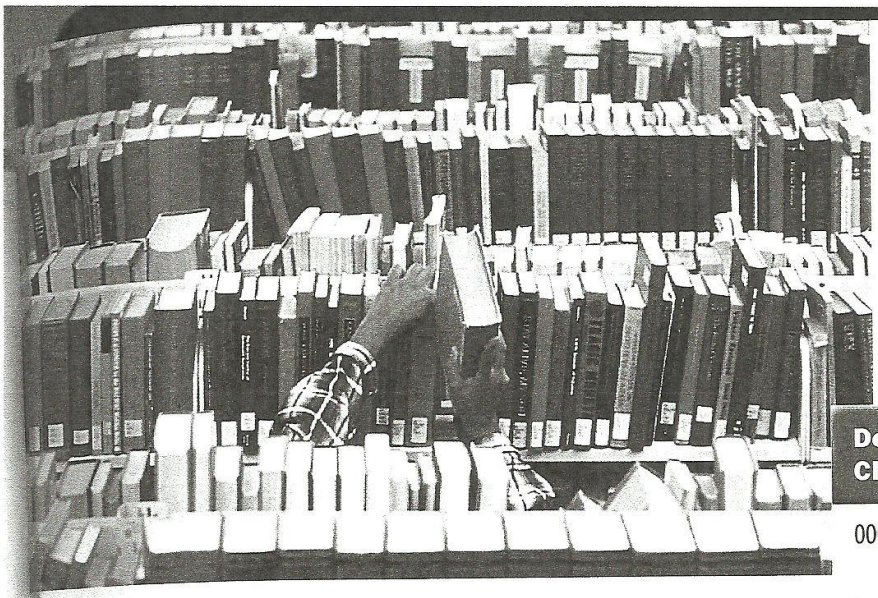


Figure 11 When you look for information in the library, a system of organization called the Dewey Decimal Classification System helps you find a book quickly and efficiently.

Dewey Decimal Classification System	
000	Computers, information and general reference
100	Philosophy and psychology
200	Religion
300	Social sciences
400	Languages
500	Science
600	Technology
700	Arts and recreation
800	Literature
900	History and geography

The Periodic Table

Suppose you go to a library, like the one shown in **Figure 11,** to look up information for a school assignment. How would you find the information? You could look randomly on shelves as you walk up and down rows of books, but the chances of finding your book would be slim. To avoid such haphazard searching, some libraries use the Dewey Decimal Classification System to categorize and organize their volumes and to help you find books quickly and efficiently.

Charting the Elements Chemists have created a chart called the periodic table of the elements to help them organize and display the elements. **Figure 12** shows how scientists changed their model of the periodic table over time.

On the inside back cover of this book, you will find a modern version of the periodic table. Each element is represented by a chemical symbol that contains one to three letters. The symbols are a form of chemical shorthand that chemists use to save time and space—on the periodic table as well as in written formulas. The symbols are an important part of an international system that is understood by scientists everywhere.

The elements are organized on the periodic table by their properties. There are rows and columns that represent relationships between the elements. The rows in the table are called periods. The elements in a row have the same number of energy levels. The columns are called groups. The elements in each group have similar properties related to their structure. They also tend to form similar bonds.

Science Online

Topic: New Elements

Visit red.msscience.com for Web links to information about new elements.

Activity Research physical properties of two synthetic elements.

Identifying Characteristics

Each element is different and has unique properties. These differences can be described in part by looking at the relationships between the atomic particles in each element. The periodic table contains numbers that describe these relationships.

Number of Protons and Neutrons Look up the element chlorine on the periodic table found on the inside back cover of your book. Cl is the symbol for chlorine, as shown in **Figure 13,** but what are the two numbers? The top number is the element's **atomic number.** It tells you the number of protons in the nucleus of each atom of that element. Every atom of chlorine, for example, has 17 protons in its nucleus.

