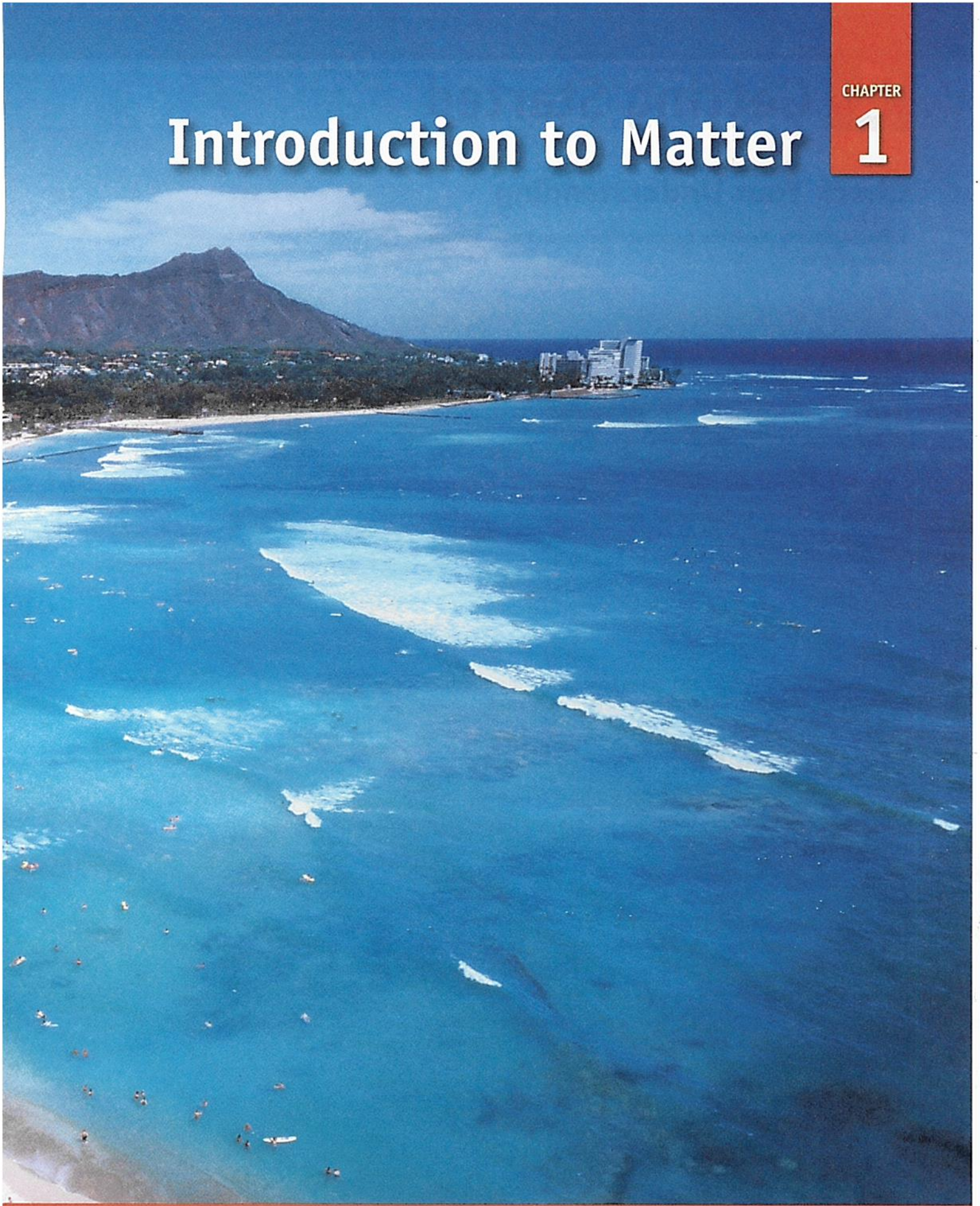


CHAPTER 1

Introduction to Matter

CHAPTER 1

Getting Started

Check Your Understanding

1. Background Read the paragraph below and then answer the question.

On a hot day, Jorge decides to make a pitcher of cold lemonade. He combines **pure** water with lemon juice in a **ratio** of six to one. He adds sugar and ice and stirs all the ingredients together. The **properties** of the lemonade are that it is cold, yellow, and sweet.

A **pure** material is not mixed with any other matter.

A **ratio** tells you the relationship between two or more things.

A **property** is a characteristic that belongs to a person or thing.

- How would the properties of the lemonade change if the ratio of pure water to lemon juice were three to one? Assume the amount of sugar is the same.

_____

_____

MY READING WEB If you had trouble completing the question above, visit **My Reading Web** and type in ***Introduction to Matter.***

Vocabulary Skill

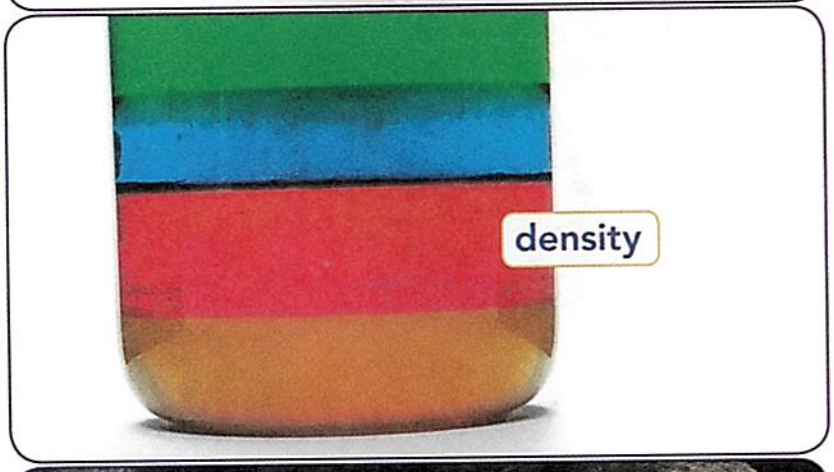
Prefixes A prefix is a word part that is added at the beginning of a root word to change the word's meaning. The prefixes below will help you understand some of the vocabulary in this chapter.

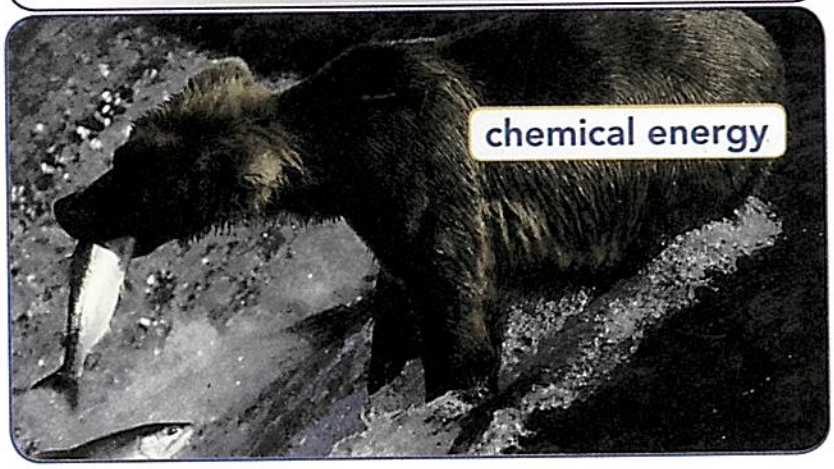
Prefix	Meaning	Example
endo-	in, within	endogenous, *adj.* describes something that arises from inside an organism's tissues or cells
exo-	out	exoskeleton, *n.* an outer shell or outer skeleton that protects animals, such as crustaceans

2. Quick Check **The Greek root *therm* means "heat." Predict the meaning of the term *endothermic change*.**

_____

_____





Chapter Preview

LESSON 1

- matter
- chemistry
- substance
- physical property
- chemical property

Summarize
Classify

LESSON 2

- element
- atom
- chemical bond
- molecule
- compound
- chemical formula
- mixture

Compare and Contrast
Infer

LESSON 3

- weight
- mass
- International System of Units
- volume
- density

Identify the Main Idea
Calculate

LESSON 4

- physical change
- chemical change
- law of conservation of mass
- temperature
- thermal energy
- endothermic change
- exothermic change
- chemical energy

Relate Cause and Effect
Draw Conclusions

VOCAB FLASH CARDS For extra help with vocabulary, visit **Vocab Flash Cards** and type in ***Introduction to Matter.***

LESSON 1

Describing Matter

UNLOCK THE BIG ?

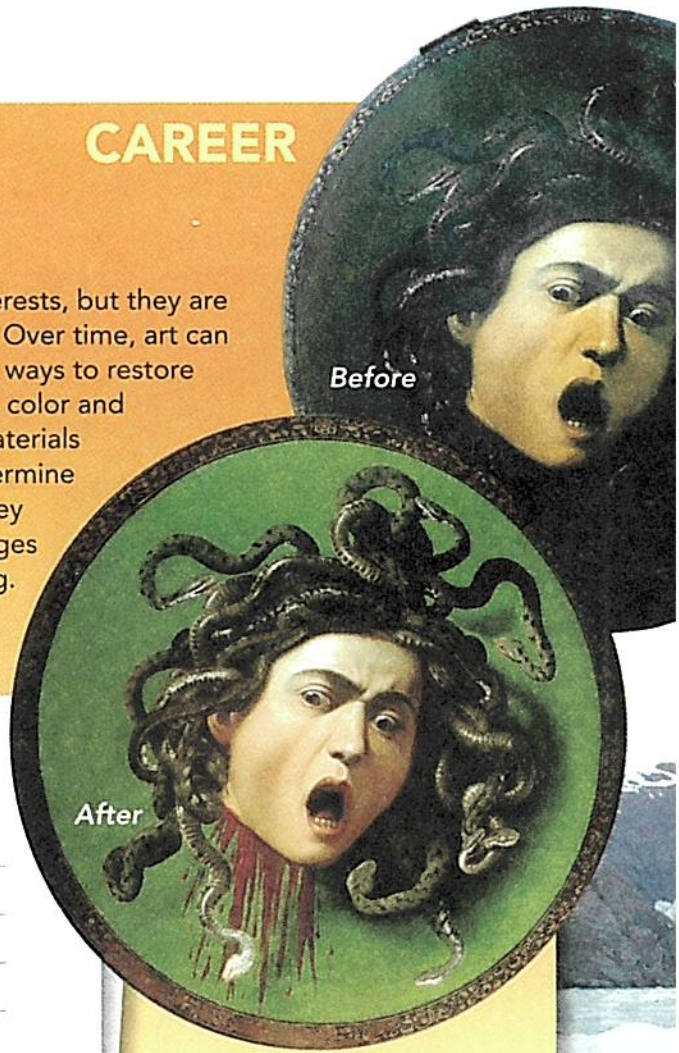
What Properties Describe Matter?

MY PLANET DIARY

CAREER

Art Conservation Scientist

Science and art may seem like two very different interests, but they are both part of the job for an art conservation scientist. Over time, art can fade, decay, or get dirty. Conservation scientists find ways to restore art by examining its properties. They look at texture, color and age of the paint, the condition of the canvas, and materials used to make the paint. Then, the scientists can determine chemical properties of the painting. For example, they can predict how the painting will react to light, changes in temperature, and the use of chemicals for cleaning. Thanks to art conservation scientists, masterpieces of art can be enjoyed for many years.



