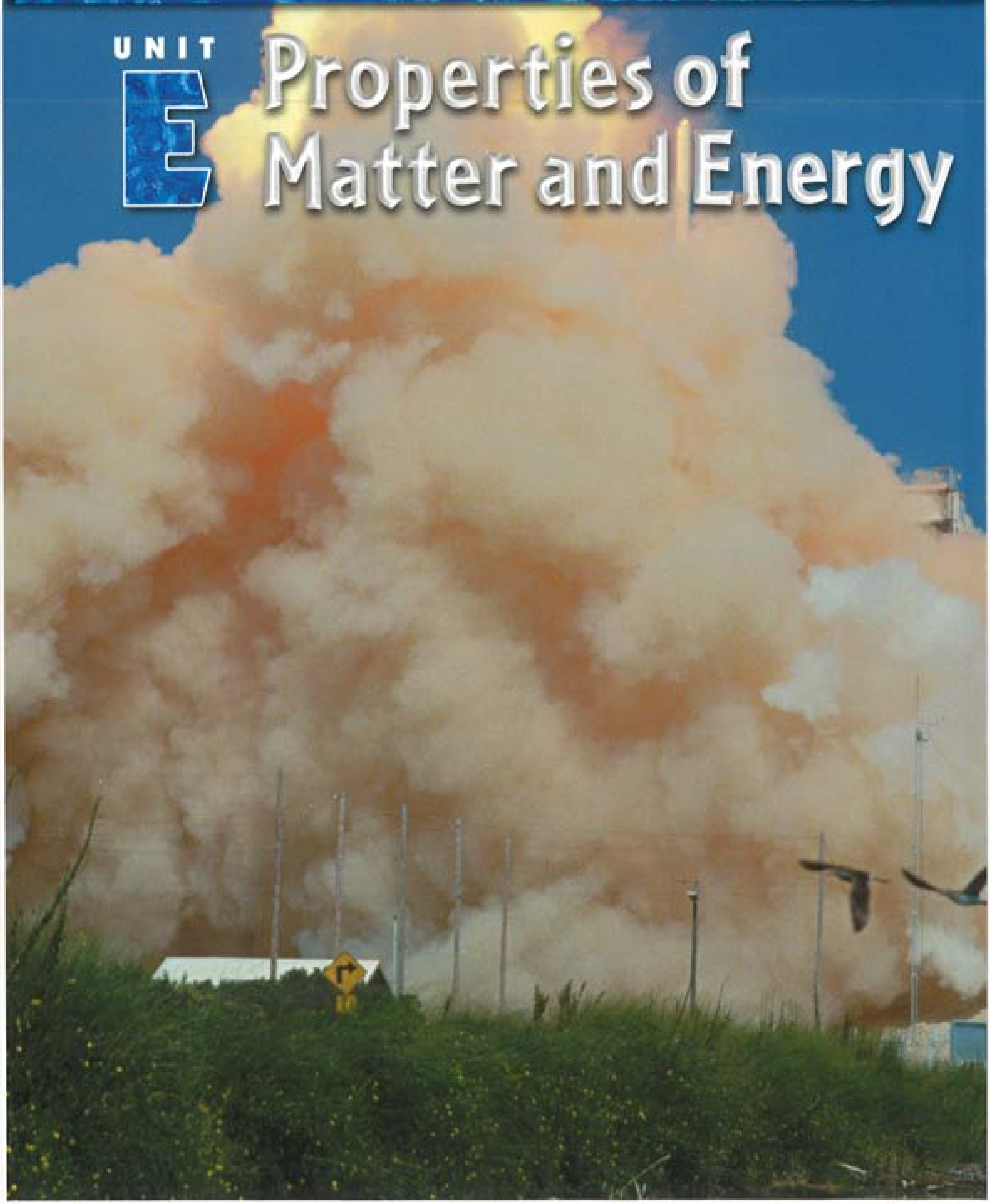
Physical Science

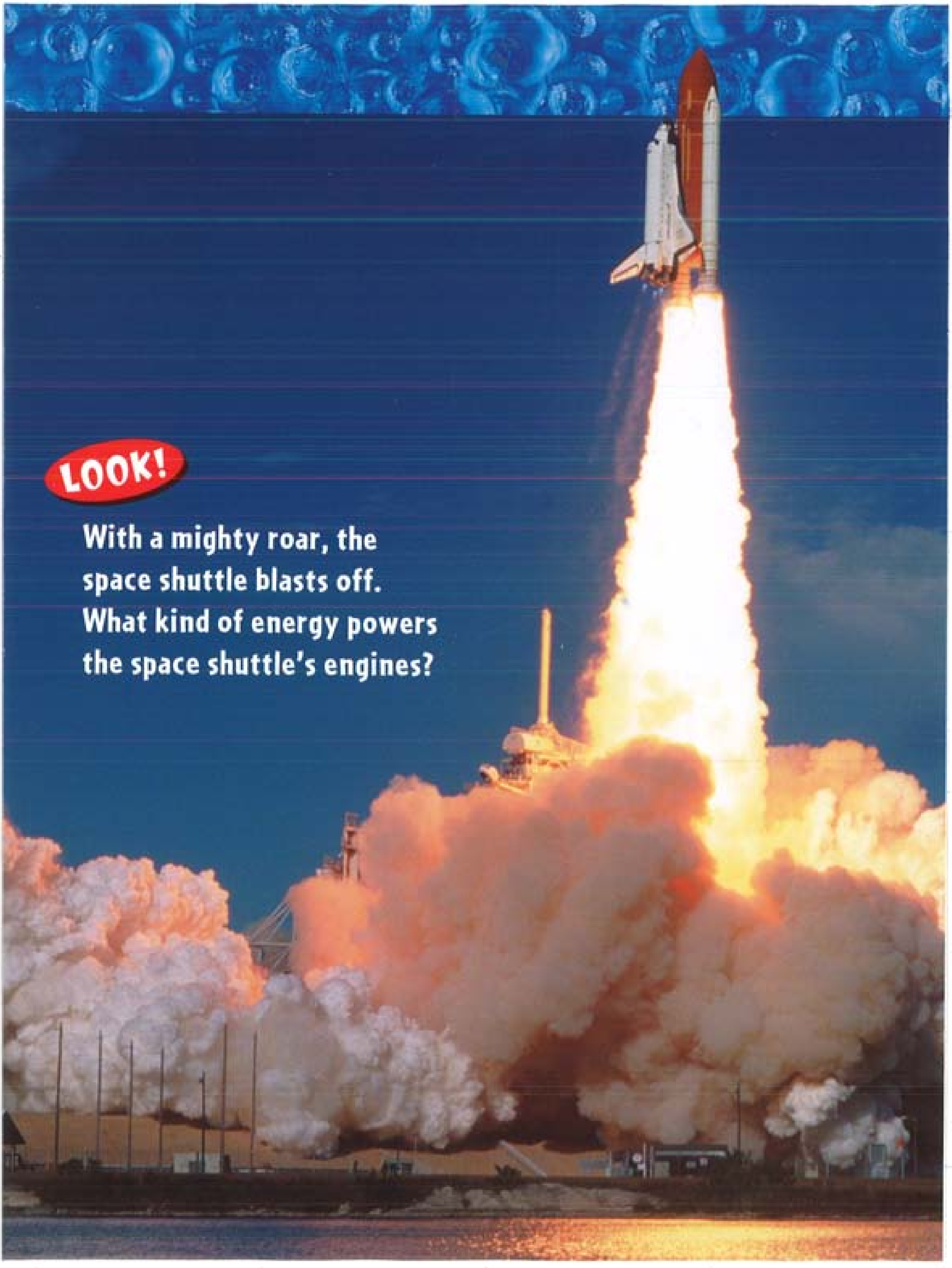
UNIT E

Properties of Matter and Energy



LOOK!

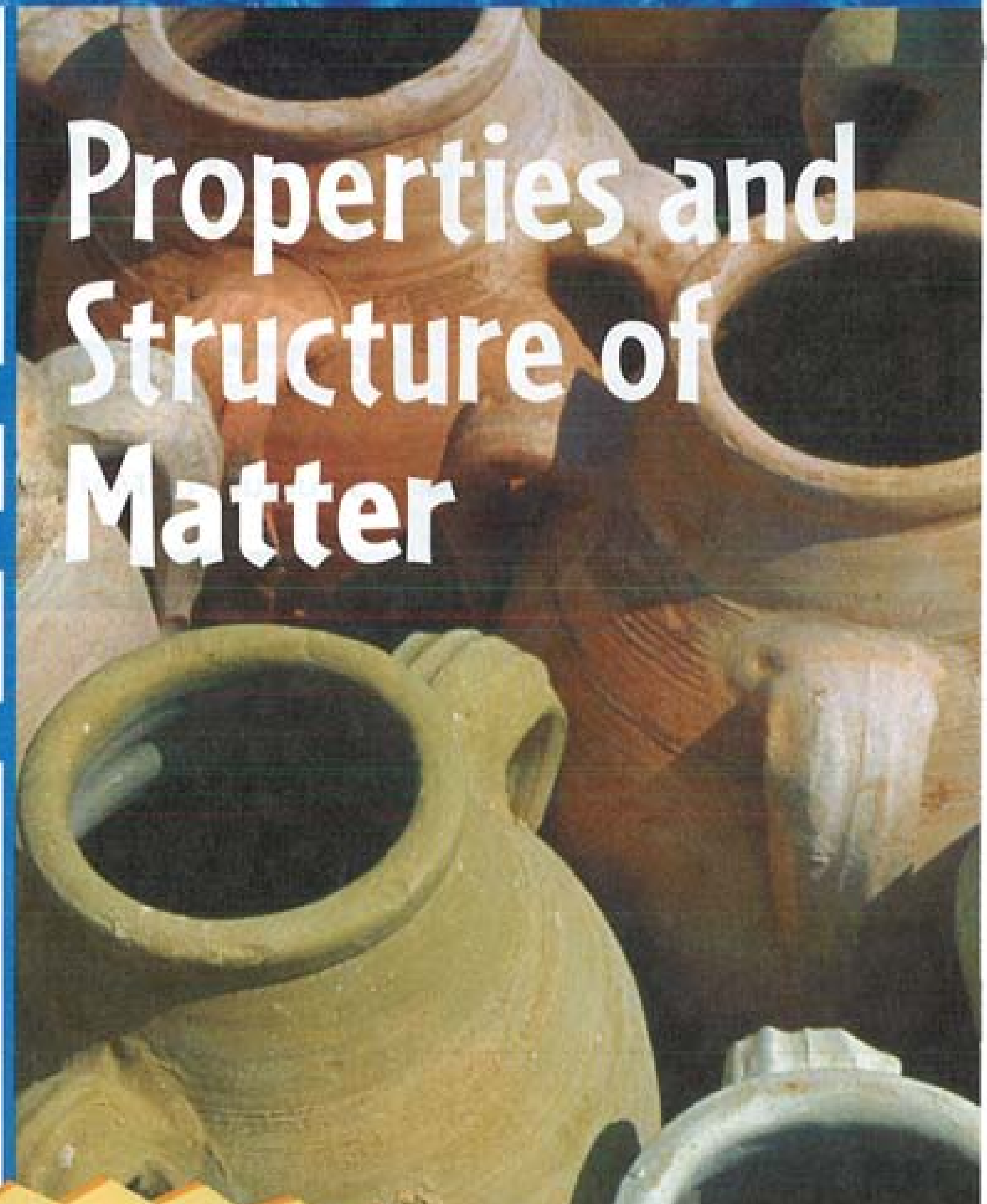
With a mighty roar, the space shuttle blasts off. What kind of energy powers the space shuttle's engines?



Properties of Matter and Energy

CHAPTER 12

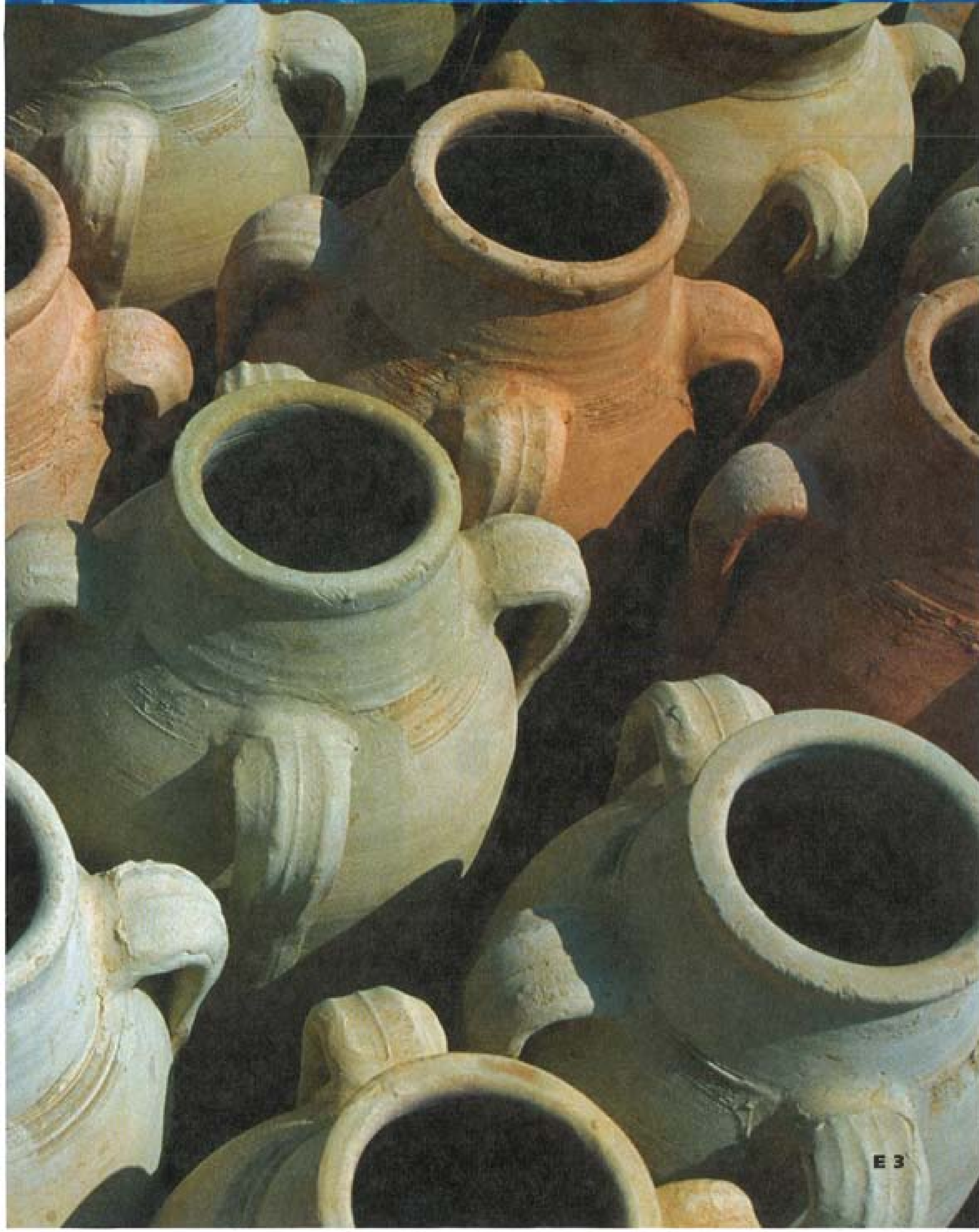
Properties and Structure of Matter



Did You Ever Wonder?

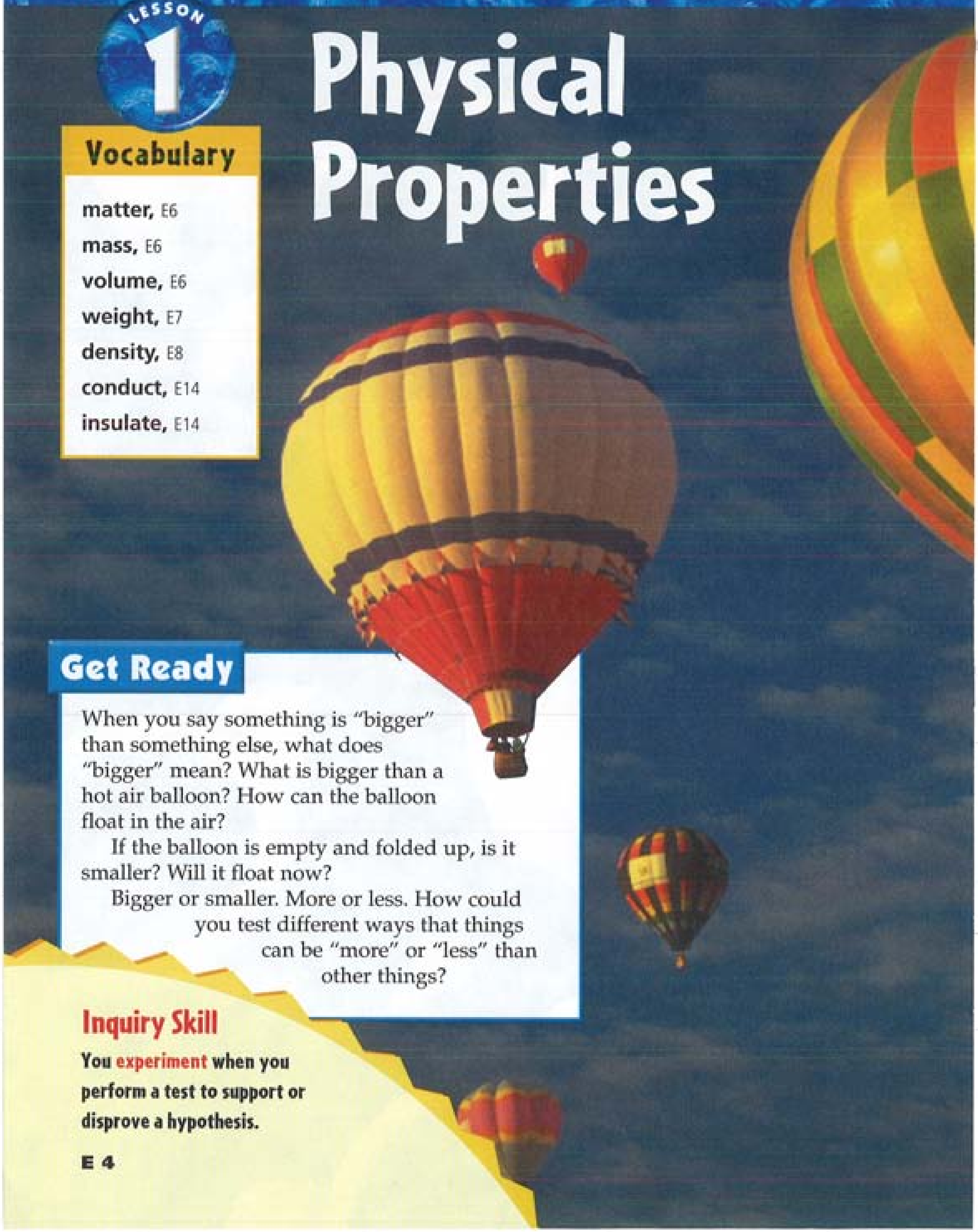
How can potters use their talent and creativity to turn clay and water into beautiful vases? When wet, clay has certain physical properties that allow potters to shape it into different forms. What happens to the clay when the vases are dried in a hot kiln, or oven?

INQUIRY SKILL **Classify** One property of clay is that it is heavy. Make a list of movable things you have touched in the last hour. Rearrange the list from the heaviest to the lightest items.



LESSON 1

Physical Properties



Vocabulary

matter, E6
mass, E6
volume, E6
weight, E7
density, E8
conduct, E14
insulate, E14

Get Ready

When you say something is "bigger" than something else, what does "bigger" mean? What is bigger than a hot air balloon? How can the balloon float in the air?

If the balloon is empty and folded up, is it smaller? Will it float now?

Bigger or smaller. More or less. How could you test different ways that things can be "more" or "less" than other things?

Inquiry Skill

You experiment when you perform a test to support or disprove a hypothesis.

Explore Activity

Which Is More?

Procedure: Design Your Own

1 **Observe** Look at the golf ball (or wooden block) and blown-up balloon. Which is "more"? Think of how one object could be "more":
- more when you use a balance
- more when you put it in water and see how much the water level goes up, and so on

Record your observations.

2 Use the equipment to verify one way that one object is more than another. Decide which of the two objects is "more" and which one is "less."

3 Repeat your measurements to verify your answer.

4 Now use different equipment to compare the two objects. Is the same object still "more"? Explain.

5 Repeat your measurements to verify your answer.

Drawing Conclusions

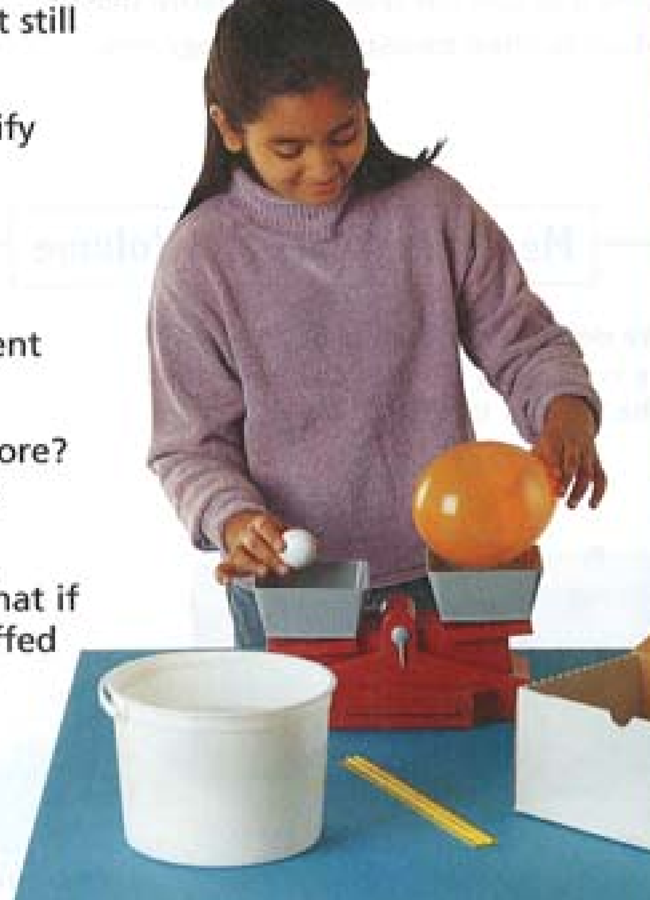
1 **Communicate** Identify the equipment you used. Report your results.

2 For each test, which object was more? In what way was it more than the other object?

3 FURTHER INQUIRY **Experiment** What if you were given a large box of puffed oats and a small box of oatmeal? Which do you think would be more? Design an experiment to test your hypothesis. Tell what equipment you would use.

Materials

- golf ball or wooden block
- blown-up balloon
- equal-pan balance
- ruler
- string
- box, such as a shoe box
- pail of water



Read to Learn

Main Idea **Matter is anything that has mass and occupies space.**

What Is Matter?

All of the gases, liquids, and solids in the world around you—the air you breathe, the water you drink, and the chair you sit on—are made of **matter**. Testing to see whether a golf ball or a balloon is "more" measures *properties* of the matter in these objects.

A golf ball has more **mass** because it tips the balance more. However, a balloon has more **volume** because it fills up a greater amount of space.

Mass is a measure of the amount of matter in an object. The photo shows how a balance is used to measure mass. Mass is often measured in kilograms.

Volume describes how much space a sample of matter takes up. Volumes are often measured in milliliters (mL). As the photo shows, the volume of a liquid may be measured using a graduated cylinder, a beaker, or a measuring cup. The volume of a solid may be measured by multiplying its height times its length times its width. Solids don't always have regular shapes, however. We can also measure the volume of a solid by seeing how much water it displaces from a container. A solid with a volume of 1 cm^3 will make the water rise 1 mL, for example. A volume of 1 cm^3 equals 1 mL.

Matter is defined using the properties of mass and volume. Matter is anything that has mass and takes up space.

Measuring Mass and Volume

We determine the mass of an object by comparing it with known masses. The mass of this block is 25 g.


Equal-pan balance


Measuring cup


Graduated cylinder


Beaker

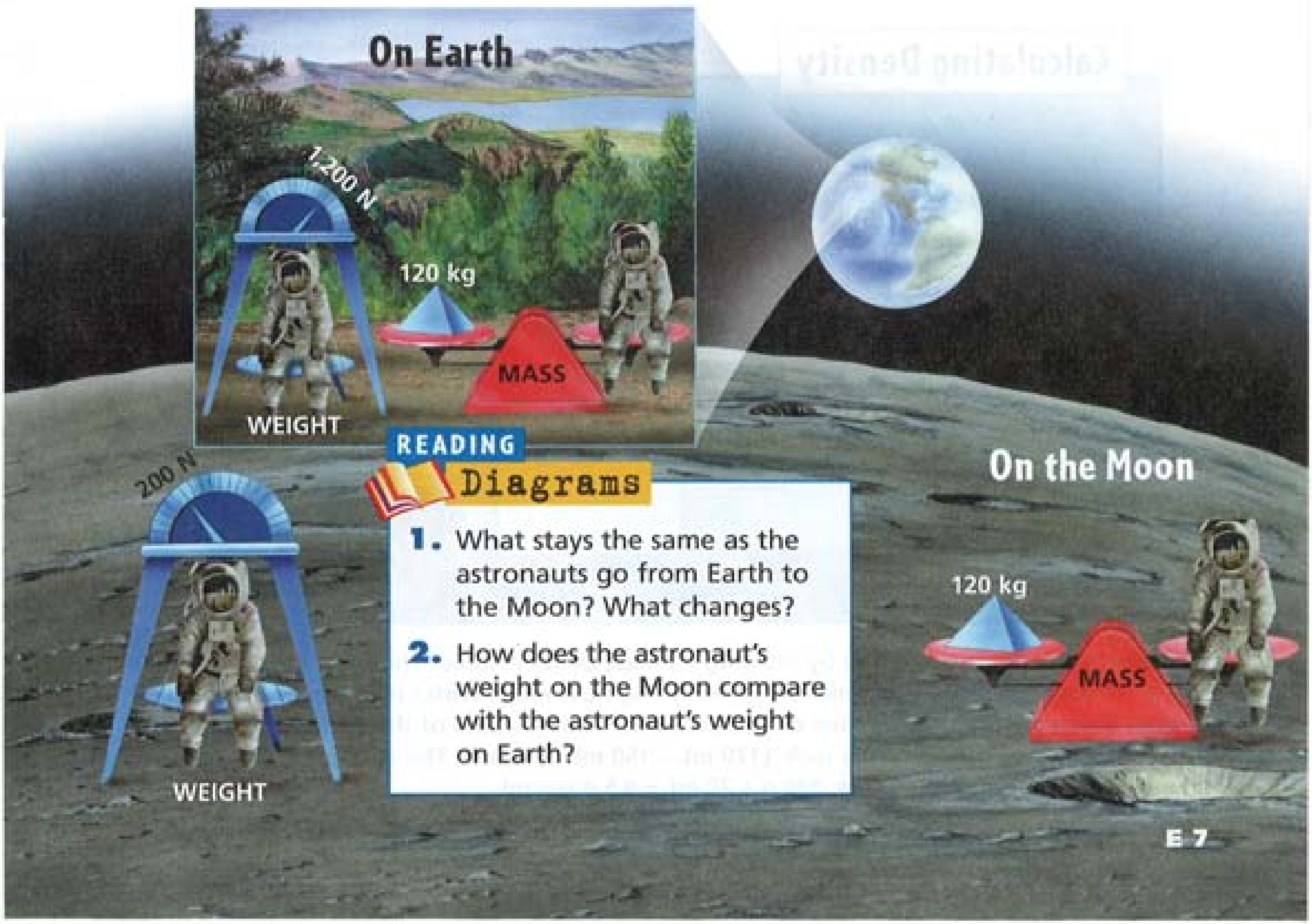
Weight

What if you find the mass of a certain book to be 1 kilogram? You might be tempted to say, "This book weighs 1 kilogram." However, this is incorrect. The book's **weight** is actually the force of gravity between Earth and the book. The book's mass, on the other hand, is a measure of the amount of matter in the book compared with known masses.

As you know, we can use kilograms to measure an object's mass. However, to measure weight, we must use a quantity that describes the force of gravity between two masses. Scientists prefer to use a quantity called the *newton* (N) to measure force. One newton is the same as 0.22 pound. (One pound is 4.45 newtons.) Newtons and pounds both describe the amount of pull or push a force produces. In this case the force is the pull of gravity.

An object's weight depends on its location in the universe. If you were to travel to the Moon, for example, you would have less weight. The Moon has less mass than Earth, so the force of gravity between your body and the Moon would be less. However, your mass would remain unchanged, as shown in the diagram.

What are two properties of matter?



READING Diagrams

1. What stays the same as the astronauts go from Earth to the Moon? What changes?
2. How does the astronaut's weight on the Moon compare with the astronaut's weight on Earth?

What Is Density?

As you learned on page E6, mass and volume are two properties of matter. Can we use these properties to tell us more about matter? How can these two measurements tell us something new?

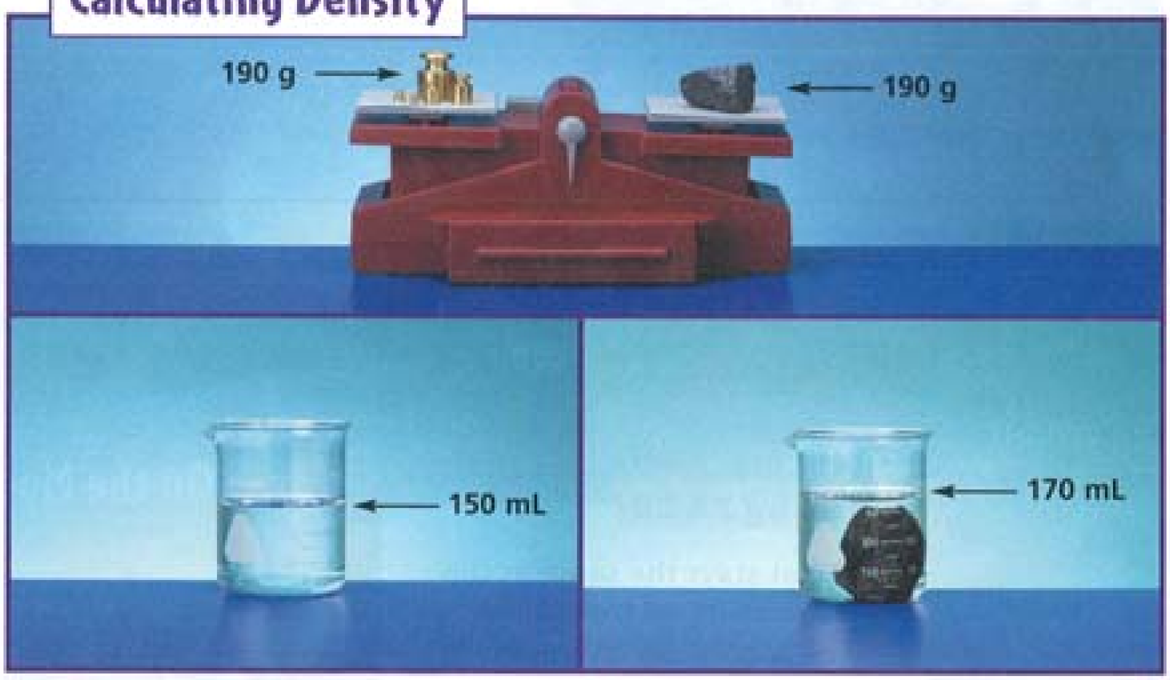
If we divide the mass of a sample by its volume, we get a new measurement of matter. This property is called **density**. The density of an object tells us how massive something is for its size. It compares an object's mass with its volume.

Let's look at an example. If 2 mL of water has a mass of 2 g, then 2 g divided by 2 mL equals 1 g per mL. The density is 1 g per mL. If we combined that water sample with another 2 mL sample, we would have 4 mL and 4 g of water. The density would still be 1 g per mL.

As long as conditions, such as temperature, do not change, the density of a substance does not change. The size of the sample does not matter. Density can be used to help identify materials because of this. If you had a piece of metal with a density of 11.3 g per mL, it would probably be lead. A similar-looking piece with a density of 2.7 g per mL, however, would probably be aluminum. Each material has its own density.

How can density be measured?

Calculating Density



An object's density is calculated by dividing its mass by its volume. The mass of this rock is 190 g. Its volume can be determined by calculating how much water it displaces from the beaker. If you subtract the volume of the water from the volume of the water plus the rock, you get the volume of the rock. (170 mL – 150 mL = 20 mL). The volume of this rock is 20 mL. The density of this rock is: 190 g ÷ 20 mL = 9.5 g per mL.

Inquiry Skill BUILDER

SKILL **Make a Model**

How Metal Boats Float

Think about objects that have more matter packed into the space they take up than water does. Will such objects sink or float in water? You have probably seen how a metal object like a nail or a spoon sinks in water. However, huge ships made of similar metal float even when they carry large cargoes. How is this possible? In this activity you will make different sized models of a metal boat. Scientists use models to help them understand properties of matter. Models also make experimenting easier. Try different designs to see how well the model boats can carry heavy cargo.

Materials

- aluminum foil
- large paper clips
- pan of water

Procedure

1. **Make a Model** Prepare 3 sheets of aluminum foil of different sizes. Record their lengths and widths and use them to make 3 boats. Experiment with different designs and float them on water.
2. **Predict** Write down what you think will happen when you place more and more matter in the empty space of the boat. What steps should you follow to test your prediction? Be sure to use only the materials listed above.
3. **Experiment** Carry out your procedure, keeping a written record of what you observe.

Drawing Conclusions

1. **Communicate** How well did your results agree with your prediction?
2. Compare your model with those of your classmates. Which boat held the most clips? Why?
3. **Make a Model** The aluminum foil boat is a model of a steel ship. Use the way your boat floats to explain how a steel ship floats. Why was using a model of a large ship helpful?
4. **Communicate** What changed as more and more matter was added to the empty space of the boat? What happened as a result of this change?

How Dense Are Solids, Liquids, and Gases?