Reading Check ***What are the atomic numbers for Cs, Ne, Pb, and U?***

Isotopes Although the number of protons changes from element to element, every atom of the same element has the same number of protons. However, the number of neutrons can vary even for one element. For example, some chlorine atoms have 18 neutrons in their nucleus while others have 20. These two types of chlorine atoms are chlorine-35 and chlorine-37. They are called **isotopes** (I suh tohps), which are atoms of the same element that have different numbers of neutrons.

You can tell someone exactly which isotope you are referring to by using its mass number. An atom's **mass number** is the number of protons plus the number of neutrons it contains. The numbers 35 and 37, which were used to refer to chlorine, are mass numbers. Hydrogen has three isotopes with mass numbers of 1, 2, and 3. They are shown in **Figure 14.** Each hydrogen atom always has one proton, but in each isotope the number of neutrons is different.

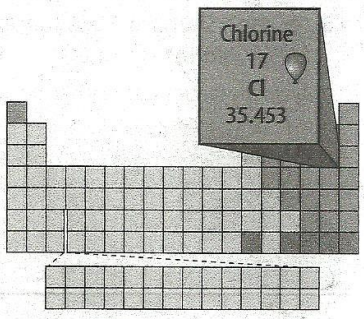


Figure 13 The periodic table block for chlorine shows its symbol, atomic number, and atomic mass.
Determine *if chlorine atoms are more or less massive than carbon atoms.*

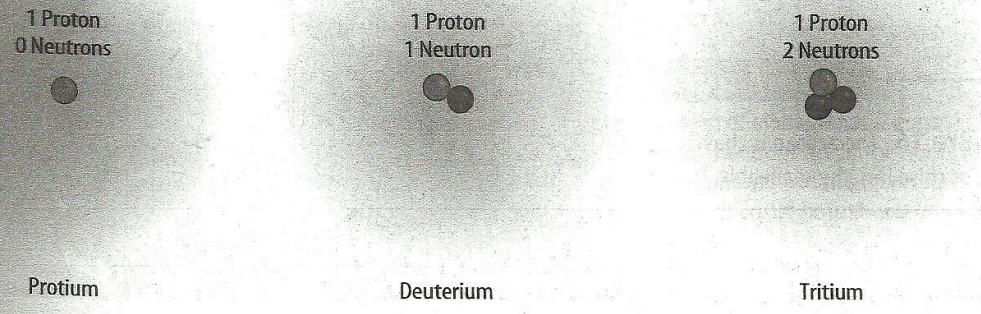


Figure 14 Three isotopes of hydrogen are known to exist. They have zero, one, and two neutrons in addition to their one proton. Protium, with only the one proton, is the most abundant isotope.

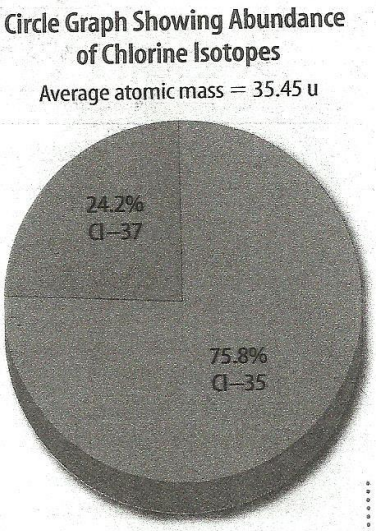


Figure 15 If you have 1,000 atoms of chlorine, about 758 will be chlorine-35 and have a mass of 34.97 u each. About 242 will be chlorine-37 and have a mass of 36.97 u each. The total mass of the 1,000 atoms is 35,454 u, so the average mass of one chlorine atom is about 35.45 u.

Atomic Mass The **atomic mass** is the weighted average mass of the isotopes of an element. The atomic mass is the number found below the element symbol in **Figure 13.** The unit that scientists use for atomic mass is called the atomic mass unit, which is given the symbol u. It is defined as 1/12 the mass of a carbon-12 atom.

The calculation of atomic mass takes into account the different isotopes of the element. Chlorine's atomic mass of 35.45 u could be confusing because there aren't any chlorine atoms that have that exact mass. About 76 percent of chlorine atoms are chlorine-35 and about 24 percent are chlorine-37, as shown in **Figure 15.** The weighted average mass of all chlorine atoms is 35.45 u.