Medusa by Caravaggio, about 1598. Uffizi Gallery, Florence, Italy

Write your answers to the questions below.

1. Why is it important for an art conservation scientist to study the properties of a painting before it's repaired?

2. Name another career that combines science with another interest.

PLANET DIARY Go to **Planet Diary** to learn more about matter.

Lab zone Do the Inquiry Warm-Up *How Do You Describe Matter?*

Vocabulary

- matter
- chemistry
- substance
- physical property
- chemical property

Skills

- Reading: Summarize
- Inquiry: Classify

What Properties Describe Matter?

You have probably heard the word *matter* used many times. "As a matter of fact…" or "Hey, what's the matter?" In science, **matter** is anything that has mass and takes up space. All the "stuff" around you is matter, and you are matter too. Air, plastic, metal, wood, glass, paper, and cloth are all matter.

Even though air and paper are both matter, you know they are different materials. Matter can have many different properties, or characteristics that can be used to identify and classify it. Materials can be hard or soft, hot or cold, liquid, solid, or gas. Some materials catch fire easily, but others do not burn. **Chemistry** is the study of matter and how matter changes.

Summarize How are matter and substances related?

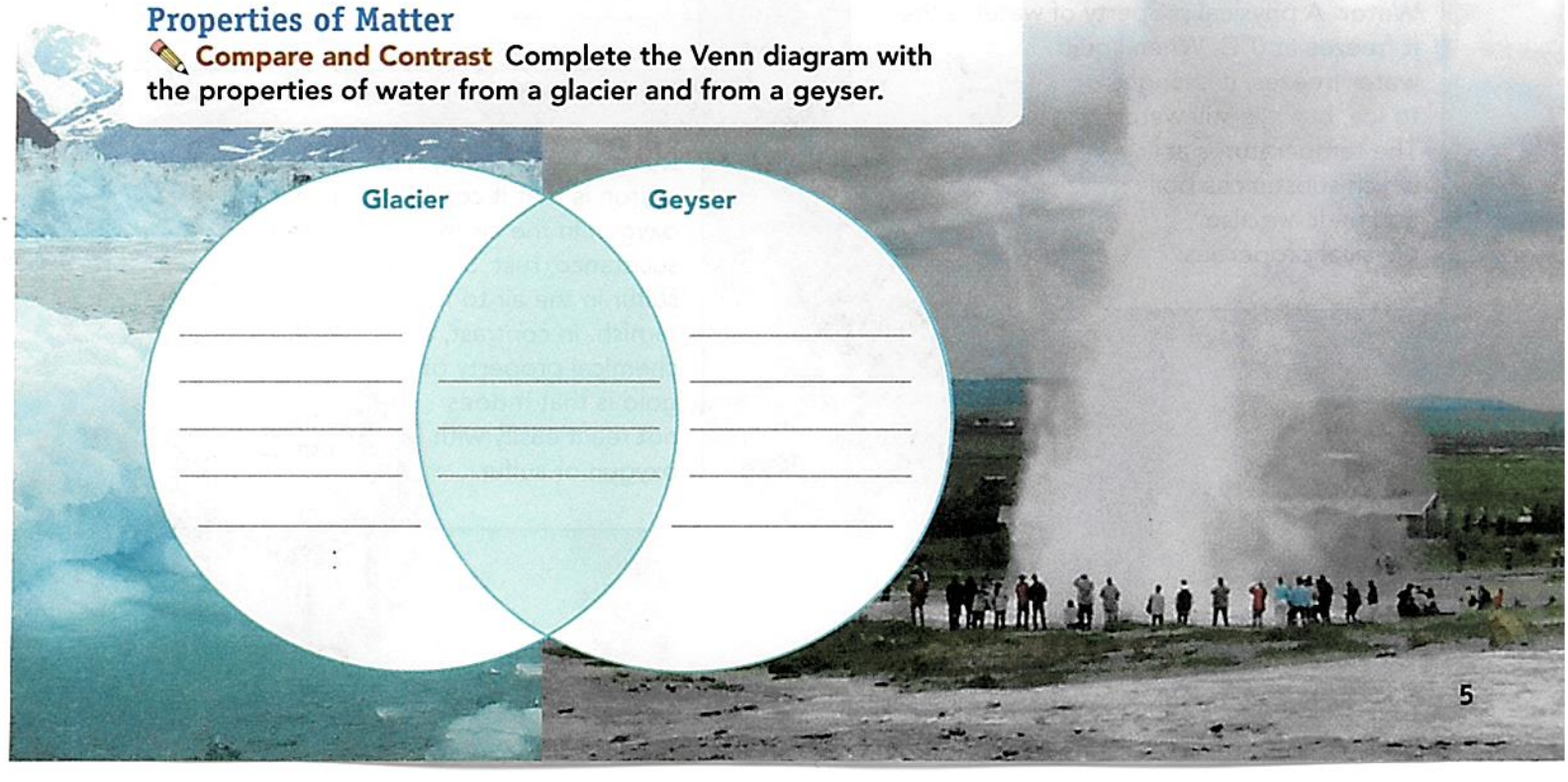
Substances

Some types of matter are substances and some are not. In chemistry, a **substance** is a single kind of matter that is pure, meaning it always has a specific makeup, or composition. For example, table salt has the same composition and properties whether it comes from seawater or a salt mine. **Figure 1** shows two examples of water that appear to be very different. Water is a substance. Pure water is always the same, whether it comes from a glacier or from a geyser.

FIGURE 1

Properties of Matter

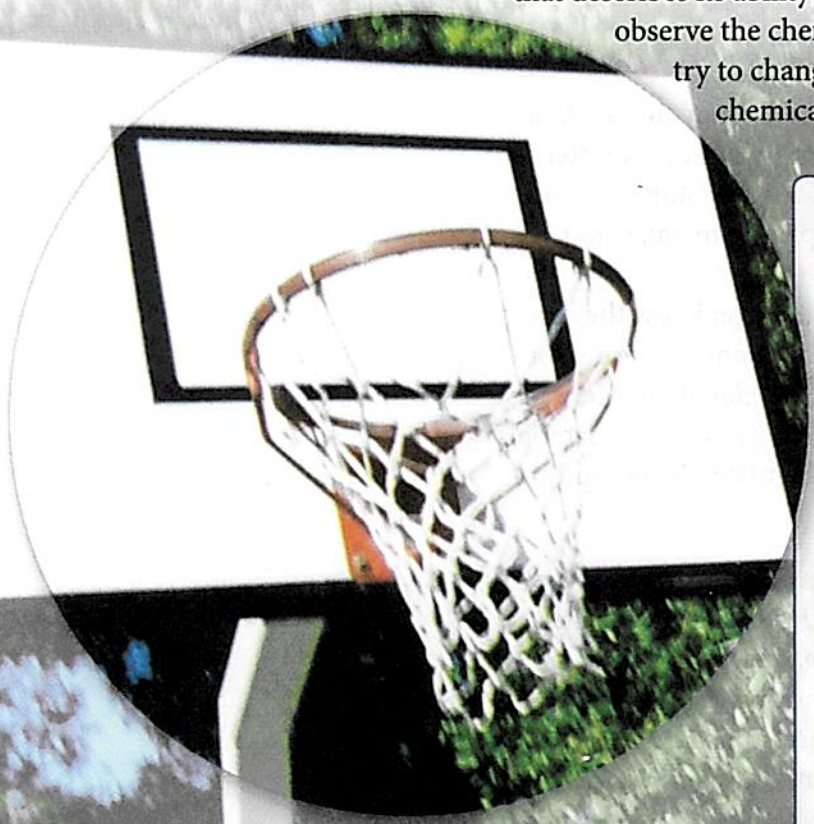
Compare and Contrast Complete the Venn diagram with the properties of water from a glacier and from a geyser.



Physical and Chemical Properties of Matter

Matter is described by its properties. **Every form of matter has two kinds of properties—physical properties and chemical properties.** A **physical property** is a characteristic of a substance that can be observed without changing it into another substance.

Some properties of matter can't be seen just by observation or touch. A **chemical property** is a characteristic of a substance that describes its ability to change into different substances. To observe the chemical properties of a substance, you must try to change it into another substance. Physical and chemical properties are used to classify matter.



Basketball Hoop Two physical properties of metals are luster, or shine, and the ability to conduct electric current and heat. Another physical property is flexibility, which is the ability to be bent into shapes.

Mark all the objects that are flexible.

- ◯ Aluminum can
- ◯ Copper sheeting
- ◯ Brick house
- ◯ Glass window
- ◯ Silver spoon
- ◯ Wood drumstick

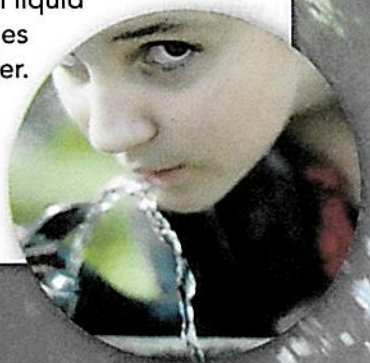
What do all of the flexible objects have in common?

_____

What physical property makes metal pots good for cooking?

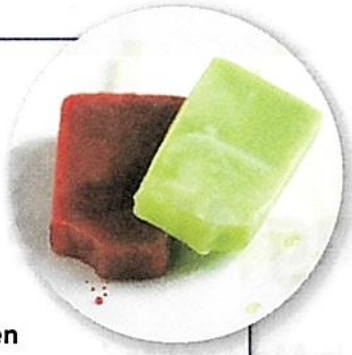
_____

Water A physical property of water is that it freezes at 0°C. When liquid water freezes, it changes to ice, but it is still water. The temperatures at which substances boil and melt are also physical properties.



Rusty Metal Chain A chemical property of iron is that it combines slowly with oxygen in the air to form a different substance, rust. Silver reacts with sulfur in the air to form tarnish. In contrast, a chemical property of gold is that it does not react easily with oxygen or sulfur.

Frozen Fruit Bar Hardness, texture, temperature, and color are examples of physical properties. When you describe a material as a solid, a liquid, or a gas, you are describing its state of matter. State of matter is another physical property.



Describe three properties of a frozen fruit bar, including its state of matter.

_____

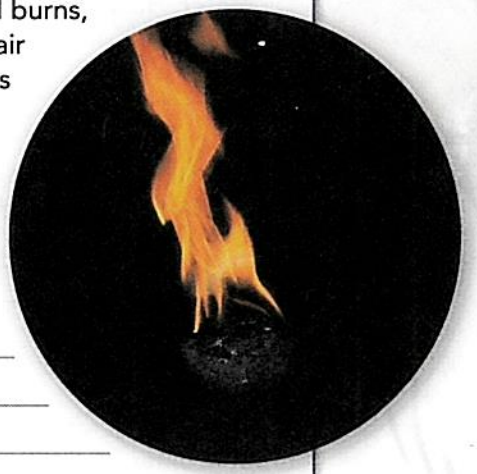
_____

Will any of these properties change after a couple of hours in the sun? Explain.

_____

_____

Charcoal Briquettes Fuels, like charcoal, can catch fire and burn. When a fuel burns, it combines with oxygen in the air and changes into the substances water and carbon dioxide. The ability to burn, or flammability, is a chemical property.



How do you know that flammability is a chemical property?

_____

_____

_____

_____

apply it!

The wax in a burning candle can be described by both physical and chemical properties.