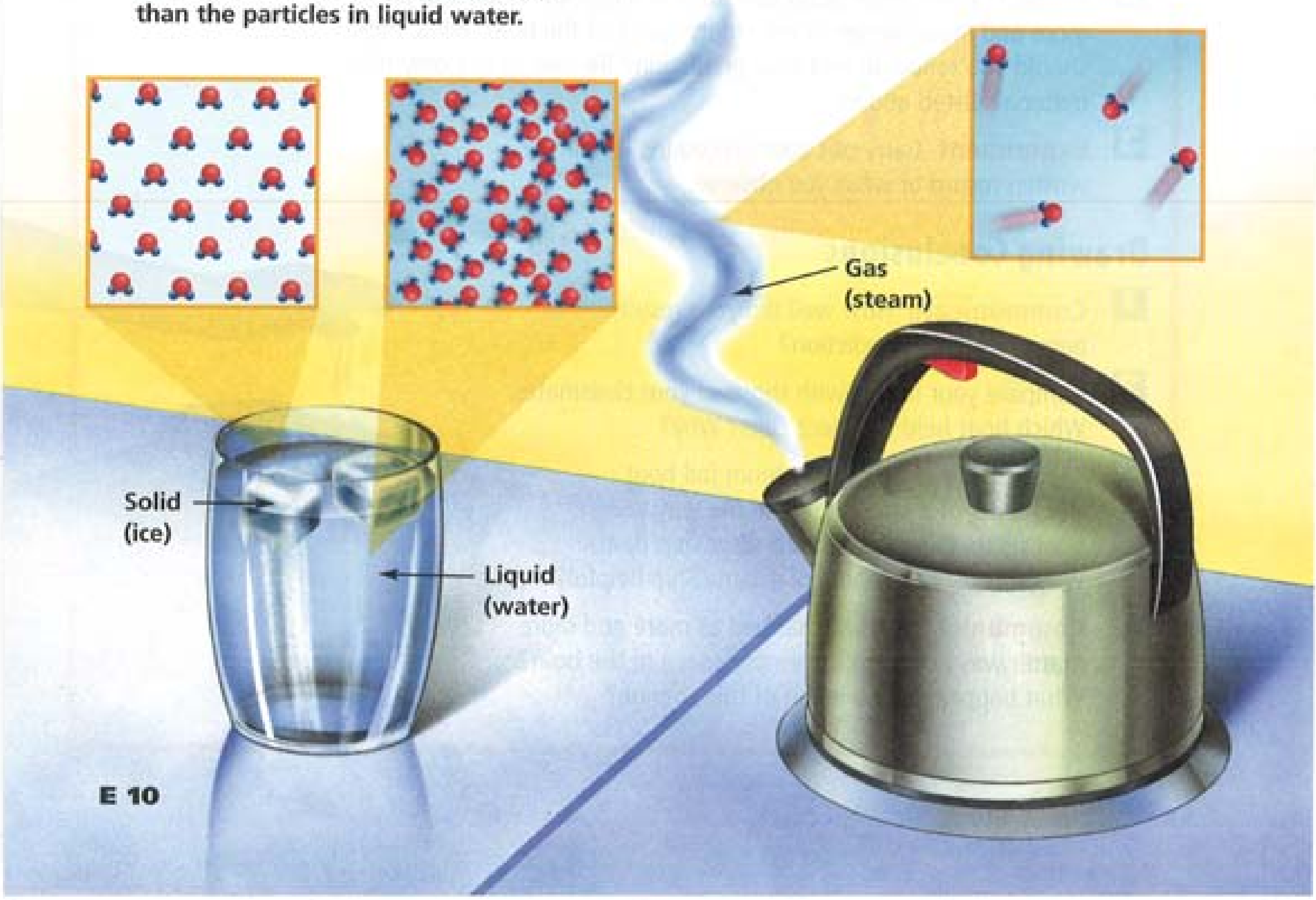
Think of cutting a piece of aluminum foil into smaller and smaller pieces until the pieces are tinier than specks of dust. All matter—solids, liquids, and gases—is made of similar tiny particles. An object's mass is related to the number and type of particles it has.

Density describes how tightly these particles are packed together. A high density means that many particles are packed tightly into a given space. A low density means that only a few particles fill the same amount of space.

The particles of a solid tend to be packed tightly together. They don't have a lot of room to move around. However, the particles of a gas usually spread out. In general, matter in the solid state is more dense than in the liquid state. Likewise, matter in the liquid state tends to be more dense than in the gaseous state.

READING Main Idea
How do the densities of solids, liquids, and gases compare?

Water is special! Solid water, ice, is less dense than liquid water. The particles in ice are more spread out than the particles in liquid water.



Densities of Common Substances

State	Substance		Density (g/cm³)
Solid	 Aluminum	 Gold	Aluminum, 2.7 Gold, 18.9
Liquid	 Water	 Mercury	Water, 1.0 Mercury, 13.5
Gas	Helium 	 Air	Helium, 0.00018 Air at sea level, 0.0012

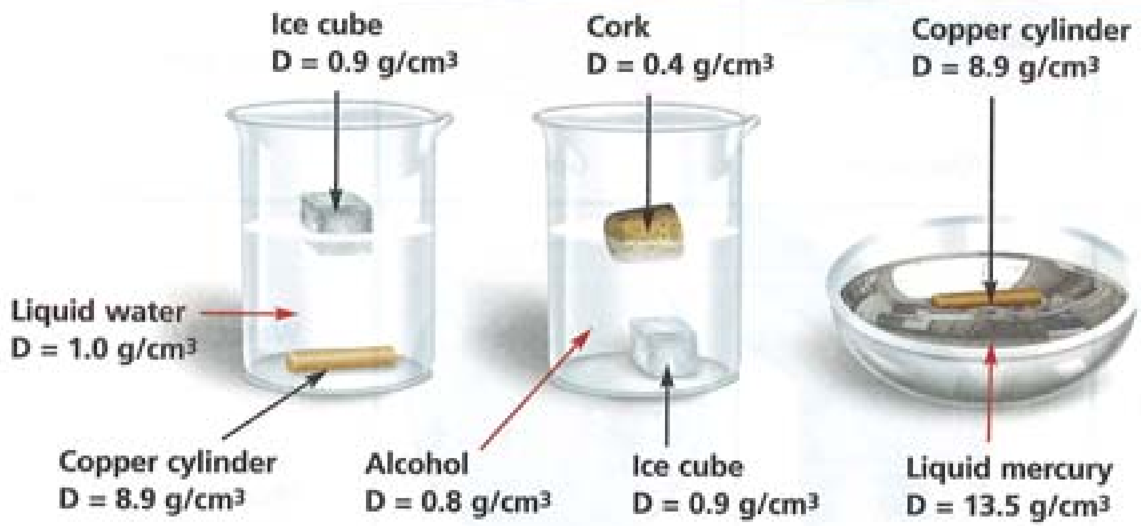
READING Charts

1. Which is denser—aluminum or gold? Mercury or gold?
2. Organize the substances in the chart from the least dense to the most dense. Make a bar graph with the densities of these substances.

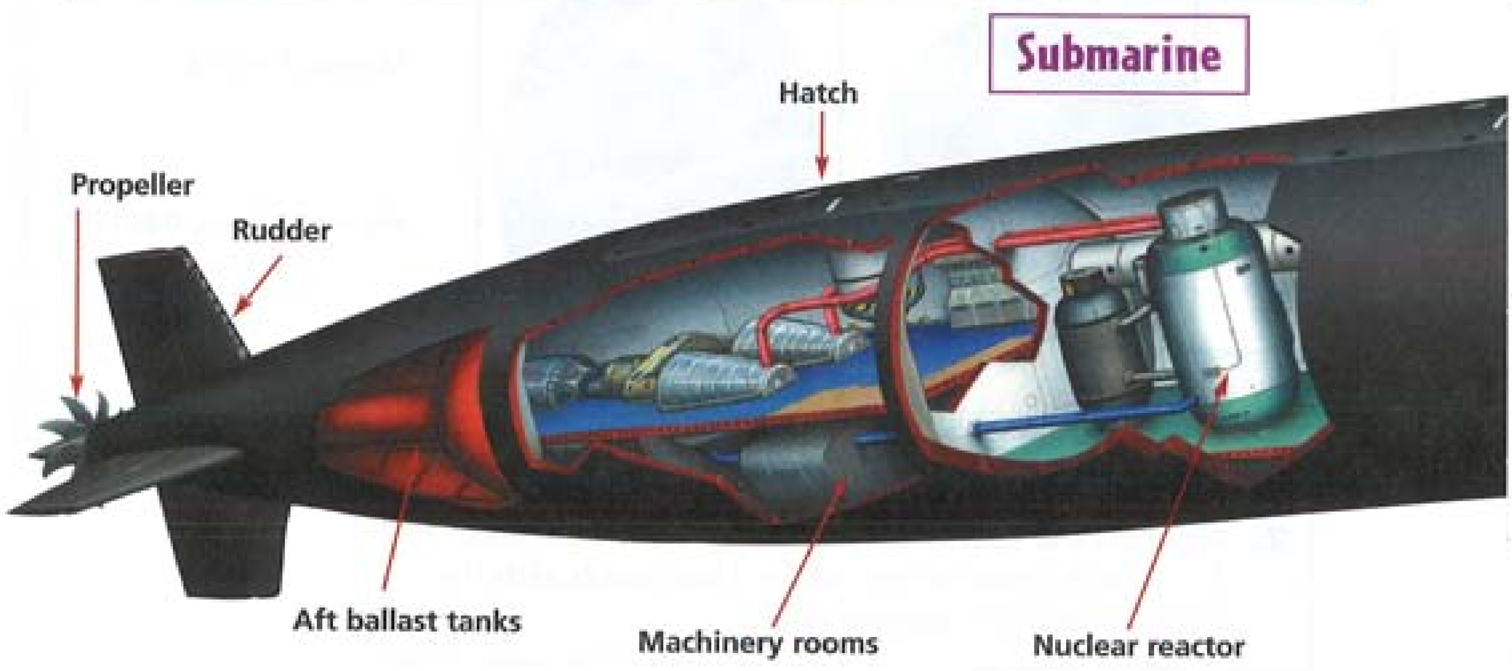
How Does Density Make Things Sink or Float?

Have you ever observed a beach ball floating in a pool? Have you ever dropped your towel in the water, only to see it sink to the bottom? What makes some things float, and others sink?

Density determines an object's ability to sink or float. An object floats in a liquid when its density is less than the liquid's density. A beach ball is filled with air. Air is less dense than water, so the beach ball floats. We describe an object's ability to float as its *buoyancy* (BOY·uhn·see).



Why does ice float in water? Why does it sink in alcohol? The copper cylinder floats in mercury but sinks in water. Do you think it will sink or float in alcohol?

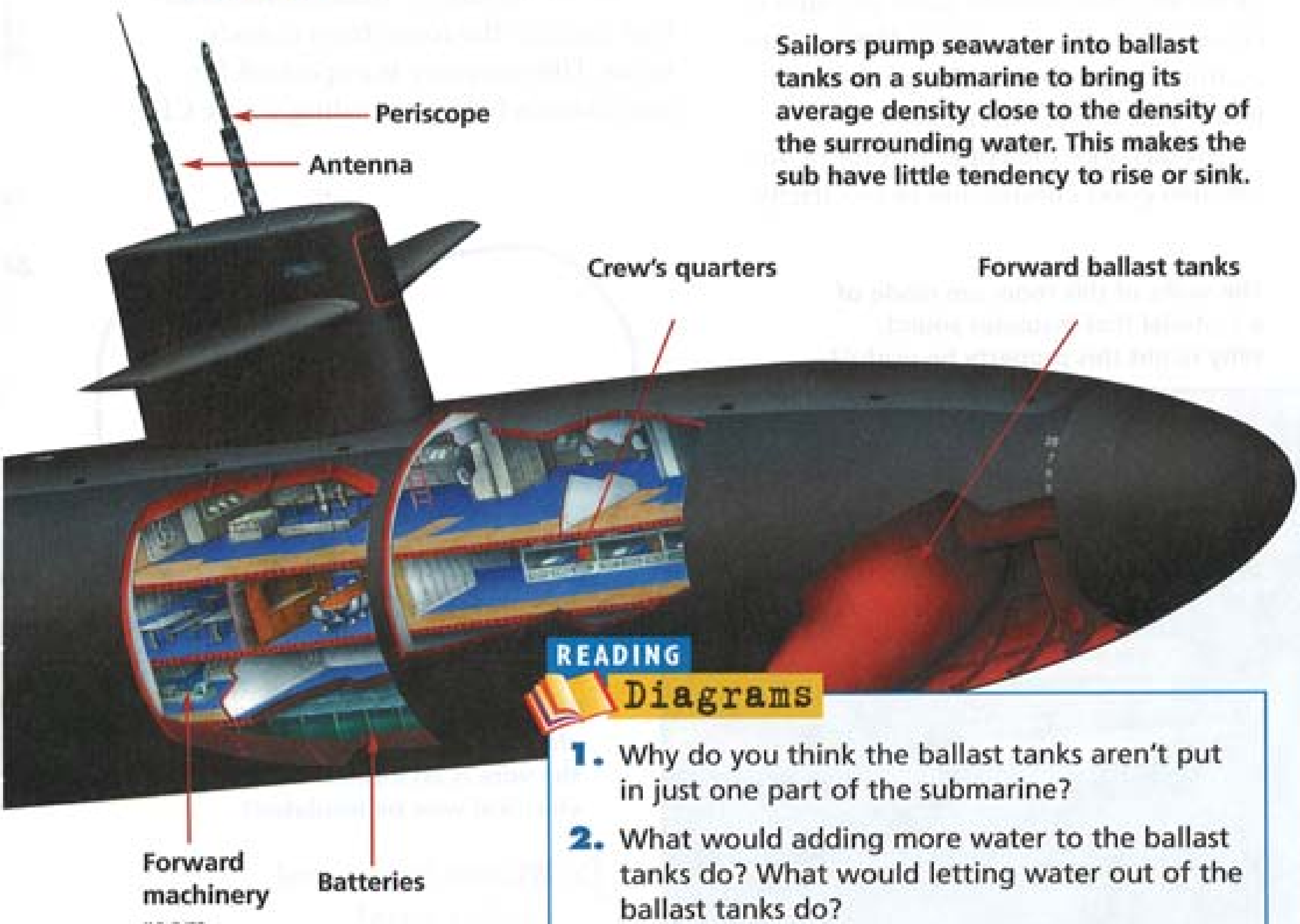


Helium balloons can float, too. However, they float in air instead of water. Helium is less dense than air, so helium balloons rise into the sky.

As you know, not all objects float. An object sinks in a liquid when it is more dense than the liquid. The copper cylinder shown in the diagram sinks in water. The ice cube sinks in alcohol.

It's easy to float in the Dead Sea because salt water is denser than fresh water. The Dead Sea has the densest saltiest water on Earth. Swimmers float higher in this sea than in ocean water.

How does density determine an object's ability to float in water?



Sailors pump seawater into ballast tanks on a submarine to bring its average density close to the density of the surrounding water. This makes the sub have little tendency to rise or sink.

READING Diagrams

1. Why do you think the ballast tanks aren't put in just one part of the submarine?
2. What would adding more water to the ballast tanks do? What would letting water out of the ballast tanks do?

What Are Conductors and Insulators?

Which material in this pan is a conductor? Which is an insulator?

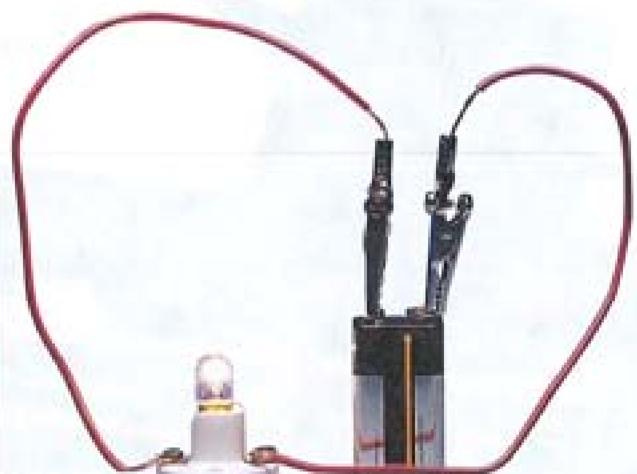
Matter has many important properties besides density. For example, some materials conduct energy very well. These materials allow energy to flow through them easily. However, other materials insulate against the passage of energy. They do not readily permit energy to flow. Look carefully at the photographs to learn about materials that conduct or insulate.

Cooking pots and pans are made of metal because metal conducts heat well. However, they should have wooden or ceramic handles. Such handles insulate against heat so you don't get burned when you touch the handles.

Metals, like the copper in the wire, are also good conductors of electricity. The electricity flows from the battery to the light bulb through the wire, producing light and heat. The plastic that coats the wire is an insulator. Anyone who touches the plastic coating will not be shocked, because the electricity cannot pass through it.

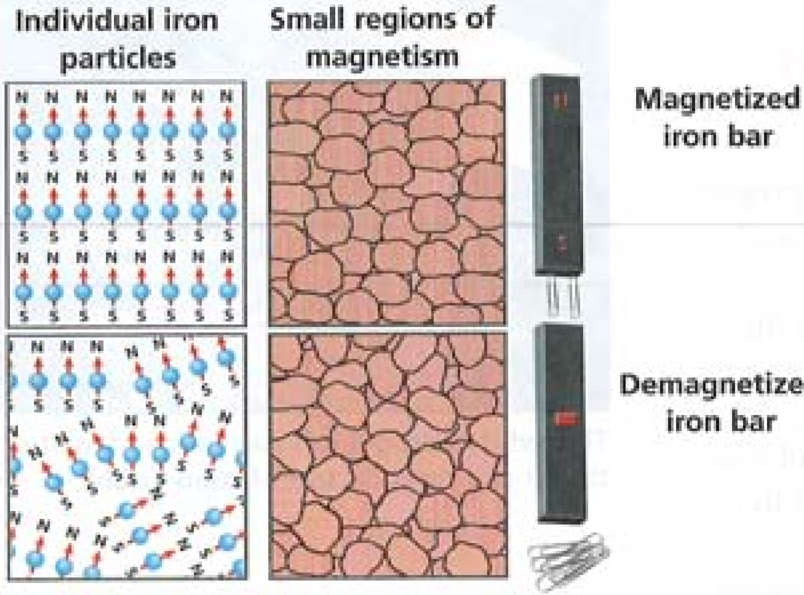
Sound booths are made of materials that insulate the room from outside noise. This property is important for musicians who are recording a new CD.

The walls of this room are made of a material that insulates sound. Why might this property be useful?



The wire is a good conductor of electricity. The plastic that coats the wire is an insulator. Why must electrical wire be insulated?

What do *insulate* and *conduct* mean?



When iron particles in small areas of the metal line up, a permanent magnet is formed.

What Is Magnetism?

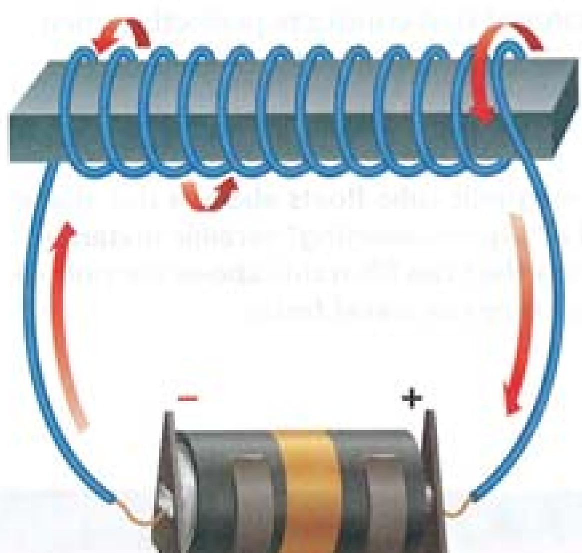
What makes a material magnetic?

Certain objects push or pull on each other because they are *magnetic*. Magnetism is another property of some kinds of matter. A magnet has a north pole and a south pole. North poles and south poles of magnets attract, but two poles that are alike repel. Magnets can also attract certain materials that are made of a metal like iron.

Like density, magnetism results from the combined effect of the properties of tiny particles. In iron, for example, each tiny particle of iron is itself a magnet.

Look at the diagram above. Each particle has a north and a south pole. When the particles line up, the material is magnetic. When the particles do not line up pole to pole, however, the material is not magnetic.

Earth acts like a huge magnet. A compass needle is a magnet that points to the Earth's magnetic North pole.



The electric current flowing through the coils lines up the iron core particles pole to pole, making a strong electromagnet. Without the current, the lineup ends and the magnetism disappears.

How Do We Use Properties of Matter?

Engineers and scientists use properties of matter when they design and build new things.

Aerogels are new materials with very low density and relatively great strength. They are made of tiny pockets of air surrounded by thin walls of silica. Silica is the same material found in sand and in window glass.

Aerogels are very good insulators of heat. Insulated windows containing aerogel would be from 10 to 20 times better at holding in heat than ordinary glass windows.

Scientists have discovered that some materials become perfect conductors of electricity when they are very cold. The photo shows a ceramic, glasslike material that conducts perfectly when cooled to –196°C (–320.8°F).

This white aerogel has such a low density that it can float on top of soap bubbles.

How are properties of matter used?

A magnetic cube floats above a disk made of a "superconducting" ceramic material. This effect can lift trains above the rails so that they can travel faster.

Lesson Review

L·I·N·K·S

Why It Matters

You use many different properties of matter every day. Matter that conducts electricity lets you use a reading lamp at night or listen to your favorite CDs. Density allows you to float in a boat on a lake or float through the sky in a hot air balloon. Magnets help you find your way home with a compass.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on properties and structure of matter.

Think and Write

1. List four properties of matter.
2. If a rock was taken from Earth to the Moon, how would its mass and weight be affected?
3. What if you had rubber bands, wood chips, straight pins, aluminum foil, and glass beads? Using a property of matter, classify these objects. Show your results in a table.
4. INQUIRY SKILL **Make a Model** Design a strong, light (up to 100 g), cardboard structure to bridge a 30-cm gap. How much weight can it support?
5. **Critical Thinking** Think of the properties of matter you use every day. In what ways are they important to you?

WRITING LINK

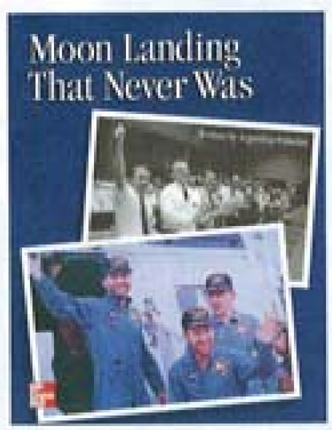
Personal Narrative Write about a typical day from the time you get up until the time you go to sleep. Tell the events in order. What properties of matter do you rely on to get to school, do your homework, and play with your friends?

MATH LINK

Calculate density. Find some small objects around your classroom or house—a seashell, a rock, or even a piece of fruit. Measure its mass and its volume. Use its mass and volume to find its density.

LITERATURE LINK

Read *Moon Landing That Never Was* to learn about the spacecraft *Apollo 13*. Try the activities at the end of the book.



TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.

Animals: Icy Survival

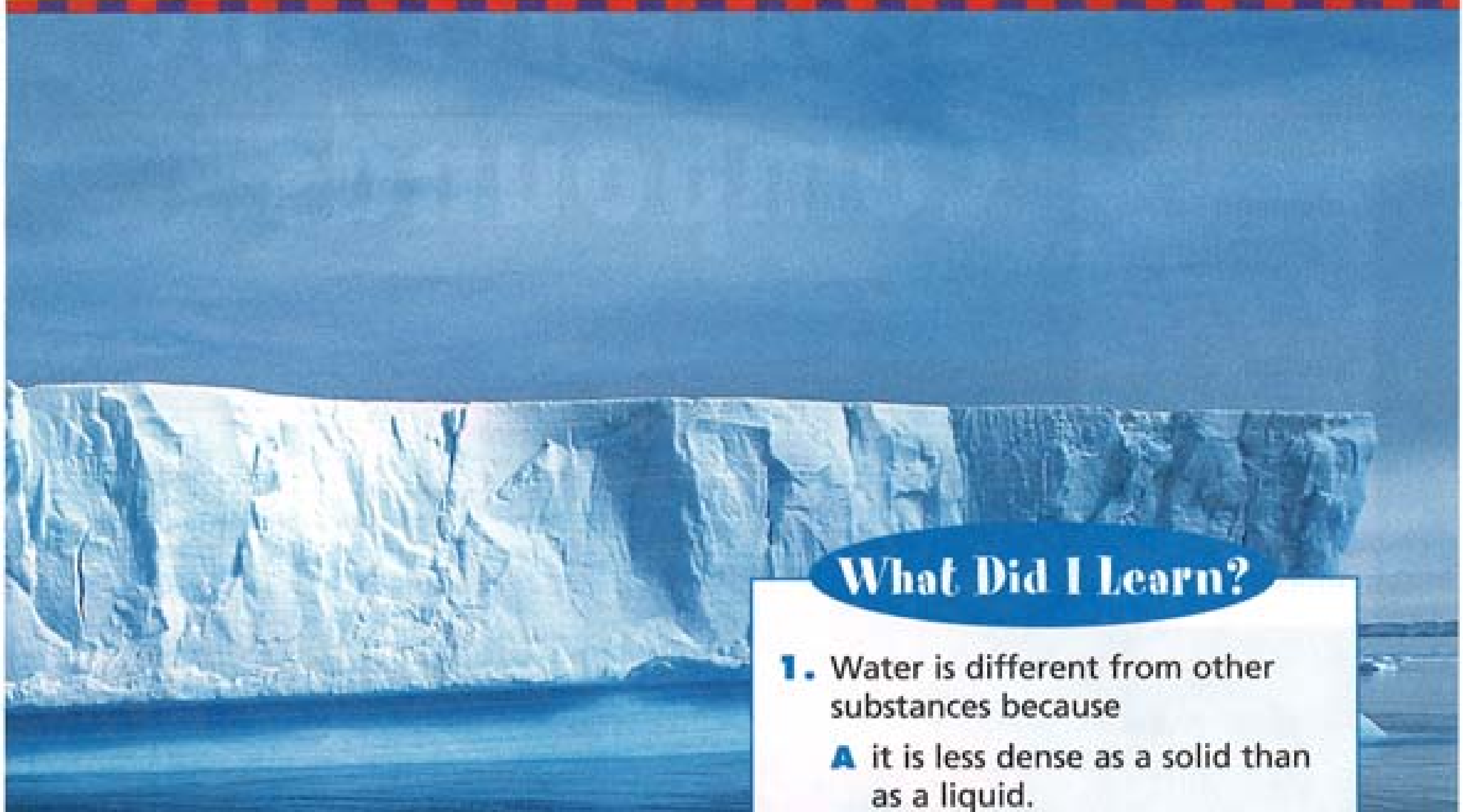
Imagine a world where water's like most other substances—it becomes denser as it freezes. Ice, now heavier than water, sinks to the bottoms of ponds. The water quickly freezes from the bottom up into solid blocks of ice. Fish in the ponds freeze, too. That's the end of most freshwater fish.

In summer the ice near the tops of the ponds melts, but not the ice at the bottom. That ice never melts. Each summer things get worse. Before long there's no liquid water left on Earth!

Luckily that scenario is science fiction, but real water is stranger than science fiction! Why doesn't it become denser when it turns solid? The answer lies in what happens when water molecules get cold enough to freeze.

As you know, water molecules are made of two hydrogen atoms and one oxygen atom. When water freezes, the molecules are kept farther apart than they are in liquid water.

Ice is only nine-tenths as dense as liquid water, so when water freezes, it expands. A given volume of ice weighs



less than the same volume of water. That's why ice floats in your lemonade!

Ice forms a protective covering for ponds. Under the ice the water stays liquid, allowing plants and animals to survive the winter. Because ice floats, oceans have icebergs. They can mean trouble for ships, because most of an iceberg is underwater. Look at the ice cube in your next drink. How much of it is under the surface?

What Did I Learn?

1. Water is different from other substances because

A it is less dense as a solid than as a liquid.
B it is more dense as a solid than as a liquid.
C its molecules are packed more tightly as a solid.
D none of the above

2. Ice helps plants and animals in ponds survive by

F preserving their habitat.
G providing more molecules of water.
H keeping the temperature low.
J forming a protective covering.

LOG ON Visit **www.science.mmhschool.com** to learn more about survival in cold.

LESSON 2

Elements and Compounds

Vocabulary

element, E22
compound, E24
atom, E26
proton, E27
neutron, E27
electron, E27
nucleus, E27
molecule, E30

Get Ready

Look at Jupiter! It's hidden by dense clouds. Are they similar to Earth's clouds? What is Jupiter made of "beneath" its clouds?

Here's a similar question. What is matter made of? Scientists share information as they seek answers to their questions.

If you cannot "look inside" something—a planet or a piece of matter—how can scientists tell what a planet or any piece of matter is made of?

Inquiry Skill

You communicate when you share information.

Explore Activity

How Do We Know What's "Inside" Matter?

Materials
- 3 identical, sealed, opaque boxes
- equal-pan balance with set of masses
- magnet

Procedure

1. **Observe** Examine the three boxes, but do not open them. You can lift them, shake them, listen to the noises they make, feel the way their contents shift as you move them, and so on. Use the magnet and balance to obtain more data about the unknown contents. Record your observations.
2. **Infer** Try to determine what is in each box.

Drawing Conclusions

1. **Communicate** Describe what you think is in each box.
2. How did you make your decisions?
3. Do these boxes have anything in common? In what ways are they similar? In what ways are they different?
4. **FURTHER INQUIRY** **Experiment** What if you have a can of peanuts and a can of stewed tomatoes? The cans look the same except for the labels. Now what if your baby brother takes the labels off? You want the peanuts, but you don't want to open the tomatoes by mistake. What experiments can you do to find out what is inside—before you open the cans?

Read to Learn

Main Idea All matter is made of elements.

What Is Matter Made Of?

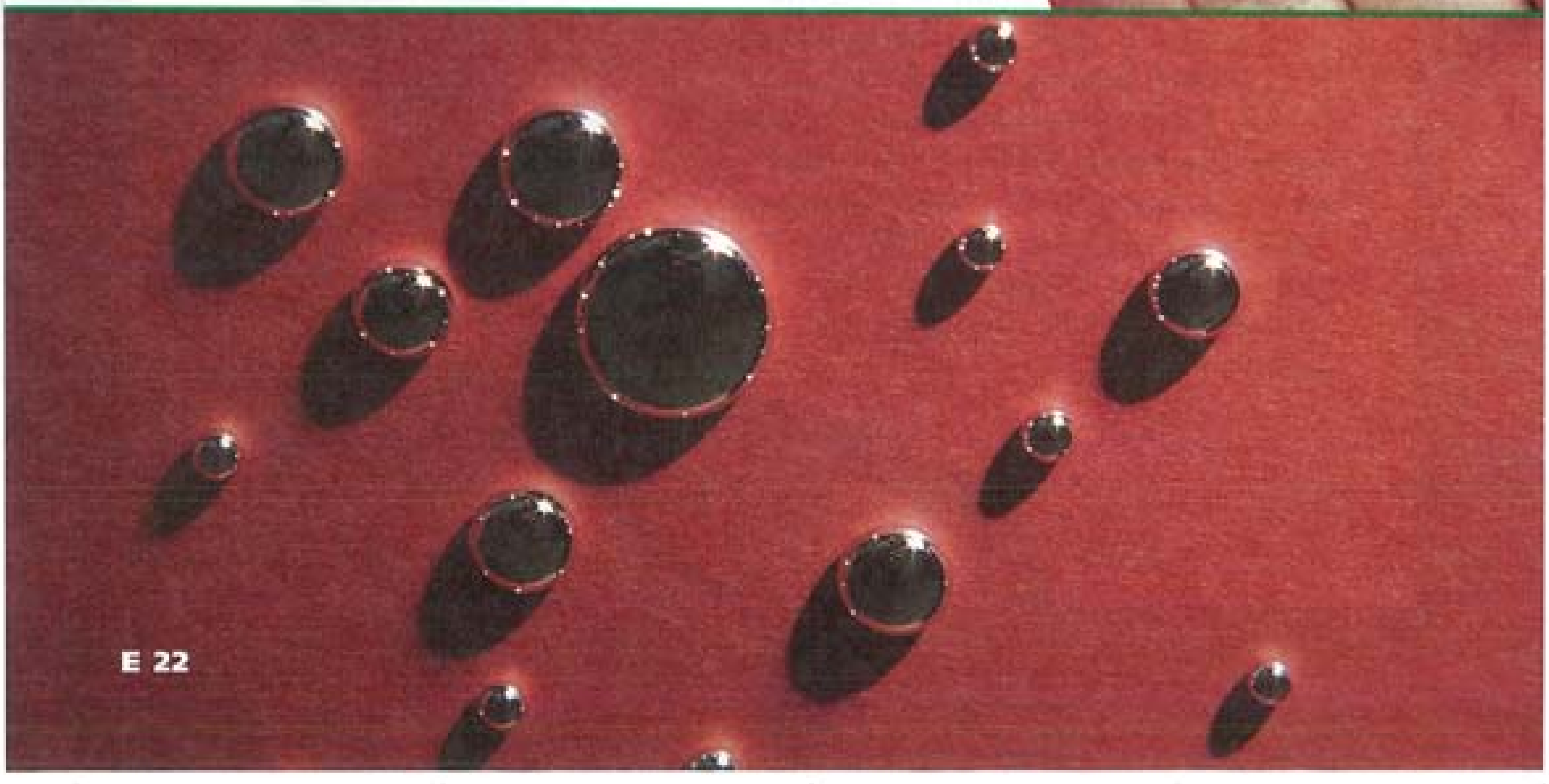
In studying matter scientists face a challenge. The basic particles that make up matter are too small to be seen directly. In the past the tests scientists performed on matter gave only hints about how matter is put together. That's because particles of matter cannot be observed.

People have experimented with matter for thousands of years. In ancient times the goal was often a practical product like a colorful dye, a metal sword, or a plow. In recent centuries matter has also been studied with carefully planned scientific experiments.

The ancient Greek philosopher Aristotle believed that all matter was composed of four elements—earth, air, fire, and water. However, during the last three centuries, scientists have identified the true chemical **elements**. These substances are the basic building blocks of all matter. One of the most interesting elements is shown in the photograph at the bottom of the page. It expands evenly when warmed and makes a good liquid for thermometers. What is it?

This bronze coin was made about 2,500 years ago. Bronze is made by mixing the metals copper and tin.

The element mercury is also known as liquid silver. It is beautiful but highly poisonous. Mercury is often used in thermometers. Why?



The Elements

Elements are pure substances that cannot be broken down into any simpler substances. You are probably familiar with many of them. Several are shown in the photographs. How many do you recognize?

Many elements have been known since ancient times but were not truly recognized as elements until the last few centuries. Other elements were found for the first time only recently. For example, germanium was not discovered until 1885. Also, some elements are not even found in nature. They have been made by scientists in nuclear reactors and huge machines called particle accelerators. Even though there are many different elements, living organisms and most materials are made up of just a few elements.

Each element is given a special symbol of one or two letters. The first letter is always a capital. The second letter is never a capital. Sometimes the letters match the English name, such as Ni for nickel or Zn for zinc. In other cases the symbol comes from an ancient name. Gold, for instance, is given the symbol Au from its Latin name, *aurum*.