Classification of Elements

Elements fall into three general categories—metals, metalloids (ME tuh loydz), and nonmetals. The elements in each category have similar properties.

Metals generally have a shiny or metallic luster and are good conductors of heat and electricity. All metals, except mercury, are solids at room temperature. Metals are malleable (MAL yuh bul), which means they can be bent and pounded into various shapes. The beautiful form of the shell-shaped basin in **Figure 16** is a result of this characteristic. Metals are also ductile, which means they can be drawn into wires without breaking. If you look at the periodic table, you can see that most of the elements are metals.

Figure 16 The artisan is chasing, or chiseling, the malleable metal into the desired form.

Other Elements

Nonmetals are elements that are usually dull in appearance. Most are poor conductors of heat and electricity. Many are gases at room temperature, and bromine is a liquid. The solid nonmetals are generally brittle, meaning they cannot change shape easily without breaking. The nonmetals are essential to the chemicals of life. More than 97 percent of your body is made up of various nonmetals, as shown in **Figure 17.** You can see that, except for hydrogen, the nonmetals are found on the right side of the periodic table.

Metalloids are elements that have characteristics of metals and nonmetals. On the periodic table, metalloids are found between the metals and nonmetals. All metalloids are solids at room temperature. Some metalloids are shiny and many are conductors, but they are not as good at conducting heat and electricity as metals are. Some metalloids, such as silicon, are used to make the electronic circuits in computers, televisions, and other electronic devices.

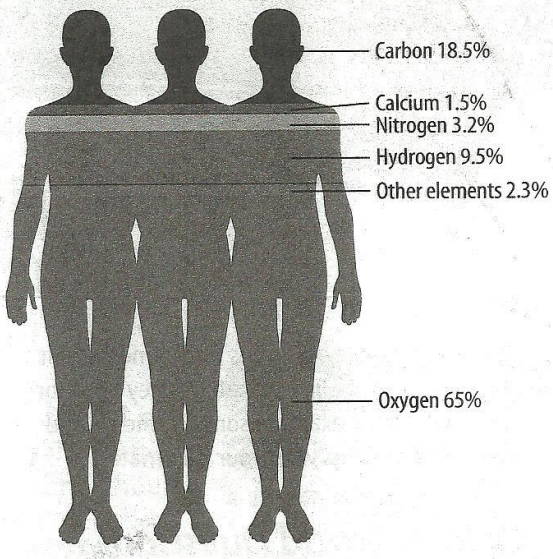


Figure 17 You are made up of mostly nonmetals.

Reading Check *What is a metalloid?*

section 2 review

Summary

The Elements

- An element is matter made of only one type of atom.
- Some elements occur naturally on Earth. Synthetic elements are made in nuclear reactions in particle accelerators.
- Elements are divided into three categories based on certain properties.

The Periodic Table

- The periodic table arranges and displays all known elements in an orderly way.
- Each element has a chemical symbol.

Identifying Characteristics

- Each element has a unique number of protons, called the atomic mass number.
- Isotopes of an element are important when determining the atomic mass of an element.

Self Check

1. **Explain** some of the uses of metals based on their properties.
2. **Describe** the difference between atomic number and atomic mass.
3. **Define** the term *isotope*. Explain how two isotopes of an element are different.
4. **Identify** the isotopes of hydrogen.
5. **Think Critically** Describe how to find the atomic number for the element oxygen. Explain what this information tells you about oxygen.

Applying Math

6. **Simple Equation** An atom of niobium has a mass number of 93. How many neutrons are in the nucleus of this atom? An atom of phosphorus has 15 protons and 15 neutrons in the nucleus. What is the mass number of this isotope?