1 **Describe** What are the physical properties of the wax in a burning candle?

_____

_____

_____

_____

_____

2 CHALLENGE Why is melting a physical property of the wax, but flammability is a chemical property?

_____

_____

_____

_____

_____

_____

_____

Lab zone® Do the Quick Lab *Observing Physical Properties.*

Assess Your Understanding

1a. Classify The melting point of table salt is 801°C. Is this a physical or chemical property?

_____

b. Draw Conclusions Helium does not usually react with other substances. Does this mean that helium has no chemical properties? Explain.

_____

_____

got it?

○ I get it! Now I know that matter is described by its _____

_____

_____

○ I need extra help with _____

_____

Go to my science coach *online for help with this subject.*

LESSON 2

Classifying Matter

- What Is Matter Made Of?
- What Are Two Types of Mixtures?

MY PLANET DIARY

Smaller Than Small

What's the smallest thing you can think of? A grain of sand? A speck of dust? If you look at these items under a powerful microscope, you'll see that they're made up of smaller and smaller pieces. All matter is made up of very tiny particles called atoms. Atoms are so small, there is a special unit of measure used to describe them called a nanometer (nm). A nanometer is equal to 1/1,000,000,000 or one-billionth of a meter!

At least 50,000 of these tiny compounds called nanobouquets could fit on the head of a pin.

SCIENCE STATS

Write your answers to the questions below.

1. A nickel is about 2 millimeters thick, or 2/1,000 of a meter. How many nanometers is this?

2. Imagine being the size of an atom. Describe how something like a red blood cell might look to you.

PLANET DIARY Go to **Planet Diary** to learn more about atoms.

Common Objects in Nanometers (nm)

Object	Approximate Size
Compact disc diameter	120,000,000 nm
Grain of sand	3,000,000 nm
Grain of pollen	500,000 nm
Human hair diameter	100,000 nm
Red blood cell	7000 nm
Length of 3–10 atoms lined up	1 nm

Lab zone® Do the Inquiry Warm-Up *What Is a Mixture?*

Vocabulary

- element
- atom
- chemical bond
- molecule
- compound
- chemical formula
- mixture

Skills

- Reading: Compare and Contrast
- Inquiry: Infer

What Is Matter Made Of?

What is matter? Why is one kind of matter different from another kind of matter? Around 450 B.C., a Greek philosopher named Empedocles attempted to answer these questions. He proposed that all matter was made of four "elements"—air, earth, fire, and water. Empedocles thought that all other matter was a combination of these elements. The idea of four elements was so convincing that people believed it for more than 2,000 years.

Elements In the late 1600s, experiments by early chemists began to show that matter was made up of many more than four elements. Scientists know that all matter in the universe is made of more than 100 different substances, called elements. An **element** is a substance that cannot be broken down into any other substances by chemical or physical means. Elements are the simplest substances. Each element can be identified by its specific physical and chemical properties. You may already be familiar with some elements such as aluminum or tin. Elements are represented by one- or two-letter symbols, such as C for carbon, O for oxygen, and Ca for calcium.

apply it!

The elements make up all the matter in the universe.

1. **Explain** How can you tell one element from another?

2. **Infer** Match the pictures on this page of items containing common elements to the element's name.

A) helium B) gold C) copper
D) iron E) neon

3. **CHALLENGE** Choose another element that you are familiar with and describe its properties.

Compare and Contrast How are atoms and molecules the same? How are they different?

_____

_____

_____

_____

_____

_____

Atoms Imagine tearing a piece of aluminum foil in half over and over again. Would you reach a point where you had the smallest possible piece of aluminum? The answer is yes. The particle theory of matter explains that all matter is made of atoms. An **atom** is the basic particle from which all elements are made. An atom has a positively charged center, or nucleus, containing smaller particles. The nucleus is surrounded by a "cloud" of negative charge. The elements have different properties because their atoms are different.

Molecules Atoms of most elements are able to combine with other atoms. When atoms combine, they form a **chemical bond,** which is a force of attraction between two atoms. In many cases, atoms combine to form larger particles called molecules. A **molecule** (MAHL uh kyool) is a group of two or more atoms held together by chemical bonds. A molecule of water, for example, is made up of an oxygen atom chemically bonded to two hydrogen atoms. Two atoms of the same element can also combine to form a molecule. Oxygen molecules are made up of two oxygen atoms. **Figure 1** shows models of some common molecules.

FIGURE 1

Atoms and Molecules

Molecules are made up of groups of atoms.

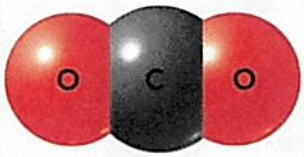
Use the molecule models to complete the activities.

1. **Interpret Diagrams** Count the number of atoms of each element in the molecules and write it on the lines below.
2. CHALLENGE On the bottom line, write a representation for each molecule using letters and numbers.

Key

C = Carbon
H = Hydrogen
O = Oxygen
N = Nitrogen

Carbon dioxide



_____

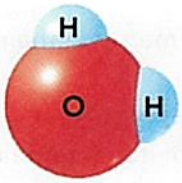
_____

_____

CHALLENGE

_____

Water



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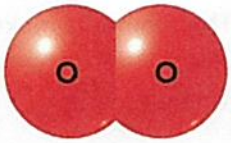
Oxygen



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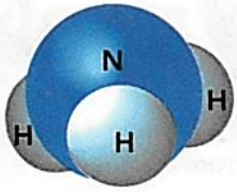
_____

_____

_____

Ammonia



_____

_____

_____

_____

Compounds

Water, ammonia, and carbon dioxide are all compounds. A **compound** is a substance made of two or more elements that are chemically combined in a set ratio. A compound is represented by a **chemical formula,** which shows the elements in the compound and the ratio of atoms. For example, the chemical formula for carbon dioxide is CO_2. The 2 below the O for oxygen tells you that the ratio of carbon atoms to oxygen atoms is 1 to 2. If there is no number after an element's symbol, it is understood that the number is 1. A different number of atoms in a formula represents a different compound. For example, the formula for carbon monoxide is CO. Here, the ratio of carbon atoms to oxygen atoms is 1 to 1.

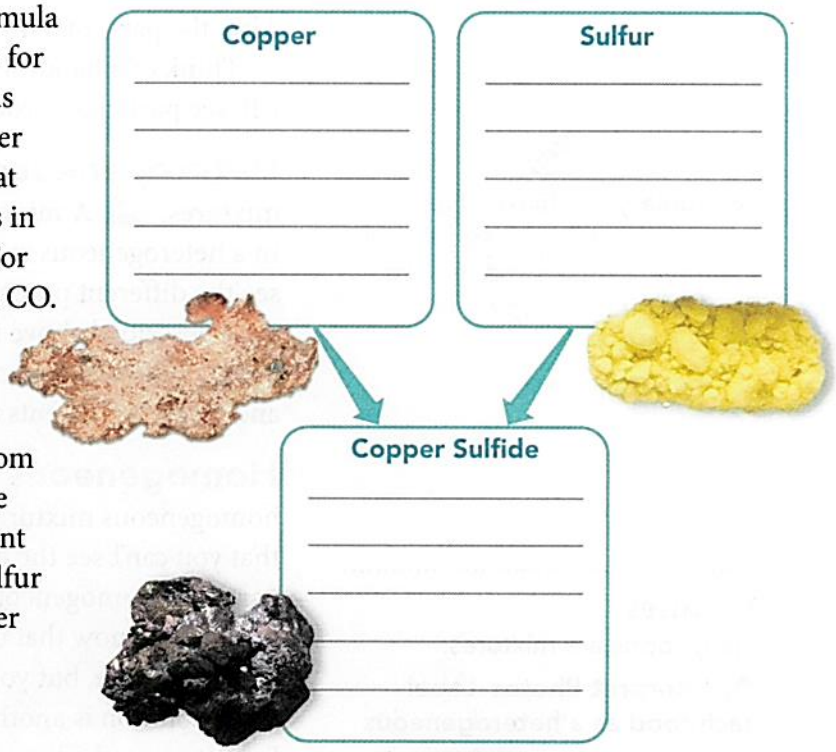
When elements chemically combine, they form compounds with properties different from those of the elements. **Figure 2** shows that the element sulfur is a yellow solid and the element copper is a shiny metal. When copper and sulfur combine, they form a compound called copper sulfide. The new compound has different properties from both copper and sulfur.

FIGURE 2

ART IN MOTION **Compounds From Elements**

When elements combine, the compound that forms has different properties than the original elements.

Describe **List the properties of copper, sulfur, and copper sulfide.**



Lab zone Do the Quick Lab *Modeling Atoms and Molecules.*

Assess Your Understanding

1a. Review What holds the hydrogen and oxygen atoms together in a water molecule?

b. Identify Table sugar has the chemical formula $C_{12}H_{22}O_{11}$. What is the ratio of carbon atoms to oxygen atoms in this compound?

c. Draw Conclusions Two formulas for compounds containing hydrogen and oxygen are H_2O and H_2O_2. Do these formulas represent the same compound? Explain.

got it?

○ I get it! Now I know that all matter is made up of

○ I need extra help with

Go to MY SCIENCE COACH *online for help with this subject.*

What Are Two Types of Mixtures?

Elements and compounds are substances, but most materials are mixtures. **Figure 3** shows some common mixtures. A **mixture** is made of two or more substances that are together in the same place, but their atoms are not chemically bonded. Mixtures differ from compounds. Each substance in a mixture keeps its own properties. Also, the parts of a mixture are not combined in a set ratio.

Think of a handful of sand. If you look closely at the sand, you will see particles of rock, bits of shells, maybe even crystals of salt.

Vocabulary Prefixes The prefix *homo-* comes from a Greek word that means "the same or alike." Predict the meaning of the prefix *hetero-*.

- ○ more than one
- ○ different
- ○ equal

Heterogeneous Mixtures

There are two types of mixtures. **A mixture can be heterogeneous or homogeneous.** In a heterogeneous mixture (het ur oh JEE nee us), you can usually see the different parts and they can easily be separated out. The sand described above is a heterogeneous mixture. So is a salad. Think of how easy it is to see the pieces of lettuce, tomatoes, onions, and other ingredients that can be mixed in countless ways.

