Chapter 2

Changes in Matter

When you put the silverware away, it's easy to separate the spoons from the forks. But if you tried to unscramble an egg, you'd have a pretty hard time. What changes mixtures so you can't separate them? In this chapter, you'll find out.

Vocabulary Preview

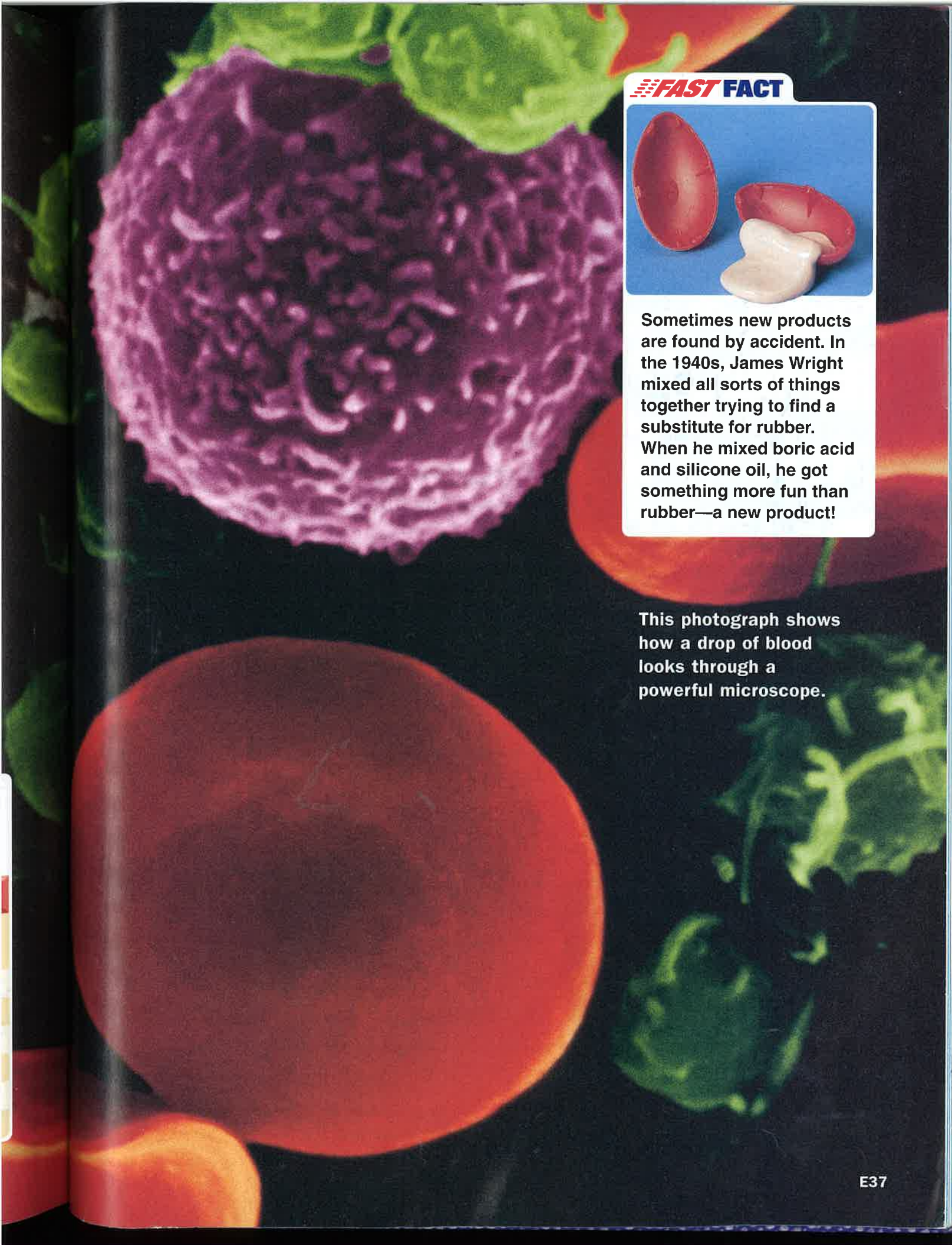
physical change
mixture
solution
chemical change

FAST FACT

When you cut yourself, blood looks like a thick red liquid. But blood is really a mixture of liquids and cells of different sizes. Here are some other things that you might not think of as mixtures.

Different Kinds of Mixtures

Kinds of Matter Mixed	Result
Carbon and iron	Steel
Water and gelatin	Jelly
Air and rock	Pumice
Fat and water	Milk
Ash and air	Smoke
Water and air	Fog



FAST FACT

Sometimes new products are found by accident. In the 1940s, James Wright mixed all sorts of things together trying to find a substitute for rubber. When he mixed boric acid and silicone oil, he got something more fun than rubber—a new product!

This photograph shows how a drop of blood looks through a powerful microscope.

LESSON 1

What Are Physical Changes?

In this lesson, you can . . .

INVESTIGATE how to separate mixtures.