section 3

Compounds and Mixtures

Substances

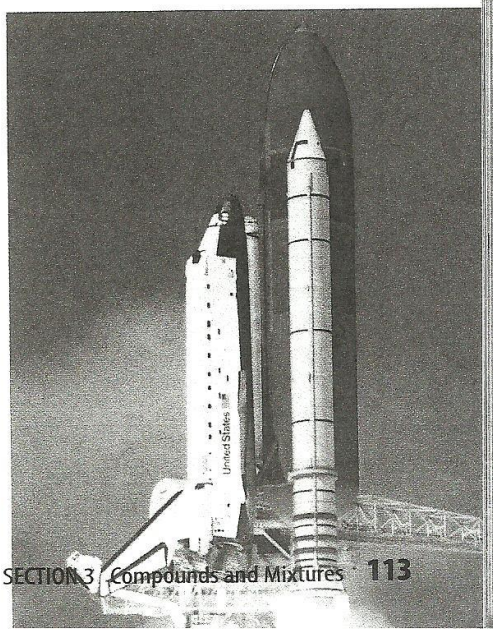
Scientists classify matter in several ways that depend on what it is made of and how it behaves. For example, matter that has the same composition and properties throughout is called a **substance.** Elements, such as a bar of gold or a sheet of aluminum, are substances. When different elements combine, other substances are formed.

Compounds What do you call the colorless liquid that flows from the kitchen faucet? You probably call it water, but maybe you've seen it written H_2O. The elements hydrogen and oxygen exist as separate, colorless gases. However, these two elements can combine, as shown in **Figure 18,** to form the compound water, which is different from the elements that make it up. A **compound** is a substance whose smallest unit is made up of atoms of more than one element bonded together.

Compounds often have properties that are different from the elements that make them up. Water is distinctly different from the elements that make it up. It is also different from another compound made from the same elements. Have you ever used hydrogen peroxide (H_2O_2) to disinfect a cut? This compound is a different combination of hydrogen and oxygen and has different properties from those of water.

Water is a nonirritating liquid that is used for bathing, drinking, cooking, and much more. In contrast, hydrogen peroxide carries warnings on its labels such as *Keep Hydrogen Peroxide Out of the Eyes.* Although it is useful in solutions for cleaning contact lenses, it is not safe for your eyes as it comes from the bottle.

Figure 18 A space shuttle is powered by the reaction between liquid hydrogen and liquid oxygen. The reaction produces a large amount of energy and the compound water.
Explain *why a car that burns hydrogen rather than gasoline would be friendly to the environment.*



as you read

What You'll Learn

- **Identify** the characteristics of a compound.
- **Compare and contrast** different types of mixtures.

Why It's Important

The food you eat, the materials you use, and all matter can be classified by compounds or mixtures.

Review Vocabulary

formula: shows which elements and how many atoms of each make up a compound

New Vocabulary

- substance
- mixture
- compound

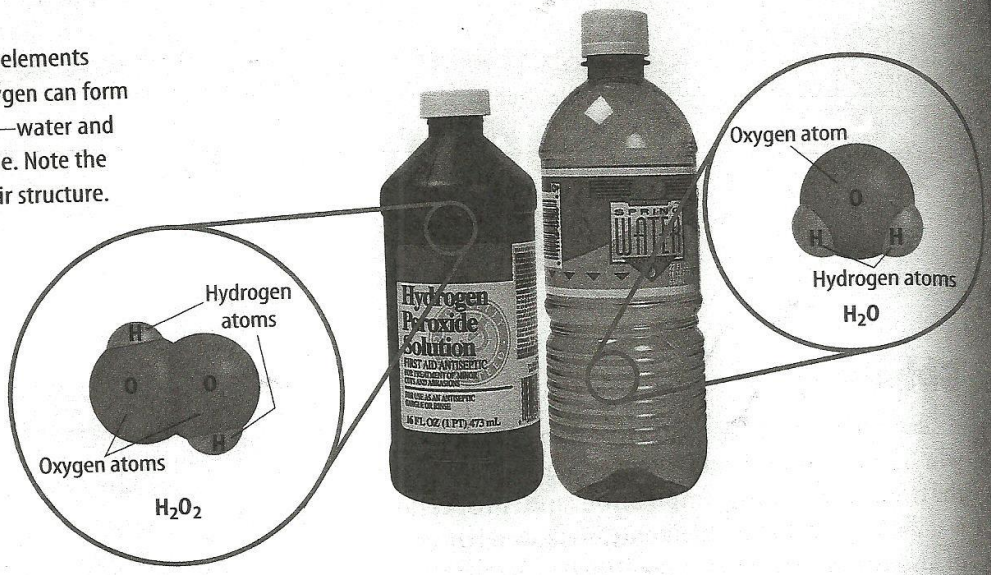


Figure 19 The elements hydrogen and oxygen can form two compounds—water and hydrogen peroxide. Note the differences in their structure.

