chapter 6 Chemistry in Biology

section 4 The Building Blocks of Life

Before You Read

You have probably heard about DNA— the "genetic code." On the lines below, describe what you think DNA does. Then read the section to learn about DNA and the other compounds that make up all living things.

MAIN Idea

Organisms are made up of carbon-based molecules.

What You'll Learn

- the four major families of biological macromolecules
- the functions of each group of biological macromolecules

Read to Learn

Organic Chemistry

Almost all biological molecules contain the element carbon. For this reason, all life is considered carbon-based. Organic chemistry is the study of organic compounds—the compounds that contain carbon.

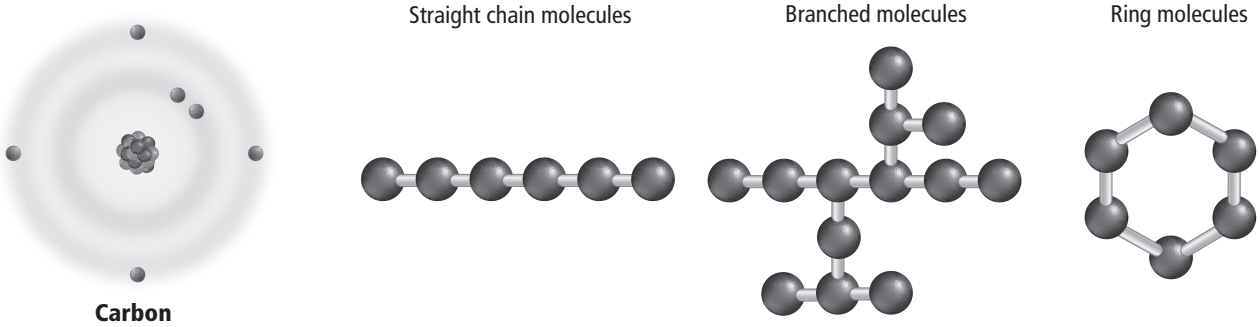
In the figure below, notice that carbon has four electrons in its outer energy level. Recall that the second energy level can hold eight electrons. Therefore, a carbon atom can form four covalent bonds with other atoms. Carbon atoms can bond with each other, forming a variety of organic compounds. These organic compounds can take the form of straight chains, branched chains, and rings, as illustrated in the figure below. Carbon compounds are responsible for the diversity of life on Earth.

Study Coach

Make an Outline Make an outline of the information you learn in this section. Start with the headings. Include the boldface terms.

Picture This

1. **Calculate** What percentage of the carbon atom's second energy level is filled?



Carbon

Picture This

2. Draw Conclusions
To what group of macromolecules do you think DNA belongs?

_____

Think it Over

3. Contrast monosaccharides, disaccharides, and polysaccharides.

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Macromolecules

Macromolecules are large molecules that are formed by joining smaller molecules together. Macromolecules are also called polymers. **Polymers** are made from repeating units of identical or nearly identical compounds called monomers. The monomers are linked together by a series of covalent bonds.

The four major groups of biological macromolecules are carbohydrates, lipids, proteins, and nucleic acids. The table below summarizes the functions of each group.

Biological Macromolecules

Group	Function
Carbohydrates	• stores energy • provides structural support
Lipids	• stores energy • provides steroids • waterproofs coatings
Proteins	• transports substances • speeds reactions • provides structural support • provides hormones
Nucleic acids	• stores and communicates genetic information

What roles do carbohydrates play in biology?

Carbohydrates are composed of carbon, hydrogen, and oxygen with a ratio of one oxygen and two hydrogen atoms for each carbon atom: CH_2O. Short chains of carbohydrates are monosaccharides (mah nuh SA kuh ridz), or simple sugars. A disaccharide (di SA kuh rid) is two monosaccharides linked together. Longer carbohydrate chains are called polysaccharides.

Carbohydrates serve as energy sources for organisms. Also, carbohydrates provide structural support in the cell walls of plants, fungi, and in the hard shells of shrimp, lobsters, and some insects.

What is the main function of lipids?

Lipids are molecules made mostly of carbon and hydrogen. Fats, oils, and waxes are all lipids. The main function of lipids is to store energy. A lipid called a triglyceride (tri GLIH suh rid) is called a fat when solid and an oil when liquid. Plant leaves are coated with lipids called waxes to prevent water loss.

Saturated and Unsaturated Fats When the carbon atoms in a fat cannot bond with any more hydrogen atoms, the fat is a saturated fat. The carbon atoms of unsaturated fats can bond with more hydrogen atoms.