LEARN ABOUT physical changes in matter.

LINK to math, writing, social studies, and technology.

Heat causes a physical change in the ice pop. It melts.

INVESTIGATE

Separate a Mixture

Activity Purpose In a mixture of sand, shells, twigs, and seaweed, you might want to separate the shells. You could do it easily with your hands. To separate other mixtures, you might need to use different methods or tools. **Plan and conduct an investigation** to discover methods for separating mixtures.

Materials

- 4 clear plastic cups
- 6 marbles
- water
- steel paper clips
- rice
- magnet
- measuring cup
- paper towels
- funnel

Activity Procedure

1. In one cup, make a mixture of marbles and water. Plan a way to separate the marbles from the water. Try it. **Record** your method and your results.

VESTIGATE

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another cup, make a mixture of
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to separate the mixture. Try it.
cord your method and your results.

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different methods until you find one
t works. Try using the magnet.
cord each method you try.

another cup, mix $\frac{1}{4}$ cup of rice with 1
of water. How could you separate the
from the water? **Record** your ideas.

ke a filter with the paper towels and the
nel. **Predict** how this tool could be used to
arate the mixture. Then use the filter to
arate the mixture. (Picture A)

Picture A

Conclusions

n would it be easy to use only your hands to
rate a mixture?

n might you need a tool to separate a
ure?

ntists at Work Scientists often use charts
cord the results of an investigation. How
d setting up charts help you **plan and**
luct an investigation?

gate Further Make a mixture of sand and
lan and conduct an investigation to
e the mixture. Would a tool be useful?
tool would you use?

Process Skill Tip

Scientists ask questions about the world around them. To find the answers, they **plan and conduct investigations**. First, they think about the question they want to answer. Then, they plan a way to answer the question. As they conduct the investigation, they **record** their results.

uses a physical change
e pop. It melts.

LEARN ABOUT

Physical Changes in Matter

FIND OUT

- how matter can change and still be the same
- about two kinds of mixtures

VOCABULARY

physical change
mixture
solution

Kinds of Physical Changes

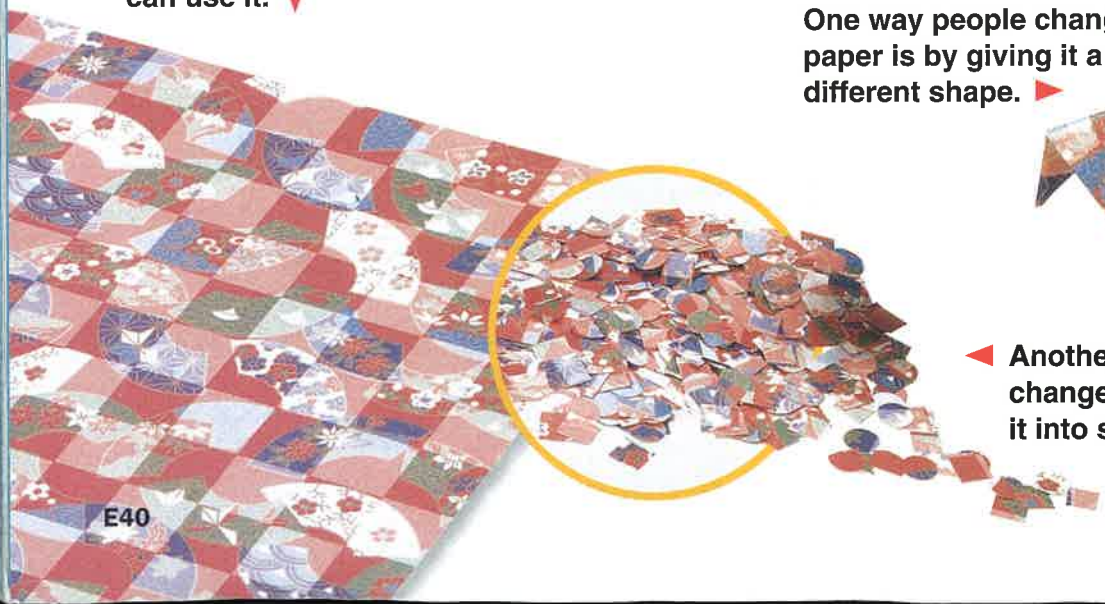
When you wash your clothes, they get wet, soapy, and wrinkled. Even with all these changes, they are still your clothes. No new kinds of matter are formed. Changes to matter in which no new kinds of matter are formed are called **physical changes**.

Some physical changes make objects look very different. Paper can be cut, painted on, written on, torn, folded, and glued. Each time, the paper looks different, but it is still paper.

Changing the temperature can make matter change. Cooling makes liquid water change to ice. The ice has the same particles in it that the liquid water had. No new kinds of matter are formed.

✓ **What are some ways that matter can change and still be the same matter?**

People make paper so they can use it. ▼



One way people change paper is by giving it a different shape. ►

◄ Another way people change paper is by cutting it into smaller pieces.

