those glucose molecules are bound together in a long chain. As it turns out, there are two types of carbohydrates, the simple sugars and those carbohydrates that are made of long chains of sugars - the complex carbohydrates.

Simple Sugars: All carbohydrates are made up of units of sugar (also called saccharide units). Carbohydrates that contain only one sugar unit (monosaccharides) or two sugar units (disaccharides) are referred to as simple sugars. Simple sugars are sweet in taste and are broken down quickly in the body to release energy. Two of the most common monosaccharides are glucose and fructose. Glucose is the primary form of sugar stored in the human body for energy. Fructose is the main sugar found in most fruits. Both glucose and fructose have the same chemical formula (\( C_6H_{12}O_6 \)) however they have different structures as seen below (note: the carbon atoms that sit in the 'corners' of the rings are not labeled):

\[
\text{(Simple Sugar Structure)}
\]
Disaccharides have two sugar units bonded together. For example, common table sugar is sucrose a disaccharide that consists of a glucose unit bonded to a fructose unit:

**Complex Carbohydrates:** Complex carbohydrates are polymers of the simple sugars. In other words, the complex carbohydrates are long chains of simple sugar units bonded together (for this reason the complex carbohydrates are often referred to as polysaccharides). The potato we discussed earlier actually contains the complex carbohydrate starch. Starch is a polymer of the monosaccharide glucose:

Starch is the principal polysaccharide used by plants to store glucose for later use as energy. Plants often store starch in seeds or other specialized organs, for example, common sources of starch include rice, beans, wheat, corn, potatoes, etc. When humans eat starch, an enzyme that occurs in saliva and in the intestines called amylase breaks the bonds between the repeating glucose units thus allowing the sugar to be absorbed into the bloodstream. Once absorbed into the bloodstream, the human body distributes glucose to the areas where it is needed for energy or stores it as its own
special polymer - glycogen. Glycogen, another polymer of glucose, is the polysaccharide used by animals to store energy. Excess glucose is bonded together to form glycogen molecules, which the animal stores in the liver and muscle tissue as an "instant" source of energy. Both starch and glycogen are polymers of glucose, however starch is a long, straight chain of glucose units, whereas glycogen is a branched chain of glucose units, as seen in the illustrations linked below:

The Starch Molecule • The Glycogen Molecule (See Below)

Another important polysaccharide is cellulose. Cellulose is yet a third polymer of the monosaccharide glucose. Cellulose differs from starch and glycogen because the glucose units form a two-dimensional structure, with hydrogen bonds holding together nearby polymers, thus giving the molecule added stability. Cellulose, also known as plant fiber, cannot be digested by human beings therefore cellulose passes through the digestive tract without being absorbed into the body. Some animals, such as cows and termites, contain bacteria in their digestive tract that help them to digest cellulose. Cellulose is a relatively stiff material, and in plants cellulose is used as a structural molecule to add support to the leaves, stem and other plant parts. Despite the fact that it cannot be used as an energy source in most animals, cellulose fiber is essential in the diet because it helps exercise the digestive track and keep it clean and healthy.