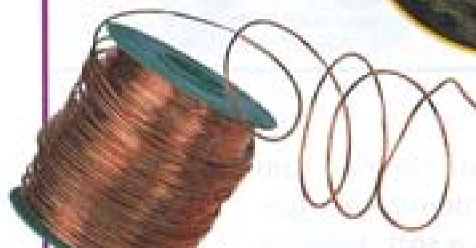
READING **Main Idea**
What are the building blocks of matter?

Gold
Au

Aluminum
Al

Carbon
C

Sulfur
S



Copper
Cu

Oxygen
O

A few elements are pictured here. How many other elements can you name?

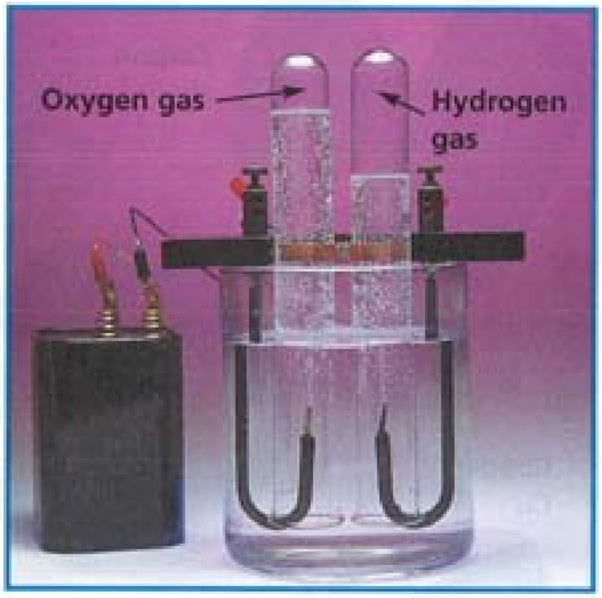
What Are Compounds?

Imagine looking at pure water through a microscope. It would look the same everywhere. Water has this appearance because it is a single substance. However, the photograph below shows how passing electricity through water breaks it apart into two elements, hydrogen and oxygen. If water is a single substance, how could it contain the elements hydrogen and oxygen?

Actually, the hydrogen and oxygen in water are chemically combined. This makes them act like a single substance. Any substance that is formed by the chemical combination of two or more elements is called a **compound**.

All compounds are single substances that can only be broken into simpler substances by chemical reactions. Compounds have different properties than the elements that make them up, as the lower photographs show.

Water is made of hydrogen and oxygen, as this experiment shows.



How is a compound different from an element?

The compound sodium chloride is a solid at room temperature. We use it on our foods to give them more flavor. It belongs to a group of compounds called salts. Salts are always made up of a metal and a nonmetal.

Sodium and chlorine combine to make sodium chloride. Sodium is a soft, reactive metal that can explode on contact with water. Chlorine is a very poisonous gas.

Sodium

+

Chlorine

=

Sodium chloride (table salt)

1 When sulfuric acid is added to sugar, it breaks the compound into its elements.

2 The steamy cloud you observe is condensing water vapor, composed of hydrogen and oxygen.

3 The black solid left behind is carbon.

How Do You Write a Compound's Name?

As you know, each element has a one or two letter symbol. Scientists also write symbols for compounds, which are called *chemical formulas*. A compound's chemical formula contains the symbols for the elements that make it up.

The formula also contains numbers below the element symbols called *subscripts*. The table shows chemical formulas for some familiar compounds.

The subscripts in a chemical formula tell us the number of particles that combine in a compound. For example, water is made up of two elements—hydrogen and oxygen. For every oxygen particle, there are two hydrogen particles. The formula for water is written H_2O.

Table sugar is made up of the elements carbon, hydrogen, and oxygen.

Common Compounds

Compound	Chemical Formula
Water	H_2O
Carbon dioxide	CO_2
Baking soda	$NaHCO_3$
Table salt	NaCl
Table sugar	$C_{12}H_{22}O_{11}$
Glucose (a sugar)	$C_6H_{12}O_6$

For every 12 carbon particles, there are 22 hydrogen particles and 11 oxygen particles. We write $C_{12}H_{22}O_{11}$ for table sugar's chemical formula.

The photo shows what happens to table sugar when it is treated with strong sulfuric acid. **(Warning: sulfuric acid is a dangerous substance.)** The acid takes out all the hydrogen and oxygen, leaving a black mass, carbon.

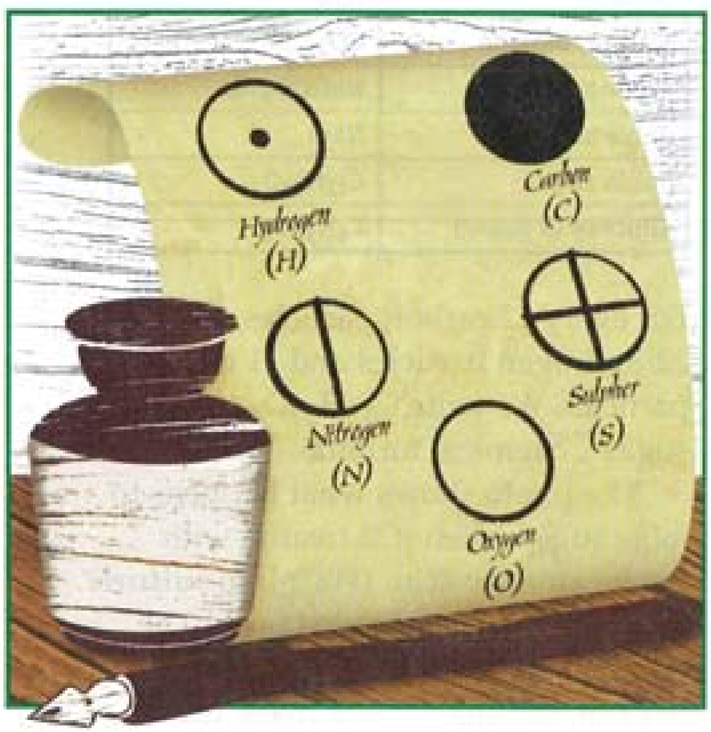
What is a chemical formula?

What Are Elements Made Of?

In 1803 an English scientist named John Dalton stated an important theory: Matter is made up of tiny particles that cannot be cut into smaller pieces. Today we call Dalton's tiny particles **atoms**.

According to Dalton, the atoms of one element were all alike. Each element was made up of one kind of atom. However, the atoms of one element were different from the atoms of any other element. While many parts of Dalton's theory have been improved since 1803, the basic idea of atoms is correct. An atom is the smallest unit of an element that retains the properties of the element.

Individual carbon atoms



Dalton drew the symbols above for atoms. He believed that each element's atoms weighed a different amount from the atoms of other elements.

Many experiments since Dalton's day have shown us what atoms are like. Atoms are so small that we cannot see them directly, even through a microscope. Scientists have had to observe atoms indirectly. A special microscope called a *scanning tunneling microscope* uses a very sharp needle that can trace the bumps in a surface made by individual atoms. The photograph above shows some of what such special microscopes can "see."

Images made by these microscopes show that atoms are discrete and often occur in well-ordered arrays. For example, the carbon atoms in the photo are arranged in rings of six atoms each.

What is an atom?

What Is Inside Atoms?

John Dalton imagined that atoms were like tiny steel marbles—solid and unbreakable. However, we now know that atoms are made of still smaller particles. Atoms are far from being solid—they are mostly empty space!

Atoms contain three kinds of particles called **protons** (PROH·tahnz), **neutrons** (NEW·trahnz), and **electrons** (i·LEK·trahnz). The protons and neutrons are located in a tiny, very dense body in the atom's center, called the atomic **nucleus** (NEW·klee·uhs). The electrons are in the space outside the nucleus.

Protons and neutrons have nearly the same mass, but electrons are about 2,000 times less massive than protons and neutrons.

Protons carry one unit of positive electric charge, while electrons carry one unit of negative electric charge.

Neutrons have no electric charge. All atoms have equal numbers of electrons and protons, so they have no overall electric charge.

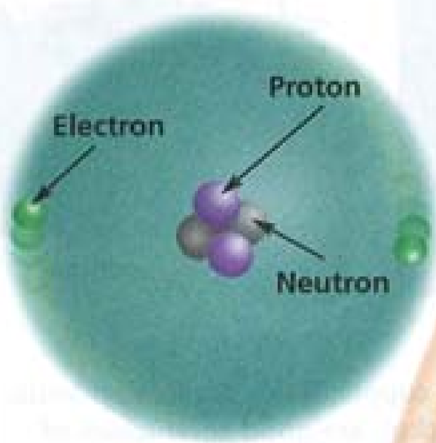
The number of protons in an atom determines what element it is. For example, any atom with six protons is a carbon atom. Any atom with eight protons is an oxygen atom.

Look carefully at the diagrams on this page to see how atoms are put together.

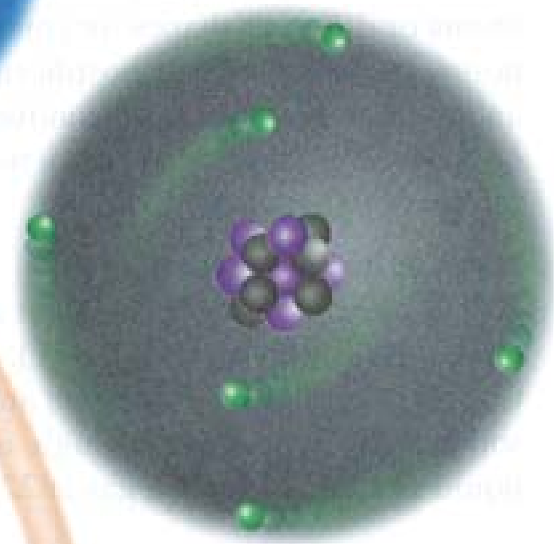
What are the three particles that make up an atom?

Atoms are made of protons, neutrons, and electrons. The number of protons an atom has determines what element it is.

Hydrogen



Helium



Carbon

What Properties Do Elements Have?

We now know of 112 elements. These substances have many different properties. There are patterns in the properties of the elements. Study the photographs on this page to learn about properties that can demonstrate these patterns.

Chemical Reactivity

Some elements take part in chemical reactions much more easily than others. A few elements like helium, a noble gas, are chemically inactive, or inert. Reactive elements, like magnesium, are usually combined with other elements when found in nature.

Metal Versus Nonmetal

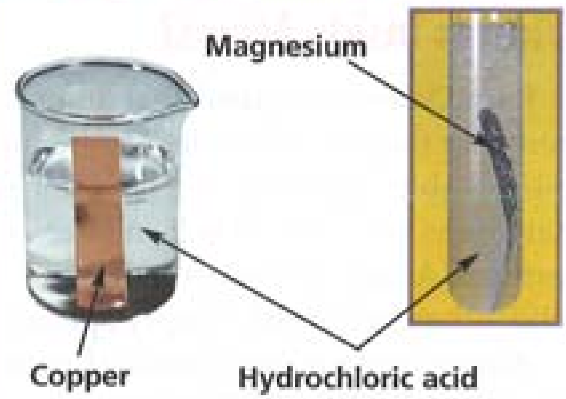
About three-fourths of the elements are metallic, like copper, gold, silver, aluminum, iron, and nickel. Metals conduct electricity and heat well. Metals are also shiny when freshly polished, and many can be worked into thin sheets or different shapes. In contrast nonmetals, like iodine, phosphorus, and carbon, are often poor conductors of heat and electricity. They are not reflective like metals.

States at Room Temperature

The elements shown are all at room temperature, about 22°C (71.6°F). Copper, aluminum, and iodine are solids at 22°C. Bromine, though, is a liquid at 22°C. Neon is a gas at 22°C.

How can elements be classified?

Property: Chemical Reactivity



Magnesium takes part in chemical reactions much more easily than copper. Here the magnesium reacts rapidly with the acid. The copper hardly reacts at all.

Property: Metal Versus Nonmetal

Metals

Nonmetals

Metals, like copper, gold, silver, aluminum, iron, and nickel, are good conductors of heat and electricity. Nonmetals are often poor conductors of heat and electricity.

How Can the Elements Be Grouped?

In 1869 a Russian scientist named Dmitry Mendeleyev found that the properties of the elements went through repeating cycles. Mendeleyev created a table of elements based on these cycles. Each group in his table contains elements with similar chemical properties. For example, one group contains lithium (Li), sodium (Na), potassium (K), rubidium (Rb), and cesium (Cs). All of these elements combine with chlorine in the same way. The formulas for their chlorine compounds are LiCl, NaCl, KCl, RbCl, and CsCl.

We call Mendeleyev's table the periodic table after the "periodic" changes he found in the elements' properties.

The metals lie on the left, and the nonmetals lie mainly on the right, with elements called metalloids in between.

Most elements are solids at 20°C, two are liquids, and the rest are gases.

The most reactive metals are at the left, the inert noble gases are on the right, and the most reactive nonmetals are in the second column from the right.

What is the periodic table? How is it organized?

READING Charts

1. Is sodium a metal or a nonmetal? Is chlorine a metal or a nonmetal?
2. Which elements are liquid at 20°C?

The Modern Periodic Table

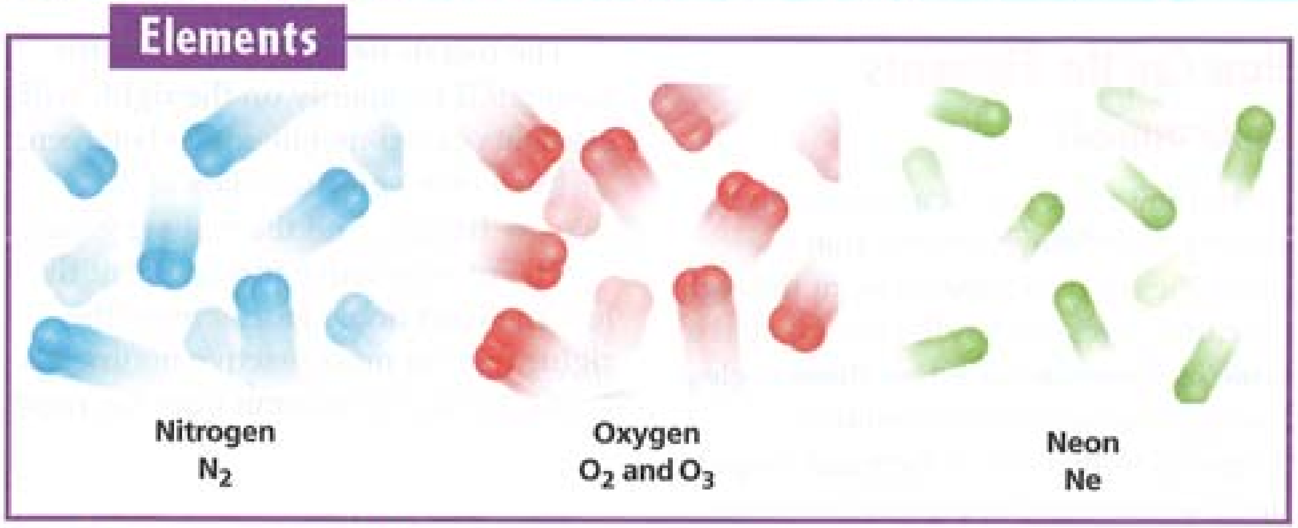
The number in each box is the number of protons an atom of that element has.

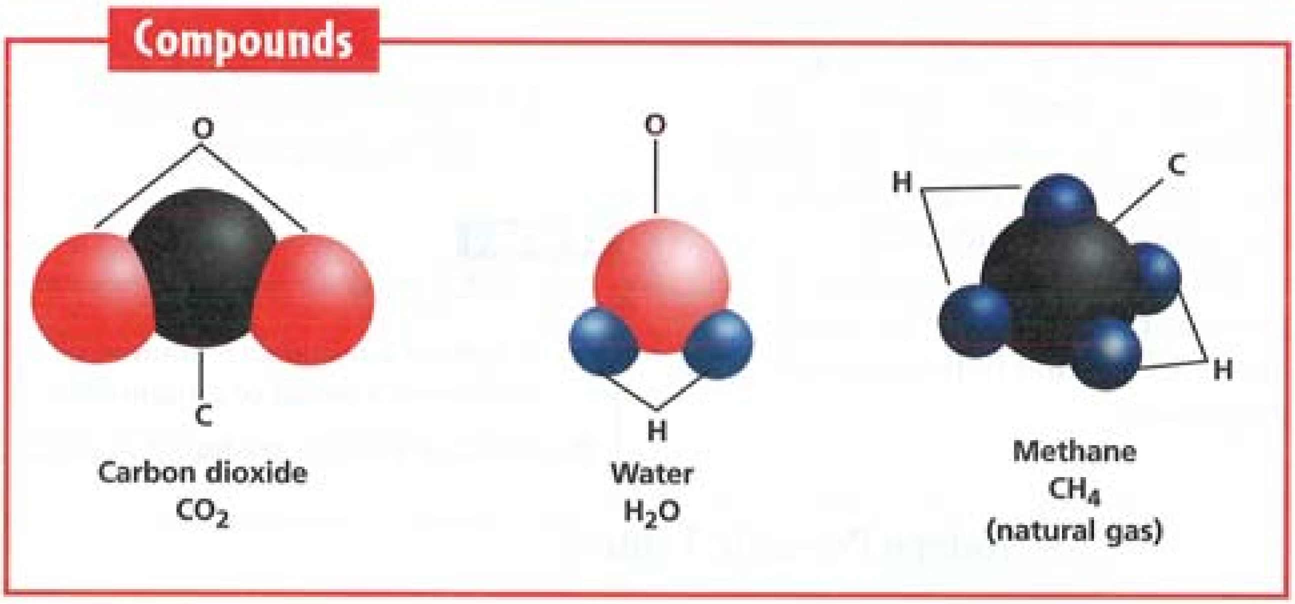
Metallic Properties: Li Metal; B Metalloid; C Nonmetal

Phase at 20°C: C Solid; Br Liquid; H Gas

H 1																	He 2
Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Cs 55	Ba 56	Lu 71	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	Lr 103	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	110	111	112		114		116		118

La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70
Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102





What Are Molecules?

Some elements, such as neon, are made up of single atoms that do not attach to any other atoms. Other elements have atoms that attach to one or more additional atoms. Particles that contain more than one atom joined together are called **molecules**.

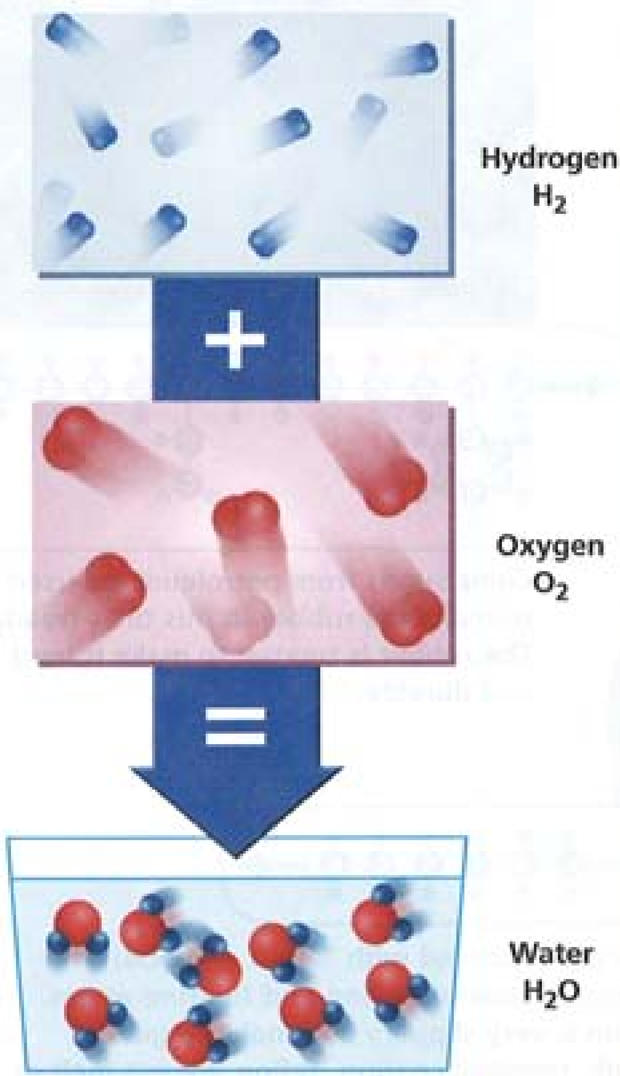
Nitrogen is an example of an element that is made up of molecules. Its molecules are made up of two nitrogen atoms. Some elements even exist in more than one form, such as oxygen. Oxygen is usually made up of two-atom molecules, much like nitrogen, but oxygen can also exist as three-atom molecules. The three-atom form of oxygen is known as ozone. The three-atom ozone has properties different from the two-atom oxygen.

Molecules of elements always contain only one kind of atom. Compounds are made up of molecules that have different kinds of atoms joined together, as the lower diagram shows.

Note how the chemical formulas in both diagrams tell you the number of atoms in the molecules.

When a compound forms from elements, changes occur in the way that atoms are linked together. This causes the compound to have properties different from the elements. For example, water is a liquid, yet it is formed from two gases, hydrogen and oxygen. The diagram shows why water has properties different from hydrogen and oxygen gas—the atoms are linked in a new way when water forms.

What is the difference between a molecule of oxygen and a molecule of methane?

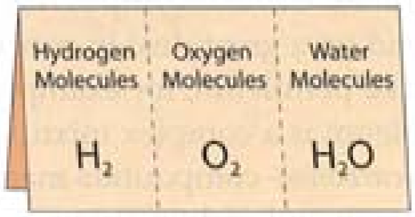


Hydrogen plus oxygen makes water.

QUICK LAB

Modeling Molecules

FOLDABLES Make a Three-Tab Book. (See p. R 43.) Label as shown.



1. Using small marshmallows for hydrogen atoms and large marshmallows for oxygen atoms, make two H_2 molecules and one O_2 molecule. Join the atoms with toothpicks.
2. **Use Numbers** Count the number of atoms of each type you have in your molecules. Record these numbers under the H_2 and O_2 tabs in your Three-Tab Book. Take these same marshmallows and make as many water molecules as you can, using toothpicks to join the atoms.
3. **Observe** How many water molecules did you make? Record under the H_2O tab.
4. **Infer** Why would real water molecules have properties different from real hydrogen and oxygen molecules?

How Do We Use Compounds?

By studying matter scientists have learned how to prepare compounds that are very useful. Many things are made from the atoms of just a small number of elements. The photographs on this page show several compounds that we depend on a great deal in modern life.

Take petroleum, for example. Petroleum is a complex mixture of *hydrocarbons*—compounds made of hydrogen and carbon atoms. Gasoline comes from petroleum. Its molecules usually have from 5 to 12 carbon atoms in chains. Gasoline gives off a lot of energy when it is burned, so we use it as a fuel in cars.

Many kinds of plastics are also made from hydrocarbons in petroleum or natural gas.

What are some useful compounds?

The bottle is made of polyethylene, a flexible plastic made from hydrocarbons.

Compounds from petroleum are used to make the rubber in this tire's tread. The rubber is treated to make it hard and durable.

This pan is coated with Teflon, a special polymer made of carbon and fluorine atoms. Teflon is very slippery and makes a good, tough, nonstick coating. Teflon doesn't melt at high temperatures as many other plastics do.

Lesson Review

L·I·N·K·S

Why It Matters

Think what the world would be like if there were no compounds. There wouldn't be any plants. There wouldn't be any water or food or animals or things people build. In fact, there wouldn't be any people, either.

New compounds are discovered in nature every day. Scientists also develop new compounds in labs. Many compounds are used to help make life better.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on the uses of new compounds.

Think and Write

1. Why must some element symbols have two letters instead of just one?
2. A beryllium atom is made of four protons, five neutrons, and four electrons. Draw a model of this type of atom.
3. Name a compound whose properties are much different from the elements it is made of. How is it different?
4. Why do scientists use models to study atoms and molecules?
5. **Critical Thinking** Are all molecules compounds? Explain.

WRITING LINK

Expository Writing John Dalton was the scientist who defined atoms. Research his life and write a biography. Use print and online sources. List your sources at the end of your report.

MATH LINK

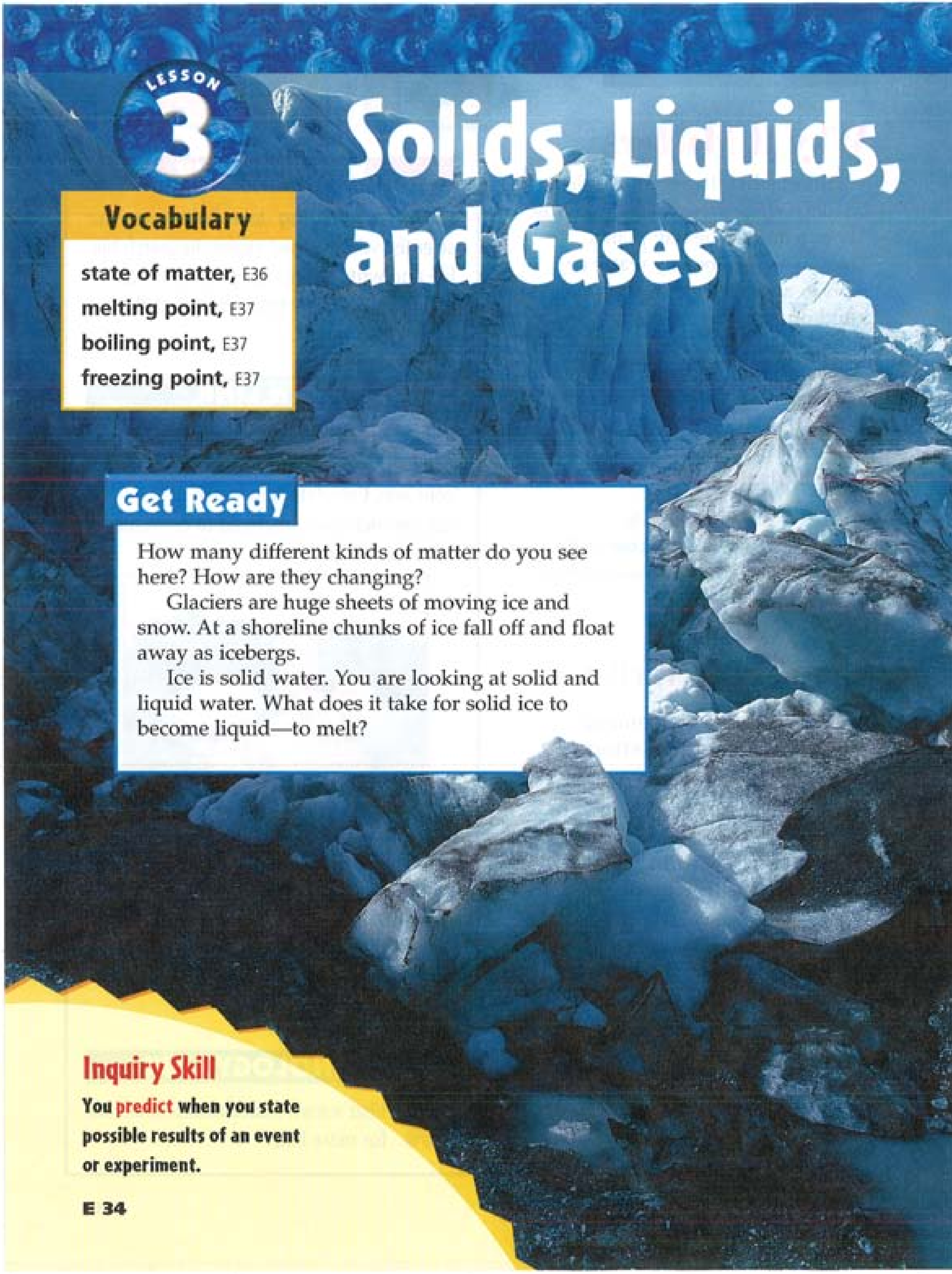
Solve this problem. Find the minimum daily requirement of calcium for someone your age. Calculate how much of a calcium-rich food you need to consume to meet this goal.

ART LINK

Make a model. What is your favorite element? Helium? Oxygen? Copper or iron? Draw a picture or make a model of this element. Include its protons, electrons, and neutrons.

TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.



LESSON 3

Solids, Liquids, and Gases

Vocabulary

state of matter, E36
melting point, E37
boiling point, E37
freezing point, E37

Get Ready

How many different kinds of matter do you see here? How are they changing?

Glaciers are huge sheets of moving ice and snow. At a shoreline chunks of ice fall off and float away as icebergs.

Ice is solid water. You are looking at solid and liquid water. What does it take for solid ice to become liquid—to melt?

Inquiry Skill

You predict when you state possible results of an event or experiment.

Explore Activity

What Happens When Ice Melts?

Materials

ice cubes

water

graduated cylinder

plastic or paper cup

thermometer

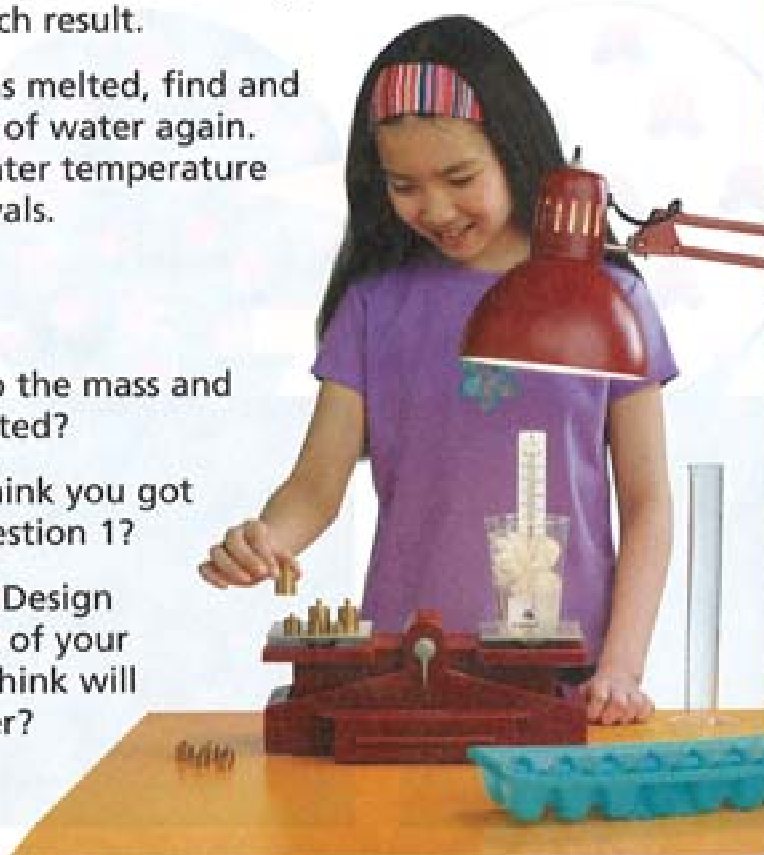
heat source (lamp or sunlight)

watch or clock

equal-pan balance with set of masses

Procedure

1. **Predict** You are going to explore the effect of heat on ice cubes as they melt. How do you think the temperature and mass of a cup of ice will change as it melts? Make a graph showing your prediction of how the temperature will change.
2. **Measure** Put ice cubes in the cup. Add 50 mL of water. Find and record the mass of the mixture. Swirl the mixture for 15 seconds.
3. **Measure** Place the thermometer in the cup. Wait 15 seconds. Then read and record the temperature. Put the cup under a heat source (lamp or sunlight). Take temperature readings every 3 minutes. Record each result.
4. **Measure** After all the ice has melted, find and record the mass of the cup of water again. Take and record 5 more water temperature readings at 3-minute intervals.



Drawing Conclusions

1. **Observe** What happened to the mass and temperature as the ice melted?
2. **Hypothesize** Why do you think you got the results described in question 1?
3. FURTHER INQUIRY **Predict** Design an experiment to test each of your predictions. What do you think will happen as you freeze water? Design an experiment to test your prediction.

Read to Learn

Main Idea Matter exists as a solid, a liquid, or a gas.

What Are the States of Matter?

Water turns from a solid to a liquid when it absorbs enough heat. If even more heat is supplied, the water will turn to a gas called steam. Most substances exist in one of three phases or **states of matter** —solid, liquid, or gas. Adding or removing heat can make substances change their phase or state.

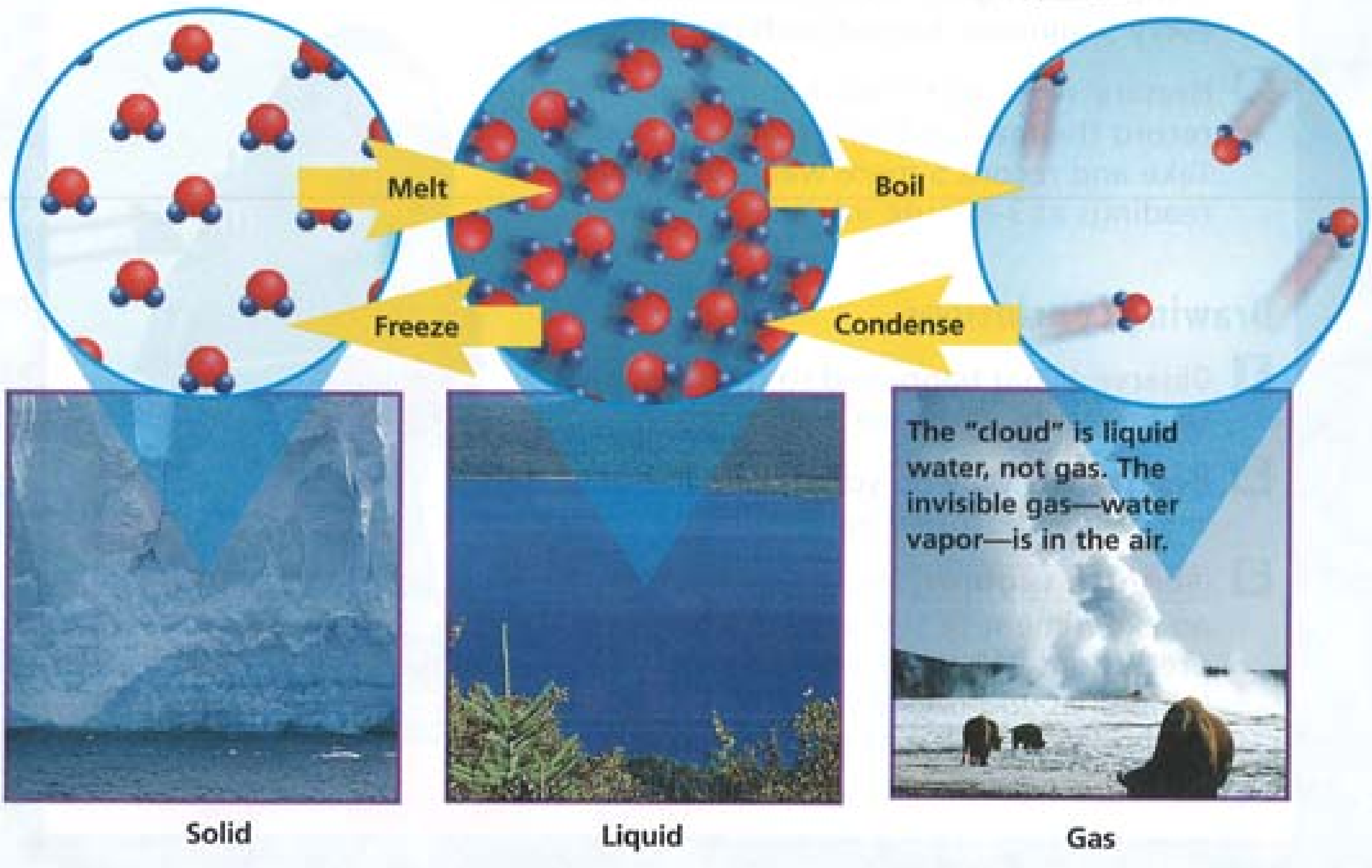
During a change of state, the mass and identity of the substance remain the same. However, the substance gains new properties because the molecules are arranged in a different way.