Mixtures

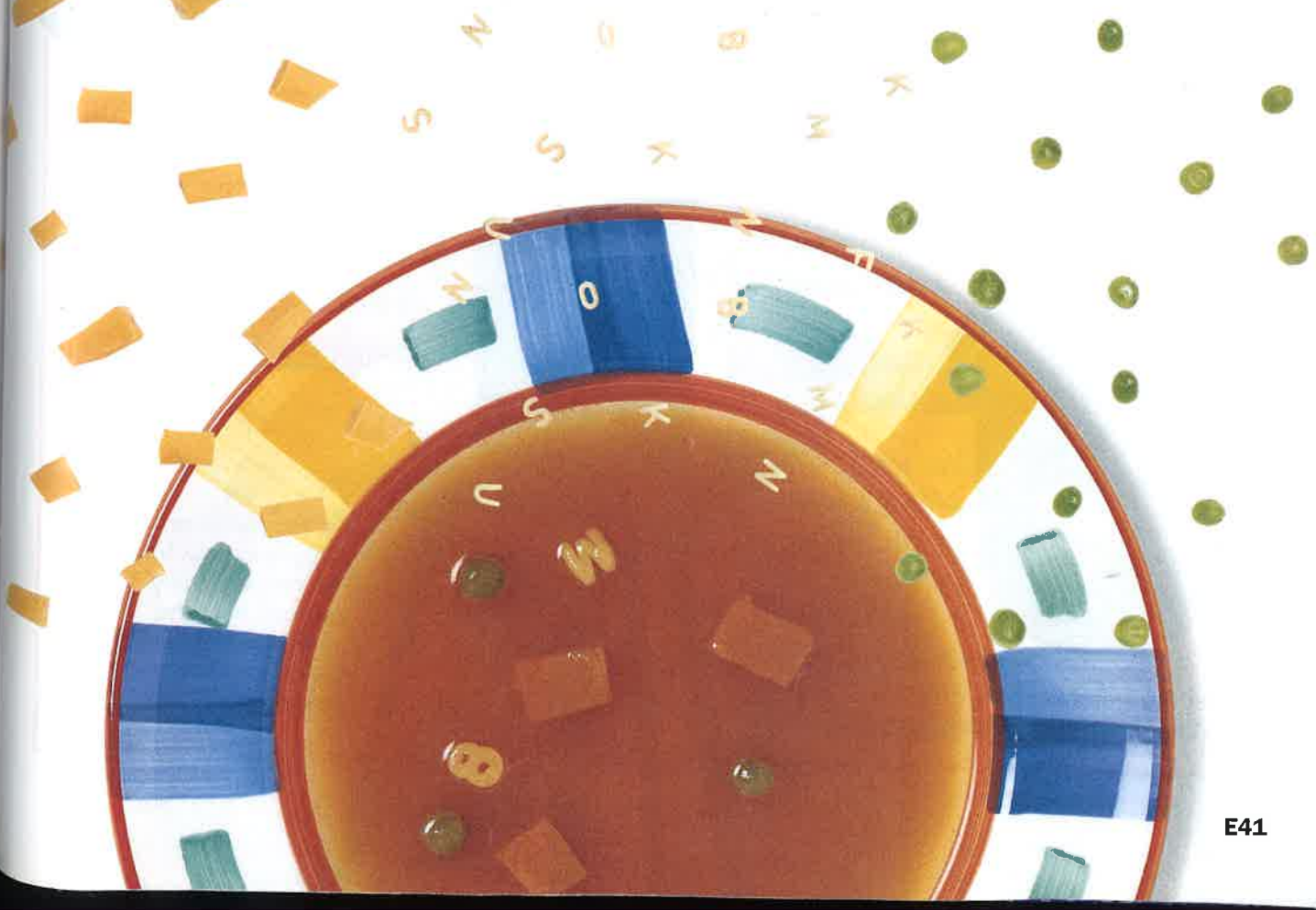
A **mixture** is a substance that contains two or more different types of matter. The types of matter in a mixture can be separated. After a mixture is separated, the matter is the same as it was before it was mixed.

In the investigation you made a mixture of rice, paper clips, and marbles. Then you separated the pieces back into separate piles of rice, paper clips, and marbles. Making a mixture is a physical change.

Separating the parts of a mixture is another physical change.

Some mixtures can be separated by hand. You separated the rice from the marbles with your hands. Some mixtures can be separated by evaporation or by condensation. In *evaporation* a liquid part of a mixture turns into a gas. This leaves the other parts behind. In *condensation* a gas in a mixture turns into a liquid. The liquid can be separated from the rest of the mixture.

✓ **What is a mixture?**



This alphabet soup is a mixture of broth, peas, pasta, carrots, and other vegetables.

Solutions

Have you ever put sugar in iced tea? After you stir the tea, you can't see the sugar anymore. You know the sugar is still there because you can taste it. This mixture of sugar and tea is called a solution. In a **solution** the particles of the different kinds of matter mix together evenly.