Homogeneous Mixtures

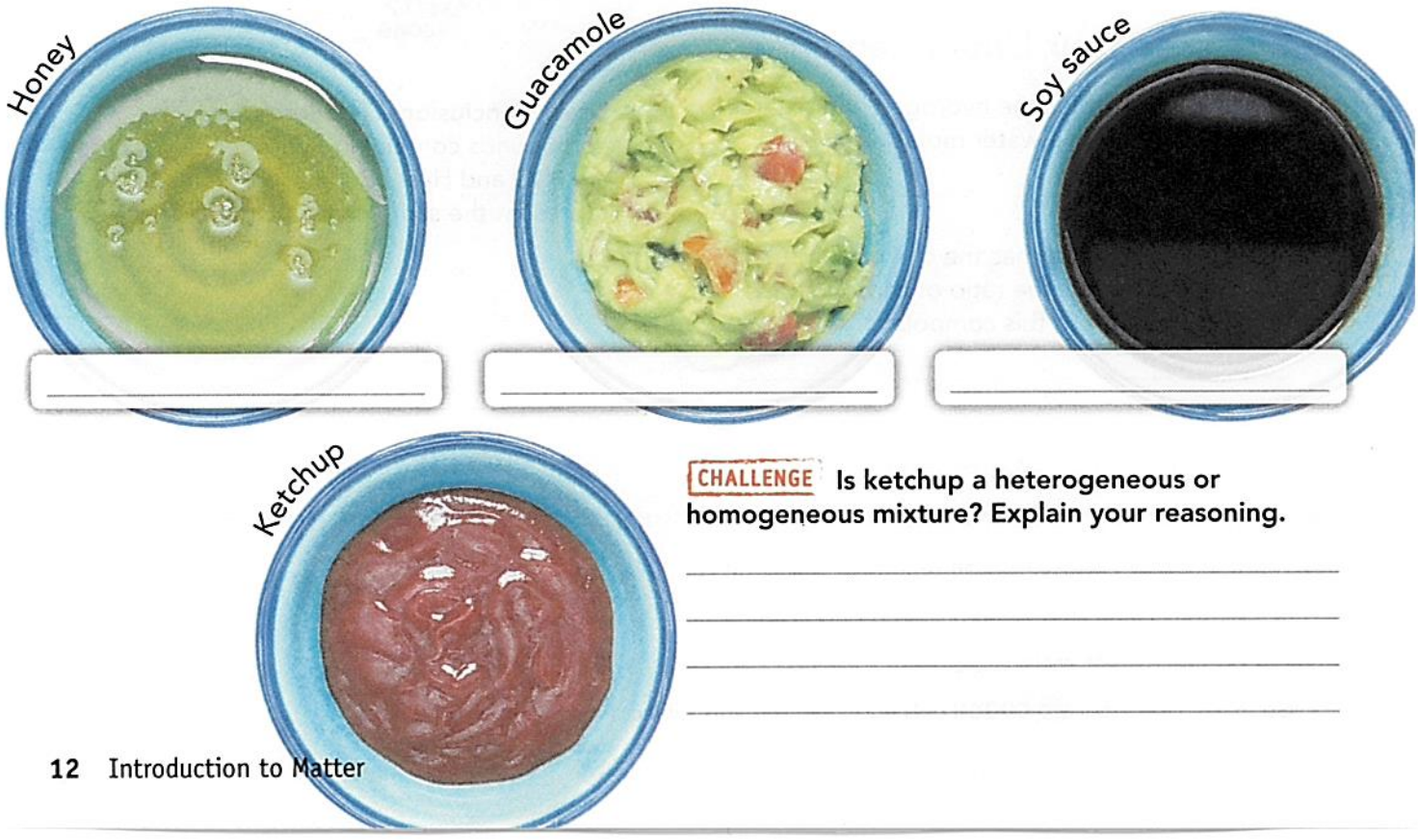
The substances involved in a homogeneous mixture (hoh moh JEE nee us), are so evenly mixed that you can't see the different parts. It is difficult to separate the parts of a homogeneous mixture. Air is a homogeneous mixture of gases. You know that oxygen is present in the air because you are able to breathe, but you cannot identify where the oxygen is in the air. A solution is another example of a homogeneous mixture. Solutions can be liquids, gases, or even solids.

FIGURE 3

Mixtures

Many foods are mixtures.

Interpret Photos **Label each food as a heterogeneous or homogeneous mixture.**



CHALLENGE **Is ketchup a heterogeneous or homogeneous mixture? Explain your reasoning.**

Separating Mixtures

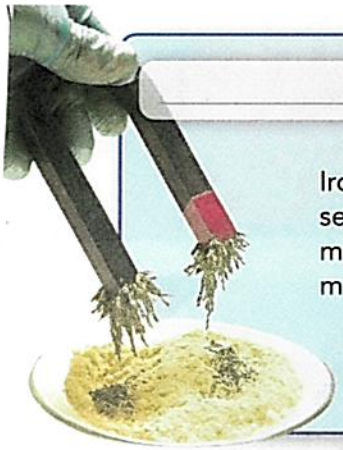
Since the substances in a mixture keep their properties, you can use those properties to separate a mixture into its parts. Methods used to separate the parts of a mixture, including distillation, evaporation, filtration, and magnetic attraction, are shown in **Figure 4.**

FIGURE 4

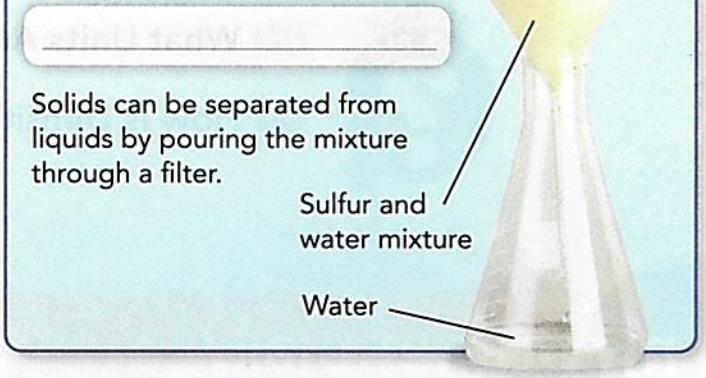
Separating a Mixture

Different methods can be used to separate mixtures.

Identify **Name the type of separation method being used in each photo.**

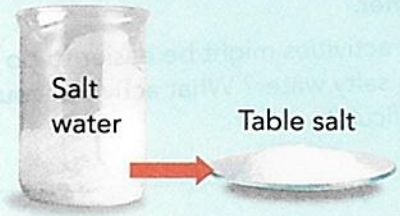


Iron objects can be separated from a mixture using a magnet.

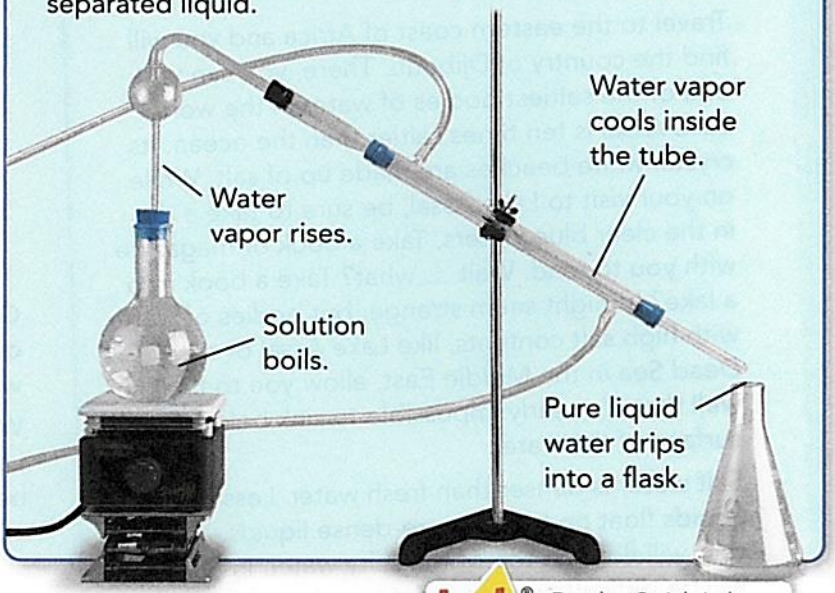


Solids can be separated from liquids by pouring the mixture through a filter.

When left in the open air, liquid solutions can change to gas, leaving solid components behind.



Liquids can be separated from each other by heating them up to the temperature at which one of the liquids boils. The liquid boils into a gas. Then the gas cools, forming the separated liquid.



Lab zone® Do the Quick Lab *Separating Mixtures.*

Assess Your Understanding

got it?

○ I get it! Now I know that the two types of mixtures are _____

_____

○ I need extra help with _____

Go to my science coach *online for help with this subject.*

LESSON 3

Measuring Matter

UNLOCK THE BIG ?

- What Units Are Used to Express Mass and Volume?
- How Is Density Determined?

MY PLANET DIARY

FIELD TRIP

Site: Lake Assal
Location: Djibouti, Republic of Djibouti

Travel to the eastern coast of Africa and you will find the country of Djibouti. There, you can visit one of the saltiest bodies of water in the world. Lake Assal is ten times saltier than the ocean. Its crystal white beaches are made up of salt. While on your visit to Lake Assal, be sure to take a dip in the clear blue waters. Take a book or magazine with you to read. Wait … what? Take a book into a lake? It might seem strange, but bodies of water with high salt contents, like Lake Assal or the Dead Sea in the Middle East, allow you to float so well that it's nearly impossible to sink below the surface of the water.

Salt water is denser than fresh water. Less-dense liquids float on top of more-dense liquids. You, too, will float on top of the salty water. In fact, it will be difficult even to swim, so what else can you do? Read a book while you float along!

Floating in the Dead Sea

Communicate **Write your answers to the questions below. Then discuss your answers with a partner.**

What water activities might be easier to do in Lake Assal's salty water? What activities could be more difficult?

PLANET DIARY Go to **Planet Diary** to learn more about density.

Lab zone® Do the Inquiry Warm-Up *Which Has More Mass?*

Vocabulary

- weight
- mass
- International System of Units
- volume
- density

Skills

- Reading: Identify the Main Idea
- Inquiry: Calculate

What Units Are Used to Express Mass and Volume?

Here's a riddle for you: Which weighs more, a pound of feathers or a pound of sand? If you answered "a pound of sand," think again. Both weigh exactly the same—one pound.

There are all sorts of ways to measure matter, and you use these measurements every day. Scientists rely on measurements as well. In fact, scientists work hard to make sure their measurements are as accurate as possible.

Weight Your **weight** is a measure of the force of gravity on you. On another planet, the force of gravity will be more if the planet is more massive than Earth and less if the planet is less massive than Earth. On the moon, you would weigh only about one sixth of your weight on Earth. On Jupiter, you would weigh more than twice your weight on Earth.

Identify the Main Idea
Underline the sentence(s) that describe how weight can be affected by location.

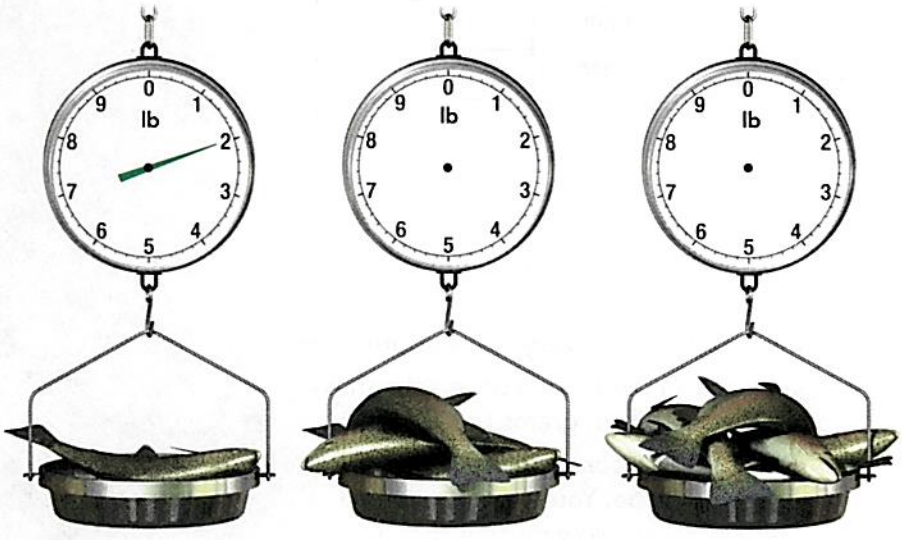
To find the weight of an object, you could place it on a scale like the ones shown in **Figure 1.** The object's weight pulls down on the mechanisms inside the scale. These mechanisms cause beams or springs inside the scale to move. The amount of movement depends on the weight of the object. From the movement of the beams, the scale displays the weight to you.

