

16.1

KEY CONCEPT

Chemical reactions take place inside cells.

BEFORE, you learned

- All living things are made of cells
- Cells need energy to sustain life
- Plant and animal cells have similarities and differences

NOW, you will learn

- About the types of elements found in all cells
- About the functions of large molecules in the cell
- Why water is important to the activities of the cell

VOCABULARY

chemical reaction p. 534

carbohydrate p. 534

lipid p. 535

protein p. 535

nucleic acid p. 535

EXPLORE Food Molecules

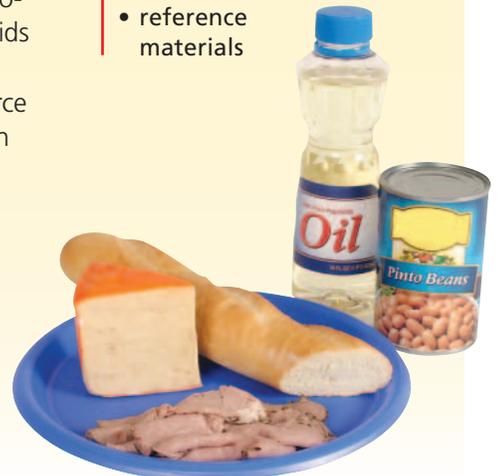
How are different types of molecules important in your everyday life?

PROCEDURE

- 1 Examine the foods shown in the photograph. Protein, carbohydrates, and lipids (fats) are important substances in the food you eat. Locate at least one source of protein, carbohydrates, and lipids in the food.
- 2 Use your textbook and additional resource materials to find out a little more about these molecules in our food supply.

MATERIALS

- notebook
- reference materials



WHAT DO YOU THINK?

What foods do you eat that supply protein, carbohydrates, and lipids?

OUTLINE

Continue the outline begun on page 532.

- I. Main idea
 - A. Supporting idea
 1. Detail
 2. Detail
 - B. Supporting idea

All cells are made of the same elements.

The microscope allowed people to observe the tiny cells that make up all living things. Even smaller, too small for a light microscope to show, is the matter that makes up the cell itself.

All matter in the universe—living and nonliving—can be broken down into basic substances called elements. About a hundred different elements are found on Earth. Each element has its own set of properties and characteristics. For example, the characteristics of oxygen include that it is colorless, odorless, and on Earth, it exists in the form of a gas.



Elements in the Human Body

Oxygen	65.0%
Carbon	18.5%
Hydrogen	9.5%
Nitrogen	3.3%
Calcium	1.5%
Phosphorus	1.0%
other 19 elements	1.2%

Source: CRC Handbook of Chemistry and Physics

Of all the elements found on Earth, about 25 are essential for life. As you can see from the table, just 6 elements account for about 99 percent of the mass of the human body. But very little of this matter exists as pure elements. Instead, most is in the form of compounds, which are substances made up of two or more different elements. For example, water is a compound made of hydrogen and oxygen.

The smallest unit of any element is called an atom. In a compound, atoms of two or more elements are joined together by chemical bonds. Most compounds in cells are made up of atoms bonded together in molecules. For example, a molecule of water is made of one atom of oxygen bonded to two atoms of hydrogen.

Most activities that take place within cells involve atoms and molecules interacting. In this process, called a **chemical reaction**, bonds between atoms are broken and new bonds form to make different molecules. Energy is needed to break bonds between atoms, and energy is released when new bonds form. Cells use chemical energy for life activities.

Large molecules support cell function.

In living things, there are four main types of large molecules: (1) carbohydrates, (2) lipids, (3) proteins, and (4) nucleic acids. Thousands of these molecules work together in a cell. The four types of molecules in all living things share one important characteristic. They all contain carbon atoms. These large molecules are made up of smaller parts called subunits.

Carbohydrates

Carbohydrates (KAHR-boh-HY-DRAYTS) provide the cell with energy. Simple carbohydrates are sugars made from atoms of carbon, oxygen, and hydrogen. Inside cells, sugar molecules are broken down. This process provides usable energy for the cell.