The different kinds of matter in a solution can't be separated by hand. But evaporation can separate some solutions. If you heat the iced tea or leave the glass out for a while, the water in the tea will evaporate. Then the sugar will be left.

✓ **What is a solution?**

THE INSIDE STORY

Solutions

This bright-blue substance is called copper sulfate. Watch what happens when it is mixed with water.

Copper sulfate mixes with water to form a solution. Like the copper sulfate, the solution is a bright-blue color.

To separate the copper sulfate from the water quickly, you can heat the solution. The heat makes the water evaporate.

After the water is gone, only the copper sulfate is left.

Summary

Matter can change size, shape, and state. Matter can be mixed. Changes to matter that don't form any new kinds of matter are called physical changes. A mixture contains two or more types of matter. A solution is a kind of mixture. In a solution the particles of the different kinds of matter are mixed evenly.

Review

1. What is a physical change?
2. Name three ways to cause a physical change in matter.
3. What is the difference between a mixture and a solution?
4. **Critical Thinking** Suppose you have a mixture of water and salt. You use evaporation to separate the water from the salt. Where does the water go?
5. **Test Prep** Which one is a solution?
   - **A** marbles mixed in water
   - **B** sugar mixed in water
   - **C** clay, rocks, and twigs
   - **D** rice mixed in water

◀ **Mixture**

LINKS

MATH LINK

Trail Mix Make a food mixture. Use a $\frac{1}{4}$-cup measuring cup and a 2-cup measuring cup. Measure $\frac{1}{4}$ cup each of raisins, dried banana chips, sunflower seeds, and pretzel circles. Put all these into the 2-cup measuring cup. How much trail mix do you have altogether?

WRITING LINK

Expressive Writing—Song Lyrics Almost all soups are mixtures. Choose a familiar tune and write song lyrics for a younger child about your favorite soup.

SOCIAL STUDIES LINK

Gold Rush Look up the California gold rush. Find out how people separated mixtures of water, sand, and rock to find gold.

TECHNOLOGY LINK

Visit the Harcourt Learning Site for related links, activities, and resources.

www.harcourtschool.com

LESSON 2

What Are Chemical Changes?

In this lesson, you can . . .

- **INVESTIGATE** a change in matter.
- **LEARN ABOUT** how new matter is formed.
- **LINK** to math, writing, language arts, and technology.

The yellow liquid mixes with the clear liquid. Together they form a new kind of matter that is a pink solid.

INVESTIGATE

Chemical Changes

Activity Purpose You mix flour, eggs, milk, and oil. Then you pour some of the mixture into a hot pan. Pancakes! The pancakes are a different kind of matter than the flour and eggs. Many changes happen to cause the new kind of matter to form. You can **observe** a new kind of matter being formed in this investigation.

Materials

- safety goggles
- cookie sheet
- large glass bowl
- measuring cup
- baking soda
- vinegar

Activity Procedure

CAUTION

1. CAUTION Put on your safety goggles.

2. Place the cookie sheet on the table. Place the bowl on the cookie sheet.

3. **Measure** $\frac{1}{4}$ cup of baking soda. Pour it into the bowl.

4. **Measure** $\frac{1}{4}$ cup of vinegar. Hold the cup with the vinegar in one hand. Use your other hand to fan some of the air from the cup toward your nose. Do not put your nose directly over the cup. (Picture A)

Picture A

5. Pour the vinegar into the bowl.

6. **Observe** the matter in the bowl. **Record** what it looks like. Use the procedure from Step 4 to smell the matter in the bowl. Record what it smells like.

Draw Conclusions

1. How is the material in the bowl like the baking soda and vinegar you started with? How is it different?
2. What can you **infer** about where the bubbles came from?
3. **Scientists at Work** Scientists **observe** changes. Then they **record** their observations. Describe the changes you observed in the bowl.

Investigate Further Mix warm water and a fresh packet of dry yeast. **Observe** the mixture. **Record** what you see. What can you **infer** about the changes you see?

Process Skill Tip

Scientists **observe** matter carefully. Sometimes they see things they don't understand right away. Sometimes they can use their experience to **infer** what those things mean. When you infer, you use your observations to form an opinion.

LEARN ABOUT

Chemical Changes in Matter

FIND OUT

- how new kinds of matter are formed
- some ways we use chemical changes every day

VOCABULARY

chemical change

Forming Different Kinds of Matter

Matter is always changing. Some changes are physical changes. In physical changes the kind of matter stays the same.

Some changes form new kinds of matter. Changes that form different kinds of matter are called **chemical changes**. In chemical changes the particles in the matter change. Cooking food makes new kinds of matter. Flour, eggs, milk, and oil turn into pancakes. The particles in the flour, eggs, milk, and oil change. The pancakes will never be just flour, eggs, milk, and oil again.

✓ **What is a chemical change?**

▲ This liquid looks like water. It is actually a solution with lead in it.