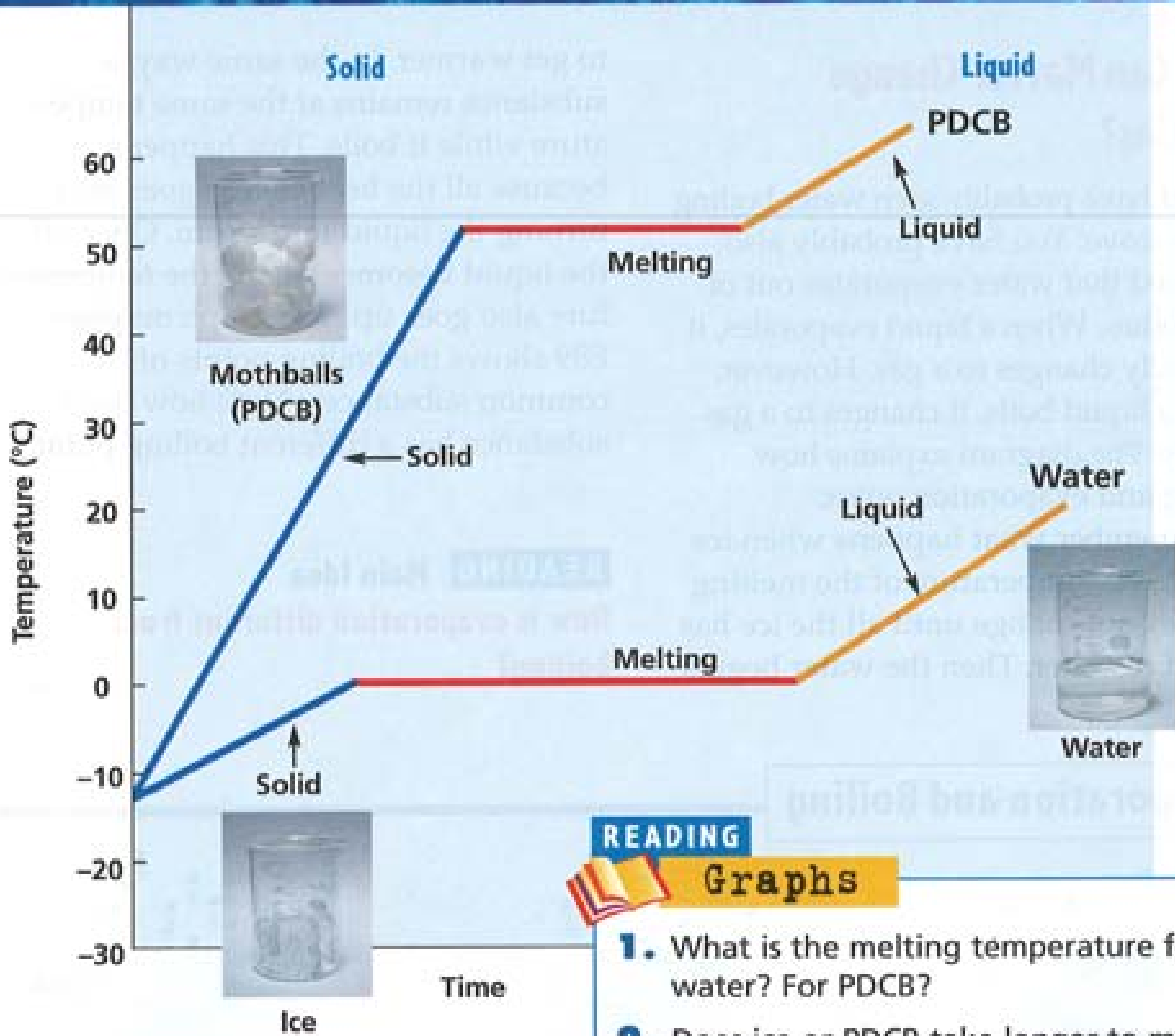
The molecules of any substance are attracted to each other. The attraction is just a weaker form of the force that links the atoms in each of the molecules. When the molecules are arranged in organized positions, a solid results.

When heat is absorbed by a solid, the molecules vibrate faster and faster. At some point the molecules separate from one another. This causes the solid to become a liquid. When even more heat is absorbed, the molecules move faster and form a gas.

Change of State

As heat is absorbed, molecules move faster and become less organized.





Melting of PDCB and water

READING Graphs

1. What is the melting temperature for water? For PDCB?
2. Does ice or PDCB take longer to melt? Explain how you got your answer.

The graph shows how the temperatures of two different compounds change as they are being heated. As you can see, these substances melt at different temperatures. In fact, each different pure substance has its own particular **melting point**. Each different substance also has its own boiling temperature, called the **boiling point**.

While a substance is melting or boiling, its temperature stays the same. It warms up only before or after the change of state.

What happens when heat is removed from the substance? It *condenses*—turns from a gas to a liquid—at the boiling temperature. It freezes—turns from a liquid to a solid—at the melting temperature. For this reason the melting point is also known as the **freezing point**.

What are melting and boiling points?

How Can Matter Change to a Gas?

You have probably seen water boiling on the stove. You have probably also observed that water evaporates out of wet clothes. When a liquid evaporates, it gradually changes to a gas. However, when a liquid boils, it changes to a gas rapidly. The diagram explains how boiling and evaporation occur.

Remember what happens when ice melts? The temperature of the melting ice does not change until all the ice has turned to water. Then the water begins to get warmer. In the same way, a substance remains at the same temperature while it boils. This happens because all the heat energy goes into turning the liquid into steam. Once all the liquid becomes steam, the temperature also goes up. The graph on page E39 shows the boiling points of common substances. Note how each substance has a different boiling point.

READING Main Idea
How is evaporation different from boiling?

Evaporation and Boiling

1. A few molecules escape into the air, causing evaporation at room temperature.
2. When the liquid is heated, more molecules escape. The liquid evaporates faster.
3. As more heat is absorbed over time, the liquid reaches its boiling temperature. Boiling begins at the boiling point.

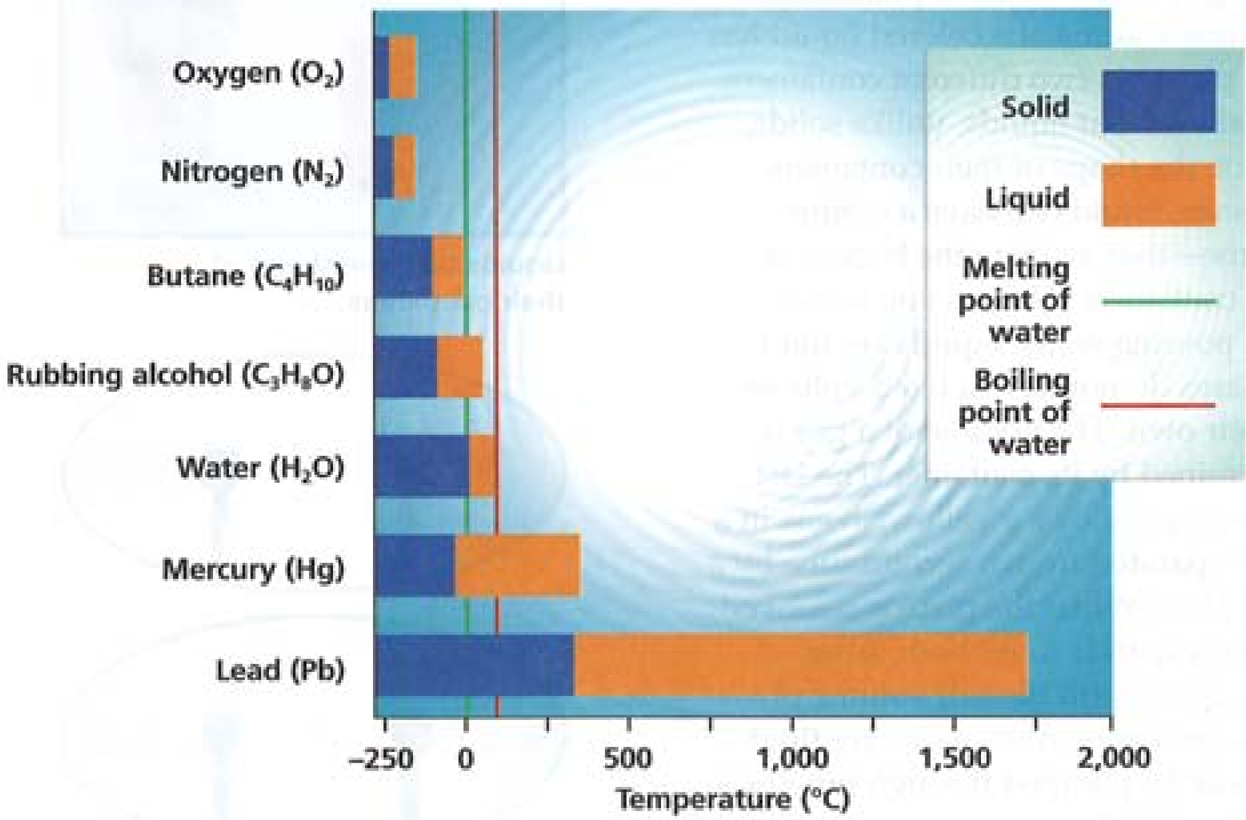
READING Tables

1. Is butane a liquid or a gas at 10°C?
2. Which boils at a lower temperature, rubbing alcohol or oxygen?
3. Which state of matter is lead at 80°C?

Solid and Liquid Ranges of Common Substances (in degrees Celsius)

Name	Formula	Melting Point	Boiling Point
Oxygen	O_2	–218°	–183°
Nitrogen	N_2	–210°	–196°
Butane	C_4H_{10}	–138°	–0.5°
Rubbing alcohol	C_3H_8O	–90°	82.4°
Water	H_2O	0°	100°
Mercury	Hg	–39°	357°
Lead	Pb	327°	1,740°

The table lists the melting points and boiling points of some common substances.



Use this graph to compare the melting points of the substances listed in the table.

What Are the Properties of Solids, Liquids, and Gases?

The aluminum cube in the first photo is a typical solid. It shows that solids retain their shape. Solids have the same volume no matter what container they are placed in. Also, solids cannot be poured, so they are not fluid.

Many solids form crystals, as in the second photograph. A gemlike crystal of alum is shown. The shape of such crystals results from the way the particles are arranged. The particles link together in an organized pattern.

Liquids have different properties from solids. Compare the first and third photographs. In the third photograph, the same volume of a colored liquid has been placed in two different containers. This shows that liquids, unlike solids, take on the shape of their containers. However, liquids do have a definite volume—they settle to the bottom of their containers. Also, as you know from pouring water, liquids are fluid.

Gases do not have a fixed volume of their own. The volume of a gas is determined by its container. The last photograph shows a yellowish gas in a tube separated from a second tube by a glass plate. When the plate is removed, the gas expands to fill both tubes. Gases always fill the full volume of their containers. Also, gases are fluid—they can be pumped through pipelines just like liquids.

Solids keep their shape.

Many solids form crystals.

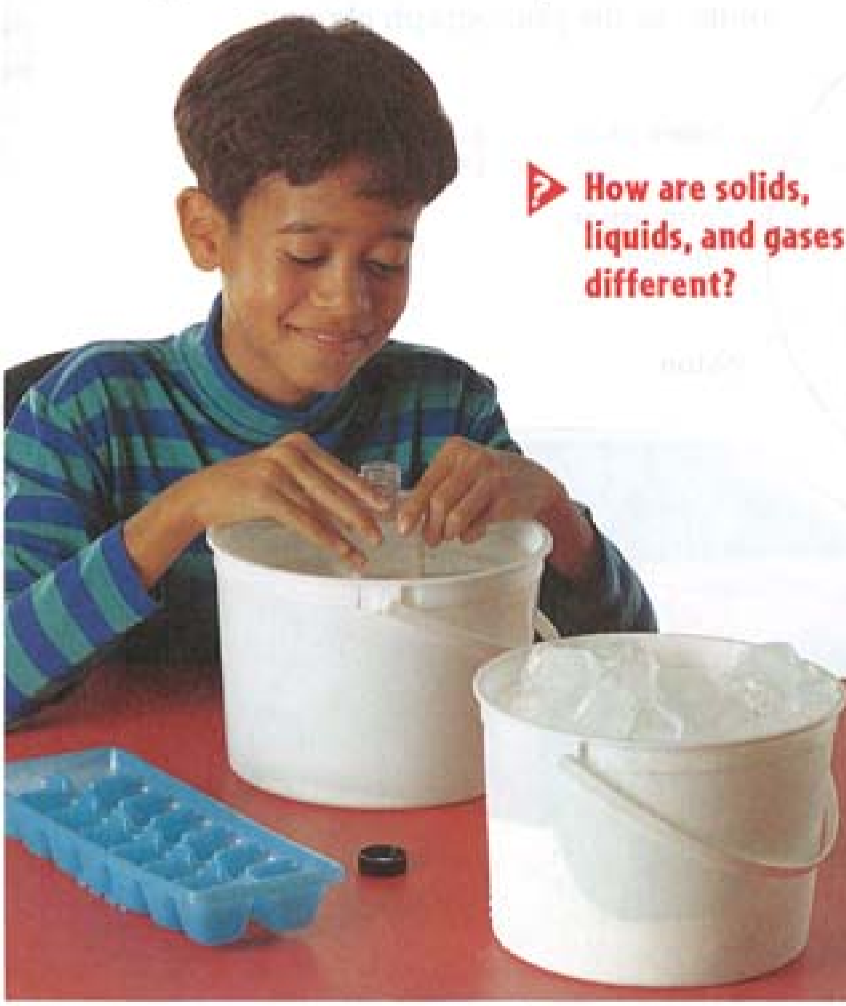
Liquids take the shape of their containers.

Gases fill the volume of their containers.

Expansion and Contraction

When the temperature of a material increases, its particles move faster. On average these particles tend to spread out more. This causes materials to *expand*—spread out—as they get hotter. The opposite happens when the temperature of a material decreases. Cool materials tend to *contract*—shrink. The material's particles tend to slow down and stay closer together. Gases expand or contract the most with changing temperature, but liquids and solids are also affected by temperature.

You have probably observed expansion and contraction in your everyday life. This property of matter makes bicycle tires and basketballs flat on cold days and your classroom door stick and be difficult to open on hot days. Can you think of other examples?

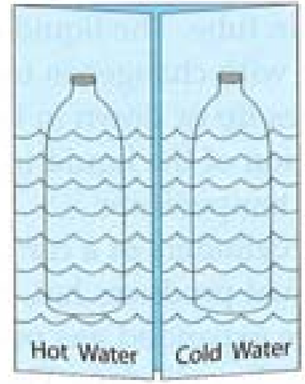


How are solids, liquids, and gases different?

QUICK LAB

Collapsing Bottles

FOLDABLES **Make a Shutter Fold. (See p. R 42.) Label it as shown.**



1. **Predict** How does heat affect an empty plastic bottle? What do you think will happen to the bottle when it is warmed? What do you think will happen to it when it is cooled? Record your predictions.
2. With the cap off, hold the bottle for a minute or two in a pail of hot tap water. Then screw the cap on tightly while the bottle is still sitting in the hot water.
3. **Experiment** Now hold the bottle in a pail of ice water for a few minutes.
4. **Communicate** Record all your observations in the Shutter Fold.
5. **Infer** Write out an explanation of why the bottle changed as it did. Be sure to use the idea of how molecules move at different temperatures.

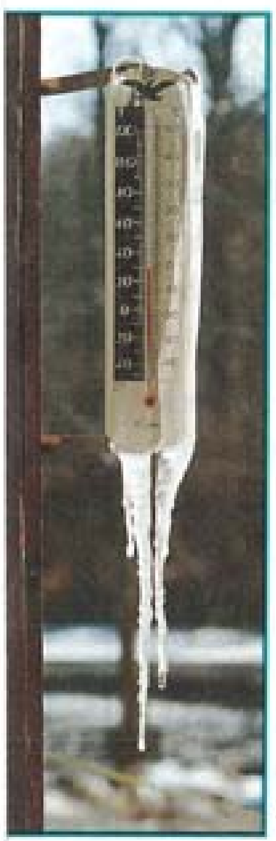
How Can Expansion and Contraction Be Used?

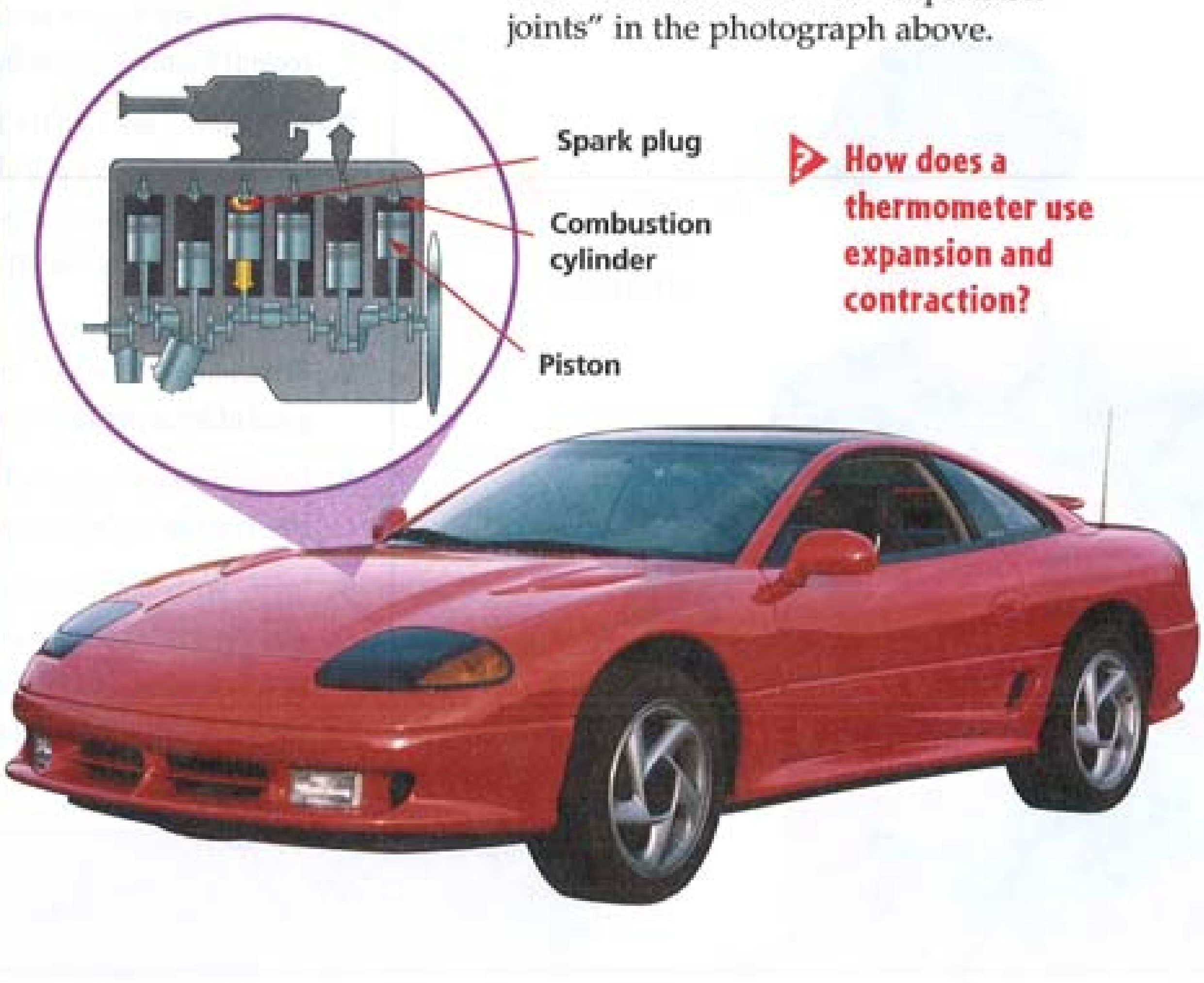
You have probably had your temperature taken with a thermometer. Thermometers have liquid mercury or colored alcohol in a bulb connected to a very thin tube. The liquid expands or contracts with changes in temperature and moves up or down in the tube. The position of the liquid in the tube gives the temperature.

In the cylinders of a car's engine, burning fuel produces hot, expanding gases. The expanded gas pushes on the pistons in the cylinders. The pistons in turn provide the power that drives the car forward.

The solid materials that make up a bridge or sidewalk expand when warmed. If the sections are assembled tightly on a normal day, they will expand against each other on very hot days. This expansion can cause cracks to form. To guard against this problem, engineers leave some space between the sections and fill it with a flexible material. Look for these "expansion joints" in the photograph above.

Expansion joints keep roads and bridges from cracking on hot days when the road expands.





How does a thermometer use expansion and contraction?

Lesson Review

Why It Matters

You sit, write, and climb on solids. Liquids allow you to bathe, swim, and drink. You breathe gases every day. They allow you to smell odors at a distance. Gases always fill the full volume of their containers. You notice this property every time you are in your room and smell food cooking in the kitchen.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on states of matter.

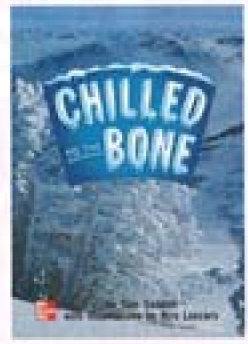
Think and Write

1. Explain what happens to the temperature of ice as it melts.
2. Acetone freezes at 95.35°C below 0°C and boils at 56.2°C. At 42°C what state of matter would acetone be in? At 84°C?
3. Gases can be easily squeezed into a smaller volume. Why is this so?
4. Explain why on a humid day, drops of water will form on the outside of a glass containing an ice cold drink.
5. **Critical Thinking** Water boils at 100°C at sea level. High up in the mountains, water boils at a lower temperature. Why does it take longer to cook potatoes high up in the mountains than it does to cook potatoes at sea level?

L·I·N·K·S

LITERATURE LINK

Read *Chilled to the Bone* to learn about icy places. Try the activities in the end of the book.



WRITING LINK

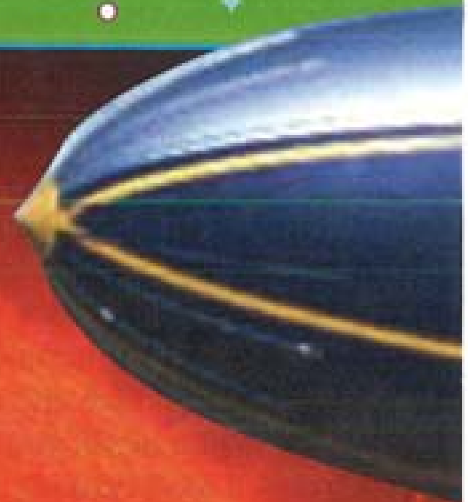
Explanatory Writing Exhale on a mirror and then fan the mirror with your hand. What happens? Write an explanatory essay to describe the task and explain the changes that you observe. Use time-order words, such as first, next, and then to present the steps in the process.

MATH LINK

Predict and try. How long will it take for different volumes of warm tap water to cool 10 degrees? Will the volume affect the cooling time? Plan the experiment. What measurement tools will you need? Try it.

TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.



The Hunt for Helium

It's colorless, odorless, and a gas. It's not very common on Earth. And this chemical element doesn't react with other elements—it doesn't form chemical compounds. No wonder it took so long to discover—even though it's the second most common element in the universe!

What is it?

In the nineteenth century, scientists were on the path to discovering all the elements. By 1868, more than 60 elements were known (today we know of over 110). That year, scientists used a spectroscope to study the Sun. They discovered a new element not yet found on Earth. They didn't know its properties, but they named it helium after *helios*, the Greek word for Sun.

Then scientists wondered if another undiscovered element was hiding in the air. Sure enough, when nitrogen was removed from a sample of air, a tiny amount of another gas was left behind. This was a new, colorless, odorless gas that didn't react with other elements. They named it argon.

Sally Ride Science

Helium is the only element to be discovered on the Sun before it was discovered on Earth. Blimps are filled with helium gas because it is lighter than air and gives them lift.

Once argon was discovered, scientists knew there must be other elements with similar properties. That's when chemists discovered a strange gas seeping out of a mineral. Much to their surprise, it matched what astronomers had seen years earlier on the Sun. Did you guess it was helium?

After that, it took only four more years to track down the other elements in this unreactive family: neon, krypton, xenon, and radon. Helium and its kin used to be called "noble" gases. The reason was that, just like nobility, they had little to do with the "common" elements.

What Did I Learn?

1. Why were the noble gases hard to discover?

A They are colorless, odorless, and unreactive.
B They aren't very plentiful.
C They're not found on Earth.
D They react with many other elements.

2. How did helium get its name?

F It is heavier than air.
G It is used to fill balloons.
H It was named after the Sun.
J It was named after a mineral.

LOG ON Visit www.science.mmhschool.com to learn more about the search for new elements.

Chapter 12 Review

Vocabulary

Fill each blank with the best word or words from the list.

atom, E26
boiling point, E37
density, E8
electron, E27
mass, E6
molecule, E30
nucleus, E27
proton, E27
state of matter, E36
weight, E7

1. An atomic particle that has a positive charge is called a(n) _____.

2. A particle made of different atoms linked together is called a(n) _____.

3. A measure of the force of gravity between Earth and an object is _____.

4. The smallest unit of an element is a(n) _____.

A substance rapidly changes its **5.** _____ to a gas at its **6.** _____ .

A negatively charged particle in the space outside an atom's **7.** _____ is a(n) **8.** _____.

A substance's **9.** _____ divided by its volume is a measure of its **10.** _____.

Test Prep

11. An object's ability to float depends on its _____.
- **A** size
- **B** temperature
- **C** insulation
- **D** density

12. Water can turn from liquid to gas by evaporating or _____.
- **F** condensing
- **G** pouring
- **H** boiling
- **J** freezing

13. Mass is the measure of the _____.
- **A** amount of material in an object
- **B** weight of an object
- **C** space an object takes up
- **D** density of an object

14. The molecules of a _____ tend to be packed tightly in an organized way.
- **F** gas
- **G** solid
- **H** liquid
- **J** neutron

15. The number of ______ an atom has determines what element it is.

A electrons

B neutrons

C protons

D charges

Concepts and Skills

16. INQUIRY SKILL **Make a Model** Scientists use a variety of models to understand and explain the natural world. A formula, such as H_2O, is a model for water. Tell what the formula means. Give another example of a chemical formula, and tell what it means.

17. **Reading in Science** What is the main difference between mass and weight? Support your answers with any facts or details necessary.

18. **Scientific Methods** Which do you think would evaporate faster—pure water or salt water? Why? Describe an experiment that would test your idea.

19. **Critical Thinking** Are all molecules compounds? Explain your answer.

20. **Product Ads** Teflon® is an artificial compound. It is a "nonstick" plastic. What products might advertise the use of this material?

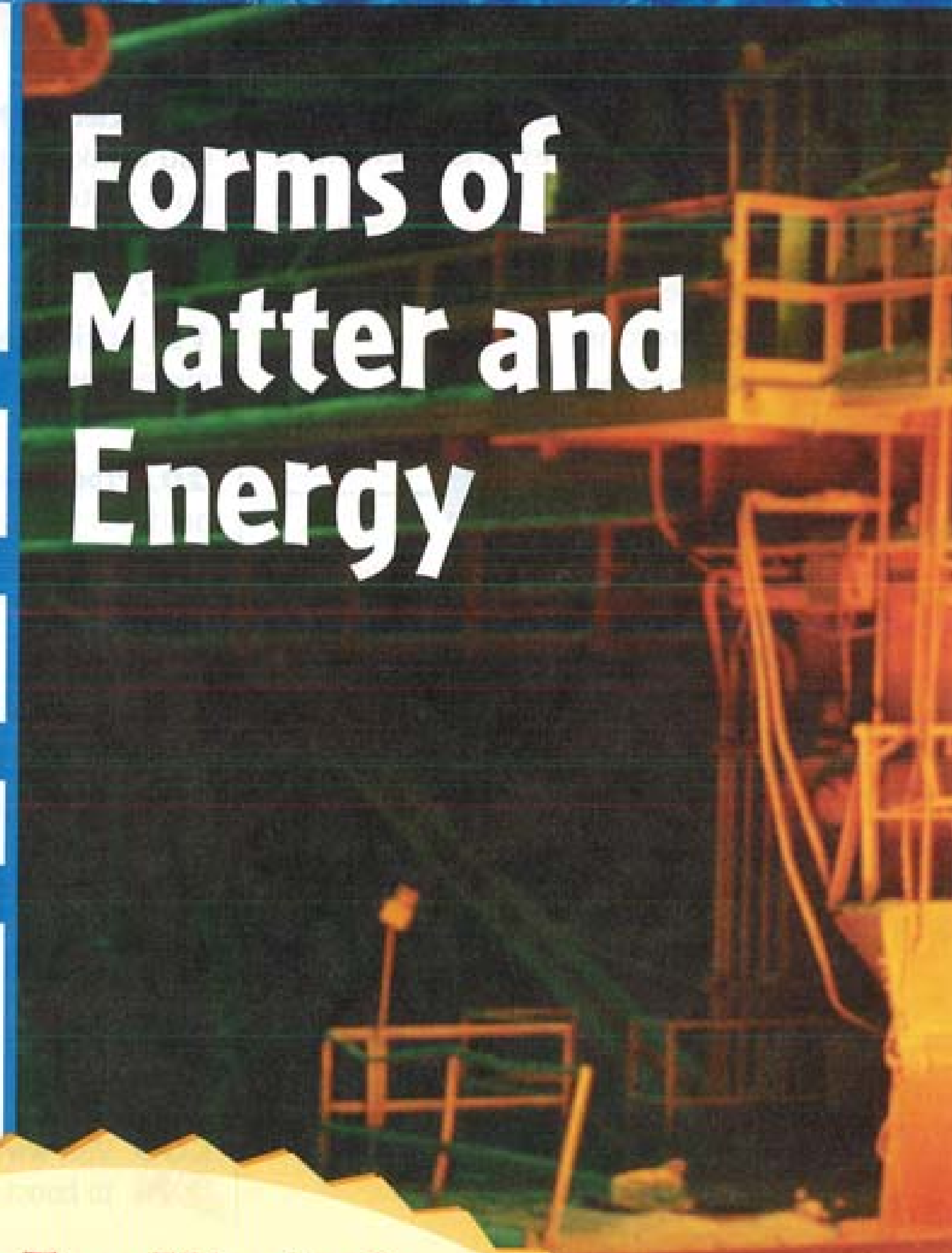
Did You Ever Wonder?

INQUIRY SKILL **Classify** Use your list from the Inquiry Skill on page E2. Add three column headings: mass, density, and volume. Write the names of the objects with the greatest mass, density, and volume under the headings. An object can be listed under more than one heading.

LOG ON Visit www.science.mmhschool.com to boost your test scores.

CHAPTER 13

Forms of Matter and Energy



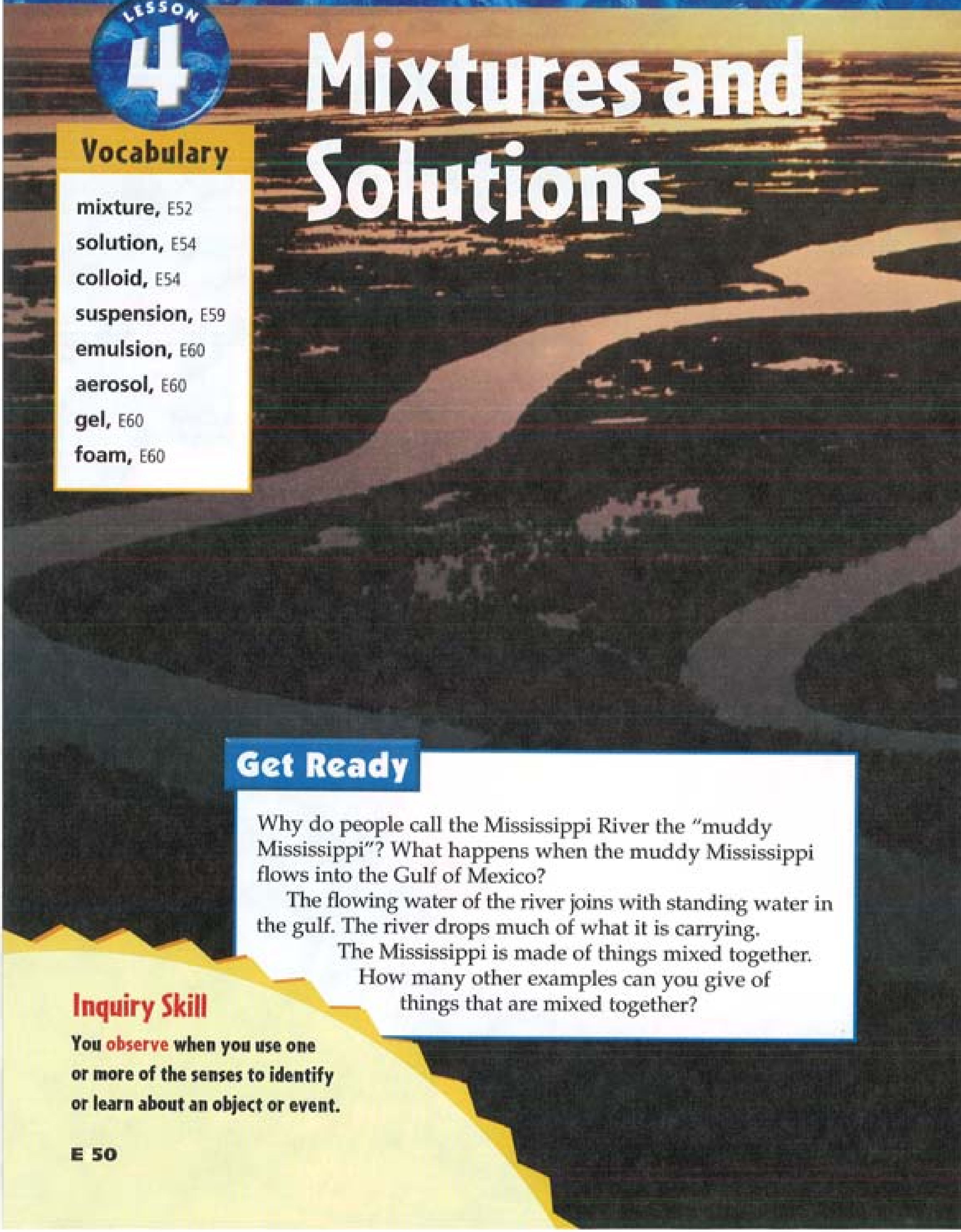
Did You Ever Wonder?

