LESSON **11**

Pure Substance or Mixture?

Milk looks like a single substance. Is it pure or is it a mixture?

INTRODUCTION

In previous lessons, you discovered how the characteristics of substances, such as density, and the behavior of substances when they are heated can be used to help identify substances. However, there is one problem. These properties are most useful in identifying pure substances. Many of the materials that we come across in our daily lives are not pure. Mixtures of substances are much more common than pure substances are. For example, look at your own body. You are made up of matter that consists of many complex substances that work together to produce the chemical reactions that occur in living organisms (see Figure 11.1).

OBJECTIVES FOR THIS LESSON

Discuss the meaning of the term "pure substance."

Discuss how you can distinguish between pure substances and mixtures.

Use your own techniques to discover whether several samples of matter are pure substances or mixtures.

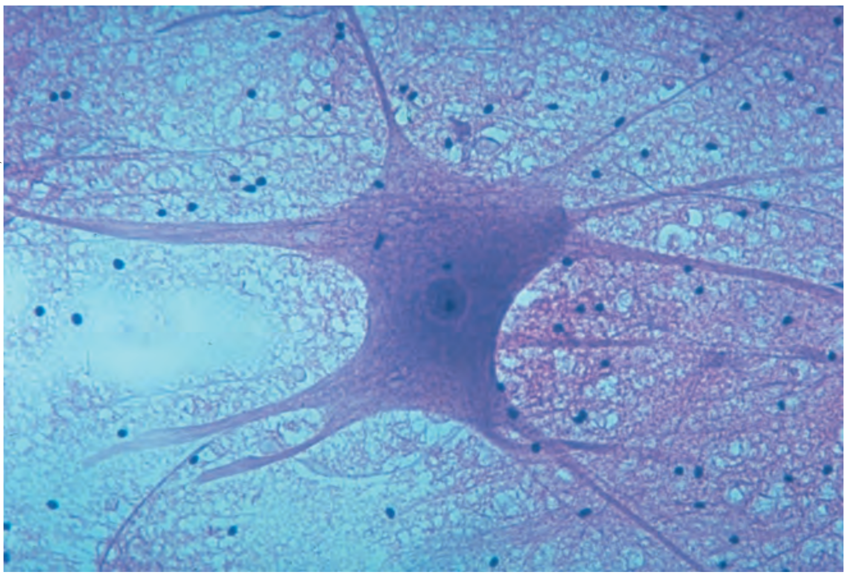

Figure 11.1 *This nerve cell, like every cell in your body, contains thousands of different substances. Each one performs a different function within the cell.*

Identifying the individual substances from which living things are made is very difficult. To separate the substances in a living cell, a biochemist would need to grind up samples of the tissue and then expose the souplike mixture to an array of separation techniques to obtain pure samples of each substance.

Finding out whether something is pure is hard work! In this lesson, you will try to define the term "pure substance." You will devise your own techniques to determine whether eight different samples are pure substances or mixtures. You will then discuss the difficulties you encountered in classifying the samples.

MATERIALS FOR LESSON 11

For you

1 copy of Student Sheet 11.1: Identifying Pure Substances and Mixtures
1 pair of safety goggles

For your group

8 samples (labeled A through H)
4 loupes (double-eye magnifiers)
2 lab scoops
2 pipettes
4 petri dish lids or bases
4 sheets of black paper
4 sheets of white paper
1 magnet
4 test tubes
1 test tube rack
1 test tube brush
Access to water

Getting Started

1. Before you start investigating whether substances are pure or mixtures, it would be useful to think about how you already use these terms. Answer the following questions on your student sheet: What is your definition of a pure substance? Give two examples of pure substances. For each, explain why you think it is pure. If you were given an unknown sample of matter, how could you tell whether it was a pure substance or a mixture?

2. Use your answers to contribute to a class discussion.

SAFETY TIPS

Wear your safety goggles throughout the inquiry.

Do not taste any of the substances.

Inquiry 11.1
Determining Whether Substances Are Pure or Mixtures

PROCEDURE

1. Have one member of your group collect the plastic box of materials. Check its contents against the list of materials.

2. Take samples A through H out of the plastic box.

3. The purpose of this inquiry is to answer the question, "Which of these substances are mixtures and which are pure substances?" You have about 20 minutes to answer this question and to record your answers, so you will need to split the work among the members of your group.

4. You may use all of the apparatus in the plastic box, plus water, to help you with your investigation. Devise your own techniques to determine whether each sample is a pure substance or a mixture.

5. For each sample, record your findings in Table 1 on the student sheet.

6. Use any additional data collected by other group members to complete Table 1. Discuss the results with the other members of your group.