This is a solution with iodine in it. It also looks like water. ►

When the two liquids are mixed, they form a yellow solid. This is an example of a chemical change. ►

Some Chemical Changes

Burning People burn things every day. Many people burn oil or gas to heat their homes. When things burn, different kinds of matter form. So burning is a chemical change. When wood burns, it combines with the oxygen in the air. The matter that forms includes smoke and ash. Another kind of matter forms that you can't see. It is a gas that mixes with the air.

Rusting Have you ever noticed orange-brown spots on the metal of a bike or a car? This orange-brown matter is rust. Rust forms when air and water mix with the iron in metal. The rust is a different kind of matter. It is flaky and soft. It is not strong like iron. When a metal gets rusty, it loses some of its strength. Often you can break the rusty part off. Rusting is a chemical change.

✓ **What are two common chemical changes?**

A chemical change is happening in this fire. The wood is combining with oxygen in the air to form new kinds of matter. ▼

▲ **When wood burns, one of the new kinds of matter that forms is ash. The ash doesn't look like the wood.**

The new bolt is shiny. The other bolts are old. The iron in the old bolts has rusted. It has combined with air and water to form a new kind of matter. ▼

Using Chemical Changes

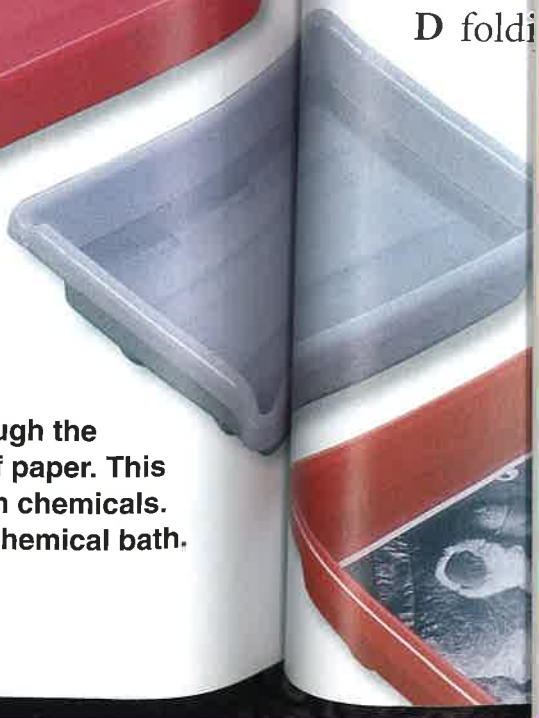
Chemical changes go on all around us. We burn fuel to heat our homes. The engines of cars and buses burn fuel to make them move. Chemical changes happen when we cook food. Many of the materials in our clothes are made by chemical changes. Plants use chemical changes to make their food. The film in a camera goes through chemical changes to make photographs.

✓ **Name three chemical changes.**

1 First you take a picture.

2 The film inside a camera has chemicals on it. These chemicals change when light hits them. The changes are the beginning of your photograph.

3 This first process makes a negative. On a negative, the colors are backward. The negative is used to make a print.



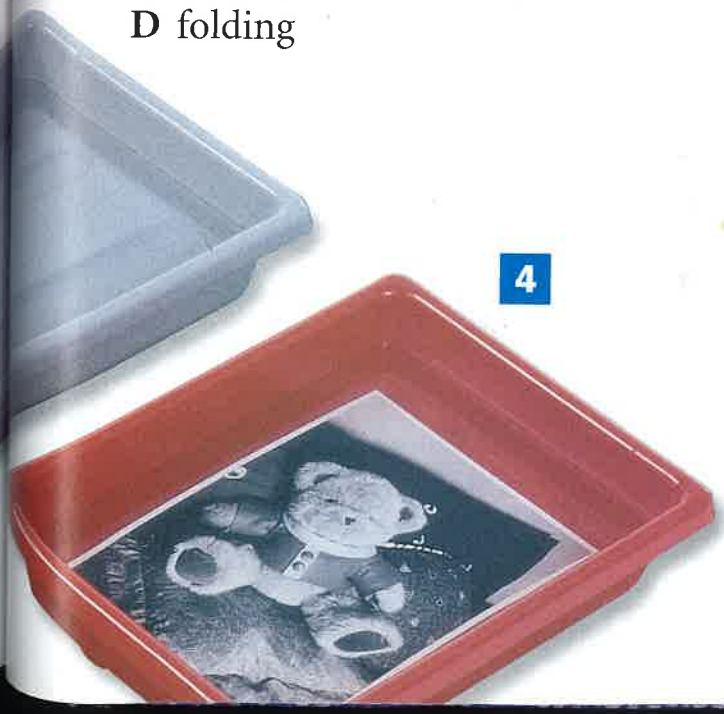
4 A machine shines light through the negative and onto a sheet of paper. This sheet of paper is coated with chemicals. The paper is put through a chemical bath.

Summary

Chemical changes cause new kinds of matter to form. Chemical changes can be very useful. We use chemical changes to cook. We use chemical changes to take pictures. Some chemical changes are harmful. Rust on metal makes the metal weak.