Mini LAB

Comparing Compounds

Procedure

1. Collect the following substances—**granular sugar, rubbing alcohol,** and **salad oil.**
2. Observe the color, appearance, and state of each substance. Note the thickness or texture of each substance.
3. Stir a spoonful of each substance into separate **glasses** of **hot tap water** and observe.

Analysis

1. Compare the different properties of the substances.
2. The formulas of the three substances are made of only carbon, hydrogen, and oxygen. Infer how they can have different properties.

Try at Home

Compounds Have Formulas What's the difference between water and hydrogen peroxide? H_2O is the chemical formula for water, and H_2O_2 is the formula for hydrogen peroxide. The formula tells you which elements make up a compound as well as how many atoms of each element are present. Look at **Figure 19.** The subscript number written below and to the right of each element's symbol tells you how many atoms of that element exist in one unit of that compound. For example, hydrogen peroxide has two atoms of hydrogen and two atoms of oxygen. Water is made up of two atoms of hydrogen and one atom of oxygen.

Carbon dioxide, CO_2, is another common compound. Carbon dioxide is made up of one atom of carbon and two atoms of oxygen. Carbon and oxygen also can form the compound carbon monoxide, CO, which is a gas that is poisonous to all warm-blooded animals. As you can see, no subscript is used when only one atom of an element is present. A given compound always is made of the same elements in the same proportion. For example, water always has two hydrogen atoms for every oxygen atom, no matter what the source of the water is. No matter what quantity of the compound you have, the formula of the compound always remains the same. If you have 12 atoms of hydrogen and six atoms of oxygen, the compound is still written H_2O, but you have six molecules of H_2O (6 H_2O), not $H_{12}O_6$. The formula of a compound communicates its identity and makeup to any scientist in the world.

Reading Check *Propane has three carbon and eight hydrogen atoms. What is its chemical formula?*

Mixtures

When two or more substances (elements or compounds) come together but don't combine to make a new substance, a **mixture** results. Unlike compounds, the proportions of the substances in a mixture can be changed without changing the identity of the mixture. For example, if you put some sand into a bucket of water, you have a mixture of sand and water. If you add more sand or more water, it's still a mixture of sand and water. Its identity has not changed. Air is another mixture. Air is a mixture of nitrogen, oxygen, and other gases, which can vary at different times and places. Whatever the proportion of gases, it is still air. Even your blood is a mixture that can be separated, as shown in **Figure 20,** by a machine called a centrifuge.

Reading Check *How do the proportions of a mixture relate to its identity?*

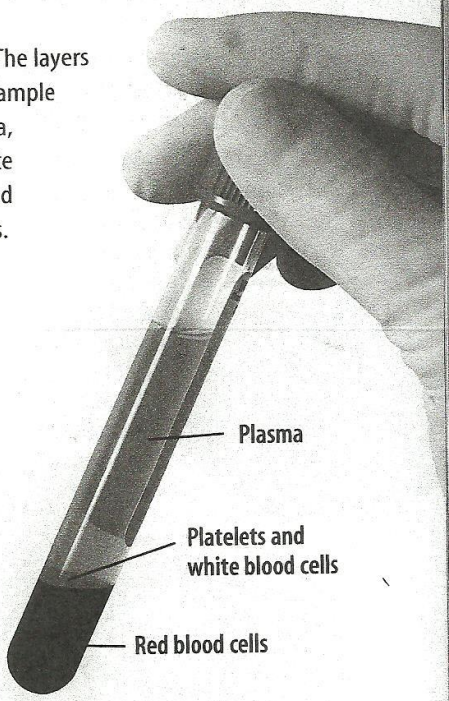


Figure 20 The layers in this blood sample include plasma, platelets, white blood cells, and red blood cells.

