

Carbohydrates

Carbohydrates serve a number of functions within cells. They can serve as energy molecules (glucose, sucrose), as energy storage molecules (starch, glycogen) and as structural molecules (cellulose and chitin). In fact cellulose is considered the most common, predominant molecule in Earth's terrestrial biomes. Cellulose, the primary component of plant cell walls, is a polysaccharide (made of many monosaccharide units). Chitin is the structural component of fungal cells walls, the exoskeletons of arthropods and insects, a major component of fish scales and the hard parts of invertebrates. Glucose is the simple sugar (monosaccharide) that nourishes animal cells and is the blood sugar of mammals. Sucrose, table sugar, is a disaccharide (two monosaccharides bonded together) produced by plants. Starch is a polysaccharide (many units of glucose bonded together) produced by plants as a means of energy storage. Tubers such as potatoes are storage organs for starch. Glycogen is the analogous molecule produced by animals. Glycogen is a short-term energy storage molecule found in muscles and in the liver.

The name carbohydrate describes the basic formula of the molecules, i.e., they are composed of 'hydrate' (water) and carbon. The formula for simple sugars is $(\text{CH}_2\text{O})_n$. The small, subscripted 'n' indicates that the molecular composition of a carbohydrates is a multiple of the formula. A monosaccharide can contain as few as 3 carbon atoms; the formula would be $(\text{CH}_2\text{O})_3$ or $\text{C}_3\text{H}_6\text{O}_3$. Glucose is a hexose sugar, meaning it contains 6 carbon atoms. Glucose's formula would be $(\text{CH}_2\text{O})_6$ or $\text{C}_6\text{H}_{12}\text{O}_6$.

Some carbohydrates have common names like starch, table sugar, and blood sugar. The scientific names for the carbohydrates end in the suffix -ose. Several examples have already been given (glucose and cellulose). The monosaccharide (mono means one or single) is the building block of the carbohydrate macromolecules. Two monosaccharides can form a covalent bond to produce a disaccharide. Sucrose, table sugar is a disaccharide formed by the covalent bond of glucose to fructose. Monosaccharides and disaccharides are also called simple sugars reflecting the ease with which they digested and absorbed. When a carbohydrate contains 3 or more monosaccharides it is called a complex carbohydrate or polysaccharide.

Disaccharides and polysaccharides are formed through dehydration or condensation synthesis. The bond formed between saccharide molecules is called a glycosidic bond. The chemical qualities of the polysaccharide are determined by the bond location or by which carbons in the saccharide participate in the bond. For example, the molecular formula for starch, cellulose and glycogen is $(\text{C}_6\text{H}_{10}\text{O}_5)_n$. All three molecules have the same formula but have very different characteristics. Starch found in foods such as potatoes, corn and rice is an important component of human nutrition. Starch is easily digested. On the other hand, cellulose which is the primary component of plant cell walls is not digested by most animals; even animals such as cows and termites need bacteria and protozoans in their guts to digest starch.

In nutritional terms, cellulose is called roughage and passes through the digestive track intact. Visually starch and cellulose can be distinguished by their interaction with iodine. When iodine interacts with starch a blue-black color is produced. However when cellulose and starch are combined, cellulose stains a yellow-brown color, the color of iodine. So even though starch, cellulose and glycogen are all built from glucose monomers, because of the location of the bonds between monomer units each of these macromolecules has its own unique chemical characteristics.