Review

1. What happens to particles of matter in a chemical change?
2. Name two common chemical changes.
3. Describe some ways we use chemical changes to help us.
4. **Critical Thinking** What is the difference between a chemical change and a physical change?
5. **Test Prep** Which of the following is a chemical change?
   - **A** tearing
   - **B** soaking
   - **C** rusting
   - **D** folding



LINKS

MATH LINK

A Fire Problem A log had a mass of 5 kilograms before it burned. After the fire was out, the ashes had a mass of 1 kilogram. What was the mass of the smoke and gas that were formed?

WRITING LINK

Narrative Writing—Story Write the story of a forest fire for your teacher. Tell how the fire begins. Describe what is left of the forest when the fire is over.

LANGUAGE ARTS LINK

Many Uses of Fire Look up the word *fire* in a dictionary. Write two sentences that use the word. But use the word in ways that are different from the way *fire* is used in science. Explain what *fire* means in each sentence.

TECHNOLOGY LINK

To learn more about how matter that has undergone a chemical change can be used, watch *Recycled Roads* on the **Harcourt Science Newsroom Video.**

Plastic Bridges

Physical changes can be useful. When you fold a sheet of paper, you want it to change shape. And you want a plastic bag to change its shape to hold the groceries you buy at the store. But if a bridge you were driving on changed shape as much as the paper or the plastic bag, you'd be in trouble.

Choosing Materials

When engineers design and make something, they choose their materials carefully. They use materials that change in ways that are useful and don't change in ways that cause problems. When they want to build a bridge, they use materials that are strong. They look for materials that won't bend or break when cars and trucks drive over them. They might use steel, or concrete—or plastic.

Why Build Plastic Bridges?

People don't usually think of plastic when they think of bridges.

▲ Building a plastic bridge

plastic building material

Plastic bags get holes in them. Plastic milk bottles bend and break. Even the hard plastic used in toys and computers breaks. But scientists have developed a new kind of plastic that is strong enough to hold the weight of cars and trucks. It is a kind of composite, or a material made of several different things put together.

Composite plastic is as strong as steel, but it is much lighter. Bridges built with plastic can be put together and used in about a day. Bridges made with steel and concrete take much longer to build.

Weathering wears out bridges made of steel and concrete. Heat, cold, rain, ice, and wind slowly break them apart. Water can erode cement and make steel rust. But water and salt don't affect composite plastic. The plastic doesn't break down or rust.

Using Plastic in Bridges

Today plastic bridges are being tested in different places around the country. These bridges aren't made completely of plastic. They still have steel rails on the sides and concrete on the road surface. They look just like the bridges you're used to. But scientists hope they will last longer.

Plastic is also being used to fix old bridges. Plastic can be wrapped around parts of these bridges to add support. The plastic coating also keeps the bridges from being damaged by heat, cold, wind, water, and salt.

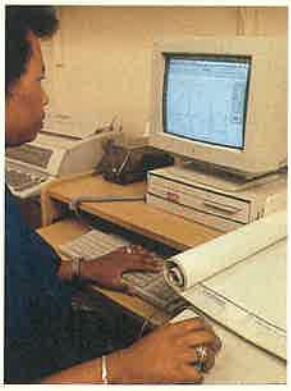
Think About It

1. Why do we still need to use concrete and steel to make bridges?
2. Why might you want to wrap plastic around the supporting parts of a building?

WEB LINK:
For Science and Technology updates, visit the Harcourt Internet site.
www.harcourtschool.com

Careers **Civil Engineer**

What They Do Civil engineers design buildings, bridges, roads, airports, and tunnels and make sure these things are safe to use.



Education and Training Civil engineers have at least a bachelor's degree in engineering. They study physics, chemistry, and math so that they can test and design structures.