Where does the steel used to build bridges and skyscrapers come from? Steel is a mixture of several different elements, including iron, carbon, and nickel. Is the process of making steel a physical change or a chemical change? How are the properties of steel different from the properties of the metals that make it up?

INQUIRY SKILL Experiment Observe objects in your classroom. Infer which objects are made of iron or steel. Use a magnet to test your inferences.

LESSON 4

Mixtures and Solutions



Vocabulary

mixture, E52
solution, E54
colloid, E54
suspension, E59
emulsion, E60
aerosol, E60
gel, E60
foam, E60

Get Ready

Why do people call the Mississippi River the "muddy Mississippi"? What happens when the muddy Mississippi flows into the Gulf of Mexico?

The flowing water of the river joins with standing water in the gulf. The river drops much of what it is carrying.

The Mississippi is made of things mixed together. How many other examples can you give of things that are mixed together?

Inquiry Skill

You observe when you use one or more of the senses to identify or learn about an object or event.

Explore Activity

How Can You Take Apart Things That Are Mixed Together?

Materials

- sample of substances mixed together
- hand lens
- toothpicks
- magnet
- paper (coffee) filters
- 2 cups or beakers
- water
- goggles

Procedure: Design Your Own

BE CAREFUL! Wear goggles. Do not taste your sample.

1. **Observe** Examine the sample your teacher gives you. It is made of different substances. One of the substances is table salt. What else does it seem to be made of? Record your observations.
2. **Experiment** Design and carry out an experiment to separate the various ingredients in your sample.

Drawing Conclusions

1. **Infer** How many parts or substances were mixed into your sample? How did you reach that conclusion?
2. You knew one substance was salt. What properties of salt might help you separate it from the rest? Could you separate salt first? Why or why not?
3. How did you separate out the substances? How did you use the properties of these substances to separate them?
4. **FURTHER INQUIRY** **Experiment** What if you were given white sand and sugar mixed together? How would you separate the two ingredients?

Read to Learn

Main Idea **Substances can combine to form mixtures.**

What Is a Mixture?

The iron filings and yellow sulfur powder in the first photo have been stirred together. The two materials were *physically* combined. The result is a **mixture**.

The substance shown in the second photograph, iron disulfide, also contains both iron and sulfur. However, now the iron and sulfur are *chemically* combined, and a new substance is formed, a compound.

How do mixtures and compounds differ? Compounds are produced by chemically combining substances. Mixtures are produced by a physical combination of substances. In mixtures the parts simply blend together without forming new substances. Differences in chemical and physical properties of substances are used to separate mixtures and identify compounds.

A compound has different properties from the substances it contains. For example, iron disulfide is not magnetic, while pure iron is. In contrast, the parts of a mixture keep their original properties. Even though the iron has been mixed with sulfur in the first picture, it remains magnetic. You could use a magnet to remove the iron filings from the mixture.

When iron filings and yellow sulfur powder are stirred together to make a *mixture*, the substances keep their original properties. The iron remains magnetic. You could use a magnet to remove the iron filings.

This is *iron disulfide*, a mineral known as iron pyrite, or "fool's gold." Iron disulfide is a compound of iron and sulfur. When a *compound* forms, it has different properties from the substances it contains. Unlike iron, iron disulfide is not magnetic.

Here are a number of household materials. Which are mixtures? Which are either elements or compounds?

What if you stir one spoonful of sugar into a glass of water to make a sugar-water mixture? A friend could stir two spoonfuls of sugar into the same amount of water. You would both have the same kind of mixture. However, your friend's drink would have a much sweeter taste.

Like the sugar water, any type of mixture can contain varying amounts of the parts that make it up. Salt water could be barely salty or very salty. Granola cereal could have many or few raisins. Tea could be strong or weak, and so on.

On the other hand, compounds are always made up in the same way. For example, about two-fifths of the mass of any sample of table salt is sodium, and three-fifths is chlorine.

What is the difference between compounds and mixtures?

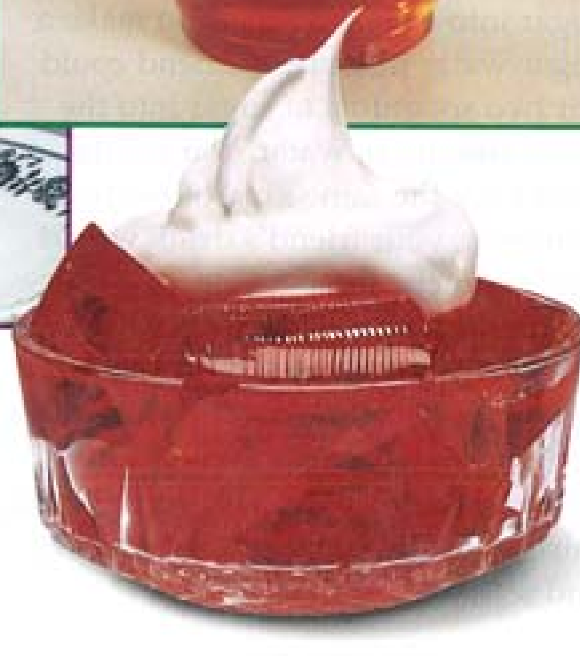
How Can Mixtures Be Classified?

Mixtures are not pure substances because they contain more than one element or compound. If the substances in a mixture are blended completely, the mixture looks the same everywhere, or is *homogeneous* (hoh·muh·JEE·nee·uhs). We call such mixtures **solutions**. There are many different types of solutions. Look at the table on page E55 for examples of some common solutions.

On the other hand, the parts of a mixture may be only partly blended. The mixture may look "speckled," either to your eye or through a microscope. This type of mixture is said to be *heterogeneous* (het·uhr·uh·JEE·nee·uhs). Most mixtures are heterogeneous. Rivers contain a mixture of water, rock, and soil. Stones are heterogeneous, too.

Some mixtures are neither solutions nor heterogeneous mixtures. These mixtures are called **colloids**. Colloids have properties in between those of solutions and heterogeneous mixtures. Like solutions, there are many types of colloids. The chart on page E55 shows some of these.

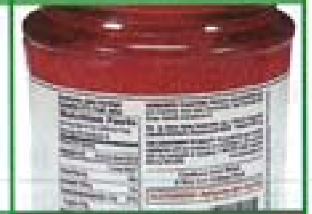
What are three types of mixtures?

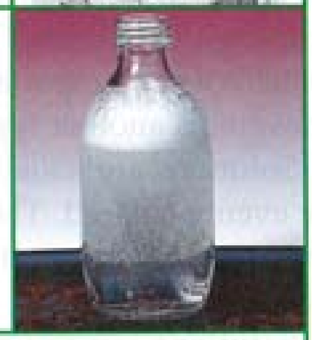


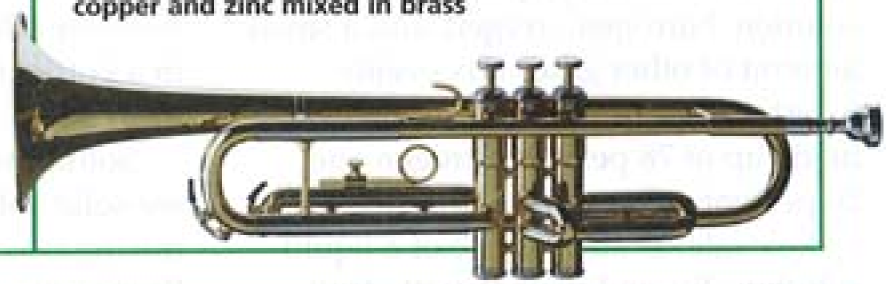
A lunch of a chicken salad sandwich, tea, and gelatin dessert with whipped cream contains each type of mixture. Can you tell which one is which?

Types of Solutions

Substance	Dissolved In	Examples
Liquid	liquid	cranberry juice in water
	gas	water dissolved in air
	solid	mercury in silver (dental fillings)
Gas	liquid	carbon dioxide under pressure dissolved in water to make soda
	gas	oxygen and nitrogen in air
Solid	liquid	salt in water
	solid	copper and zinc mixed in brass



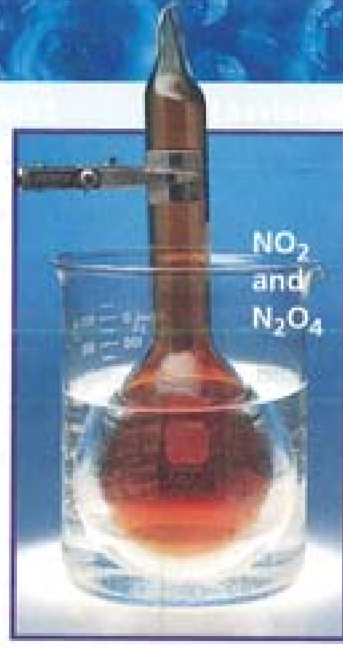




Types of Colloids

Substance	Mixed In	Examples
Liquid	liquid	mayonnaise
	gas	clouds
	solid	jam
Gas	liquid	shaving cream
	solid	marshmallows
Solid	liquid	toothpaste
	gas	smog

What Kinds of Solutions Are There?



Not all solutions are liquid. The flask contains a solution of two gaseous compounds, NO_2 and N_2O_4. NO_2 is red-brown, while N_2O_4 is colorless.

You are already familiar with many solutions. In fact, you are surrounded by them all the time. The atmosphere contains a very important solution—air. Seawater is another type of solution.

Solutions are usually transparent or are evenly colored. They never settle into layers. They are the same all the way through.

Solutions come in many different forms. Air is an example of a gaseous solution. Nitrogen, oxygen, and a small amount of other gases mix evenly together. One breath of air is always made up of 78 percent nitrogen and 20 percent oxygen gas.

Seawater is an example of a liquid solution. Tea and your favorite fruit punch are other examples. These solutions are all made from solids that dissolve in a liquid—water. Liquid solutions can also be made by mixing two liquids together, as in nail polish remover. Mixing a liquid with a gas, as in a bottle of soda, is another way to form a liquid solution.

Solutions may also be solid. Alloys are solid solutions. They are made by mixing two or more metals together. Bronze, steel, and brass are all alloys.

The properties of an alloy can be varied by changing the amounts of pure metals it contains. The stainless steel used in silverware uses only a slightly different mixture of elements than the

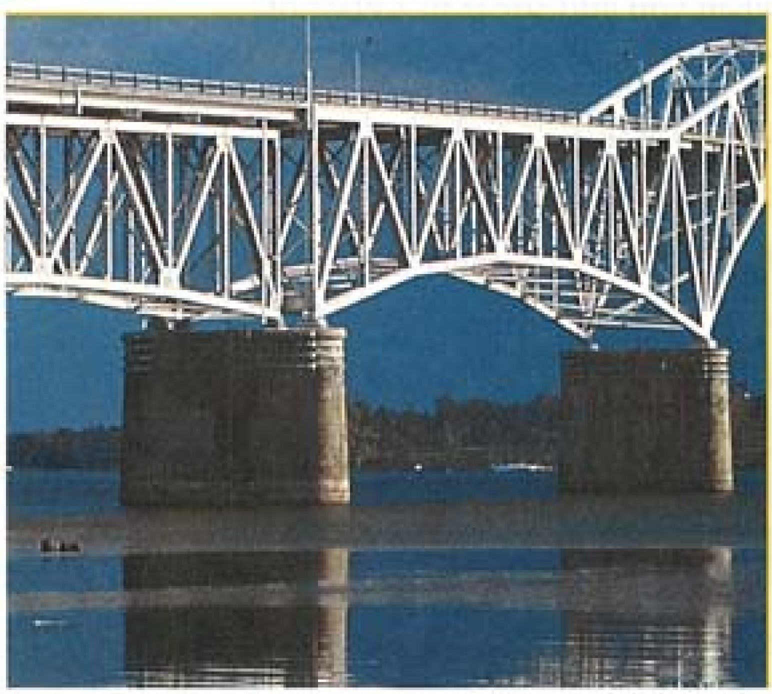
This bridge is made of an alloy, steel.

Heat is released when calcium chloride dissolves in water. Hot packs can be used to warm your hands on a cold day for this reason.

high-strength steel you might find in construction.

Solutes and Solvents

Solutions may form in many different ways. However, no matter how they form, all solutions have two parts. The substance that makes up the smaller part of a solution is called the *solute*. The substance that makes up the larger amount is the *solvent*. The solute dissolves in the solvent to form a homogeneous mixture. All solutions consist of at least one solute and one solvent.



Think about the examples on page E56. What is the solvent in fruit punch? What is the solute in seawater? Think about which of the substances is in the greater amount.

Water is an important solvent. Many different kinds of compounds can dissolve in water, such as salts, minerals, proteins, and sugars. Nutrients from food dissolve and are carried through your body because of the water in blood.

Some solute and solvent pairs give off or absorb heat when they are combined. Hot and cold packs use this property of solutions. Calcium chloride is a salt that releases a great deal of heat when it is mixed with water. A hot pack often contains a small pouch of this salt in a sealed package of water. When the package is struck, the pouch of salt breaks open. This allows the salt to dissolve. Heat is then released.

What are five types of solutions?

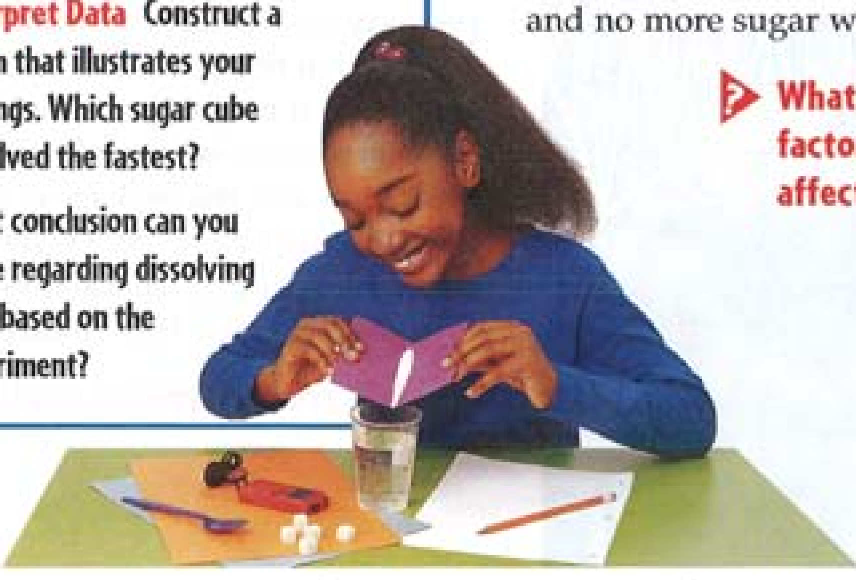
QUICK LAB

Solubility

FOLDABLES Make a Folded Table (See p. R 44.) Label as shown.

Cup	Dissolving Time	
	Prediction	Actual
1		
2		
3		

1. **Measure** Add 100 mL of water to each of three cups. Place a sugar cube in one. Stir until it dissolves. Record the time it took to dissolve.
2. **Predict** Break a second sugar cube into two pieces. How long will they take to dissolve? Place them in a second cup. Stir until they dissolve. Record the dissolving time.
3. **Use Variables** Fold a piece of paper around a sugar cube. Break the cube into many pieces. Pour the pieces in the third cup. Stir until dissolved. Record the dissolving time.
4. **Interpret Data** Construct a graph that illustrates your findings. Which sugar cube dissolved the fastest?
5. What conclusion can you make regarding dissolving time based on the experiment?



What Is Solubility?

Have you ever tried making fruit punch from a mix? How easy is it to get all of the mix to dissolve? Solutes act differently in different solvents. This property describes *solubility*. Solubility explains the ability of a solute to dissolve in a solvent.

Many things affect solubility. Temperature is an example. Most solutes dissolve more quickly when a solvent is hot. Sugar is more soluble in hot tea than in cold, iced tea.

The structure of a solute affects its solubility in various solvents. Oil will not dissolve in water. Their structures are different. Oil dissolves in dish detergent. They have similar structures.

Most solute-solvent combinations have a limit of how much solute will dissolve in a volume of solvent. After that limit is reached, no more solute will dissolve. The concentration of a solution is a measure of the amount of solute dissolved in a solvent. A solution becomes saturated when no more solute can dissolve in it. You may observe this when you add sugar to a glass of lemonade. After a few teaspoons, the sugar settles to the bottom of the glass, and no more sugar will dissolve.

What are some factors that affect solubility?

What Are Heterogeneous Mixtures Like?

Rocks are an example of heterogeneous mixtures. Tomato sauce, casseroles, and taco salads are also familiar examples.

Heterogeneous mixtures are even more common than solutions. Heterogeneous mixtures, unlike solutions, settle into layers in a fluid. Oil-and-vinegar salad dressing separates when it is left alone, for example.

Heterogeneous mixtures are either cloudy or opaque. They are not evenly mixed. Think of a pot of chicken soup. One ladle may have a lot of carrots. The next may have few carrots and a lot of rice. One part of a mixture may have more of one substance than another.

Mixtures like clay and water, with particles that are easily seen, are called **suspensions**. Suspensions form when one substance is insoluble, or does not dissolve in a solvent.

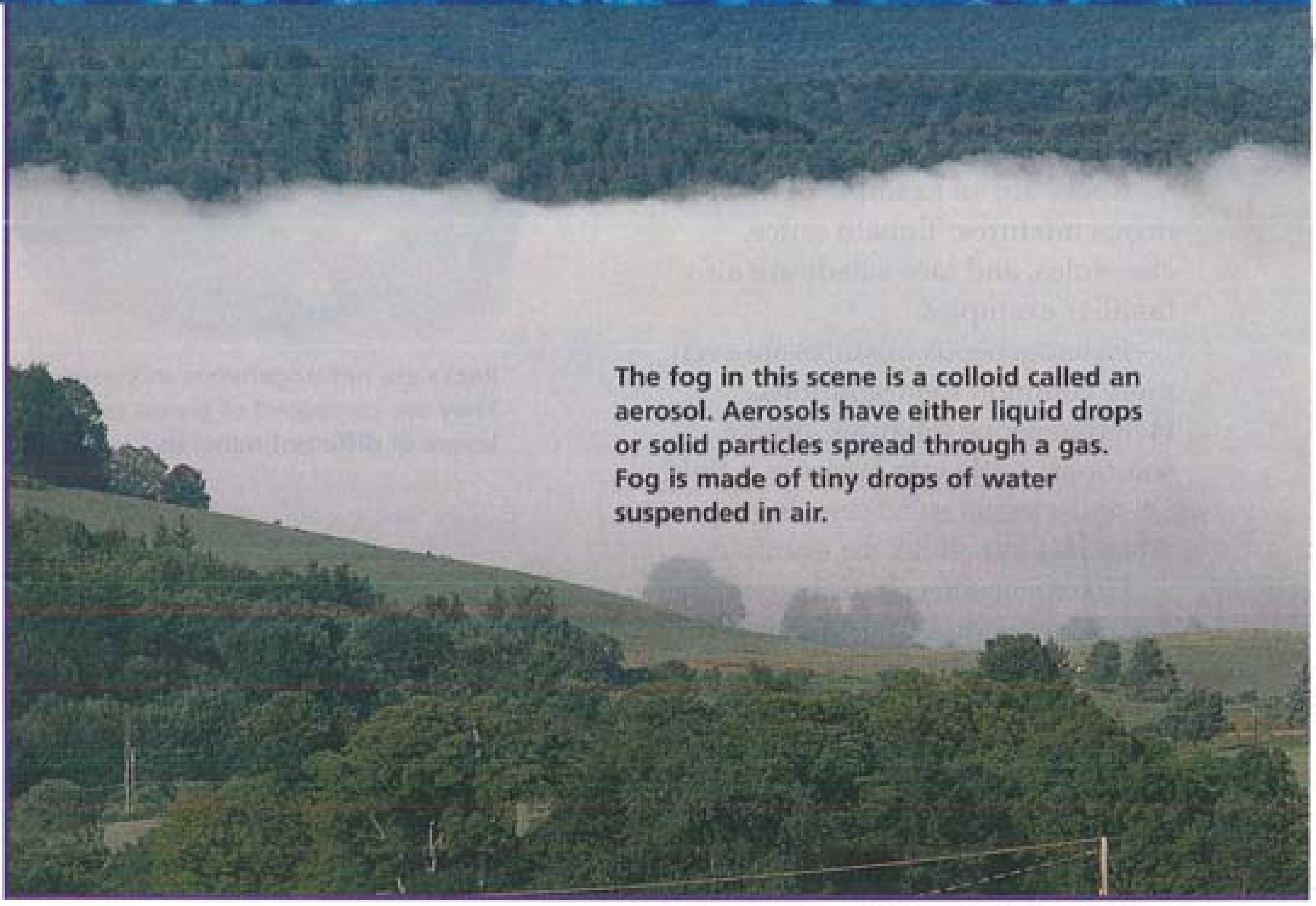
Rocks are heterogeneous mixtures. They are composed of pieces or layers of different minerals.

What are the characteristics of heterogeneous mixtures?

Heterogeneous Mixtures Can Settle into Layers

Freshly shaken mixtures of clay and water, and oil and water

The mixtures after they were allowed to stand for a length of time



The fog in this scene is a colloid called an aerosol. Aerosols have either liquid drops or solid particles spread through a gas. Fog is made of tiny drops of water suspended in air.

What Types of Colloids Are There?

Milk is not transparent, so it cannot be a solution. It does not settle out into layers, so it is not a heterogeneous mixture. Milk is a colloid. Like milk, all colloids have properties between those of solutions and heterogeneous mixtures.

The photograph on page E61 shows what milk looks like under a microscope—droplets of fat spread throughout water. Other colloids are similar. They have particles of one material scattered through another. The particles are big enough to block or scatter light but not big enough to settle out.

There are many types of colloids. Milk is an example of an **emulsion**, a liquid (fat) spread through another liquid (water).

Another type of colloid is called an **aerosol**. Aerosols have either liquid drops or solid particles spread through a gas. Fog is made of tiny drops of water suspended in air.

Many food products are colloids. Gelatin dessert is a **gel**. A gel is a solid spread through a liquid. The solid in the gelatin is protein. The liquid in the gelatin is water.

Whipped cream is a **foam**. A foam is a gas spread through a liquid. The gas in the whipped cream is air. The

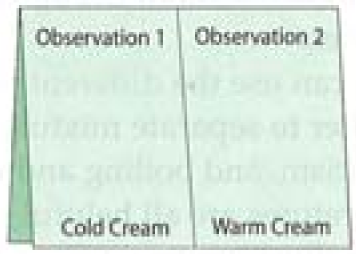
liquid in the whipped cream is water and fat. Marshmallows are a solid foam—a gas spread through a solid. The gas in the marshmallows is air. The solid in the marshmallows is a sweetened gelatin.

What are four types of colloids?

QUICK LAB

Kitchen Colloids

FOLDABLES Make a Two-Tab Book. (See p. R 41.) Label as shown.



1. Pour some whipping cream into a bowl. Set it in a bed of ice in another bowl. Let the cream and bowl chill. Whip the cream until it is fluffy.
2. **Observe** Let the cream warm. Whip it more. How does it change? Record your observations under the tabs.
3. **Interpret Data** What kind of colloids did you make in steps 1 and 2?
4. **Infer** What are these colloids commonly known as?

How Can Mixtures Be Separated?

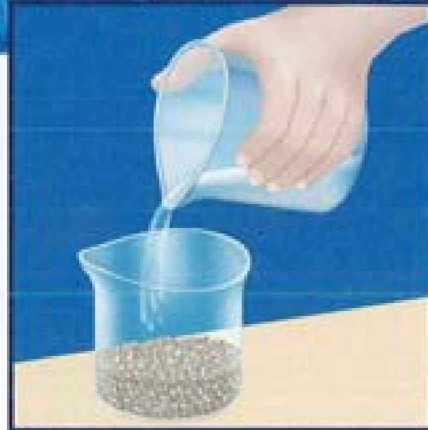
We can separate the parts of mixtures using methods called physical separations. A physical separation gets the parts of a mixture away from one another without changing their identities.

We can use the different properties of matter to separate mixtures. Density, magnetism, and boiling and melting temperatures are all helpful tools.

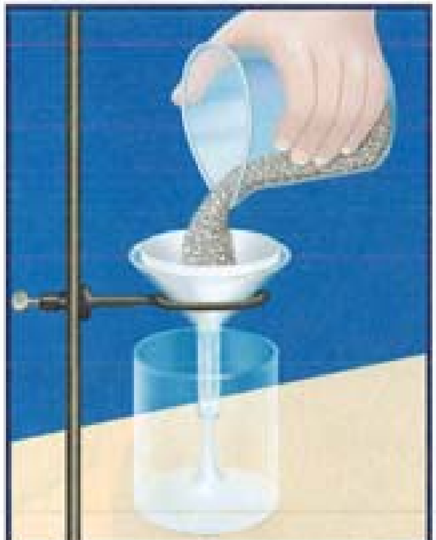
The illustrations on these pages show examples of physical separation methods. Study them to see the steps and equipment needed.

What properties might you use to separate mixtures?

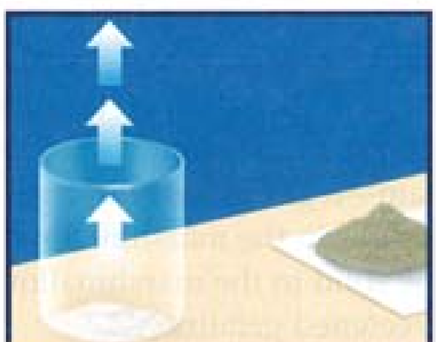
The mud particles cannot pass through the pores in the paper, but the water molecules can. The mud collects in the paper, while the water drips through.



1 To separate a mixture of sand and salt, pour in water and stir. The salt dissolves, but the sand doesn't.

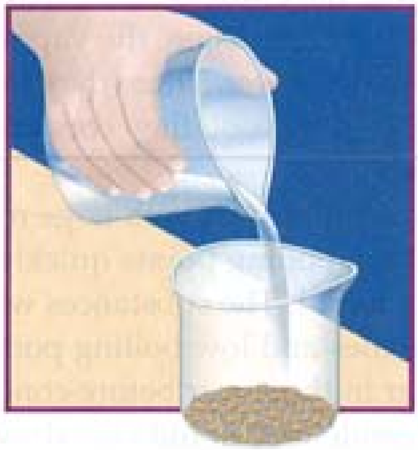


2 Use a filter to separate the sand from the salt water.

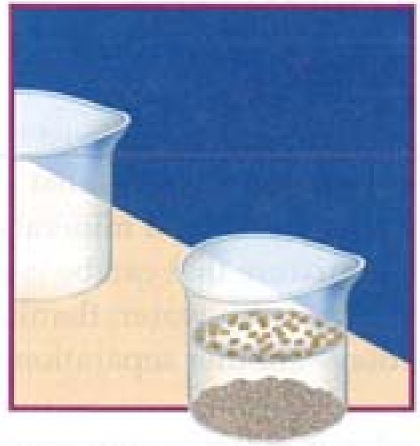


3 Then let the water evaporate to get back the salt.

Separating Sand and Wood Chips



To separate sand and wood chips, first pour in water. Stir briefly.

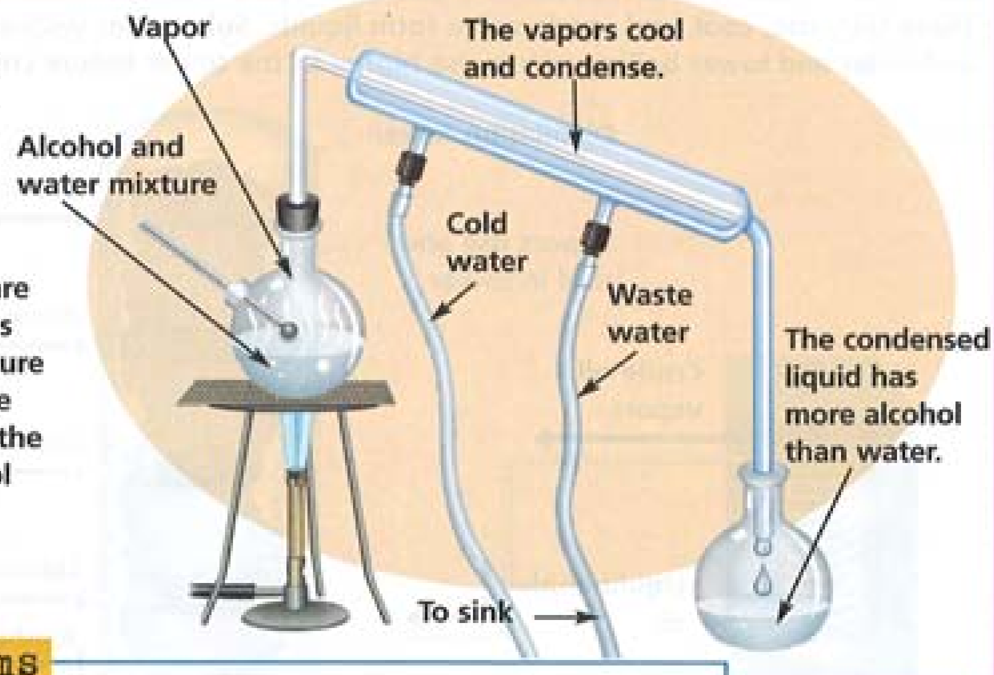


The wood chips float to the top, while the sand settles to the bottom. The wood chips can be skimmed off and dried. The water can be poured off, and the sand dried.

Separating Alcohol and Water

You could separate alcohol and water by heating them in this apparatus.

Alcohol and water are heated. Alcohol boils at a lower temperature than water, so at the beginning, more of the vapor will be alcohol than water.



READING Diagrams

1. What is one way to separate two substances in a mixture?
2. Could you separate sand and wood chips the same way you separate sand and salt? Explain.
3. Make a list of three ways to separate parts of a mixture.

Which Resources Come from Mixtures?

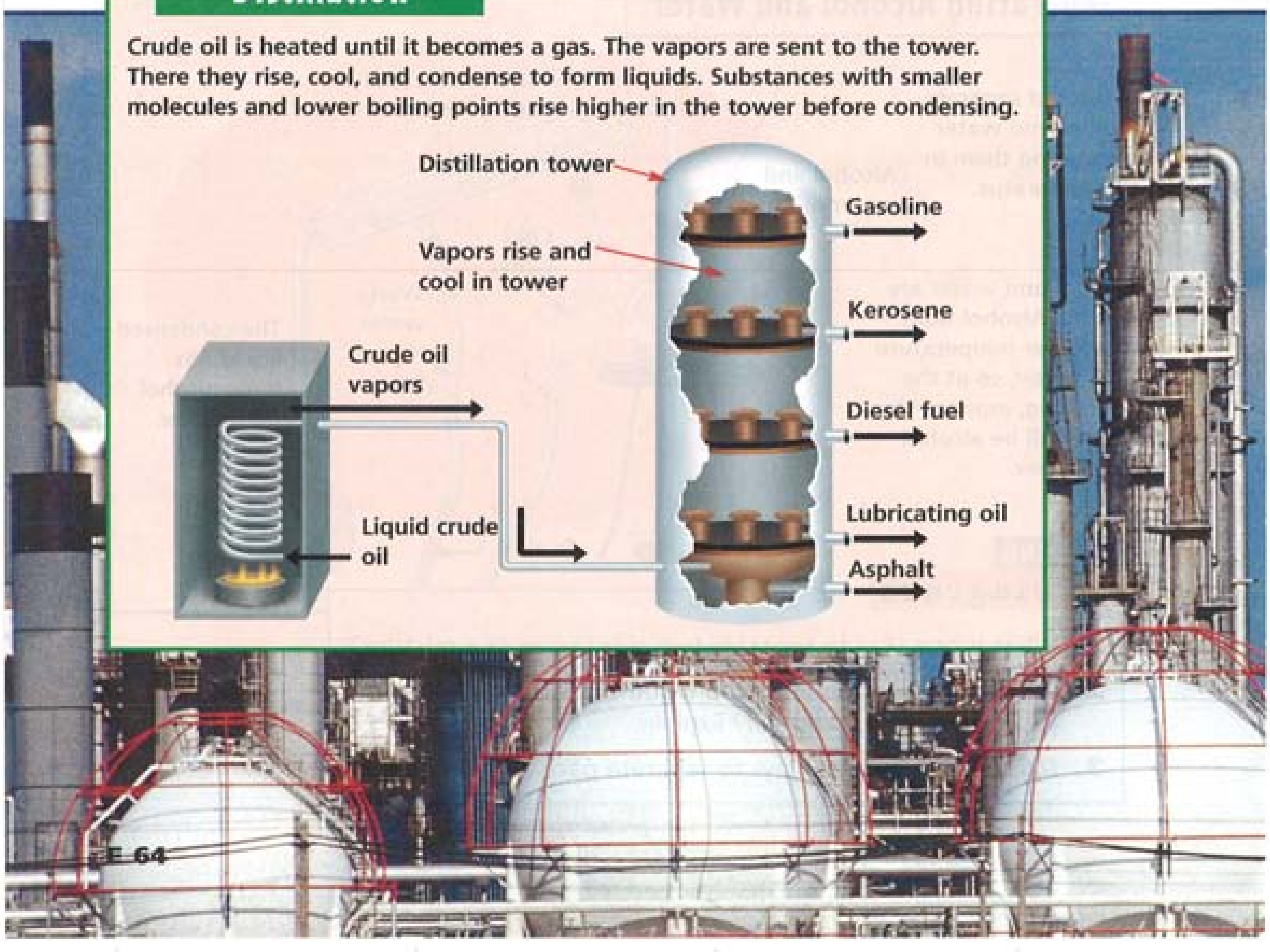
Many of Earth's resources exist as mixtures. Ores are mixtures that provide us with metals and minerals. Seawater is a mixture that can be used as a resource for fresh water, thanks to desalination—another separation process.

Crude oil, our major energy source, is a mixture, too. The diagram below shows a process called *distillation*. We use this process to separate important chemicals out of crude oil.