Applying Science

What's the best way to desalt ocean water?

You can't drink ocean water because it contains salt and other suspended materials. Or can you? In many areas of the world where drinking water is in short supply, methods for getting the salt out of salt water are being used to meet the demand for fresh water. Use your problem-solving skills to find the best method to use in a particular area.

Methods for Desalting Ocean Water

Process	Amount of Water a Unit Can Desalt in a Day (m^3)	Special Needs	Number of People Needed to Operate
Distillation	1,000 to 200,000	lots of energy to boil the water	many
Electrodialysis	10 to 4,000	stable source of electricity	1 to 2 persons

Identifying the Problem

The table above compares desalting methods. In distillation, the ocean water is heated. Pure water boils off and is collected, and the salt is left behind. Electrodialysis uses an electric current to pull salt particles out of water.

Solving the Problem

1. What method(s) might you use to desalt the water for a large population where energy is plentiful?
2. What method(s) would you choose to use in a single home?

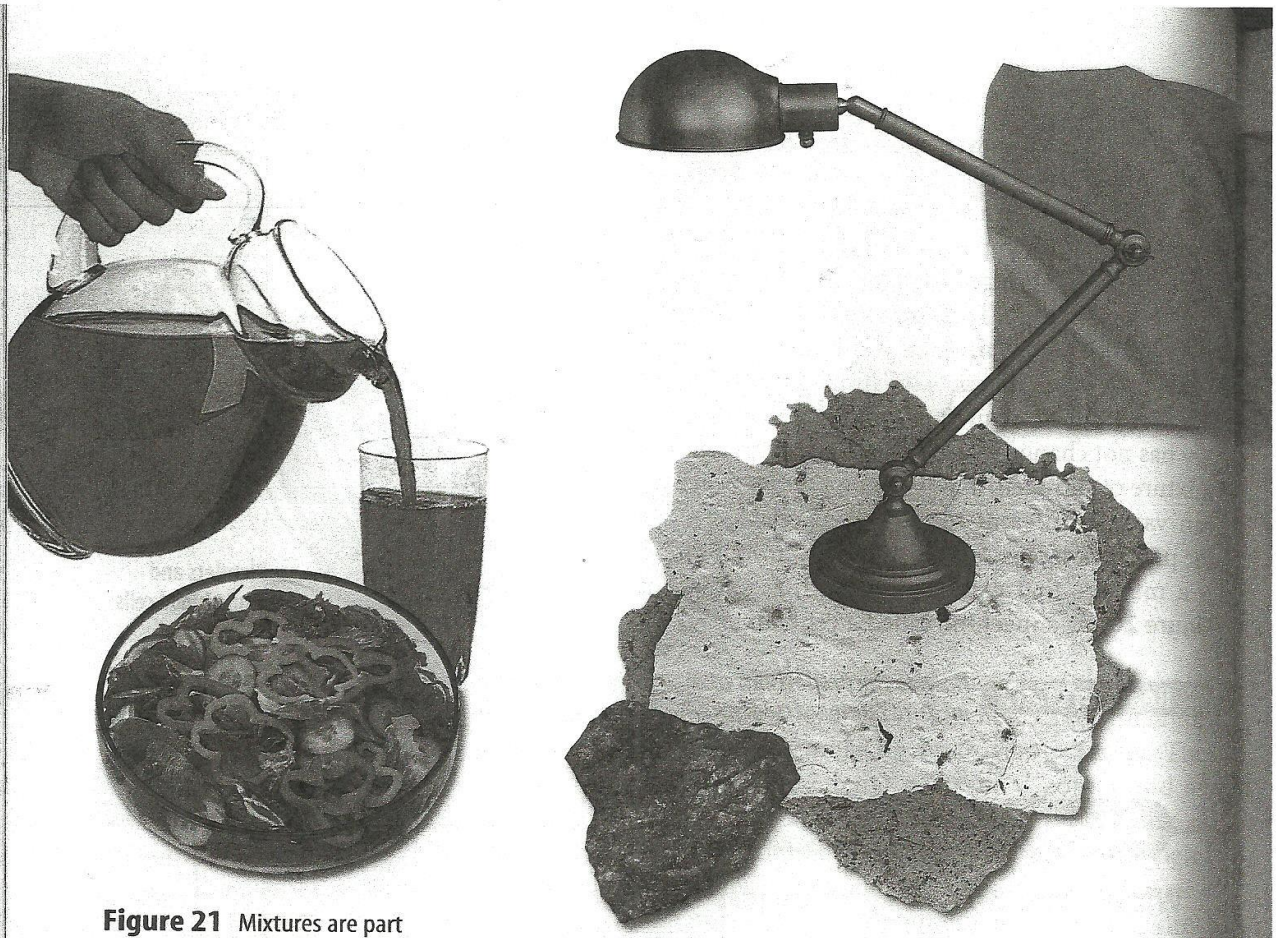


Figure 21 Mixtures are part of your everyday life.

Science Online

Topic: Mixtures

Visit red.msscience.com for Web links to information about separating mixtures.

Activity Describe the difference between mixtures and compounds.

INTEGRATE Life Science

Your blood is a mixture made up of elements and compounds. It contains white blood cells, red blood cells, water, and a number of dissolved substances. The different parts of blood can be separated and used by doctors in different ways. The proportions of the substances in your blood change daily, but the mixture does not change its identity.

Separating Mixtures Sometimes you can use a liquid to separate a mixture of solids. For example, if you add water to a mixture of sugar and sand, only the sugar dissolves in the water. The sand then can be separated from the sugar and water by pouring the mixture through a filter. Heating the remaining solution will separate the water from the sugar.

At other times, separating a mixture of solids of different sizes might be as easy as pouring them through successively smaller sieves or filters. A mixture of marbles, pebbles, and sand could be separated in this way.