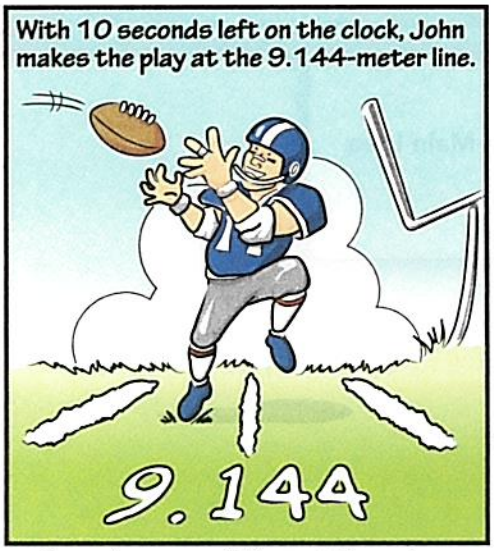
FIGURE 1

Measuring Weight

Complete the tasks below.

1. **Estimate** Use the weight of the first scale to estimate the weight of the fish on the other scales. Draw in the pointers.
2. **Describe** How would their weight change on a planet with less mass like Mercury? Or a planet with more mass like Neptune?





If we always used the metric system

did you know?

The first country to use an SI-based system of measurement was France in 1795. Today, there are only three countries in the world who have not adopted the SI system—Liberia, Myanmar, and the United States.

Mass How can you weigh less on the moon than on Earth when nothing about you has changed? Your weight is dependent on the gravity of the planet you are visiting. The amount of matter in an object is its **mass,** which does not change with location even if the force of gravity changes. If you travel to the moon, the amount of matter in your body—your mass—does not change. You are the same size. For this reason, scientists prefer to describe matter in terms of mass rather than weight. The mass of an object is a physical property.

To measure the properties of matter, scientists use a system called the **International System of Units** (abbreviated SI for the French name, *Système International d'Unités*). **The SI unit of mass is the kilogram (kg).** If you weigh 90 pounds on Earth, your mass is about 40 kilograms. Often, a smaller unit is used to measure mass, the gram (g). There are 1,000 grams in a kilogram, or 0.001 kilograms in a gram. The table in **Figure 2** lists the masses of some common items.

Mass of Common Objects

Object	Mass (g)	Mass (kg)
Nickel	5	0.005
Baseball	150	
Pineapple	1,600	
Full can of soda	390	
Inflated balloon	3	

FIGURE 2

Measuring Mass

The SI system uses grams and kilograms to measure mass.

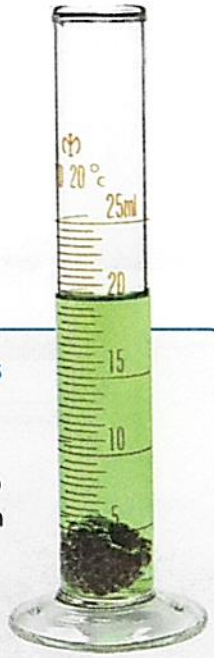
Complete the following tasks about mass.

1. Calculate In the table, convert the mass of each object from grams to kilograms.
2. CHALLENGE Suppose you are taking a flight to Europe. You are only allowed a 23-kg suitcase. How much is that in pounds? (*Hint:* 1 kg = 2.2 lbs.)

○ 50.6 lbs ○ 46.2 lbs ○ 10.5 lbs

Volume All matter has mass and takes up space. The amount of space that matter occupies is called its **volume.** It's easy to see that solids and liquids take up space, but gases have volume, too.

The SI unit of volume is the cubic meter (m^3). Other common SI units of volume include the cubic centimeter (cm^3), the liter (L), and the milliliter (mL). Common plastic soda bottles hold 2 liters of liquid. A milliliter is 1/1,000 of a liter and is exactly the same volume as 1 cubic centimeter. A teaspoonful of water has a volume of about 5 milliliters. In a lab, volumes of liquid are often measured with a graduated cylinder.



Calculating Volume

Suppose you want to know the volume of a rectangular object, like one of the suitcases shown in **Figure 3.** First, measure the length, width, and height (or thickness) of the suitcase. Then, multiply the measurements together.

Volume = Length × Width × Height

When you multiply the three measurements, you must also multiply the units.

Units = cm × cm × cm = cm^3

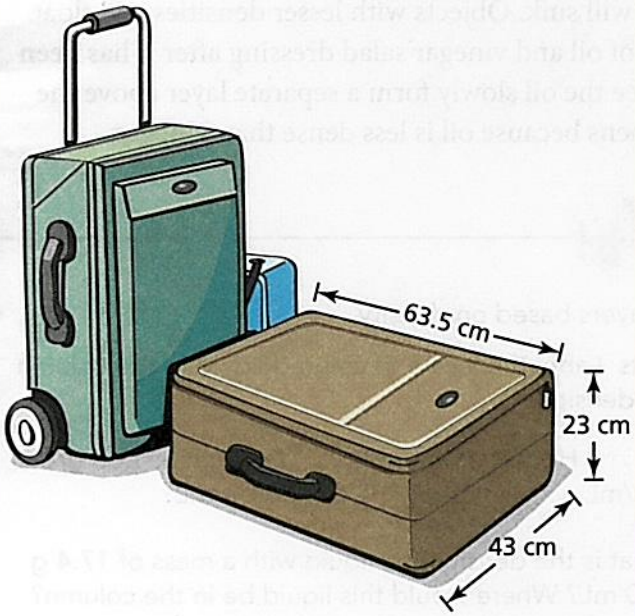


FIGURE 3

VIRTUAL LAB **Calculating Volume**

Calculate **Find the volume of the suitcase.**

_____

_____

Measuring Irregular Objects

How do you measure the volume of an irregular object, such as a key or a raspberry? One way is to submerge the object in a liquid in a graduated cylinder. The liquid level will rise by an amount that is equal to the volume of the object in milliliters.

Lab zone® Do the Quick Lab *Calculating Volume.*

Assess Your Understanding

1. **Explain** Why is mass more useful than weight for measuring matter?

_____

_____

_____

_____

_____

got it?

○ **I get it!** Now I know that the SI unit for mass is _____

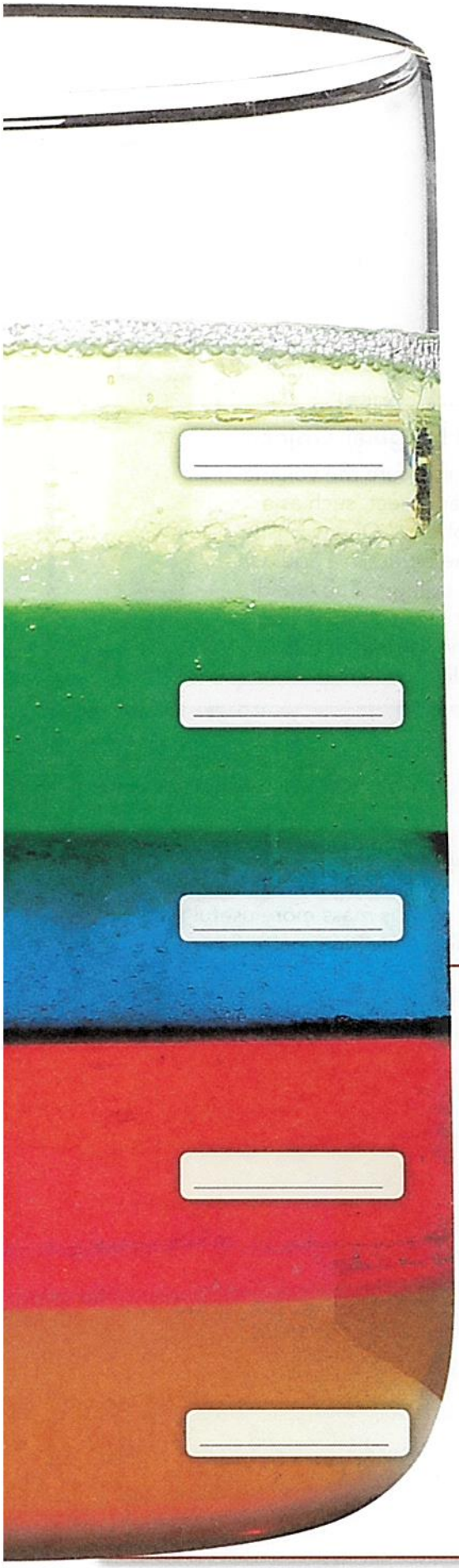
and the SI unit for volume is _____

_____

○ I need extra help with _____

_____

Go to MY SCIENCE COACH *online for help with this subject.*



How Is Density Determined?

Remember the riddle about the sand and the feathers? Although they weigh the same, a kilogram of sand takes up much less space than a kilogram of feathers. The volumes differ because sand and feathers have different densities—an important property of matter.

Calculating Density

Density is a measure of the mass of a material in a given volume. Density can be expressed as the number of grams in one cubic centimeter (g/cm^3). For example, the density of water at room temperature is stated as "one gram per cubic centimeter" (1 g/cm^3). Recall that volume can also be measured in milliliters. So the density of water can also be expressed as 1 g/mL.

You can determine the density of a sample of matter by dividing its mass by its volume.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Sinking or Floating?

Suppose you have a block of wood and a block of iron of equal mass. When you drop both blocks into a tub of water, you see that the wood floats and the iron sinks. You know the density of water is 1 g/cm^3. Objects with densities greater than that of water will sink. Objects with lesser densities will float.

Watch a bottle of oil and vinegar salad dressing after it has been shaken. You will see the oil slowly form a separate layer above the vinegar. This happens because oil is less dense than vinegar.

apply it!

Liquids can form layers based on density.

1. **Apply Concepts** Label the layers of colored liquid in the column according to their densities.

Water: 1.00 g/mL Honey: 1.36 g/mL Dish soap: 1.03 g/mL
Corn syrup: 1.33 g/mL Vegetable oil: 0.91 g/mL

2. **Calculate** What is the density of a liquid with a mass of 17.4 g and a volume of 20 mL? Where would this liquid be in the column?

3. **CHALLENGE** In which layer(s) would a solid cube with 6-cm sides and a mass of 270 g float? Explain.

Using Density

Suppose you are a gold miner in the 1800s, like the men in **Figure 4.** One day, while panning through the sediment in a stream, you come across a shiny golden rock. How do you know if the rock is real gold? Since density is a physical property of a substance, it can be used to identify an unknown substance. You can measure the mass and volume of the rock and find its density. If it matches 19.3 g/cm^3, the density of gold, then you have struck it rich!

FIGURE 4

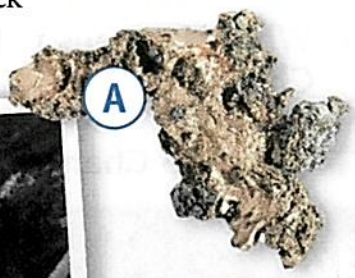
VIRTUAL LAB Using Density

Density can be used to identify substances.