Phospholipids A lipid called a phospholipid is responsible for the structure and function of the cell membrane. Lipids do not dissolve in water. This characteristic enables lipids to serve as barriers in biological membranes.

Steroids Cholesterol and hormones are types of steroids, another group of lipids. In spite of its bad reputation, cholesterol provides the starting point for other important lipids, such as the hormones estrogen and testosterone.

What compounds make up proteins?

A **protein** is made of small carbon compounds called amino acids. **Amino acids** are made of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur.

Amino Acids There are 20 different amino acids. Proteins are made of different combinations of all 20 amino acids. Covalent bonds called peptide bonds join amino acids together to form proteins.

Protein Structure A protein's amino acid chain folds into a three-dimensional shape. The figure below shows two basic protein shapes—the helix and the pleat. A protein might contain many helices, pleats, and folds. Hydrogen bonds help the protein hold its shape.

Reading Check

4. Identify the key characteristic of lipids that enables them to keep unwanted substances from penetrating cell membranes.

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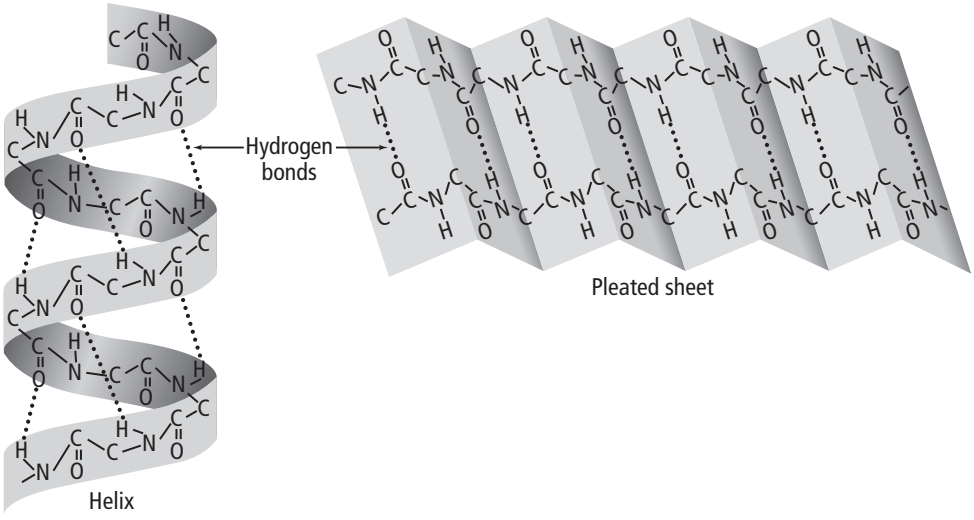
_____

Picture This

5. Label Add these descriptive labels to the appropriate protein shape in the figure: *folded paper* and *spiral*.



Think it Over

6. Draw Conclusions
What protein function listed here suggests that most enzymes are proteins?

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Protein Function Proteins are involved in nearly every function of your body. Your muscles, skin, and hair are made of proteins. Your cells contain about 10,000 different proteins that serve many functions. They

- provide structural support;
- transport substances inside the cell and between cells;
- communicate signals within the cell and between cells;
- speed up chemical reactions;
- control cell growth.

What roles do nucleic acids play in organisms?

Nucleic acids are the fourth group of biological macromolecules. **Nucleic acids** are complex macromolecules that store and transmit genetic information. Repeating subunits, called **nucleotides,** make up nucleic acids.

Nucleotides are composed of carbon, hydrogen, oxygen, nitrogen, and phosphorus. All nucleotides have the three units shown in the figure below—a phosphate, a nitrogenous base, and a sugar.

To form a nucleic acid, the sugar of one nucleotide bonds to the phosphate of another nucleotide, as illustrated in the figure on the right. The nitrogenous base sticks out from the chain. It is available to bond with bases in other nucleic acids.

Two types of nucleic acids are found in living things. One is deoxyribonucleic (dee AHK sih rib oh noo klay ihk) acid, or DNA. The other is ribonucleic (rib oh noo KLAY ihk) acid, or RNA.

DNA is the "genetic code." DNA stores all the instructions for organisms to grow, reproduce, and adapt. The main function of RNA is to use the information stored in DNA to make proteins.

Picture This

7. Circle each nucleotide grouping in the nucleic acid on the right of the figure.