Homogeneous or Heterogeneous Mixtures, such as the ones shown in **Figure 21,** can be classified as homogeneous or heterogeneous. *Homogeneous* means "the same throughout." You can't see the different parts in this type of mixture. In fact, you might not always know that homogeneous mixtures are mixtures because you can't tell by looking. Which mixtures in **Figure 21** are homogeneous? No matter how closely you look, you can't see the individual parts that make up air or the parts of the mixture called brass in the lamp shown. Homogeneous mixtures can be solids, liquids, or gases.

A heterogeneous mixture has larger parts that are different from each other. You can see the different parts of a heterogeneous mixture, such as sand and water. How many heterogeneous mixtures are in **Figure 21?** A pepperoni and mushroom pizza is a tasty kind of heterogeneous mixture. Other examples of this kind of mixture include tacos, vegetable soup, a toy box full of toys, or a toolbox full of nuts and bolts.

Rocks and Minerals
Scientists called geologists study rocks and minerals. A mineral is composed of a pure substance. Rocks are mixtures and can be described as being homogeneous or heterogeneous. Research to learn more about rocks and minerals and note some examples of homogeneous and heterogeneous rocks in your Science Journal.

section 3 review

Summary

Substances

- A substance can be either an element or a compound.
- A compound contains more than one kind of element bonded together.
- A chemical formula shows which elements and how many atoms of each make up a compound.

Mixtures

- A mixture contains substances that are not chemically bonded together.
- There are many ways to separate mixtures, based on their physical properties.
- Homogeneous mixtures are those that are the same throughout. These types of mixtures can be solids, liquids, or gases.
- Heterogeneous mixtures have larger parts that are different from each other.

Self Check

1. **List** three examples of compounds and three examples of mixtures. Explain your choices.
2. **Determine** A container contains a mixture of sand, salt, and pebbles. How can each substance be separated from the others?
3. **Think Critically** Explain whether your breakfast was a compound, a homogeneous mixture, or a heterogeneous mixture.

Applying Skills

4. **Compare and contrast** compounds and mixtures based on what you have learned from this section.
5. **Use a Database** Use a computerized card catalog or database to find information about one element from the periodic table. Include information about the properties and uses of the mixtures and/or compounds in which the element is frequently found.