First, the crude oil is heated until it becomes a gas. Then, the vapors are sent to the tower. There they rise and cool. As they cool, they condense to form liquids.

The substances with large molecules and high boiling points quickly cool into a liquid. The substances with small molecules and low boiling points rise higher in the tower before condensing. The condensed liquids are drawn off as shown.

READING **Cause and Effect** **How can we get resources from mixtures?**



Distillation

Crude oil is heated until it becomes a gas. The vapors are sent to the tower. There they rise, cool, and condense to form liquids. Substances with smaller molecules and lower boiling points rise higher in the tower before condensing.

Lesson Review

Why It Matters

Many things you use every day—from the air you breathe to the milk you drink to the steel in your bicycle—are mixtures. Some mixtures need to have just the right amounts of their ingredients each time. For example, you need a certain amount of oxygen in the air you breathe. The amount of iron, carbon, and other metals in steel determines its properties, such as hardness and resistance to rusting.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on mixtures and solutions.

Think and Write

1. How do the properties of sugar and water alone compare with the properties of a sugar-water solution?
2. How are mixtures different from compounds?
3. Air is a mixture of oxygen and nitrogen gas. What type of mixture is air? Why?
4. Oil paints are made of colored particles spread through an oil. Are oil paints solutions, heterogeneous mixtures, or colloids? How do you know?
5. **Critical Thinking** Describe the steps that could separate a mixture of sawdust and salt.

L·I·N·K·S

ART LINK

Make a collage. Cut pictures of mixtures from magazines. Paste them on a board. Tell your classmates which are solutions, colloids, and heterogeneous mixtures.

MATH LINK

Make a graph. Air is a solution of gases. Research what the gases are and how much of each gas is in air. Show the results in a graph.

WRITING LINK

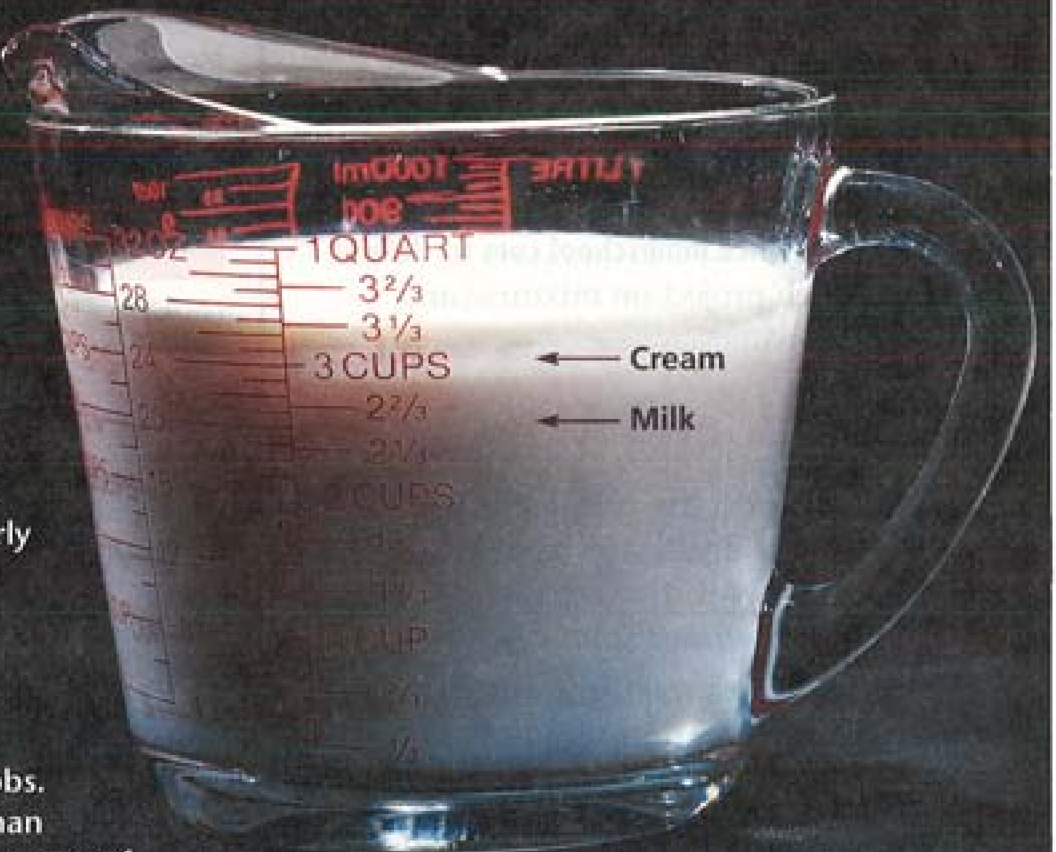
Writing a Story Many dishes, such as salad, a casserole, and pizza, are made from a mixture of foods. Often the mixture tastes better than the ingredients by themselves. Write a story about a dish like this. Tell it from the dish's point of view. Do all the ingredients get along?

TECHNOLOGY LINK

Science Newsroom CD-ROM Choose *Here's the Solution* to learn how the three types of mixtures are similar.

LOG ON Visit **www.science.mmhschool.com** for more links.

Got Milk? Got Butter?



The success of mammals on Earth is helped by what they feed their newborns: milk produced by their mothers. Humans also raise other large mammals to produce milk for them.

A mammal's milk is seven-eighths water, but the other eighth has nearly everything needed for good health! Some food value comes from the lactose, or milk sugar, dissolved in it.

Milk has a lot of fat globs. Because they're lighter than water, the globs rise to the top of a container. Gravity pulls the heavier liquid down. The fat globs merge to become cream. Milk with little or no fat is skim milk.

Many people prefer skim or low-fat milk. The fat in milk contributes to weight problems, heart disease, and possibly other diseases.

Milk you buy has vitamins D and A added to make it more nutritious. It's been pasteurized—heated to kill disease-causing bacteria. The heating also makes some milk proteins inactive and slows down the spoiling.

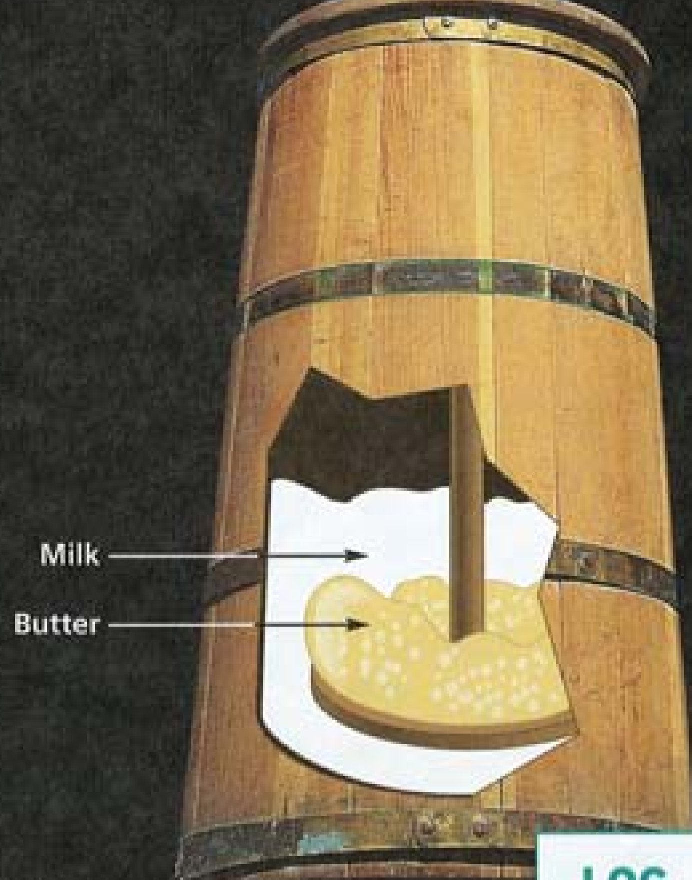
Milk is homogenized by putting it through a fine screen to break fat globs into tiny specks. They're so small that the movement of the other molecules in milk keeps them from rising. For that reason cream doesn't form at the top of homogenized milk.

By constantly moving cream in a closed container, you cause the fat globs to merge. Drain off the thin, watery stuff and you've got . . . butter!

Automatic milking machine

Write ABOUT IT

1. What other foods are vitamins added to? Why do you think that is done?
2. Fat is used to make cells' outer membranes. How does this explain why mammals' milk is high in fat?

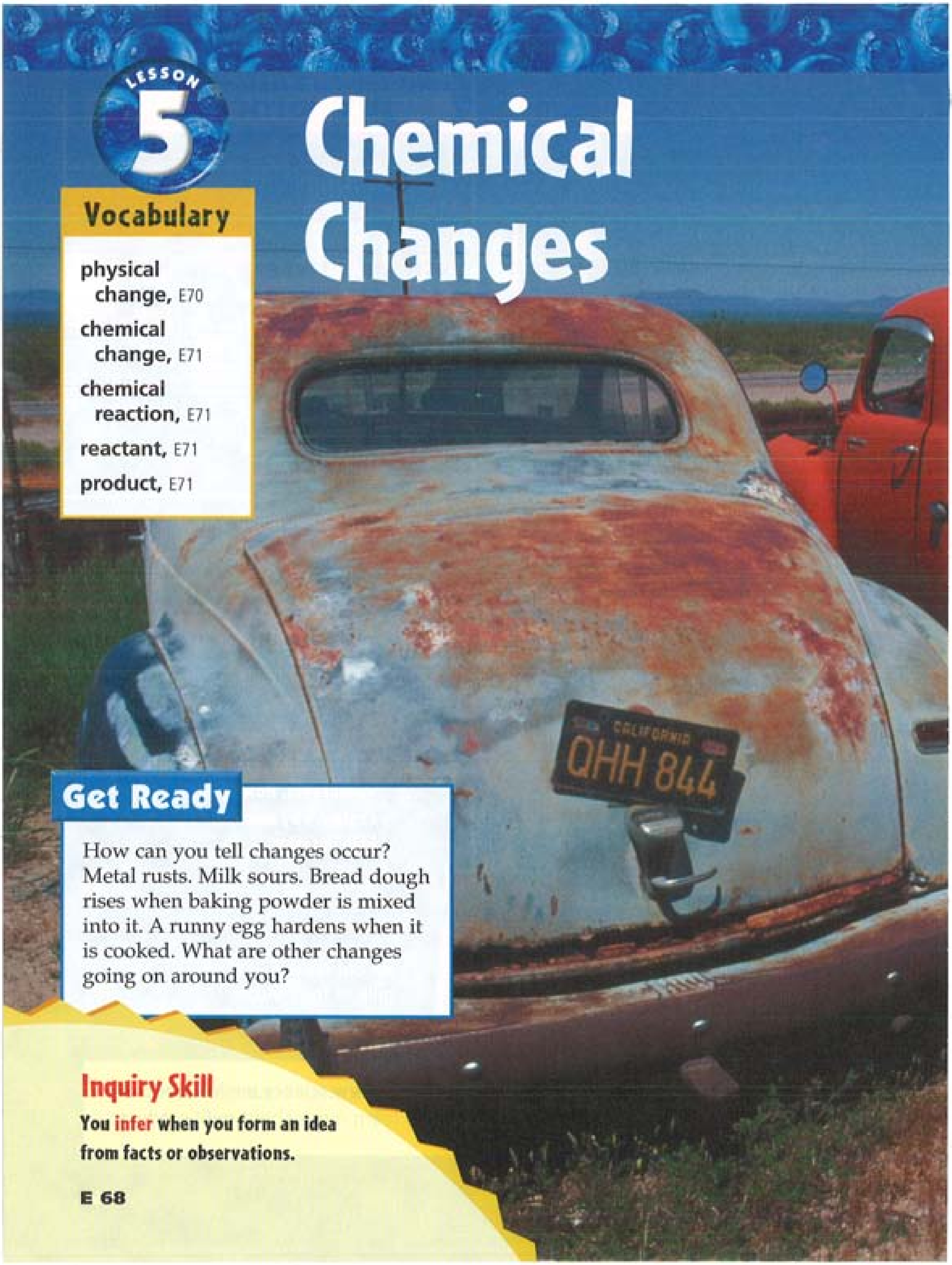


An old-fashioned churn stirs up milk to form butter.

LOG ON Visit **www.science.mmhschool.com** to learn more about milk products.

LESSON 5

Chemical Changes



Vocabulary

- **physical change,** E70
- **chemical change,** E71
- **chemical reaction,** E71
- **reactant,** E71
- **product,** E71

Get Ready

How can you tell changes occur? Metal rusts. Milk sours. Bread dough rises when baking powder is mixed into it. A runny egg hardens when it is cooked. What are other changes going on around you?

Inquiry Skill

You infer when you form an idea from facts or observations.

Explore Activity

How Can You Recognize a Chemical Change?

Procedure

BE CAREFUL! Wear goggles.

1. Copy this grid on wax paper with a marking pen. Using a spoon, put a pea-sized amount of cornstarch in each of the three boxes in the first row.
2. **Observe** Use a dropper to add five drops of water to the cornstarch in the first column. Stir with a toothpick. Record your observations.
3. **Experiment** Using a different dropper, add five drops of vinegar to the cornstarch in the second column. Stir with a new toothpick. Record your observations.
4. **Observe** Use a third dropper to add five drops of iodine solution to the cornstarch in the third column. Record your observations.
   CAUTION: Iodine can stain and is poisonous.
5. **Experiment** Repeat steps 1–4 for baking powder, baking soda, and salt.

Drawing Conclusions

1. **Infer** In which boxes of the grid do you think substances changed into new substances? Explain your answers.
2. FURTHER INQUIRY **Infer** Your teacher will give you samples of two unknown powders. Use what you have learned to identify these powders. Report on your findings.

	Water	Vinegar	Iodine Solution
Cornstarch			
Baking powder			
Baking soda			
Salt			

Materials

- baking soda
- baking powder
- cornstarch
- salt
- iodine solution
- vinegar
- water
- wax paper
- permanent marker
- 4 toothpicks
- 3 droppers
- 4 plastic spoons
- 7 small cups
- goggles

Read to Learn

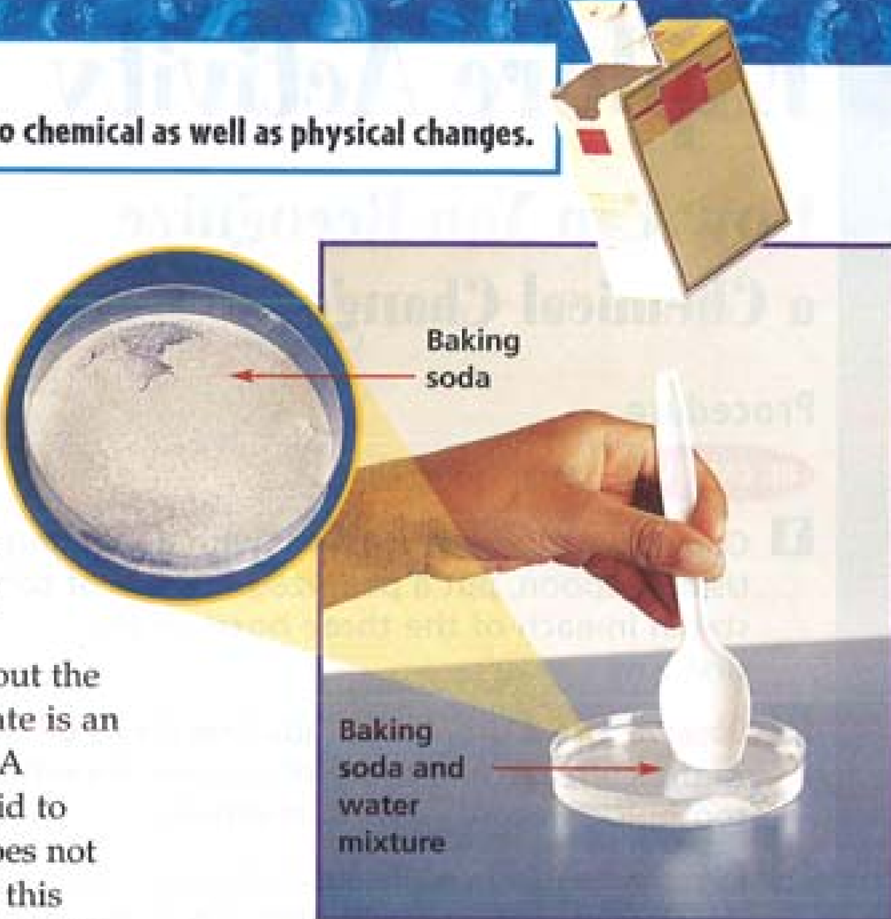
Main Idea Matter can undergo chemical as well as physical changes.

What Are Physical and Chemical Changes?

Different kinds of changes are going on all the time. In a **physical change**, matter changes in size, shape, or state without also changing identity.

In Lesson 3 you learned about the states of matter. Change of state is an example of a physical change. A substance can change from solid to liquid to gas. The substance does not change its chemical identity in this process. Its state simply changes. The photograph below shows why a change of state is a physical change.

You also learned in Lesson 4 about mixtures. Combining two substances to form a solution is another example of physical change. The two substances do not lose their identities. They can be physically separated from each other to give back the original substances. The photograph above shows this kind of physical change.



When baking soda mixes with water, the baking soda seems to disappear. However, when the water evaporates, baking soda is left behind. This is a physical change.

A change of state is a physical change. When the steam—gaseous water—hits the dish, it cools and turns back into liquid water.

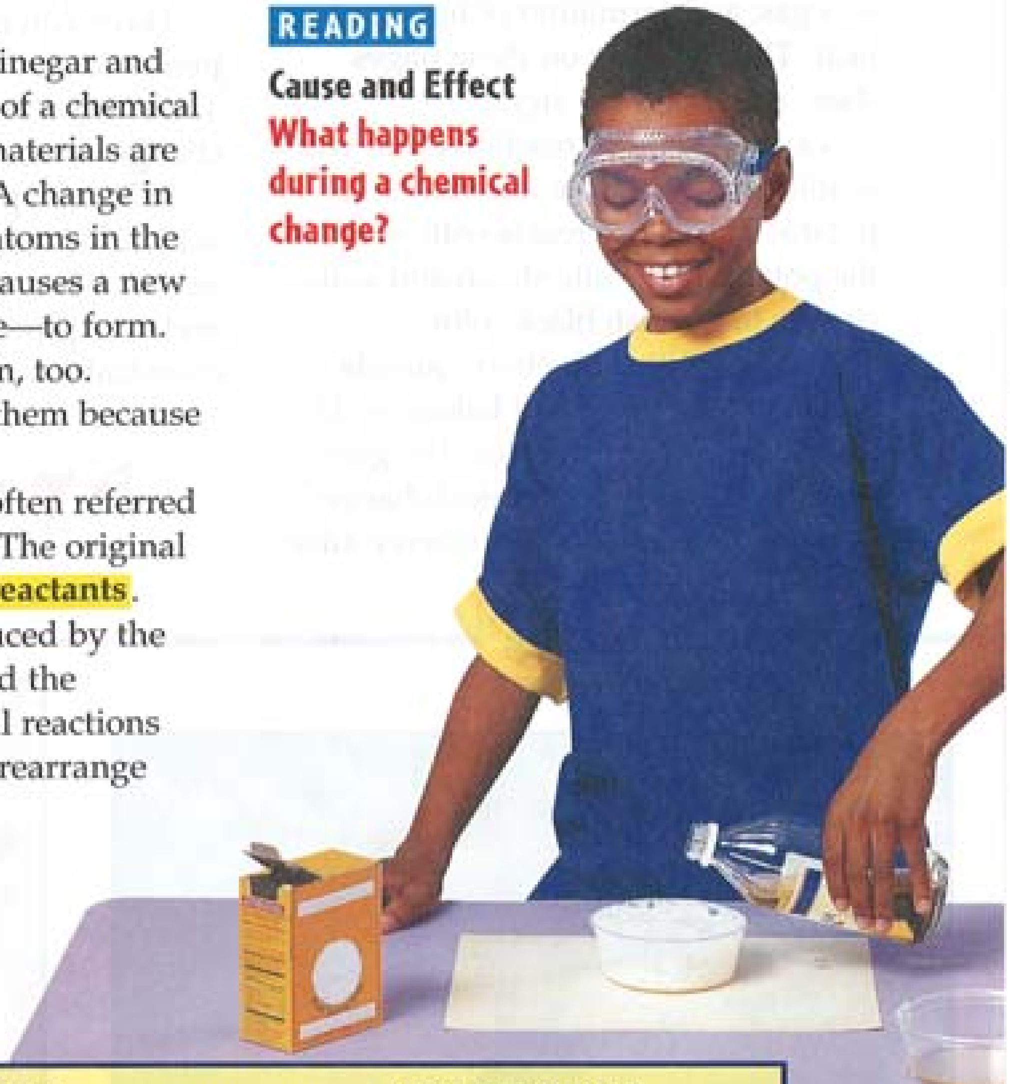
The photo on page E68 shows a **chemical change**. Chemical changes occur when atoms link together in new ways. The changes cause new compounds to form. The new compounds have properties different from the original substances from which they were formed.

The reaction between vinegar and baking soda is an example of a chemical change. When these two materials are mixed, gas bubbles form. A change in the linking pattern of the atoms in the vinegar and baking soda causes a new substance—carbon dioxide—to form. Other new substances form, too. However, you cannot see them because they remain in the liquid.

Chemical changes are often referred to as **chemical reactions**. The original substances are called the **reactants**. The new substances produced by the chemical reaction are called the **products**. During chemical reactions the atoms in the reactants rearrange to form products with different properties. In the reaction between baking soda and vinegar, the baking soda and the vinegar are the reactants. The carbon dioxide, water, and a chemical called sodium acetate are the products.

READING

Cause and Effect
What happens during a chemical change?



What happens when baking soda and vinegar mix?

STARTING SUBSTANCES — NEW SUBSTANCES

$$NaHCO_3 + CH_3COOH \rightarrow H_2O + CO_2 + NaC_2H_3O_2$$

Baking soda + Acetic acid (part of vinegar) → Water + Carbon dioxide + Sodium acetate

What Are the Signs of a Chemical Change?

Chemical reactions often show one or more signs that a chemical change has occurred. These signs include a color change, formation of a gas, and formation of light and heat. The reactions on these pages show some of these signs.

Does a chemical reaction occur when reddish brown iodine is placed on a potato? The iodine reacts with starch in the potato. The white starch and iodine change to a bluish black color.

When reddish blueberry juice is mixed with a solution of baking soda, it turns to a greenish color. The green color results from a chemical change in the molecules of the blueberry juice.

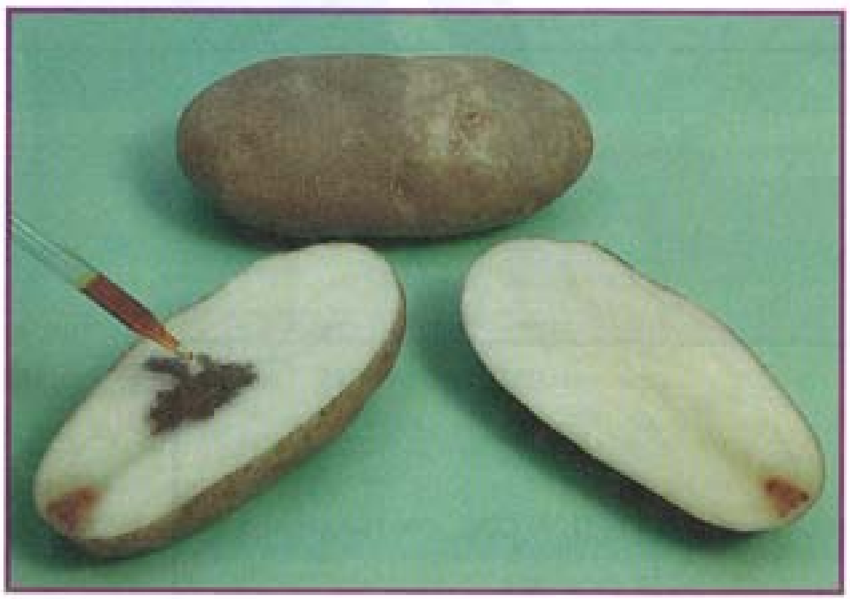
The bubbles you see when lemon juice is added to a solution of baking soda are a sign of a chemical change. Carbon dioxide gas forms by the reaction between acid in the lemon juice and the sodium bicarbonate in the baking soda.

Have you ever put hydrogen peroxide on a cut to kill germs? The bubbles tell you that a chemical change is occurring.

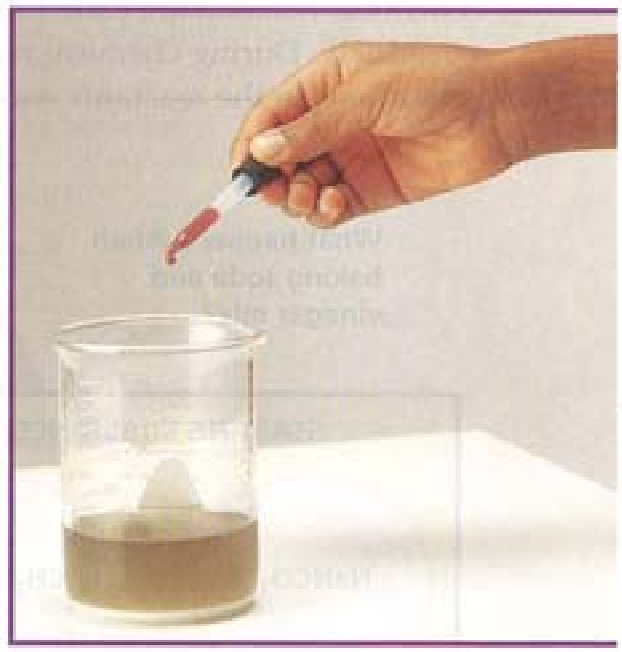
What happens when propane gas is released from a tank and ignited? It reacts with oxygen in the air. The light and heat produced are signs of this chemical reaction.

What are three signs of a chemical change?

Color Change



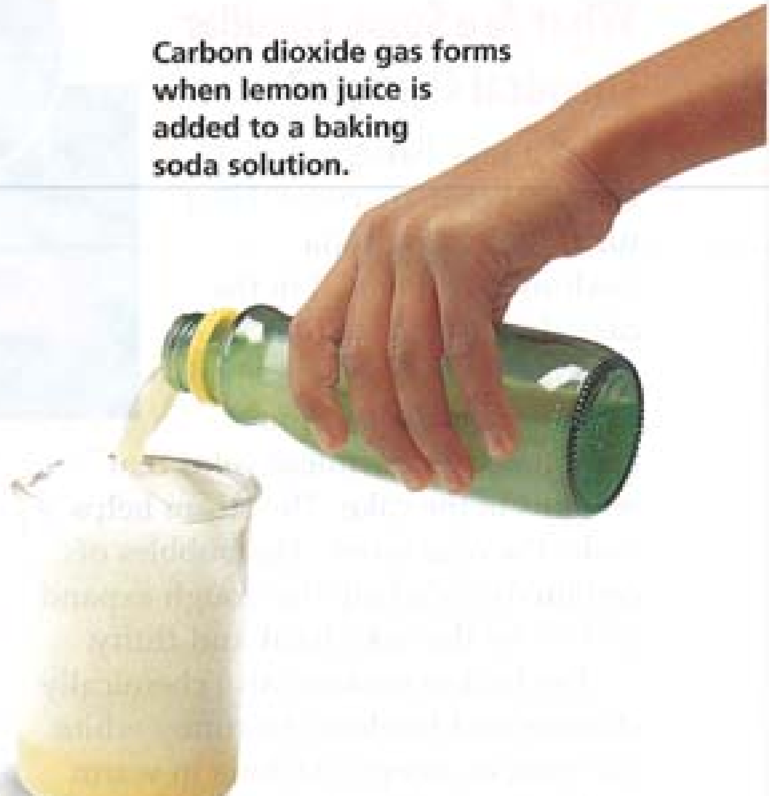
When iodine is dropped onto a potato, a color change is observed.



The reaction of blueberry juice and baking soda shows a change of color.

Formation of a Gas

When hydrogen peroxide comes into contact with bodily fluids, it reacts and gives off pure oxygen gas. The oxygen gas, in turn, kills germs in the cut and guards against infection.



Carbon dioxide gas forms when lemon juice is added to a baking soda solution.

Formation of Light and Heat

When propane burns in air, it chemically reacts with oxygen.

When you light a match, it gives off light and heat all on its own. This tells you that a chemical change is occurring.

What Are Some Familiar Chemical Changes?

Rust

Tarnish

As a cake bakes, several chemical changes occur. Heat turns the baking soda (sodium bicarbonate) in the cake dough into sodium carbonate, steam, and carbon dioxide gas. The sodium carbonate is a harmless solid that remains in the cake. The steam helps make the cake moist. The bubbles of carbon dioxide help the dough expand and make the cake light and fluffy.

The heat of cooking also chemically changes and hardens the runny white and yolk of an egg. Bacteria in warm milk can change it chemically and turn it sour.

The red powder covering the wheelbarrow above is iron oxide. Iron oxide is commonly known as rust. Rust forms when iron atoms in steel react with oxygen from the air. The reaction is very complex and needs moisture to occur. Steel objects are most likely to rust if they get wet and are not dried right away.

Rocket engines use chemical reactions to produce lots of heat. This space shuttle's main engines are fueled by liquid hydrogen and liquid oxygen. The two react together to make water vapor and the energy the shuttle needs. The shuttle also uses launch boosters containing a solid fuel, aluminum powder. When it burns, it changes to aluminum oxide.

The silver spoon in the photo is partly covered with a tarnish of silver sulfide. The silver sulfide forms when silver reacts with sulfur or hydrogen sulfide in foods or the air. You can even tarnish silver by wrapping it with a rubber band. Sulfur added to strengthen the rubber causes the tarnish to form. Polishes can be used to remove the tarnish and restore the silver's shiny appearance.

What are three examples of chemical changes?

Inquiry Skill BUILDER

SKILL Experiment

Preventing Rust

You've learned that steel forms rust when exposed to oxygen and moisture. Rusting can ruin metal objects. Can you find a way to stop or slow rusting? In this activity you will experiment to try to find the answer. In order to experiment, you need to do the following things. Form a hypothesis. Design a control. Carry out your experiment. Analyze and communicate your results.

Materials

- steel nails
- sand paper
- paper cups
- dilute salt water
- goggles

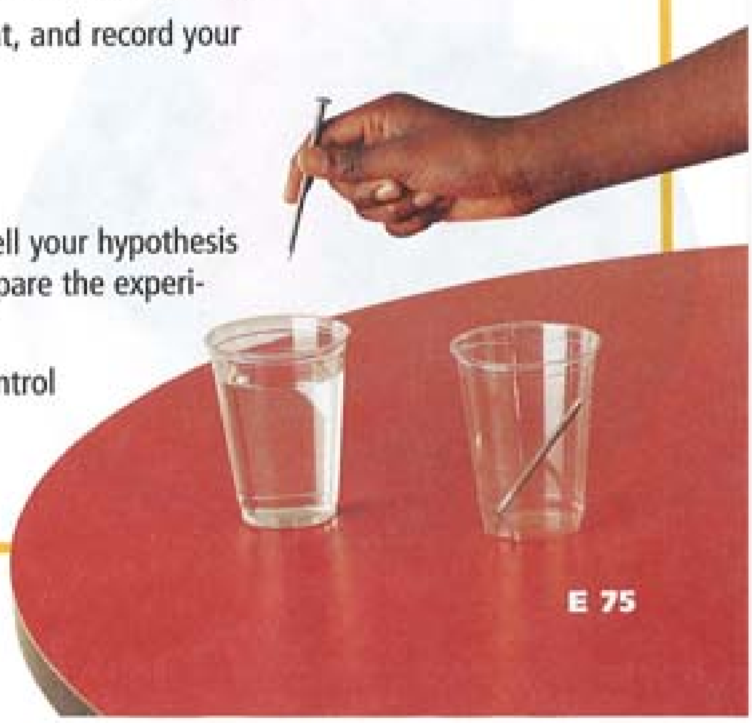
Procedure

BE CAREFUL! Wear goggles.

1. **Hypothesize** The photograph shows a method for making a steel nail rust. Think of a way to protect a steel nail from rusting under such conditions. Write down an explanation of why you think your method will work.
2. **Experiment** To test your method of rust protection, you need a control nail kept under normal conditions. Each experimental nail will have just one condition (variable) change. For example, what if you wanted to make a nail rust? You might leave one nail in a clean, empty jar (the control). You might put another in water. You might put a third in lemon juice. The amount of rusting that occurs is called the *dependent variable*. Write out how you will set up the experimental and control nails for your experiment.
3. **Experiment** Carry out your experiment, and record your observations.

Drawing Conclusions

1. **Infer** Write out a description of how well your hypothesis agreed with your results. Be sure to compare the experimental nail with the control nail.
2. **Communicate** Why did you need a control in this experiment?



Which Are Easier to Reverse – Chemical or Physical Changes?

You would probably agree that turning carbon dioxide gas, water, and sodium acetate back into baking soda and vinegar would be difficult. Simply stirring the three ingredients together would not give you baking soda and vinegar. In general, chemical changes are difficult to reverse. Imagine trying to "unburn" toast or "unspoil" milk!

On the other hand, physical changes can sometimes be easily reversed. Although this is not always true. For example, melting an ice cube can easily be reversed by cooling it until it freezes again. Stirring sugar into water can be reversed by letting the water evaporate.

What changes occur when toast burns? What happens when a candle burns?

However, it would not be so easy to put pieces of paper back together after cutting them from a single page. Still, if a change seems very easy to reverse, it is more likely to be a physical change.

The photograph of a burning candle shows that many changes are happening. Wax melts, runs down the side, and turns solid again. However, some of the wax turns into carbon dioxide gas and steam when it combines with oxygen in the air. This change releases enough heat to make the candle flame you see.

Why are chemical changes more difficult to reverse than physical changes?

Lesson Review

Why It Matters

Chemical changes harden the yolk and white of your cooked egg. They make cake and bread rise and bake. Chemical changes turn milk sour. They turn fuels into heat to warm your home. Chemical changes even turn the food you eat into energy to keep you going. In what other ways are chemical changes important to you?

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on chemical changes.

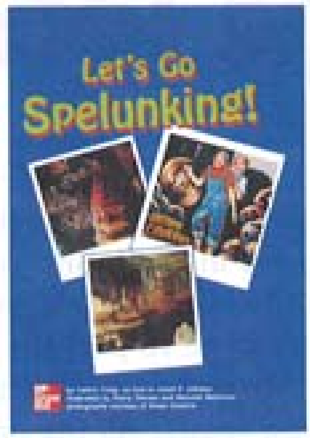
Think and Write

1. Is the rusting of a nail a chemical or a physical change?
2. Is the melting of ice a chemical or a physical change? Why?
3. When a match burns, what evidence is there that a chemical change is occurring?
4. **FURTHER INQUIRY** **Experiment** What if you wanted to find out if a cake bakes better with baking soda or baking powder? Design an experiment to test your ideas. Why might you want to use a control?
5. **Critical Thinking** What could you do to protect a bike from rusting?