Estimate Hypothesize which rock sample is gold. Then, calculate the density of each sample. Circle the rock that is real gold.

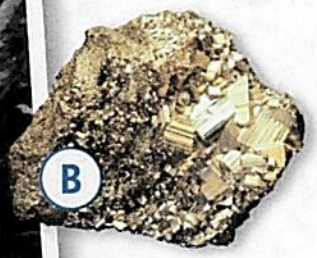
My hypothesis is that the gold rock is:

○ A ○ B ○ C



Mass = 108 g
Volume = 12 cm^3

Density = _____



Mass = 126 g
Volume = 15 cm^3

Density = _____

Mass = 386 g
Volume = 20 cm^3

Density = _____

Lab zone® Do the Lab Investigation *Making Sense of Density.*

Assess Your Understanding

2a. Identify Maple syrup will (float/sink) in water because its density is greater than 1 g/cm^3.

b. Calculate What is the mass of a sample of a substance with a volume of 120 mL and a density of 0.75 g/mL?

_____

c. CHALLENGE Liquid water and ice are the same substance, H_2O. How would you explain why ice floats in water?

_____

_____

_____

got it?

○ I get it! Now I know density is calculated by _____

_____

○ I need extra help with _____

Go to my science coach *online for help with this subject.*

LESSON 4

Changes in Matter

UNLOCK THE BIG ?

- What Happens to a Substance in a Physical Change?
- What Happens to a Substance in a Chemical Change?
- How Are Changes in Energy and Matter Related?

MY PLANET DIARY

BLOG

Posted by: Dylan
Location: Fountain Valley, California

Whenever I go to the beach, I spend a majority of my time building a sand castle. I try to build it after a high tide comes. That way I have a lot of time to build up the walls and they will not be destroyed as quickly by the water.

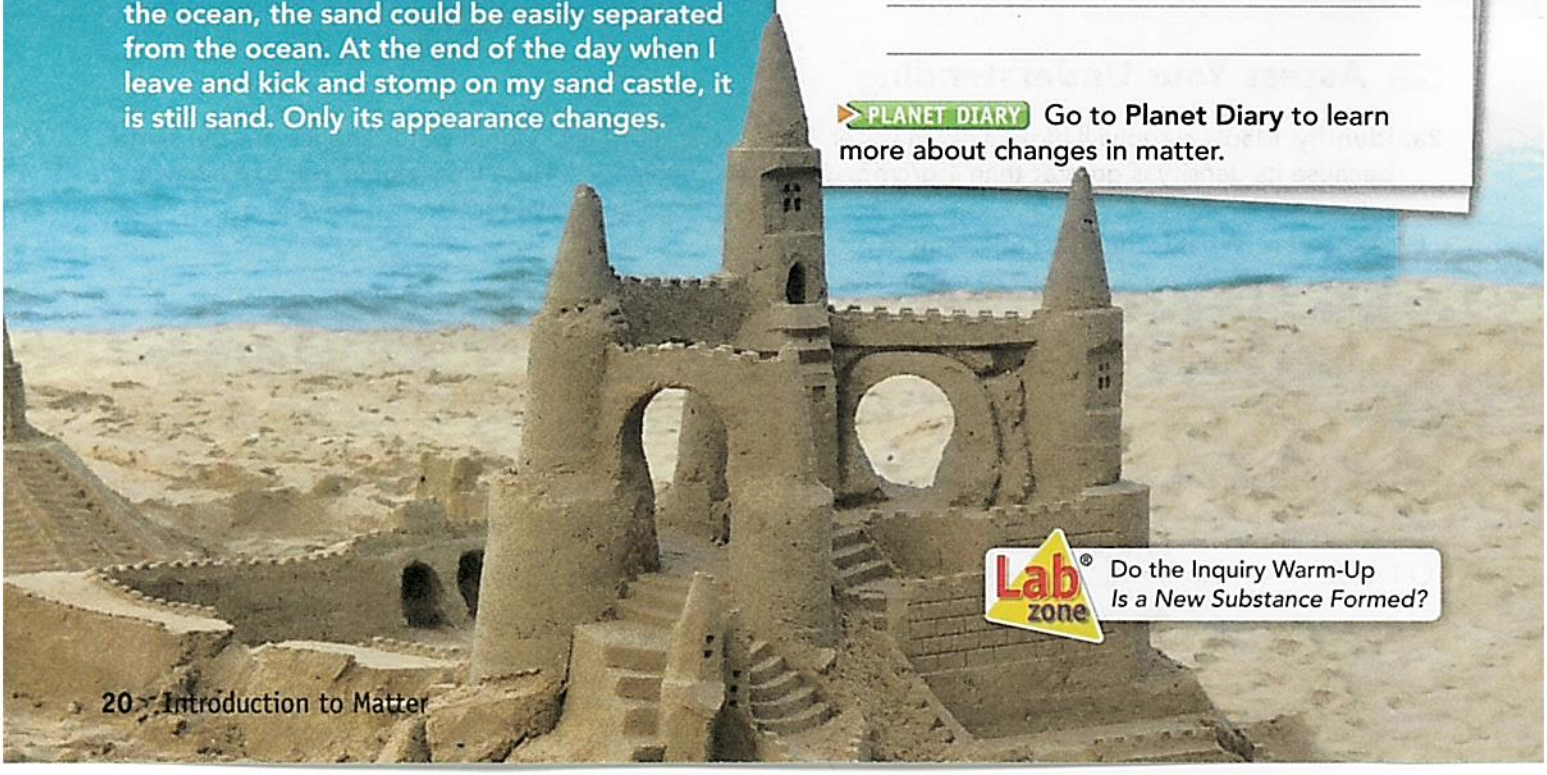
Even though the waves will eventually destroy the castle and take the sand with them back to the ocean, the sand could be easily separated from the ocean. At the end of the day when I leave and kick and stomp on my sand castle, it is still sand. Only its appearance changes.

Write your answers to the questions below.

1. Describe the differences in the ways the sand castle is changed by an ocean wave and by Dylan stomping on it.

2. Dylan changed a formless pile of sand into a sand castle. What other natural materials can be changed into art?

PLANET DIARY Go to **Planet Diary** to learn more about changes in matter.



Lab zone® Do the Inquiry Warm-Up *Is a New Substance Formed?*

Vocabulary

- physical change
- chemical change
- law of conservation of mass
- temperature
- thermal energy
- endothermic change
- exothermic change
- chemical energy

Skills

- Reading: Relate Cause and Effect
- Inquiry: Draw Conclusions

What Happens to a Substance in a Physical Change?

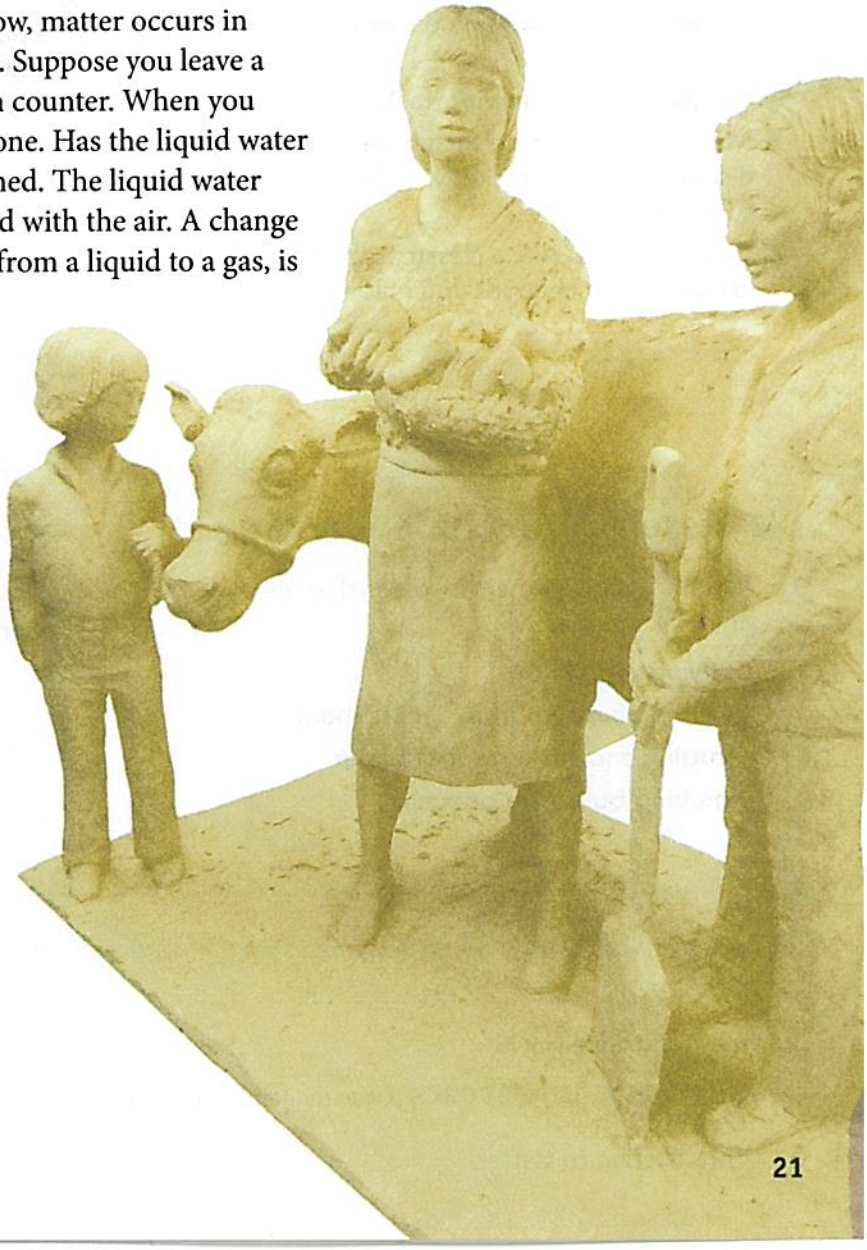
How can matter change? A **physical change** alters the form or appearance of matter but does not turn any substance in the matter into a different substance. In **Figure 1,** a butter artist has changed a formless block of butter into artwork. Although it looks different, the sculpture is still butter. **A substance that undergoes a physical change is still the same substance after the change.** Many physical changes, such as snow melting into water, occur in nature.

Changes of State As you may know, matter occurs in three familiar states—solid, liquid, and gas. Suppose you leave a small puddle of liquid water on the kitchen counter. When you come back two hours later, the puddle is gone. Has the liquid water disappeared? No, a physical change happened. The liquid water changed into water vapor (a gas) and mixed with the air. A change in state, such as from a solid to a liquid or from a liquid to a gas, is an example of a physical change.

FIGURE 1

Change of State
Changes between solids, liquids, and gases are physical changes.