7. Answer the following questions on your student sheet: How can the properties of pure substances be used to discover whether a sample is a mixture? Were the samples all well mixed? How did the extent of mixing affect your investigation?

8. Put the wastes from Mixtures G and H in the appropriate container. Wash all of the test tubes and return the materials to the plastic box. Make sure you also wash your hands when you are finished.

9. Your teacher will lead a class discussion about your procedures and results. Listen carefully as other students describe their approaches to answering the question of whether a sample is a pure substance or a mixture, explain their results, and make suggestions for alternative approaches to the problem.

REFLECTING ON WHAT YOU'VE DONE

1. After the discussion, your teacher will return to the concept of "pure substance." Look at the definition you provided at the start of the lesson.

2. Review your original definition of "pure substance." If it is different from the new one agreed on in class, write the new one on the student sheet.

Perfect Teamwork

Wouldn't it be great to have a baseball team made entirely of the world's greatest pitchers? Well, no. This would not be a happy team. It wouldn't matter how many strikes these superstars could throw. A team without players who are good at catching, hitting, and stealing bases would have a hard time winning. A team with a good balance of skills is more likely to make it to the World Series.

Combining skills is important for making strong materials, too. Often, a pure substance on its own does not have all of the necessary properties for a particular material. But you can make many useful materials by combining two or more substances that have different properties. The result is a mixture called a composite. A good composite exploits the best properties of each ingredient.

People have been making composites since the beginning of civilization. For ancient peoples, dried mud and even animal dung were handy for making huts. The huts were simple to make: Find dirt, add water. The mud kept out the wind and didn't rot, but it crumbled and cracked. Ancient peoples also used straw, grass, or sticks, which were woven into durable mats, to make hut walls. But woven walls leaked.

The Masai of Kenya have been using composite materials—mud, dung, and straw—to make homes for thousands of years.

The solution was to combine the two. In many parts of the world, people realized they could weave a house frame (usually supported by timber) out of straw, grass, or sticks and cover it with mud. The result, called "wattle-and-daub" construction, wasn't always pretty. But it kept out the cold and did not fall apart every time the kids got a little rowdy.

People have been coming up with new composite materials ever since. Usually, a composite has two materials with opposite properties. The two materials put together as a composite can do what each ingredient alone cannot. Like ancient wattle-and-daub huts, modern composites are often made of fibers embedded in a solid that sticks the fibers together. The fibers are strong but floppy. The solid isn't floppy, but it easily shatters or cracks. A combination of these two opposites can be unbeatable.

PHOTO BY BRIAN O'KEEFE

Why are fiberglass and carbon fiber composites good materials for making fishing rods?

The solid provides stiffness. The fibers keep the solid from cracking apart. (This is because a crack would have to break too many of the strong fibers running through the solid.)

Fiberglass is one example of a modern composite. To make fiberglass, glass is melted and stretched into long threads. The glass threads are woven into cloth. The cloth is embedded in plastic goo, and the whole thing is shaped in a mold. When the goo hardens, the object has the shape of the mold, is light in weight, and is cheap to make. Fiberglass was originally developed to cover radar dishes on World War II bombers. It is now used for everything from boats to fishing rods to picnic tables.

PHOTO COURTESY OF U.S. NAVY BLUE ANGELS

Navy Blue Angels fly F/A-18 Hornets with composite wings.

When building the Stealth Fighter, designers used many composite materials in place of metal. The use of these materials combined with its special shape helps make the plane invisible to most radar.

More recently, engineers have developed new composite materials. One of these composites contains carbon fibers that are stiffer and much more heat-resistant than glass is. A given weight of carbon composite is stronger than steel. This lightweight strength makes carbon composites ideal for use in many types of objects that would normally be made of metal. The wings of jet fighter planes and helicopter blades are two examples.

Composites are widely used in sports equipment and are replacing many natural materials. For example, tennis rackets, originally made from wood, now have frames made from glass, carbon, or boron fibers embedded in a plastic-like nylon. The core of the racket is made from a plastic foam. The result is a lightweight, stiff racket that is easy to control and that returns the ball with maximum force.

Even though carbon composites are one of the latest advances in composite materials, they share something with ancient mud huts. Both combine the best parts of different materials to make something that is better than either one alone. ☐

CORBIS/HULTON-DEUTSCH COLLECTION

About 50 years ago, solid wooden rackets were used to play tennis.

AP/WIDE WORLD PHOTOS

Modern rackets like this one, made from several types of composites, are much stronger and lighter than wooden rackets.

QUESTIONS

1. What is one object made from a composite material that you can find in your home?
2. What is the function of the object?
3. Why was that composite material chosen for that function?