L·I·N·K·S

LITERATURE LINK

Read *Let's Go Spelunking!* to learn about a trip to Howe Caverns. Try the activities at the end of the book.



WRITING LINK

Expository Writing The Statue of Liberty is a famous statue in New York Harbor. What is it made of? How does it look today? How did it look 100 years ago? What could have caused the statue's appearance to change? Research this topic and write a cause-and-effect essay.

MATH LINK

Solve this problem. A car uses fuel at a rate of 25 miles per gallon. How much fuel is consumed after traveling 100 miles?

TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.

Can Chemical Reactions Make Food Safe or Unsafe?

Why do mold and bacteria grow in foods and spoil them? Are the foods unsafe to eat? What can be done to prevent microorganisms like molds and bacteria from spoiling foods? All the answers involve chemical reactions.

Like all living organisms, molds and bacteria require food. They can "eat" the same foods we eat and multiply in the food. They cause chemical reactions to occur in food, making it spoil.

In some cases, molds and bacteria can be harmful, perhaps even deadly, to people who eat foods in which these microorganisms have grown. Bacteria from contaminated food can multiply in the digestive tract of a person, causing vomiting, diarrhea, and intestinal bleeding. Hamburger, for example, may be contaminated with a bacterium known as *E. coli* O157:H7. Each year, *E. coli* O157:H7 causes about 73,000 illnesses and about 60 deaths in the United States.

To help prevent bacteria and molds from spoiling foods, food manufacturers may add chemicals to kill microorganisms. Sodium propionate, for example, is a chemical often added to cheeses and baked goods to keep molds from growing. Manufacturers also package foods in airtight containers and bags to prevent spoiling.

While food manufacturers take steps to keep the foods you eat safe, what can you do at home? Chemical reactions slow down as the temperature is lowered. Keeping foods in the refrigerator or freezer is a primary means of preventing the growth of bacteria and molds. The cold temperatures slow down the chemical reactions that make food spoil. Foods such as lunch meats and potato salads should not be kept out of the refrigerator for a long time.

The cheese in the photograph has spots of mold growing on it.

and Society

Vacuum-sealed containers prevent bacteria from contaminating food.

LOG ON Visit **www.science.mmhschool.com** to learn more about bacteria and mold.

Write ABOUT IT

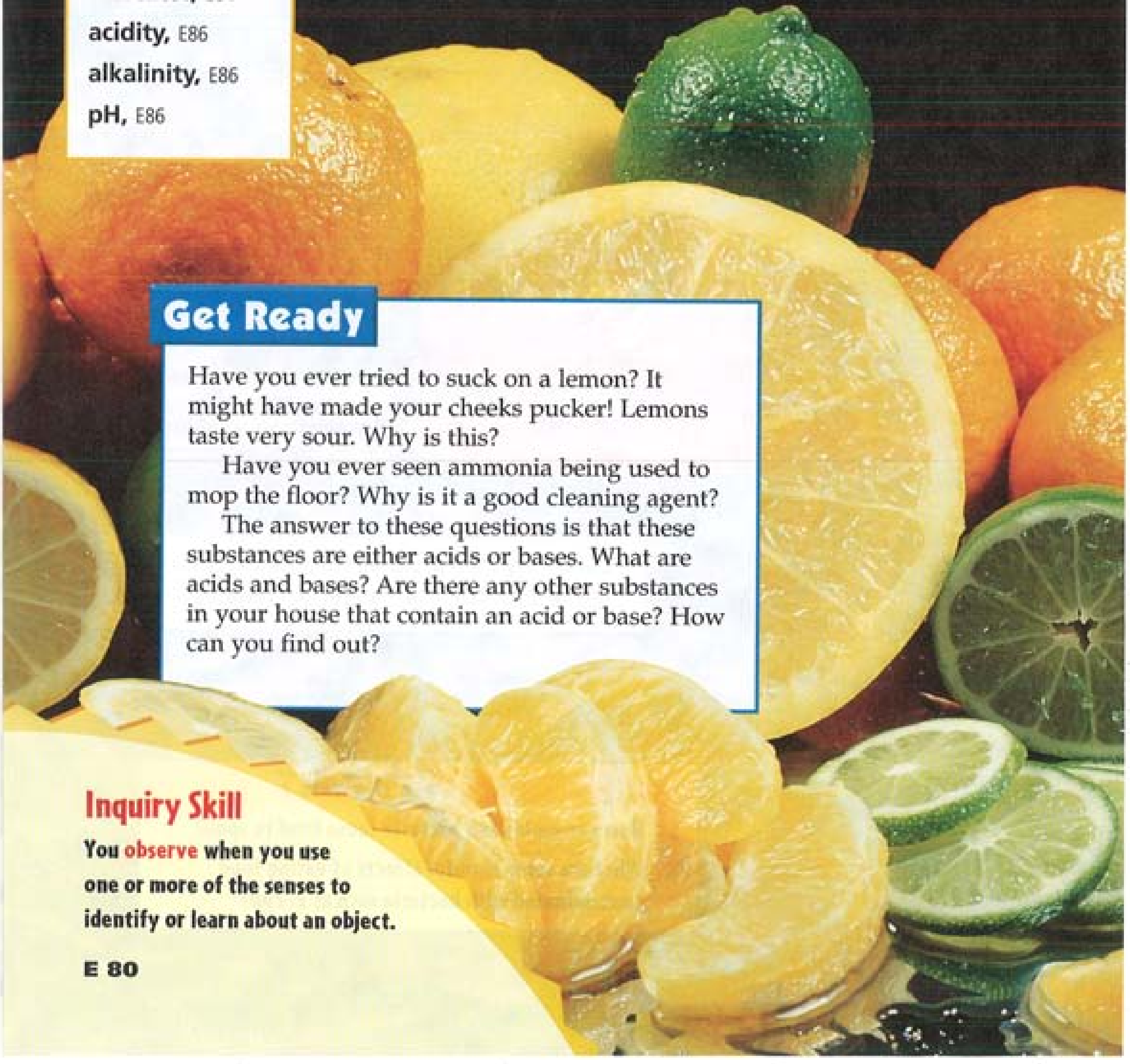
1. **How can molds and bacteria cause food to spoil?**
2. **What are some harmful effects of eating food contaminated with bacteria such as *E. coli*?**

LESSON 6

Acids and Bases

Vocabulary

acid, E82
base, E82
neutral, E82
indicator, E84
acidity, E86
alkalinity, E86
pH, E86



Get Ready

Have you ever tried to suck on a lemon? It might have made your cheeks pucker! Lemons taste very sour. Why is this?

Have you ever seen ammonia being used to mop the floor? Why is it a good cleaning agent?

The answer to these questions is that these substances are either acids or bases. What are acids and bases? Are there any other substances in your house that contain an acid or base? How can you find out?

Inquiry Skill

You observe when you use one or more of the senses to identify or learn about an object.

Explore Activity

Which Are Acids and Which Are Bases?

Procedure

BE CAREFUL! Wear goggles, gloves, and an apron.

1. **Predict** Which solutions do you think are acids and which are bases? Write your predictions in a chart like the one shown below.
2. **Observe** Vinegar is an acid. Put a small amount in a cup, and mark the cup with a label. Test by dipping a piece of red litmus paper into the vinegar. Record the result in your table. Repeat with a piece of blue litmus paper. Litmus paper is a material that allows you to tell which solutions are acids and which are bases.
3. **Classify** Test all of your other solutions in the same way, and record your results.

Sample	Predict: Acid or Base?	Effect on Red Litmus	Effect on Blue Litmus	Result: Acid or Base?
Vinegar	ACID			ACID
Baking soda				
Lemon juice				

Drawing Conclusions

1. Which samples are acids? How do you know?
2. Which samples are bases? How do you know?
3. **Measure** Now test each sample with a small strip of pH paper. Match the color of the paper to the color scale on the holder, and find the pH.
4. FURTHER INQUIRY **Interpret Data** Design and do an activity to test the acidity of the foods you eat. Which foods are acidic? Which are basic? How do you know?

Materials

- red and blue litmus paper
- wide-range pH paper
- plastic cups
- labels
- goggles
- gloves
- apron
- household solutions

Read to Learn

Main Idea Many important substances in our lives are acids or bases.

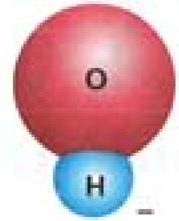
What Are Acids and Bases?

How do you know whether something is an **acid** or a **base**? Vinegar, orange juice, and lemon juice are acids. An acid tastes sour and turns blue litmus paper red. Bases, like ammonia and baking soda, taste bitter and turn red litmus paper blue. (You should never test acids and bases by tasting them, however.)

In Lesson 5 you learned about chemical reactions. When you mixed vinegar, an acid, with baking soda, a base, a chemical reaction occurred. Acids and bases can react with each other to form water and a salt.

In a reaction acids "give away" hydrogen particles, or *hydronium ions*. Bases give off *hydroxide ions*.

This is a simplified hydronium ion. Acids release them in solution.

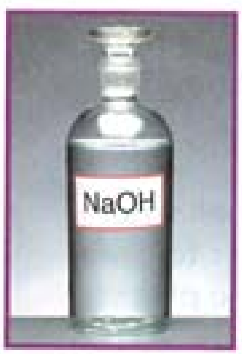


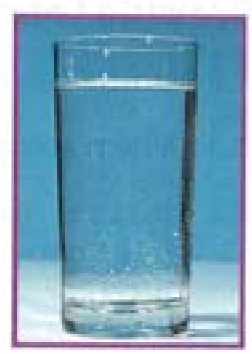
Bases release hydroxide ions, such as this, in solution.

Hydroxide ions are particles that are made up of one oxygen atom and one hydrogen atom linked together. Hydronium and hydroxide ions combine to make water. What is left of the acid and base also combines to make a new substance—a salt.

If you place a blue and a red strip of litmus paper in a glass of water, both strips will stay the same color. This tells you that water is neither acidic nor basic. A solution that is neither acidic nor basic is **neutral**. Water is a neutral substance.

When hydrochloric acid is added to a base, sodium hydroxide, a chemical reaction occurs to produce water and sodium chloride (table salt).





HCl NaOH NaCl H_2O

You can make an acid neutral by mixing it with a base. Likewise, you can make a base neutral by mixing it with an acid. Acids and bases react to form neutral compounds.

The chemical properties, or reactivity, of acids and bases are what make them useful and important. You may know not to add lemon to hot tea with milk. This is because the acid in the lemon can react with the milk, causing it to sour. Acids react strongly with metals, as well. Statues can corrode from the acid found in rain and the atmosphere. The acid in rain is also harmful to plant and animal life.

Acids aren't only harmful, however. Acids are used in batteries to help make electricity. They are used in industry to produce plastics, metals, explosives, textiles, and dyes. They are also used for many functions in your body. All living things use amino acids, for example, to build proteins. All of an organism's muscles and tissues are made up mostly of proteins.

Bases can also be reactive. You may have experienced a bloody nose from smelling ammonia. Ammonia is a strong base that can be corrosive. Bases are often used in cleansers. They can break down grease and oil. Soap is a base you use every day.

Baking soda and baking powder are bases used in cooking. They are often used in baking to make cakes rise. When these bases mix with an acid, carbon dioxide gas is produced. The carbon dioxide gas that is released helps to make cakes become airy and rise.

This statue of George Washington has been corroded by acid in rain.

READING **Cause and Effect**
What happens when an acid is added to a base?

How Can You Tell if Something Is an Acid or a Base?

Litmus paper has a different color in acids than it does in bases. Litmus is an example of an indicator. An indicator is a substance whose color changes when it is mixed with an acid or a base. You can use litmus paper to tell which household materials are acids and which are bases.

Many indicators come from plants. Litmus, for example, is made from certain lichens. Another common vegetable indicator is phenolphthalein (fee·nawl·THAL·ee·in). Phenolphthalein is colorless in acid and pink in base.

Red cabbage juice is another indicator. Add acid to red cabbage juice, and the juice turns maroon. If there is a lot of acid, the juice turns pink. A neutral substance does not change the color. A base turns it green. A very basic substance turns it yellow.

Many household materials can act as indicators. These materials include blueberry juice, beet juice, carrot juice, grape juice, red cabbage, purple hollyhock flowers, and blue iris flowers. Each has one color in an acid and another color in a base.

What is an indicator?

Hydrangeas have pink flowers in basic soil and blue flowers in acidic soil. Are these flowers indicators?

Red cabbage juice is an indicator because it changes color in acids and bases. Litmus paper can also be used as an indicator.

How Can Indicators Be Useful?

The photograph shows a test kit that can be used to find how acidic the soil is. Doing so is important because certain plants grow well only when soil is slightly acidic. The test kit has paper strips that are soaked with an indicator. When a strip is placed in moist soil, it turns a certain color. Matching the color of the strip against the colored scale on the container reveals how acidic the soil is.

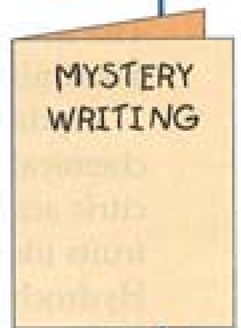
Indicators are important in many situations other than gardening. For example, swimming pool water must be routinely checked with a test kit. Aquarium owners or pond owners periodically have to check how acidic the water is to make sure it is healthy for the fish and plants.

What are some ways indicators are used?

QUICK LAB

Mystery Writing with a Base

FOLDABLES Make a Half-Book. (See p. R 41.) Label it as shown.



1. Dip a cotton swab in baking soda solution. Use it to write a short message to your partner just under the title on the front of your Half-Book.
2. Allow the paper to dry completely. Then give it to your partner.
3. Can you read your partner's message? No? Use another swab to "paint" the paper with grape juice.
4. **Observe** What happened when you painted the paper with the grape juice? Record your observations inside your Half-Book.
5. **Infer** Is the grape juice an indicator? Why or why not? Record your conclusions inside your Half-Book.

Are All Acids and Bases the Same?

Are all acids equally acidic? Are all bases equally basic? No. Acids and bases have different strengths. The strength of an acid is called its **acidity**. The strength of a base is called its **alkalinity**.

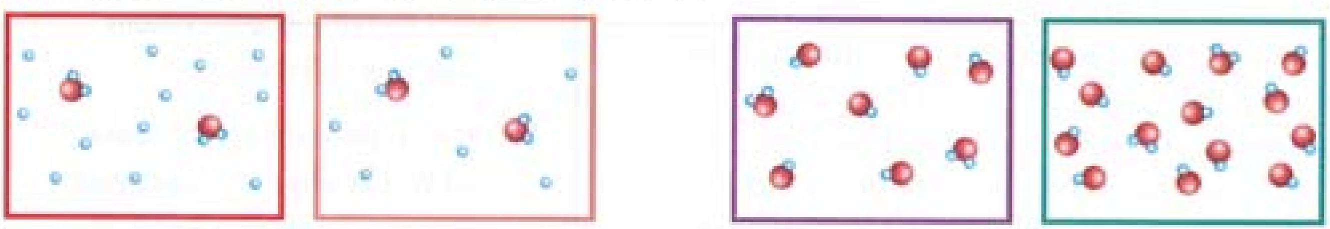
Hydrochloric acid, a laboratory chemical, is much more acidic than citric acid, the acid found in citrus fruits like oranges and lemons. Hydrochloric acid, therefore, has a higher acidity.

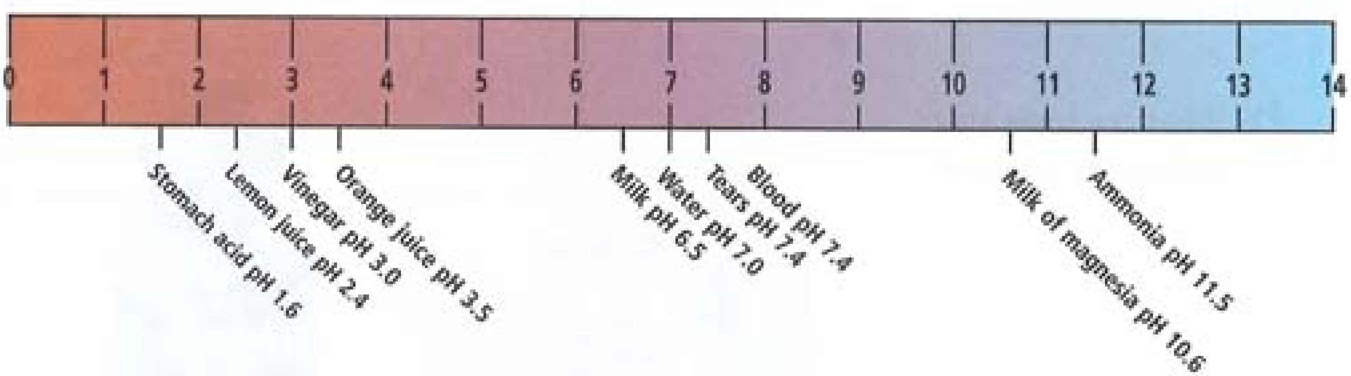
Acidity and alkalinity depend on how many hydronium and hydroxide ions are in a solution. The diagram below compares the solution of a strong acid with a weak acid, and a strong base with a weak base.

A scientist named Soren Sorenson developed a scale in 1909 to compare acidic and basic solutions. This scale is called the *pH scale*. The **pH** of a solution tells how acidic or basic the solution is. It measures acidity and alkalinity. Scientists still use this scale today.

The pH of most solutions lies between pH 1 and pH 14. A pH of 1 means that there are a lot of hydronium ions in a solution. The solution is very acidic. A pH of 14 means that there are a lot of hydroxide ions in a

The first solution is a stronger acid than the second because it has more hydronium ions. The third solution is a weaker base than the fourth solution because it has fewer hydroxide ions. Alkalinity increases as the pH increases from 7 to 14. Acidity increases as the pH decreases from 7 to 0.





pH meter

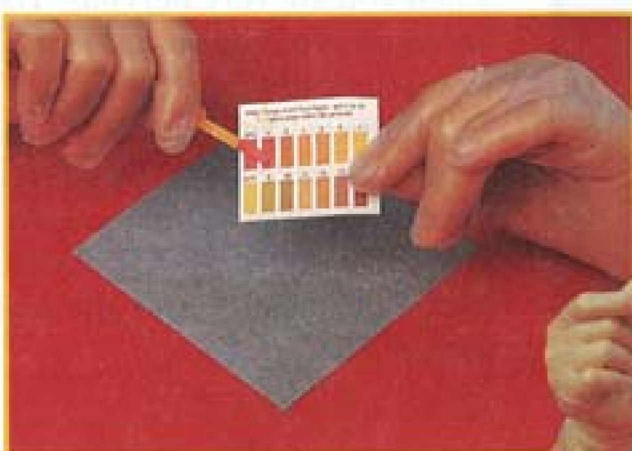
solution. The solution is very basic. A pH of 7 means that the solution is neutral.

Scientists often use a pH meter to determine the acidity or alkalinity of a solution. Strips of paper called pH paper are also commonly used. This paper changes to a different color depending on the exact pH of a solution.

Your blood has a pH of 7.4. Doctors can use this pH to diagnose certain diseases. The blood of a person with diabetes, for example, has a pH that is lower than normal.

How can acidity and alkalinity be measured?

The color match indicates that the solution has a pH of 2, which means that it is acidic.



How Can Acids and Bases Be Used?

Acids and bases are used in many different ways every day. They can be used in your home as cleaning agents. Bleach contains acids, for example. Ammonia, drain cleaners, and window cleaning solutions all contain bases. Bases are good cleaning agents because they dissolve grease, fats, and oils.

Many foods get their flavor from acids. Tomatoes, grapefruit, lemons, and limes all contain acids.

Acids and bases are used in laboratories and in industry to make plastics and textiles. Some minerals can be identified by their reaction with acids. Cotton is often treated with a base to make it look shiny.

The reaction of acids and bases is very useful. You have learned that acids and bases react to make neutral compounds. You may have even experienced this kind of reaction in your own body! Have you ever taken an antacid or milk of magnesia for an upset stomach? Your stomach contains acids to help you digest food. In fact, the pH of your stomach is usually between 1 and 2.

Sometimes there is too much acid in your stomach, causing the pH to go even lower. This may happen when you eat foods that are very acidic or when you are very nervous. The decrease in pH can cause a stomachache.

Products like antacids are basic. When you take them, they react with the extra acid in your stomach. They help increase the pH of your stomach back to its normal level and make you feel better.

How can acids and bases be useful?

Lesson Review

L·I·N·K·S

Why It Matters

Acids and bases make up many of the compounds around you. They clean your clothes and help you to digest food. Oranges are acidic, but eating one is not dangerous. However, some acids and bases must be treated with care. Use these materials safely. Wear protective eyewear and cover your skin when working with them. The pH scale shows the strength of acids and bases.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on acids and bases.

Think and Write

1. What kind of particles do acids produce?
2. What are the properties of a base?
3. Your friend wonders if a cleanser is an acid or a base. What test could you do to help him answer the question?
4. What numerical scale describes acidity? How does this scale work?
5. **Critical Thinking** A friend calls you and says he accidentally spilled some acid. Describe what you would tell him to do to clean up the spill safely.

MATH LINK

Solve this problem. An acid with a pH of 3 is 10 times more acidic than an acid with a pH of 4. How much more acidic is an acid with a pH of 1 than an acid with a pH of 3? With a pH of 4?

ART LINK

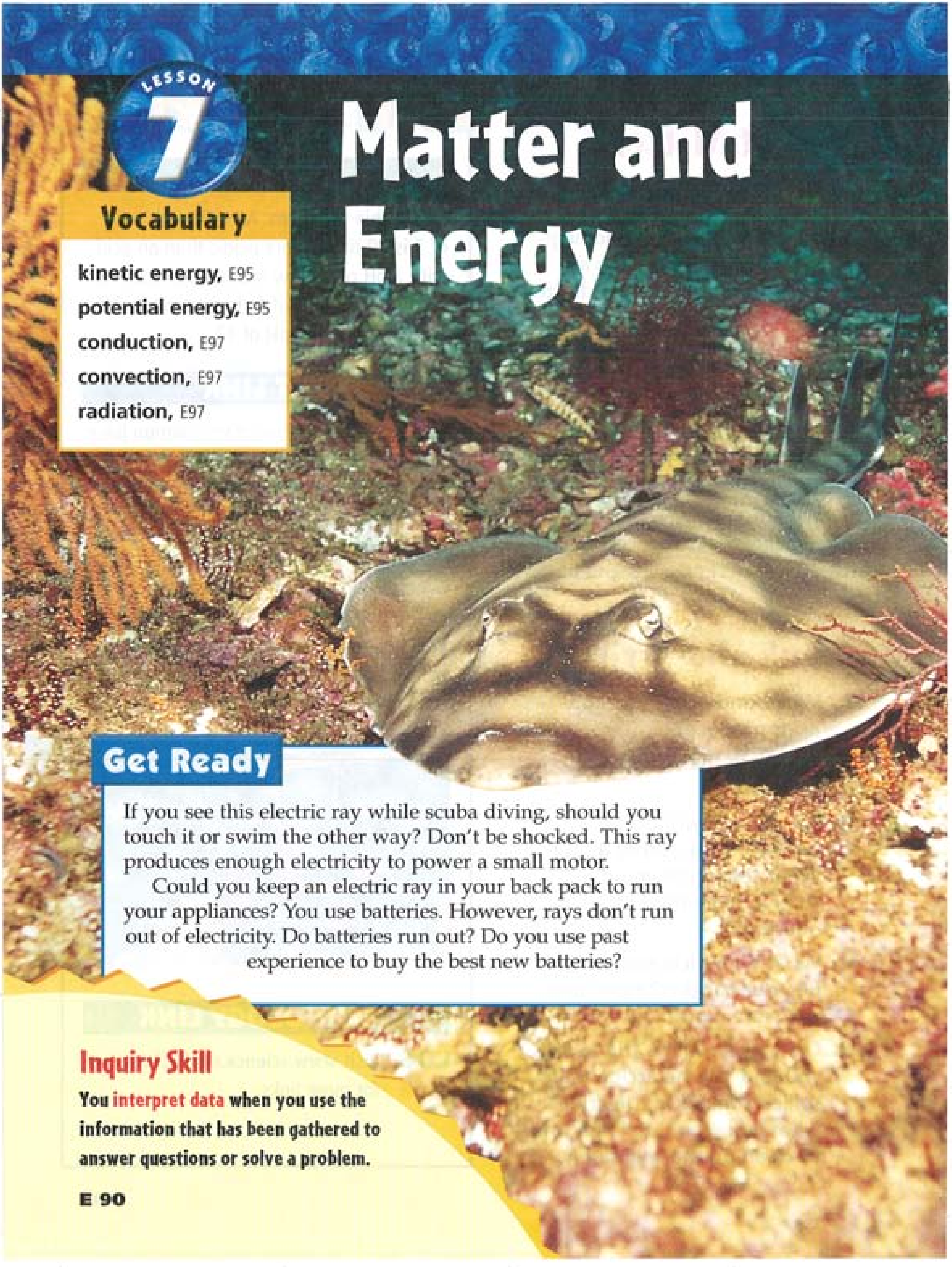
Draw a picture. Paint it with lemon juice. Let it dry. Then develop it with grape juice.

WRITING LINK

Persuasive Writing What are the benefits gained from checking and controlling pool water for its pH level? Write a public-service announcement persuading pool owners to check for and control acidity levels.

TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.



LESSON 7

Matter and Energy

Vocabulary

kinetic energy, E95
potential energy, E95
conduction, E97
convection, E97
radiation, E97

Get Ready

If you see this electric ray while scuba diving, should you touch it or swim the other way? Don't be shocked. This ray produces enough electricity to power a small motor.

Could you keep an electric ray in your back pack to run your appliances? You use batteries. However, rays don't run out of electricity. Do batteries run out? Do you use past experience to buy the best new batteries?

Inquiry Skill

You interpret data when you use the information that has been gathered to answer questions or solve a problem.

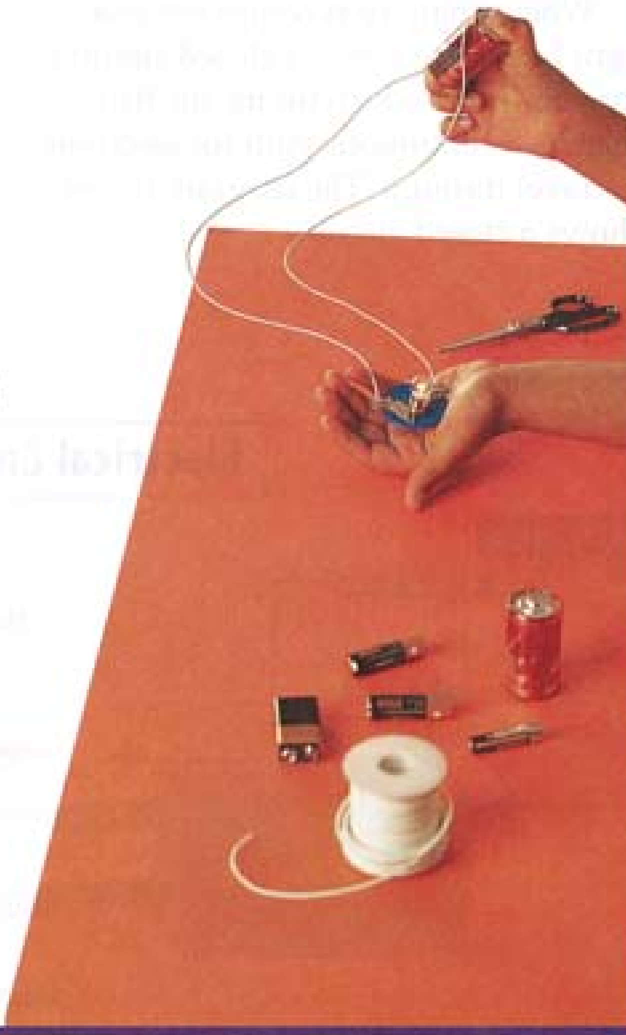
Explore Activity

How Well Do Batteries Provide Energy?

Materials
- battery
- flashlight bulb
- 2 wires

Procedure

1. **Experiment** In this activity you will determine which battery may be the best buy. Test variables such as battery type, size, voltage, brand, or cost. Connect the wires to the battery and bulb as shown. Fasten the wires with a battery holder or tape. Record the time the bulb went on and the type, size, voltage, and brand of battery used. Share your data with the class.
2. **Observe** Check the bulb every 15 minutes to see if it is still lit. Record the time it goes off.
3. Repeat using another variable.



Drawing Conclusions

1. **Use Numbers** Divide the time each battery lasted by its cost.
2. Make a graph of the class's results. Which batteries lasted the longest? Which batteries cost the least per hour of use?
3. **Infer** Which batteries are the best buy? The cheapest? The longest lasting?
4. FURTHER INQUIRY **Interpret Data** Design an experiment to see if a battery will last half as long when it is connected to two bulbs as when it is connected to one. Does it matter how the bulbs are connected?

Read to Learn

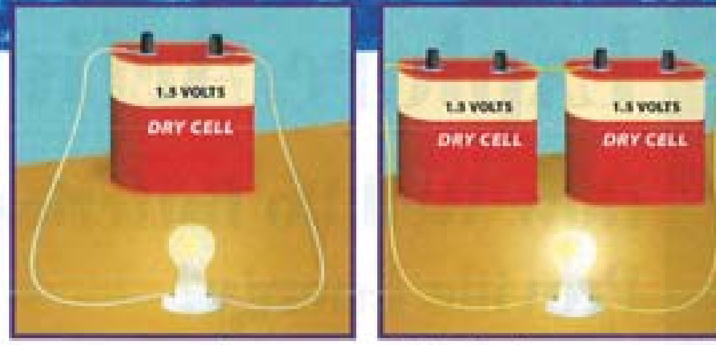
Main Idea Energy has different forms.

What Is Electrical Energy?

You know that a battery can produce enough power to light up a light bulb. How does it do this? What is the "power" in a battery? Where does it come from?

A battery provides electrical energy. Chemicals inside the battery react. These reactions produce electrons. As you learned in Lesson 2, an electron is one of the particles that make up an atom. Each electron carries energy, giving the battery its "power."

When a battery is connected to a light bulb with wires, a closed circuit is formed. A closed circuit means that there is a continuous path for electrons to travel through. The diagram below shows a closed circuit.



In some cases the amount of electrical energy in a circuit may not be great enough to light certain bulbs. For example, a flashlight battery could not light up a 60-watt light bulb from a lamp. Electrical energy can be measured by the size of the bulb it can light.

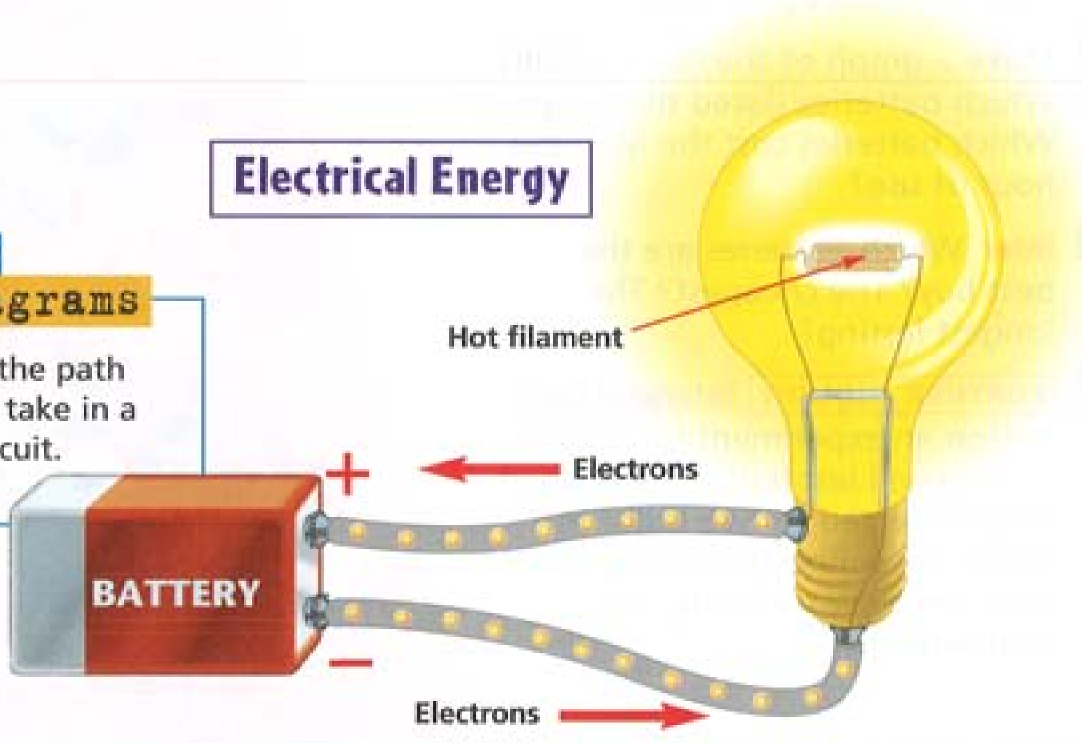
Electrons flow from the battery to the light bulb through wires. Some of the energy is given up to the wire in the light bulb, called the *filament*. The filament gets hot enough to glow and give off light. The electrical energy is changed into light and heat.

The rest of the electrons flow back into the battery.

Electrical Energy

READING Diagrams

Describe the path electrons take in a closed circuit.