Enrico Fermi

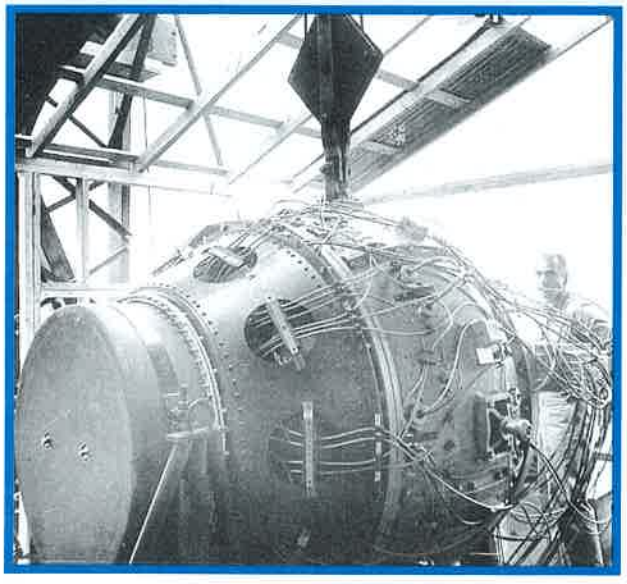
PHYSICIST

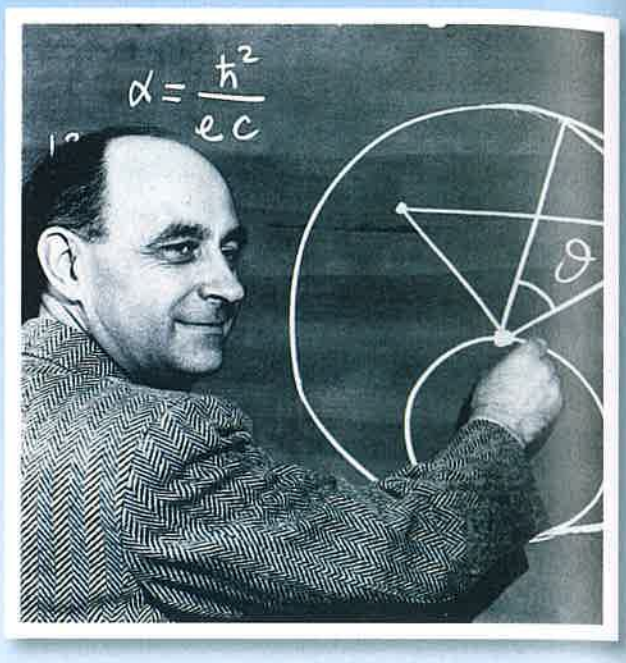
"I'm hungry. Let's go to lunch!"

Enrico Fermi was a man who lived on a schedule. It was noon and he was hungry. So work on his great experiment could wait awhile. That afternoon, December 2, 1942, his experiment succeeded and made it possible to develop the atomic bomb. The work of many scientists over several years had been completed.

Fermi became interested in atoms after reading about the research done by other scientists. In 1938 he was awarded the Nobel Prize in physics.

After Fermi, his wife, and their two children went to Sweden to accept the prize, they did not return to Italy. Fermi's wife, Laura, was Jewish. She





was in danger because of the prejudice against Jews in Italy. So the Fermi family came to the United States. Fermi taught at Columbia University. A few years later, he went to the University of Chicago, where many of his experiments took place.

In 1943 Fermi went to Los Alamos, New Mexico, to help develop the first atomic bomb. All of the major countries involved in World War II were racing to make this bomb. After the war ended, Fermi returned to the University of Chicago.

Think About It

1. Why did all the major countries in the war want to make an atomic bomb?
2. Why is it important for scientists to write about their discoveries?

Changes in Cooking

What happens to muffins as they bake?

Materials

- 1 box of muffin mix
- other needed ingredients
- mixing bowl
- spoon
- muffin pan

Procedure

1. Read and follow the directions on the box of muffin mix.
2. Halfway through the cooking time, open the oven or turn on the oven light and observe the muffins. Record your observations.

Draw Conclusions

What is happening to the muffins?

Making a Solution

Which works better, hot water or cold water?

Materials

- 2 small, heat-proof glass containers
- cold water
- spoon
- sugar
- clock with second hand
- warm water (from the tap)

Procedure

1. Fill one container with cold water.
2. Mix a spoonful of the sugar into the water. Stir until the sugar dissolves.
3. Watch the clock to see how long it takes. Record the number of seconds it takes.
4. Repeat Steps 1–3 using warm water.

Draw Conclusions

How were the results different? Why do you think they were different?

