WARD'S

Molecules of Life Lab Activity Student Study Guide

DID YOU KNOW?
Since the advent of the International System of Units (abbreviated SI for the French, *le Systeme International d'Unites)*, the calorie, equal to 1/1000th of a Calorie, is no longer used to describe energy changes in modern scientific literature. The preferred unit is now the joule (one calorie = 4.184 joules, so one Calorie equals 4,184 joules).

DID YOU KNOW?
Contrary to popular belief, camels do not store water in their humps. The humps are actually fat deposits used by the animal to provide energy in times of need. The humps of starved camels may disappear entirely, leaving sacks of loose skin.

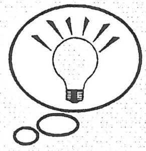
BACKGROUND

Carbohydrates, lipids, and proteins are three of the major groups of organic molecules that make up cells in organisms. They are responsible for everything from storage of energy to support structures within a cell system. Each of these molecules is composed of carbon, hydrogen, oxygen, nitrogen, and sulfur. The arrangement of these elements dictates the type of molecule that's formed.

Carbohydrates have a specific numerical relationship between their elements. The ratio of one carbon to two hydrogen to one oxygen atom is consistent throughout the smallest to largest molecules. The smallest unit of the carbohydrate family is called a monosaccharide (also known as "simple sugar"). Though occasionally found in a chain form, the monosaccharide normally exists as a ring consisting of five carbon atoms and one oxygen, surrounded with oxygen and hydrogen atoms. Glucose is a common monosaccharide with a molecular formula of $C_6H_{12}O_6$, showing the familiar empirical formula ratio of one carbon to two hydrogen to one oxygen (Figure 1).

Two monosaccharides combine via dehydration synthesis to form a disaccharide. Common disaccharides include lactose (milk sugar), sucrose (cane sugar), and maltose (malt sugar) (Figure 2). Additional dehydration synthesis reactions to a disaccharide create a polysaccharide. In nature, thousands of simple sugars bond together to form polysaccharides such as starch and cellulose. A carbohydrate's primary function, providing energy for an organism, occurs when a monosaccharide disintegrates at its carbon-hydrogen bonding sites. Each time a carbon-hydrogen bond is broken, energy is released that can be used for various purposes in a cell. Since a typical polysaccharide, like starch, contains thousands of these bonds, the energy that a carbohydrate gives off far exceeds most organic compounds.

Like carbohydrates, lipids are also used as storage sites for energy. However, lipids have a much greater hydrogen to oxygen ratio, creating many more bonds between carbon and available hydrogen atoms. For this reason, fats are considered a better source of energy than carbohydrates. In fact, lipids supply nine calories (heat energy units) per every gram, as opposed to carbohydrates providing only two to four per each gram.



DID YOU KNOW?

The body requires twenty amino acids to form the proteins used in everyday metabolic processes. Eleven of these can be synthesized by the body, but the other nine must be obtained from foods, and are commonly known as essential amino acids.

Molecularly, a lipid is composed of two types of sub-units called glycerols and fatty acids. The most commonly occurring lipids, called triglycerides, have three fatty acids bonded to a lone glycerol molecule. This bond is formed between the glycerol's characteristic hydroxyl groups (-OH) and the fatty acids' carboxylic acid groups (-COOH). The combination gives off a water molecule at each of the three bonding sites, so the formation of a triglyceride is also categorized as a dehydration synthesis. Another section of the fatty acid, called a hydrocarbon, determines whether the lipid will be saturated or unsaturated, and in turn, whether the lipid is a solid fat or a liquid oil.

The third organic molecule, protein, is responsible for the maintenance and repair of tissue, and the creation of enzymes, hormones, and defense cells in organic structures. Molecularly, a protein can be thought of as a large jigsaw puzzle, made from hundreds of individual pieces called amino acids. There are only twenty different types of amino acids that are commonly found in proteins, but the amino acids' infinite amount of sequence combinations creates the vast divergence of protein types. The twenty amino acids are composed of a specific arrangement of the elements carbon, hydrogen, oxygen, nitrogen, and, on occasion, sulfur. Each molecule is situated around a central carbon atom. Carbon's four bonding sites hold a hydrogen atom, the amine functional group ($-NH_2$), the carboxylic acid functional group (-COOH), and a fourth sub-unit which varies between amino acids. The fourth group is called a radical, and may contain various combinations of carbon, hydrogen, oxygen, nitrogen, or sulfur.

Amino acids combine similarly to carbohydrates, using dehydration synthesis. The linkage between amino acids is called a peptide bond, so two amino acids are referred to as a dipeptide. Additional amino acids are bonded to a dipeptide to create a polypeptide.

Each organism on earth contains specific proteins that are individual to that organism. Since not all amino acids can be made by an organism, proteins from other species must be ingested, broken down into their amino acids, and rearranged into the patterns of proteins necessary for the new organism. Humans take in proteins from sources such as meats, fish, beans, and dairy products.