Simple sugar molecules can also be linked into long chains to form more complex carbohydrates, such as starch, cellulose, and glycogen. Starch and cellulose are complex carbohydrates made by plant cells. When a plant cell makes more sugar than it can use, extra sugar molecules are stored in long chains called starch. Plants also make cellulose, which is the material that makes up the cell wall. Animals get their energy by eating plants or other animals that eat plants.

sugars



Carbohydrates are used for structure and energy storage. Carbohydrates, such as cellulose, are made of **sugars**.



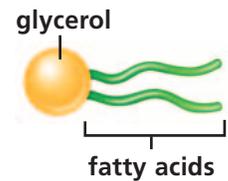
Explore molecules in living things.

Lipids

Lipids are the fats, oils, and waxes found in living things. Like carbohydrates, simple lipids are made of atoms of carbon, oxygen, and hydrogen and can be used by cells for energy and for making structures. However, the atoms in all lipids are arranged differently from the atoms in carbohydrates. Many common lipids consist of a molecule called glycerol bonded to long chains of carbon and hydrogen atoms called fatty acids. This structure gives lipids unique properties. One extremely important property of lipids is that they cannot mix with water.



How do cells use carbohydrates and lipids?



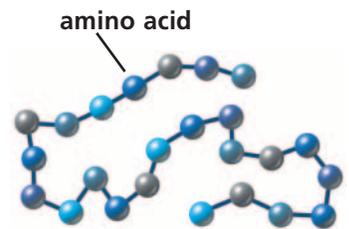
Lipids make up the membranes surrounding the cell and organelles. Lipids are made of **fatty acids** and **glycerol**.

Proteins

Proteins are made of smaller molecules called amino acids. Amino acids contain the elements carbon, oxygen, hydrogen, nitrogen, and sometimes sulfur. In proteins, amino acids are linked together into long chains that fold into three-dimensional shapes. The structure and function of a protein is determined by the type, number, and order of the amino acids in it.

Your body gets amino acids from protein in food, such as meat, eggs, cheese, and some beans. After taking in amino acids, your cells use them to build proteins needed for proper cell functioning. Some amino acids can be made by the body, but others must be taken in from an outside food source.

There are many types of proteins. Enzymes are proteins that control chemical reactions in the cells. Other proteins support the growth and repair of living matter. The action of proteins in your muscles allows you to move. Some of the proteins in your blood fight infections. Another protein in your blood delivers oxygen to all the cells in your body. Proteins are also important parts of cell membranes. Some proteins in the cell membrane transport materials into and out of the cell.

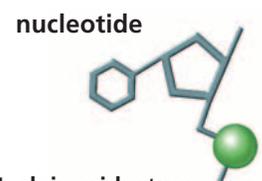


Proteins are made up of **amino acids**. Proteins carry out most of the chemical activity in cells.

Nucleic Acids

Nucleic acids (noo-KLEE-ihk) are the molecules that hold the instructions for the maintenance, growth, and reproduction of a cell. There are two types of nucleic acids: DNA and RNA. Both DNA and RNA are made from carbon, oxygen, hydrogen, nitrogen, and phosphorus. The subunits of nucleic acids are called nucleotides.

DNA provides the information used by the cell for making proteins a cell needs. This information takes the form of a code contained in the specific order of different nucleotides in the DNA.



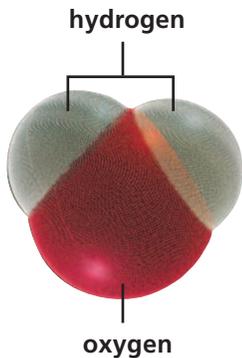
Nucleic acids store and translate the genetic information a cell needs to function. Nucleic acids, such as DNA, are made up of **nucleotides**.

The pattern of nucleotides in DNA is then coded into RNA, which delivers the information into the cytoplasm. Other RNA molecules in the cytoplasm produce the proteins.