Chapter 2 Review and Test Preparation

Vocabulary Review

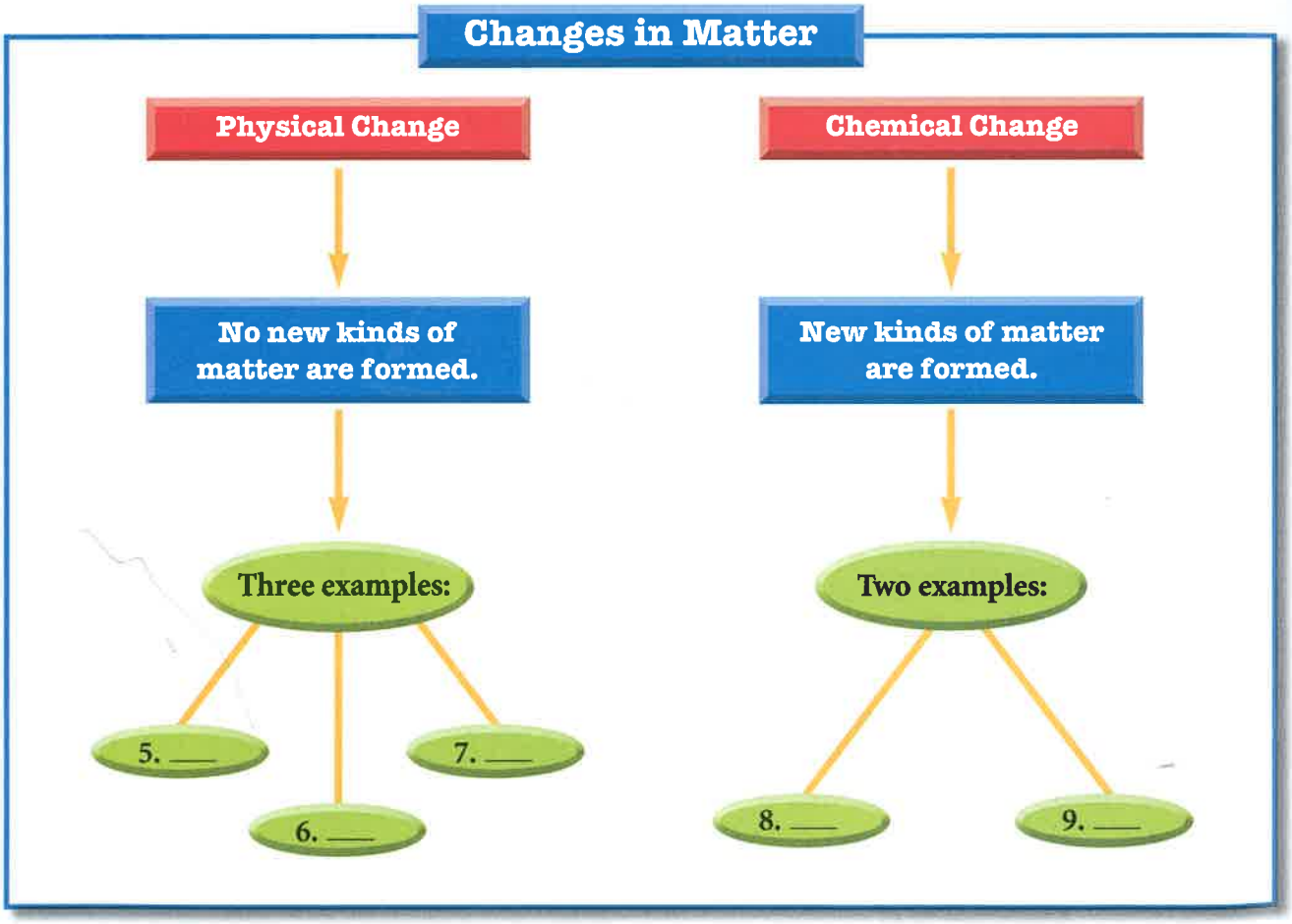
Choose a term below to match each definition. The page numbers in ( ) tell you where to look in the chapter if you need help.

physical change (E40)
mixture (E41)
solution (E42)
chemical change (E46)

1. Matter that contains two or more different things that can be separated
2. A change in which no new kinds of matter are formed
3. A change that makes new kinds of matter
4. A mixture in which the particles of the different kinds of matter mix together evenly

Connect Concepts

Complete the diagram below by listing three examples of physical change and two examples of chemical change.



Check Understanding

Write the letter of the best choice.

10. Which of the following involves a chemical change?

A dissolving soap in water
B cutting paper with scissors
C burning paper
D filling a balloon with air

11. Which of the following is a physical change?

F mixing blueberries, strawberries, and raspberries
G rusting of iron on a car
H burning a log
J cooking pancakes

12. When you add heat to ice to turn it into liquid water, you make a —

A solution **C** chemical change
B mixture **D** physical change

13. Which of the following is a solution?

F twigs, leaves, and bugs
G sugar and water
H newspapers and magazines
J milk and cereal

14. What new kind of matter forms when iron is mixed with air and water?

A wood **C** ice
B rust **D** ash

Critical Thinking

15. Think of the investigation you did with vinegar and baking soda. What happened that showed a gas was forming?

16. Suppose you leave a shovel out in the rain. Two weeks later there are orange-brown spots on it. Explain what has happened.

Process Skills Review

Write *True* or *False*. If the statement is false, change the underlined part to make it true.

17. A scientist who wants to find an answer to a question **plans and conducts an investigation.**

18. When you **observe** something, you watch it carefully.

19. When you **infer**, you make a wild guess.

Performance Assessment

Mixtures and Solutions

Work together with three or four other students. Your teacher will give you the following things: a pitcher of water, two cups, paper clips, safety pins, salt, a spoon, and unpopped popcorn. Make one mixture and one solution and correctly label each.

UNIT E

Unit Project Wrap Up

Here are some ideas for ways to wrap up your unit project.

Display at a Science Fair

Display the results of your project in a school science fair. Be prepared to explain how you identified and controlled variables in your experiments. Let volunteers conduct their own tests with materials you provide.

Draw a Billboard

Design a billboard advertisement for the best soap you tested. What claims could you make that you have evidence for?

Make an Ad Scrapbook

Collect advertisements that make claims that could be tested. Analyze the ads for proof for the claims.

Investigate Further

How could you make your project better? What other questions do you have? Plan ways to find answers to your questions. Use the Science Handbook on pages R2-R9 for help.