Predict **Describe the changes the butter sculpture will undergo in a few hours if it is left out in the sun.**



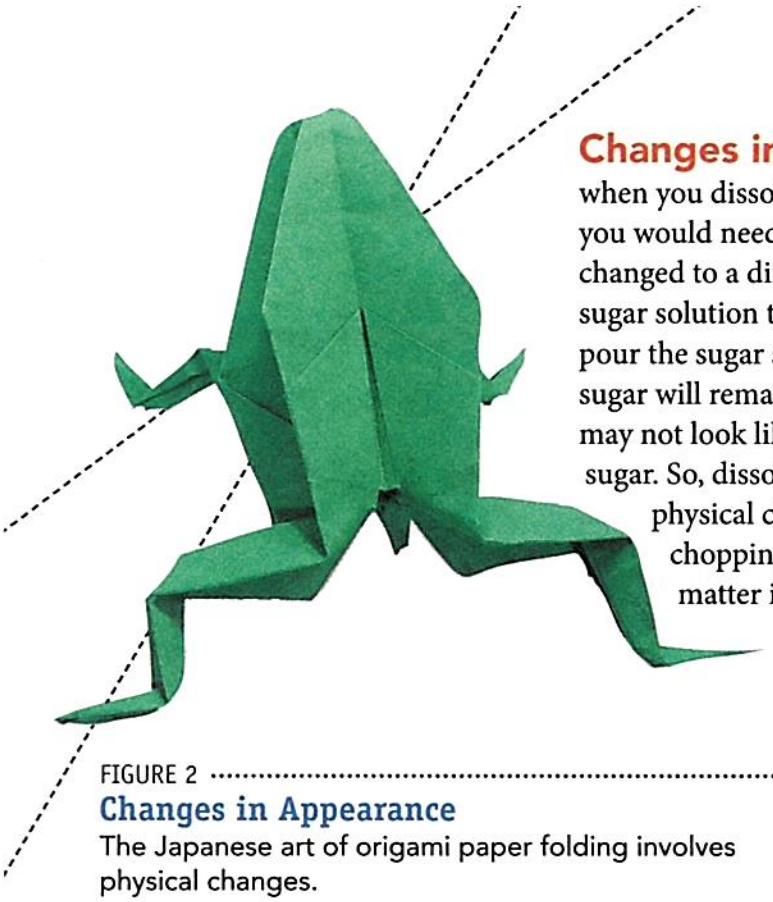


FIGURE 2

Changes in Shape or Form

Is there a physical change when you dissolve a teaspoon of table sugar in water? To be sure, you would need to know whether or not the sugar has been changed to a different substance. For example, you know that a sugar solution tastes sweet, just like the undissolved sugar. If you pour the sugar solution into a pan and let the water dry out, the sugar will remain as a crust at the bottom of the pan. The crust may not look like the sugar before you dissolved it, but it's still sugar. So, dissolving is also a physical change. Other examples of physical changes are bending, crushing, breaking, and chopping. Any change that alters only the shape or form of matter is a physical change. The methods of separating mixtures, such as filtration and distillation, also involve physical changes.

Changes in Appearance

The Japanese art of origami paper folding involves physical changes.

Complete the following tasks.

1. **Make Models** Using the corner of this page or a separate sheet, make two physical changes to the paper.
2. **Communicate** Ask a classmate to identify and list below the changes you made.

_____

_____

3. CHALLENGE Is it correct to say that dissolving a packet of juice powder in water makes a new substance, fruit punch, so it must not be a physical change?

_____

_____

_____

_____

_____

Lab zone® Do the Quick Lab *What Is a Physical Change?*

Assess Your Understanding

1a. Classify Mark all the processes that are physical changes.

- ◯ drying wet clothes
- ◯ lighting a match from a matchbook
- ◯ cutting snowflakes out of paper
- ◯ melting butter for popcorn

b. Apply Concepts Describe three physical changes that occur in nature.

_____

_____

_____

_____

got it?

◯ I get it! Now I know that a substance that undergoes a physical change is _____

_____

◯ I need extra help with _____

Go to my science coach *online for help with this subject.*

What Happens to a Substance in a Chemical Change?

Another kind of change occurs when a substance transforms int another substance. A change in matter that produces one or mo new substances is a **chemical change,** or chemical reaction. In some chemical changes, a single substance breaks down into tw or more other substances. For example, hydrogen peroxide brea down into water and oxygen gas when it's poured on a cut on yo skin. In other chemical changes, two or more substances combi to form different substances. Photosynthesis is a natural chemic change. Several compounds combine with energy from the sun produce new substances.

Figure 3 shows chemical changes that are used in forensics t collect evidence. To make fingerprints more visible, a chemical found in super-strong glues is heated. Vapors from the glue rea with sweat or other body chemicals in a fingerprint to form a white powder making the print visible. Luminol is a chemical that reacts with blood. It combines with traces of blood that are too small to see with the naked eye to form a new substance tha glows in the dark. The footprint in Figure 3 has been treated wi luminol. Unlike a physical change, a chemical change produces new substances with new and different properties.

apply it!

You are a detective investigating a robbery. When you arrive at the scene, there are not many clues that you can see to help solve the crime. You're able to write down a few

An empty jewelry box is knock

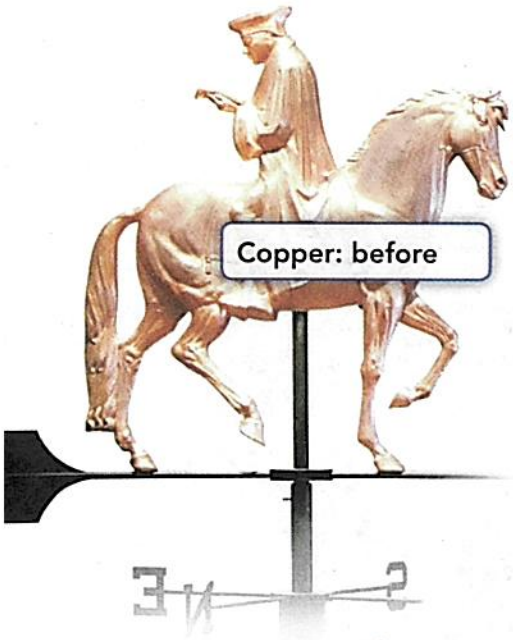
Chemical treatment: _____

_____

_____

An open box of bandages is o found nearby.

Chemical treatment: _____



Examples of Chemical Change

One common chemical change is the burning of natural gas on a gas stove. Natural gas is mostly made up of the compound methane (CH_4). When it burns, methane combines with oxygen in the air and forms new substances. These new substances include carbon dioxide gas (CO_2) and water vapor (H_2O). Both of these substances can be identified by their properties, which are different from those of methane. The chemical change that occurs when fuels, such as natural gas, candle wax, or wood, burn in air is called combustion. Other processes resulting in chemical change include electrolysis, oxidation, and tarnishing. The table in **Figure 4** describes each of these types of chemical change.

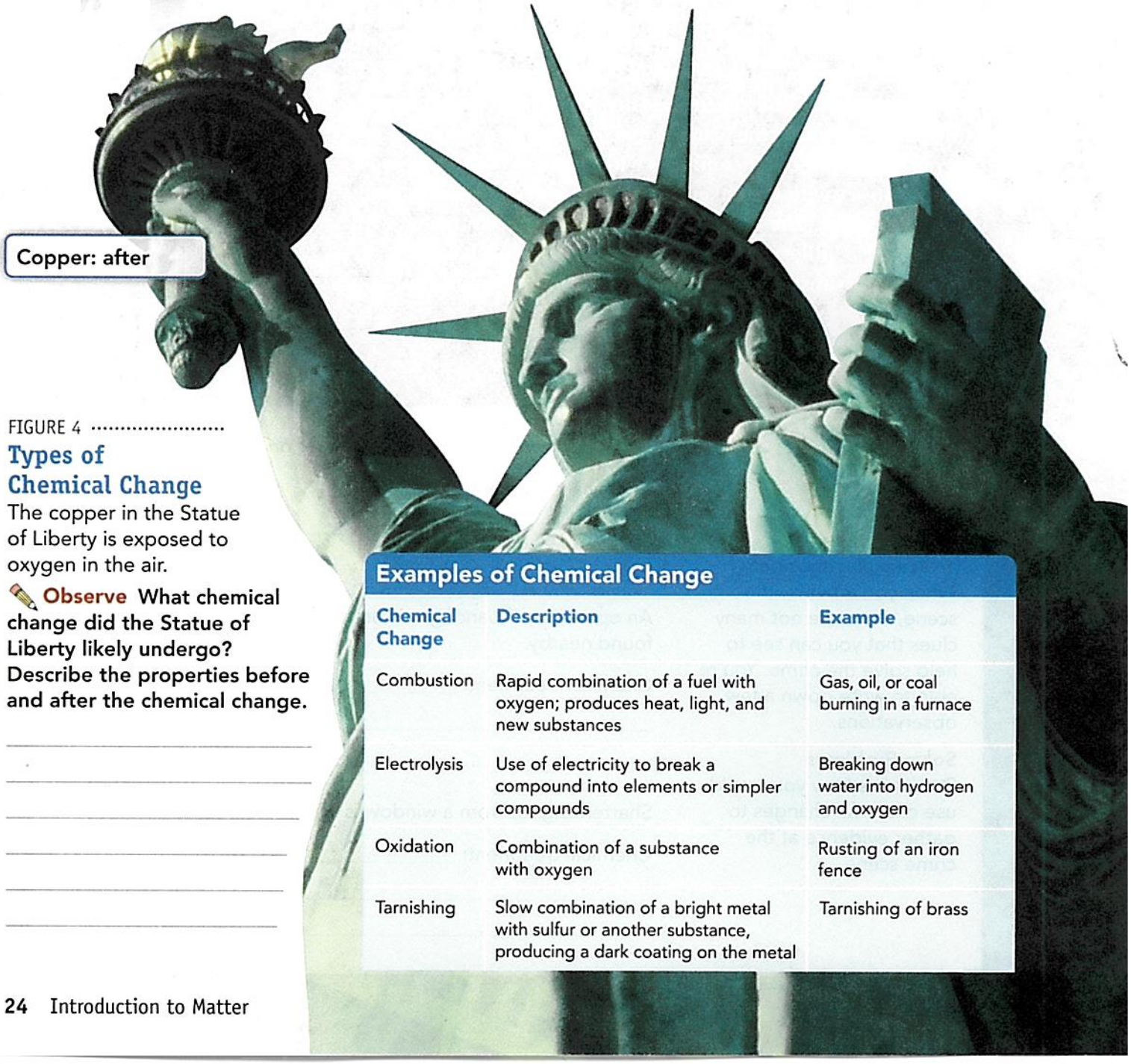


FIGURE 4

Types of Chemical Change

The copper in the Statue of Liberty is exposed to oxygen in the air.

Observe **What chemical change did the Statue of Liberty likely undergo? Describe the properties before and after the chemical change.**

Examples of Chemical Change

Chemical Change	Description	Example
Combustion	Rapid combination of a fuel with oxygen; produces heat, light, and new substances	Gas, oil, or coal burning in a furnace
Electrolysis	Use of electricity to break a compound into elements or simpler compounds	Breaking down water into hydrogen and oxygen
Oxidation	Combination of a substance with oxygen	Rusting of an iron fence
Tarnishing	Slow combination of a bright metal with sulfur or another substance, producing a dark coating on the metal	Tarnishing of brass

Conservation of Mass

Water may seem to "disappear" when it evaporates, but scientists long ago proved otherwise. In the 1770s, a French chemist, Antoine Lavoisier, measured mass both before and after a chemical change. His data showed that no mass was lost or gained during the change. The fact that matter is not created or destroyed in any chemical or physical change is called the **law of conservation of mass.** This law is also called the law of conservation of matter since mass is a measurement of matter.