What is the function of DNA and RNA?

About two thirds of every cell is water.



Each **water** molecule is made of two **hydrogen** atoms bonded to one **oxygen** atom.

All of the chemical reactions inside the cell take place in water. Water is also in the environment outside the cell. For example, water inside cells makes up about 46 percent of your body's mass, and water outside the cells in body fluids accounts for another 23 percent.

A water molecule consists of two atoms of hydrogen bonded to one atom of oxygen. Because of its structure, a water molecule has a slight positive charge near the hydrogen atoms and a slight negative charge near the oxygen atom. Molecules that have slightly charged ends are said to be polar. Like a magnet, the ends of a polar molecule attract opposite charges and repel charges that are the same. Because water is a polar molecule, many substances dissolve in water. However, not all materials dissolve in water. If you have ever shaken a bottle of salad dressing, you've probably observed that oil and water don't mix.

INVESTIGATE Oil and Water

What happens when you combine oil and water?

PROCEDURE

- 1 Put a small amount of oil into one beaker and an equal amount of milk into another.
- 2 Put water into a third beaker and add enough food coloring to make the water darkly colored.
- 3 Add equal amounts of the colored water to the beaker of oil and the beaker of milk. Stir the liquids to mix them. Record your observations.

WHAT DO YOU THINK?

- Compare and contrast the behavior of the mixture of oil and water with that of the mixture of milk and water.
- Why does a mixture of oil and water behave differently from a mixture of milk and water?

CHALLENGE The outside of a cell is surrounded by water. Explain how the water-hating nature of lipids can keep a cell's inside separated from its outside.

SKILL FOCUS

Observing

MATERIALS

- vegetable oil
- milk
- water
- 3 beakers
- food coloring
- stirring stick

TIME

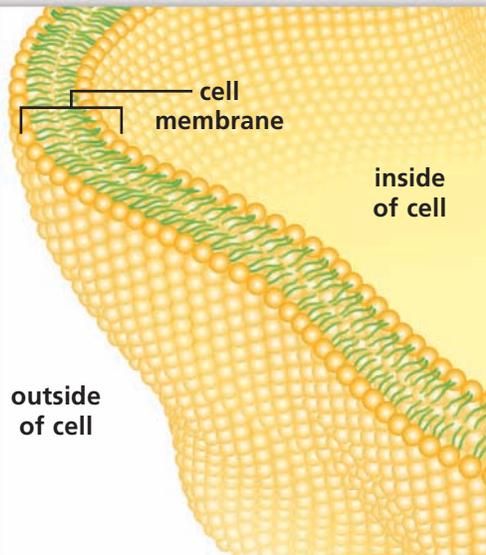
10 minutes



Cell Membrane

The cell membrane is made of a double layer of lipids.

Lipids have a water-loving head and a water-hating tail.



Most lipids do not dissolve in water. A special type of lipid is the major molecule that makes up cell membranes. These special lipid molecules have two parts: a water-loving head and two water-hating tails. In other words, the head of the lipid molecule is polar, while the tails are nonpolar.

Why is it important that cell membranes contain lipids? Remember that cell membranes function as boundaries. That is, they separate the inside of a cell from the outside. Most of the material inside and outside the cell is water. As you can see in the diagram above, the water-hating tails in the lipids repel the water while the head clings to water.

READING TIP

As you read about the properties of cell, notice the arrangements of lipids in the diagram of the cell.

16.1 Review

KEY CONCEPTS

1. Explain how just a few elements can make up all living things.
2. What functions do proteins, carbohydrates, lipids, and nucleic acids perform?
3. What does it mean to describe water molecules as being polar?

CRITICAL THINKING

4. **Compare and Contrast** How are carbohydrates and lipids similar? How are they different?
5. **Draw Conclusions** What do the major types of molecules that make up living things have in common?

CHALLENGE

6. **Model** Some people have compared the nucleic acids DNA and RNA to a blueprint for life. How are DNA and RNA like blueprints? How are they different?