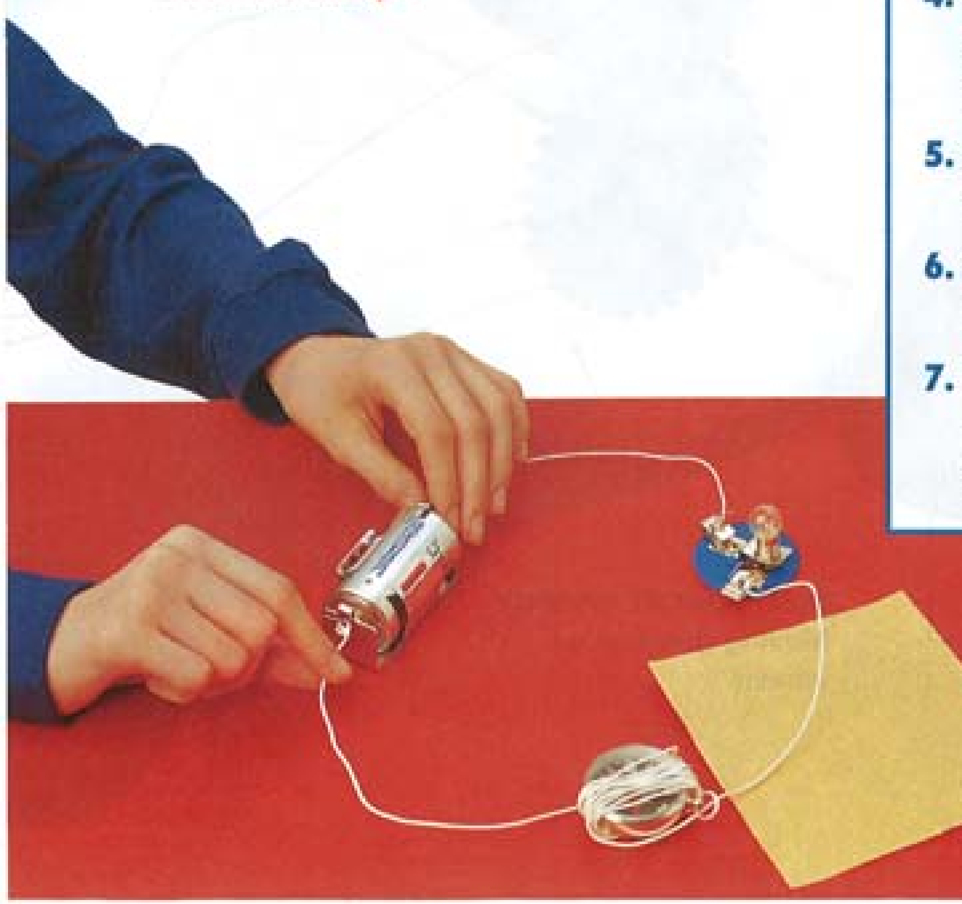
After a time the chemicals in a battery have all reacted, and no more electrons can be produced. This causes the battery to go dead.

Measuring Electrical Energy

Electrical energy can be measured in a number of ways. The circuit with two batteries has twice as many electrons flowing as the circuit with one battery. The bulb is brighter when two batteries are present. The brightness of a bulb can measure electrical energy.

We can also use different kinds of meters to measure electrical energy. An *ammeter* measures *amperes*, or *amps*. It tells us how many electrons flow each second. The *voltmeter* measures *volts*. Volts are another measure of electrical energy.

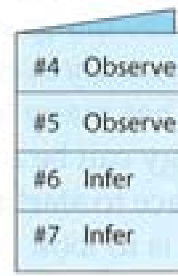
READING **Cause and Effect**
How does a battery produce electrical charge?



QUICK LAB

Measuring Electricity

FOLDABLES **Make a Four-Tab Book.** **(See p. R 44.)** **Label as shown.**



1. Wrap fine varnished wire around a compass. Remove the coating from the ends of the wire with sandpaper.
2. Turn the compass so its needle stays lined up with the coils of wire.
3. Connect the wire ends as shown to a circuit of a battery and light bulb.
4. **Observe** What do you see that tells you that electricity is flowing in the circuit?
5. **Observe** What does the needle do as you open and close the circuit?
6. **Infer** How might a more powerful battery affect the needle?
7. **Infer** How could the compass needle be used to measure electricity?

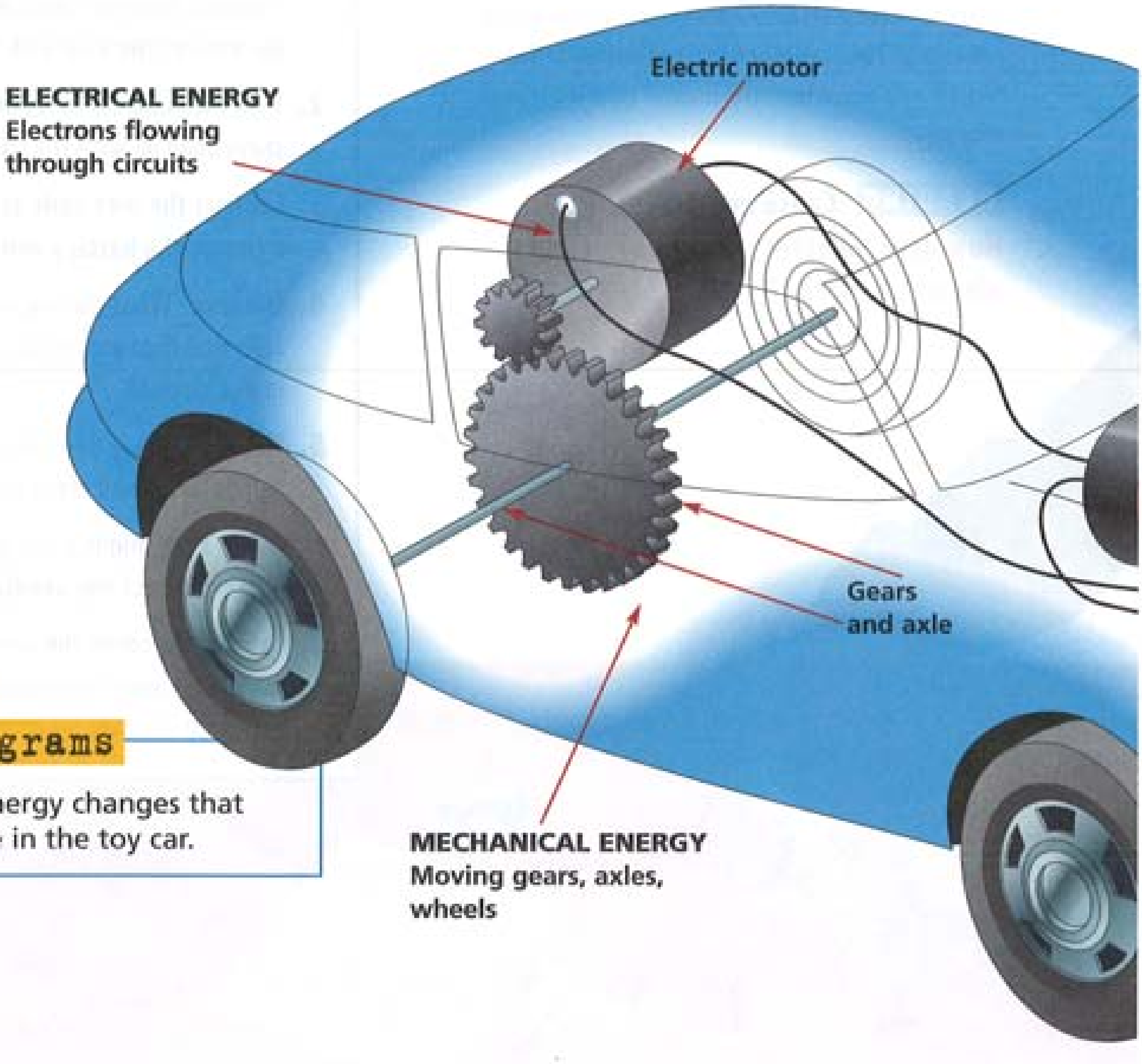
What Are Other Forms of Energy?

You've seen how chemical changes in a battery can produce electrical energy. You've also seen how that electrical energy can produce light and heat. All of these things are forms of energy. What exactly is energy? We know energy has many forms, but defining energy can be a little difficult.

A good place to start in talking about energy is to look at what energy can do. Energy is a measure of how much work something can produce. To scientists work means using a force—a push or a pull—to move an object. Energy is the ability to do work.

Energy is not a type of matter. Matter is something you can often touch or see—solids, liquids, gases. Energy may be thought of as the ability to move matter around.

We can describe energy by its source or by how it is carried. For example, the energy produced by a chemical reaction is called chemical energy. Some typical forms of energy are shown in the table on page E95.



READING Diagrams

List the energy changes that take place in the toy car.

Kinetic and Potential Energy

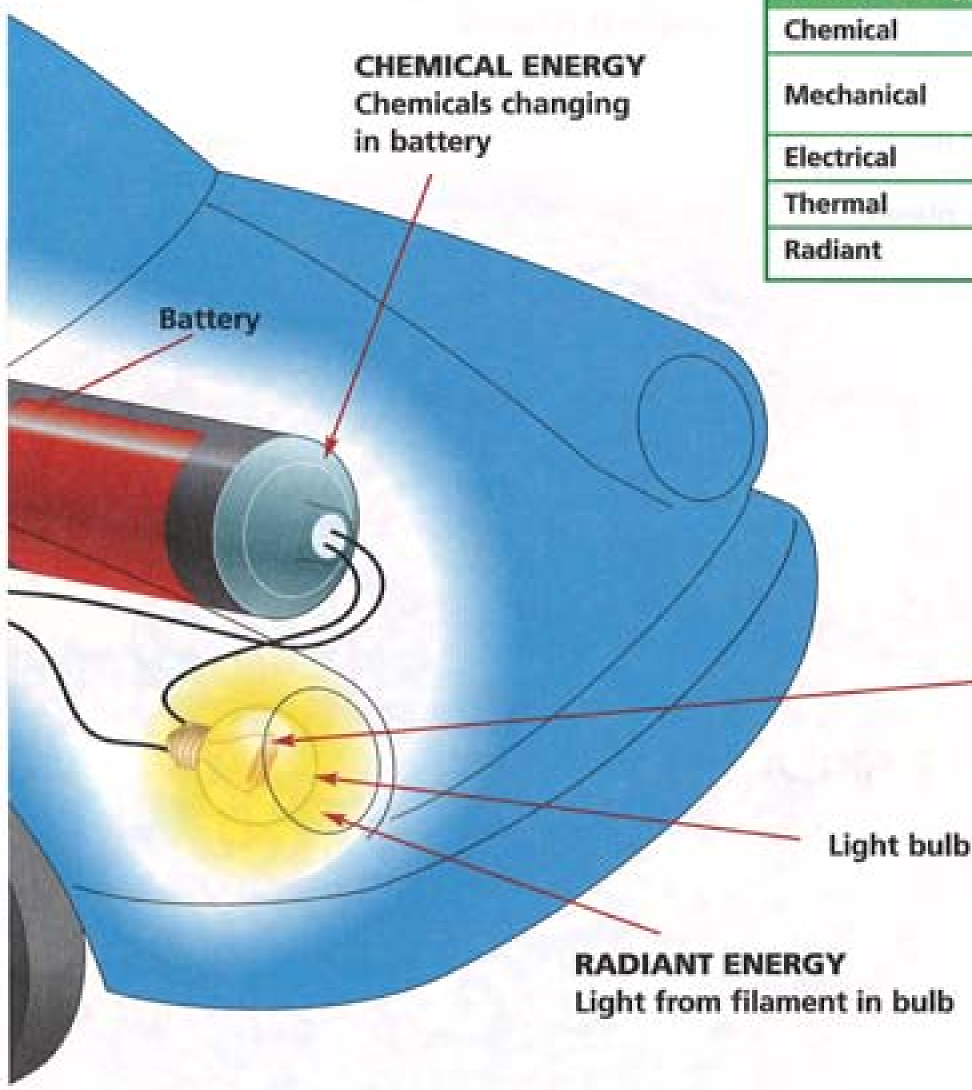
Look at the toy car in the diagram. Electrical energy is being used by the headlights. Electrons are being produced by the battery and are moved through a circuit. When something moves, its energy is called **kinetic energy**. Electrical energy is an example of kinetic energy. Any object that is in motion has kinetic energy.

When the headlights are turned off, the battery stops working. Electrons stop moving, and no new electrons are produced. No energy is being used. However, energy is stored in the chemicals in the battery. This energy is waiting to be used. We refer to stored energy as **potential energy**. Chemical energy is an example of potential energy.

Matter always has at least one of these energy forms.

What are the two main forms of energy?

Energy Forms	
Form of Energy	**Description**
Chemical	stored in links between atoms
Mechanical	sum of the kinetic and potential energy of a system
Electrical	movement of electrons
Thermal	motion of atoms and molecules
Radiant	the energy of light



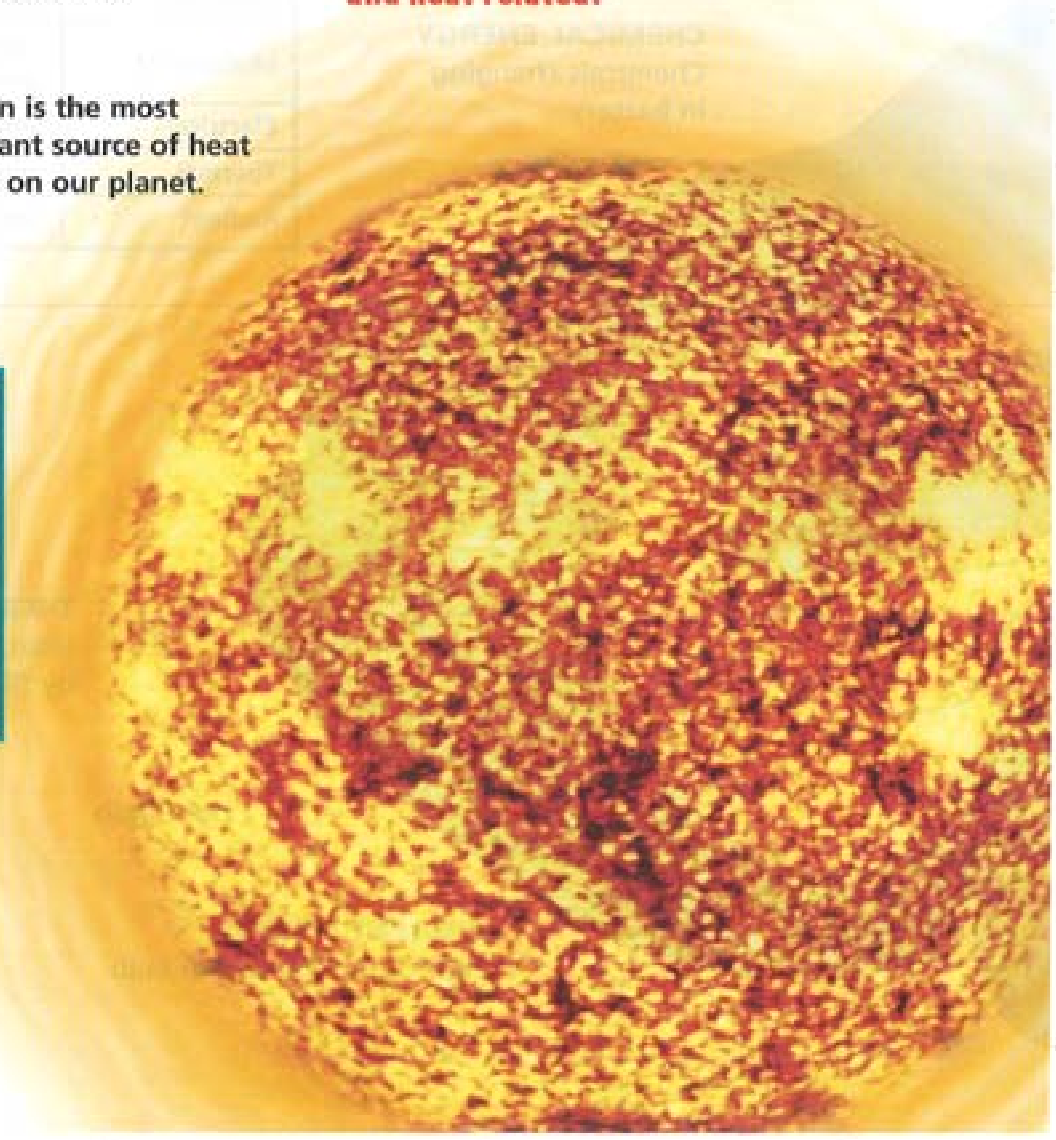
How Can We Describe Thermal Energy?

Have you ever used a thermometer to measure temperature? You have learned that thermal energy is a form of energy that describes the motion of atoms and molecules. Temperature tells us how fast the particles in matter are moving. High temperatures mean the molecules are moving fast and have a lot of energy. Lower temperatures mean the molecules are moving more slowly and have less energy. The movement of molecules is what makes things feel hot or cold.

Heat is the transfer of thermal energy from one object to another. Heat flows when an object is warmer than its surroundings. Heat always flows from hotter materials to cooler materials, never the other way. Heat flows until objects and their surroundings have the same temperature.

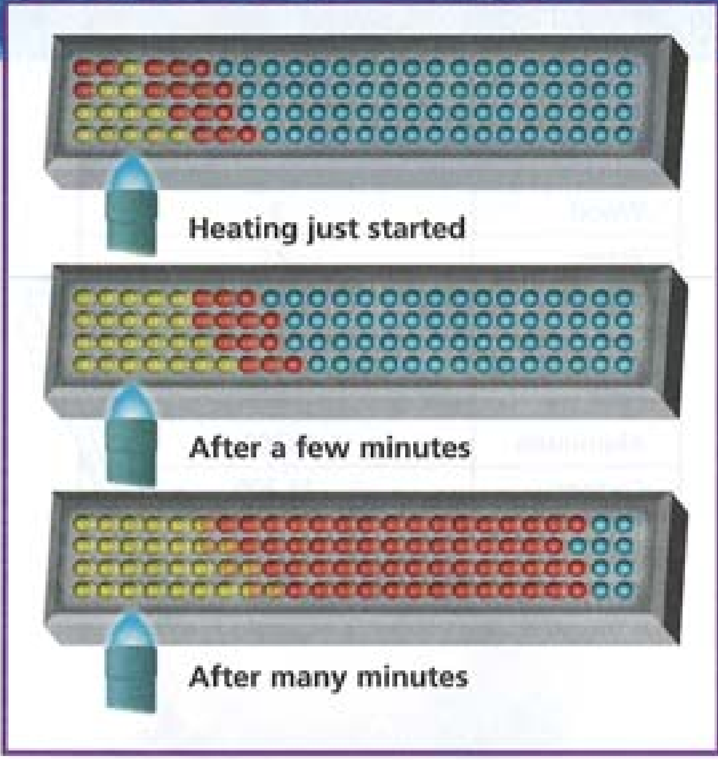
When you hold your hands around a mug of hot chocolate, your body gets warmed. This happens because heat flows from the hot mug into your skin. Thermal energy is transferred from the cup to your hands. Your body gains energy, and your temperature rises as a result. Energy is lost from the mug, however. Its temperature decreases.

How are temperature and heat related?



The Sun is the most important source of heat for life on our planet.

These heating coils in an oven are warmed by an electric current. The space inside the oven is warmed by heat flowing from the hot coils.



How Does Heat Move?

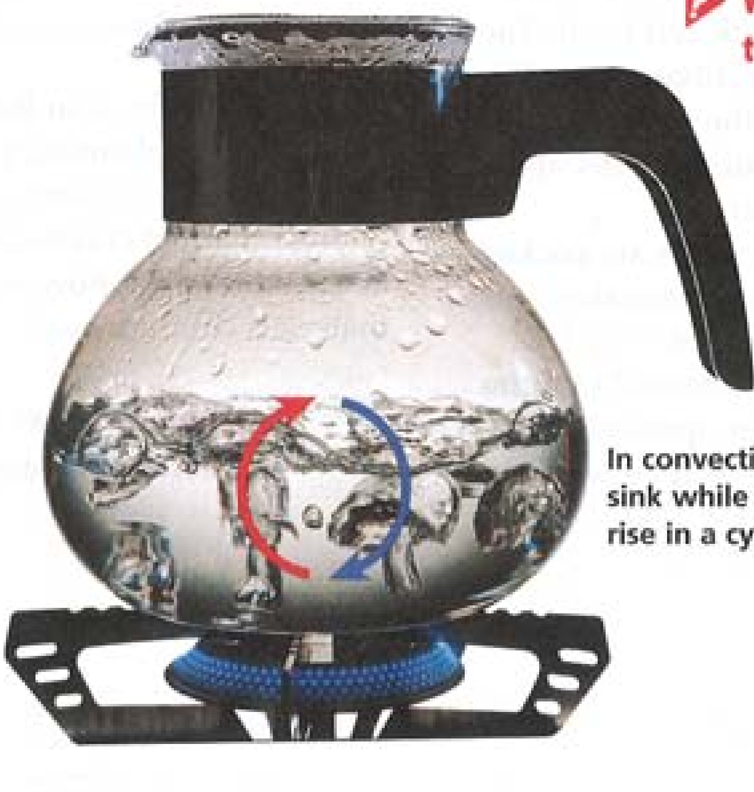
When heat flows, it can move in three ways—conduction, convection, and radiation. In **conduction** thermal energy flows through objects as their particles vibrate. Conduction, as shown above, is the way your hand is warmed by a mug of hot chocolate. It usually occurs in solids and between objects that are touching.

In **convection** thermal energy is transferred by the movement of matter. Convection occurs in liquids and gases. In convection hot parts of a material rise, while cooler parts sink. There is a flow of material and heat.

A pot of water is heated by convection, for example. As water is heated on a stove, the water near the burner gets hot and rises to the top of the pan. The cooler water near the top then sinks and gets warmed. Thermal energy is transferred by a cycle of rising and sinking matter.

In **radiation** heat is transferred through electromagnetic rays. Matter is not needed at all in this energy transfer. All objects around us give off radiation. Radiation can travel through space. Radiation from the Sun warms Earth, for example.

What are three ways that heat can move?



In convection, cooler materials sink while warmer materials rise in a cycle of motion.

What Materials Conduct Heat Well?

The photograph shows very hot tea in a foam cup. A metal spoon has been sitting in the tea for some time. The outside of the cup is slightly warm. However, the spoon's handle is almost too hot to hold. Why has more heat flowed into the handle of the spoon than into the walls of the cup?

As you learned in Lesson 1, some materials are better at conducting heat than others. The metal spoon is a good conductor of heat. However, the foam cup is a poor conductor of heat. As a result, heat flows quickly from the hot bowl of the spoon to its handle. However, heat flows very slowly from the tea into the foam.

Metals are the best conductors of heat. Why do metals conduct heat so well?

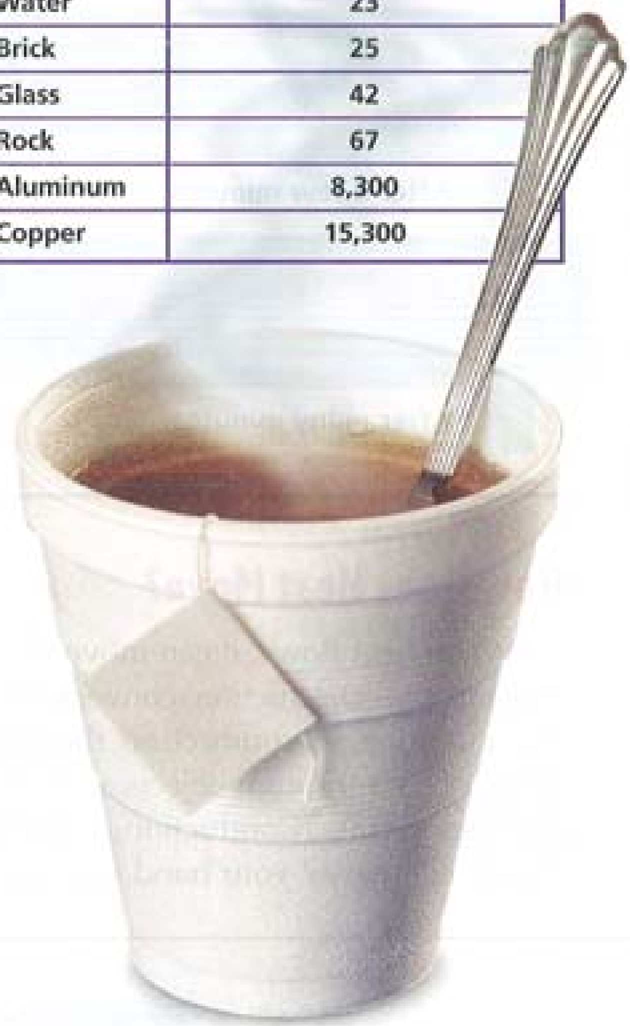
Heat is carried through a material by the motion of molecules. When a metal is heated at one end, the hot molecules vibrate back and forth. They collide with their neighbors, spreading the motion through the material. The spreading of the motion warms up other parts of the material.

The molecules in solids are packed very closely together. This makes transferring energy easier.

In Chapter 10 you learned that the molecules in gases are spread apart. They cannot transfer heat between one another as easily as in liquids and solids. This explains why air is such a poor conductor of heat. Gases are the poorest thermal conductors of all. Look at the table to see how well common materials conduct heat.

How Materials Conduct Heat

Material	How Many Times Better Than Air It Conducts Heat
Wood	5
Water	23
Brick	25
Glass	42
Rock	67
Aluminum	8,300
Copper	15,300



What materials are the best conductors?

Lesson Review

Why It Matters

Energy comes in many forms. The air in your home is warmed by convection of thermal energy. There is energy stored in batteries and energy stored in the food you eat. The Sun gives us light and heat as well. You depend on various forms of energy to live, move, and have a comfortable life.

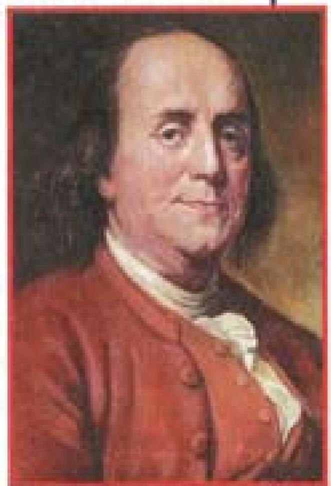
e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on energy.

Think and Write

1. Describe how a battery makes a light bulb glow. Identify the different forms energy takes.
2. Why is energy not a form of matter?
3. How does thermal energy get from place to place?
4. Insulating windows have two layers of glass with air sealed in between. Why is this layer of air important?
5. **Critical Thinking** Two flash-lights have the same kind of bulb. One glows more dimly than the other. Why do you think this is so?

L·I·N·K·S

WRITING LINK



Writing That Compares When did Benjamin Franklin discover that lightning is electricity? What was used to light and heat homes before electrical energy? Use the Internet or an encyclopedia to find the answers. Then write an essay comparing what life was like before and after the use of electrical energy became commonplace.

ART LINK

Make a collage. Cut pictures of different types of energy from a magazine. Identify the source of energy being used. Paste your pictures onto a poster. Present your poster to the class.

MATH LINK

Interpret a table. Which material in the table on the preceding page conducts heat five times better than wood?

TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.

Chapter 13 Review

Vocabulary

Fill each blank with the best word or words from the list.

acid, E82
alkalinity, E86
chemical change, E71
colloid, E54
conduction, E97
convection, E97
kinetic energy, E95
potential energy, E95
radiation, E97
solution, E54

1. A mixture that looks the same everywhere, even under a microscope, is a(n) _____ .
2. Blue litmus paper turns red when it is dipped in a(n) _____.
3. Two chemicals react to form a new substance In a(n) _____.
4. The Sun's energy is transferred to Earth by _____.
5. An object that is moving has _____.
6. Energy is usually transferred from one solid to another by _____ .
7. A substance with properties between a solution and a heterogeneous mixture is a(n) _____.
8. Stored energy is called _____.
9. Thermal Energy is usually transferred in liquids and gases by _____ .
10. The strength of a base is called its _____.

Test Prep

11. In a chemical reaction, there may be a _____.
    - **A** color change
    - **B** formation of a gas
    - **C** heat change
    - **D** all of the above
12. All of the following are poor conductors of heat EXCEPT _____.
    - **F** wood
    - **G** glass
    - **H** copper
    - **J** air
13. An example of a physical change is _____.
    - **A** ice melting
    - **B** bread baking
    - **C** a match burning
    - **D** a nail rusting

14. Heat always flows ______.

F from lighter materials to heavier materials

G from heavier materials to lighter materials

H from cooler materials to hotter materials

J from hotter materials to cooler materials

15. ______ may be used as an indicator.

A cabbage juice

B litmus paper

C a pH meter

D all of the above

Concepts and Skills

16. **Reading in Science** What signs are there that baking bread is a chemical change?

17. INQUIRY SKILL **Experiment** A friend says he removed tarnish from a silver spoon by putting it in the bottom of an aluminum pot containing a hot baking-soda solution. What really removed the tarnish? Describe how you would perform experiments to find out.

18. **Critical Thinking** A certain material can be separated by physical changes. Can it be a single compound? Why or why not?

19. **Scientific Methods** What are two things you might see during a chemical change?

20. **Safety** Whenever you use a cleaning material, you should read the label carefully. Some kinds of cleaning materials should never be used together. What may be one reason for this?

Did You Ever Wonder?

INQUIRY SKILL **Predict** Gather the following materials: penny, paper clip, nail, aluminum foil, crayon, nickel, barrette, rubber band, scissors, plastic spoon, and metal spoon. Predict which will be attracted to a magnet. Use a magnet and test your predictions.

LOG ON Visit www.science.mmhschool.com to boost your test scores.

Meet a Scientist

Dr. Jacqueline K. Barton

Chemist

You probably know that wires can conduct electricity. A wire from a socket carries electricity to a lamp, and light is produced. But what about living material—like the DNA in your body? Can it conduct electricity?

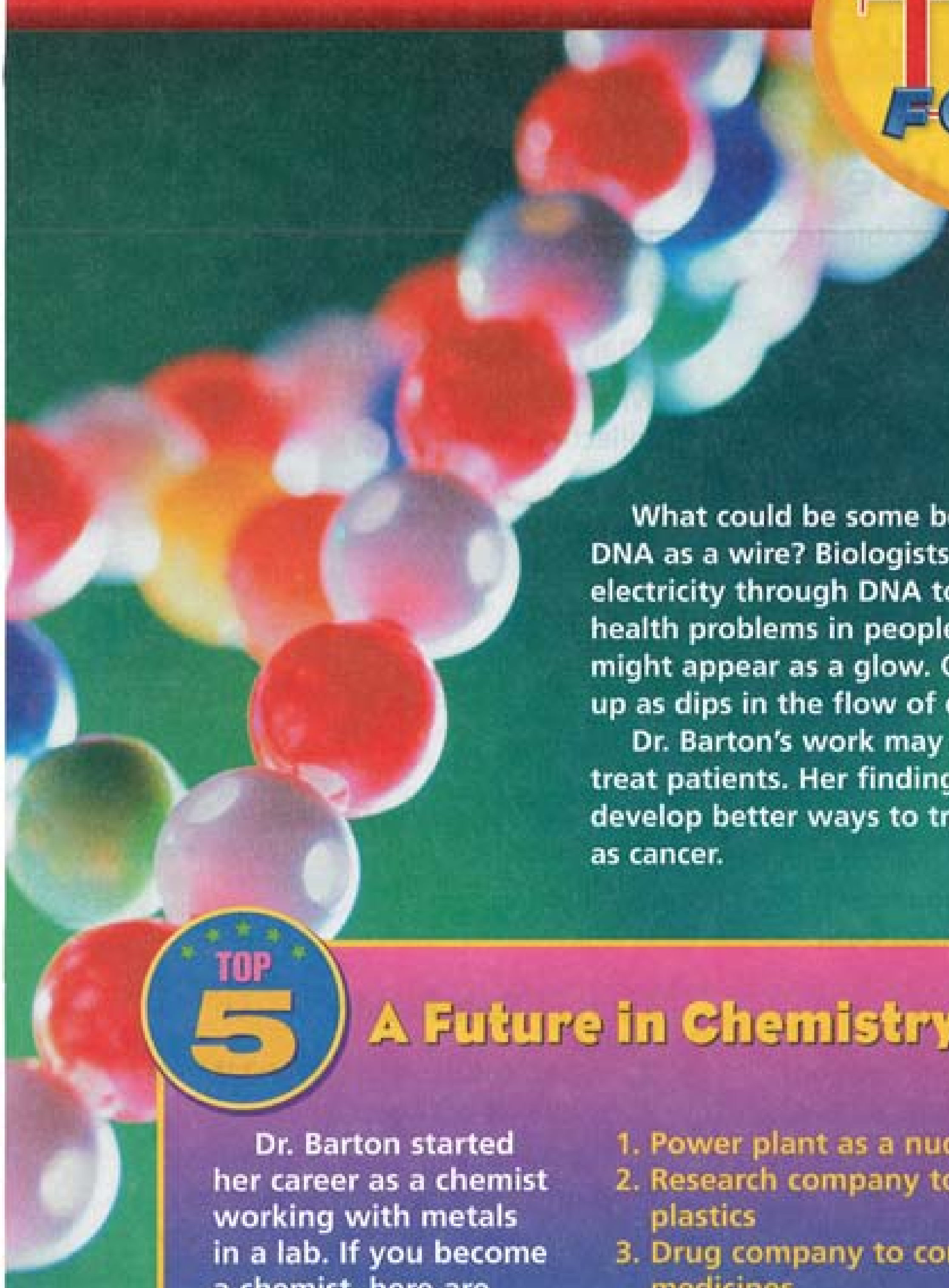
The answer is yes—according to Jacqueline K. Barton. Dr. Barton is a chemist. She studies what substances are made of and how materials react with each other. Dr. Barton took what she knew about the conductivity of metals and started studying DNA.

DNA is in every cell in your body. It determines all sorts of things about you—such as what color eyes you have and how tall you will be.

Some non-living materials with structures like DNA are able to conduct electricity. Many scientists wondered whether DNA could do the same. Thanks to Dr. Barton's experiments, we know that it can. Barton learned that DNA strands are like wires—and your body is full of them!

LOG ON Visit **www.science.mmhschool.com** to learn more about the work of chemists.

TIME FOR KIDS



What could be some benefits of using DNA as a wire? Biologists could send electricity through DNA to find possible health problems in people. Some problems might appear as a glow. Others might show up as dips in the flow of current.

Dr. Barton's work may also help doctors treat patients. Her findings could help to develop better ways to treat diseases such as cancer.

TOP 5 A Future in Chemistry

Dr. Barton started her career as a chemist working with metals in a lab. If you become a chemist, here are five places where you might work:

1. Power plant as a nuclear chemist
2. Research company to develop new plastics
3. Drug company to come up with new medicines
4. Hospital as an organic chemist
5. College as a research chemist

Write About It

1. What is DNA?
2. What is Dr. Barton's job?

PROBING the PROPERTIES

Your goal is to describe objects in a collection in terms of their properties.

What to Do

1. List each object in your collection. Leave space next to each name where you can list the object's properties.
2. List as many properties as you can observe for each object.
3. Measure the mass of each object, and record it on your list.

Analyze Your Results

What are all of the objects in your collection made of?

TESTING FOR pH

Your goal is to put eight unknown solutions in order from most acidic to most basic.

What to Do

1. Use eight unknown solutions, pH paper, a pH scale, a pencil, and paper. Dip a piece of pH paper into each solution. Compare the color of the pH paper with the pH scale. Record each pH in a table.
2. Make a new table that shows the order of the solutions from most acidic to most basic. Include the pH of each solution.

Analyze Your Results

1. Which solutions are acids? Which solutions are bases?
2. If you have an upset stomach, it might be because you have too much acid in your stomach. Why are medicines taken for a stomachache usually bases?