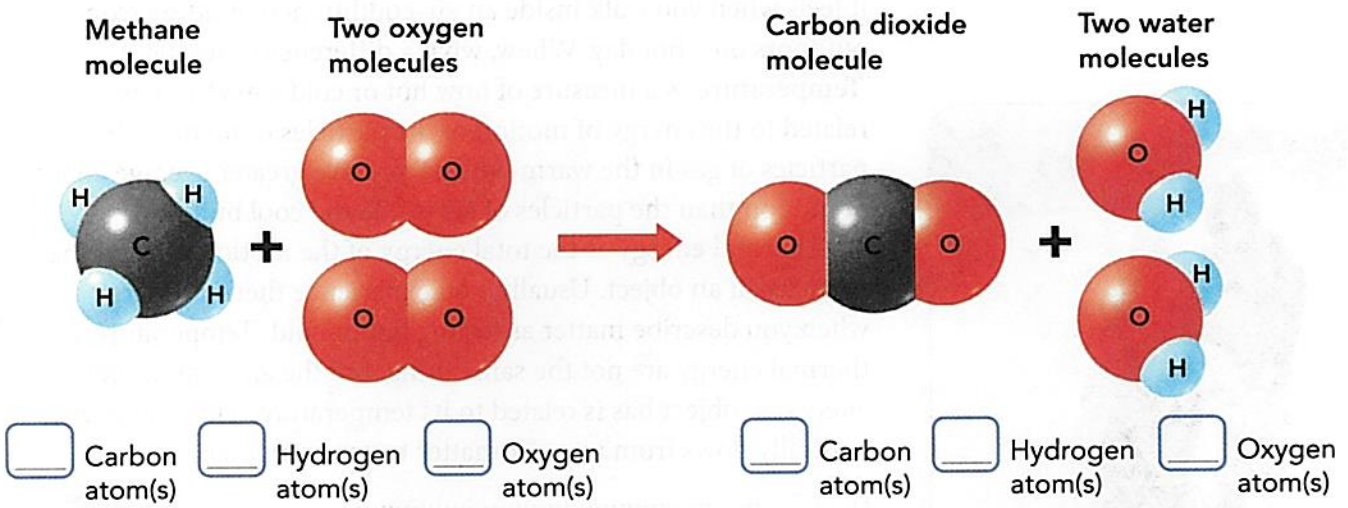
Suppose you could measure all of the carbon dioxide and water produced when methane burns. You would find that it equals the mass of the original methane plus the mass of the oxygen from the air that was used in the burning. **Figure 5** demonstrates that during a chemical change, atoms are not lost or gained, only rearranged.

FIGURE 5

INTERACTIVE ART

Conservation of Mass

Interpret Diagrams Count the atoms of each element before and after the chemical change. Is mass conserved in this reaction? Explain.



Lab zone® Do the Quick Lab *Demonstrating Tarnishing.*

Assess Your Understanding

2a. Name A chemical reaction is another name for a chemical (combustion/change).

b. Predict What kind of chemical change do you think occurs when a banana peel turns brown in the open air? Explain.

_____

_____

c. CHALLENGE Assuming no mass escapes, explain why the mass of a rusted nail is greater than the mass of a nail before it rusted.

_____

_____

_____

_____

got it?

○ I get it! Now I know that when a substance undergoes a chemical change, _____

_____

○ I need extra help with _____

Go to my science coach *online for help with this subject.*

How Are Changes in Energy and Matter Related?

Do you feel as if you are full of energy today? Energy is the ability to do work or cause change. **Every chemical and physical change in matter includes a change in energy.** A change as simple as bending a paper clip takes energy. When ice changes to liquid water, it absorbs energy from the surrounding matter. When candle wax burns, it gives off energy as light and heat.

Like matter, energy is conserved in a chemical change. Energy is never created or destroyed. It can only be transformed from one form to another.

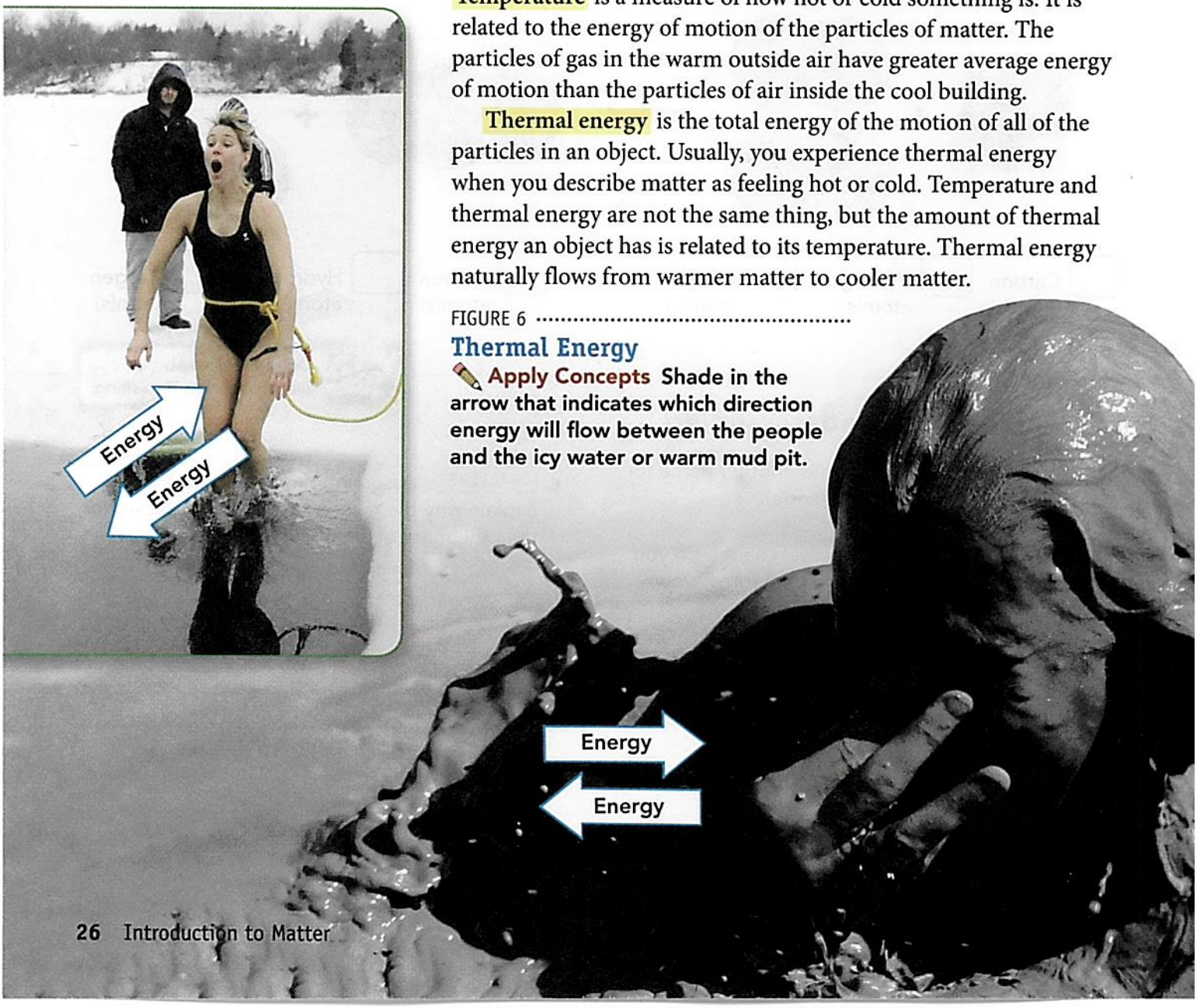
Temperature and Thermal Energy Think of how it feels when you walk inside an air-conditioned building from the outdoors on a hot day. Whew, what a difference in temperature! **Temperature** is a measure of how hot or cold something is. It is related to the energy of motion of the particles of matter. The particles of gas in the warm outside air have greater average energy of motion than the particles of air inside the cool building.

Thermal energy is the total energy of the motion of all of the particles in an object. Usually, you experience thermal energy when you describe matter as feeling hot or cold. Temperature and thermal energy are not the same thing, but the amount of thermal energy an object has is related to its temperature. Thermal energy naturally flows from warmer matter to cooler matter.

FIGURE 6

Thermal Energy

Apply Concepts **Shade in the arrow that indicates which direction energy will flow between the people and the icy water or warm mud pit.**



Thermal Energy and Changes in Matter

Thermal energy is a form of energy that is often released or absorbed when matter changes. For example, ice absorbs thermal energy from its surroundings when it melts, leaving the surroundings feeling cold. That's why you can pack food and drinks in an ice-filled picnic cooler. The melting of ice is an **endothermic change,** a change in which energy is absorbed. Changes in matter can also occur when energy is given off. An **exothermic change** releases energy. Combustion is a chemical change that releases thermal energy and light.

Relate Cause and Effect
Underline the sentence that describes how your hand would be affected if you made a snowball or held a frozen treat.

Transforming Chemical Energy The energy stored in the chemical bonds between atoms is a form of energy called **chemical energy.** Chemical energy is stored in foods, fuels, and even the cells of your body. Animals, like the bear in **Figure 7,** gain chemical energy from food.

Burning fuels transforms chemical energy and releases some of it as thermal energy. When you ride a bike up a hill, chemical energy from foods you ate changes into energy of motion. Chemical energy can change into other forms of energy, and other forms of energy can change into chemical energy.

FIGURE 7
Transforming Chemical Energy
Chemical energy from food can be transformed into other types of energy needed for activity.

do the math! Analyzing Data

A student records the temperature of two reactions once per minute. Her data are plotted on the graph.

1 **Calculate** What was the change in temperature for each reaction after 10 minutes?

_____

_____

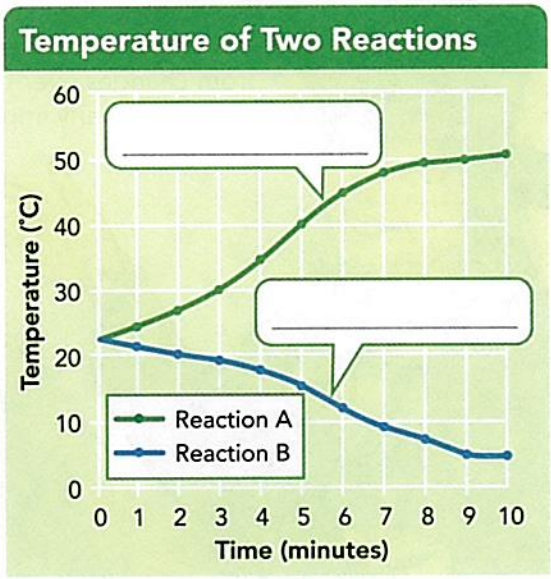
2 **Draw Conclusions** On the graph, label each reaction as exothermic or endothermic. How can you tell?

_____

_____

_____

_____



EXPLORE THE BIG Q

INDIANA JANE and the INVESTIGATION OF MATTER

How is matter described?

FIGURE 8

INTERACTIVE ART Indiana Jane is hunting for lost treasures of matter. Join her in following clues to describe different types of matter.

Review **Answer questions about Indiana's findings along the way. Then, complete the logbook with information you've gathered about the properties of matter.**

Tarnished coins I found these coins near the opening of a foul-smelling cave. I believe they were a shiny metal at one point, perhaps silver, platinum, or aluminum. I've determined the mass of each coin to be 315 g and the volume to be 30 cm^3.

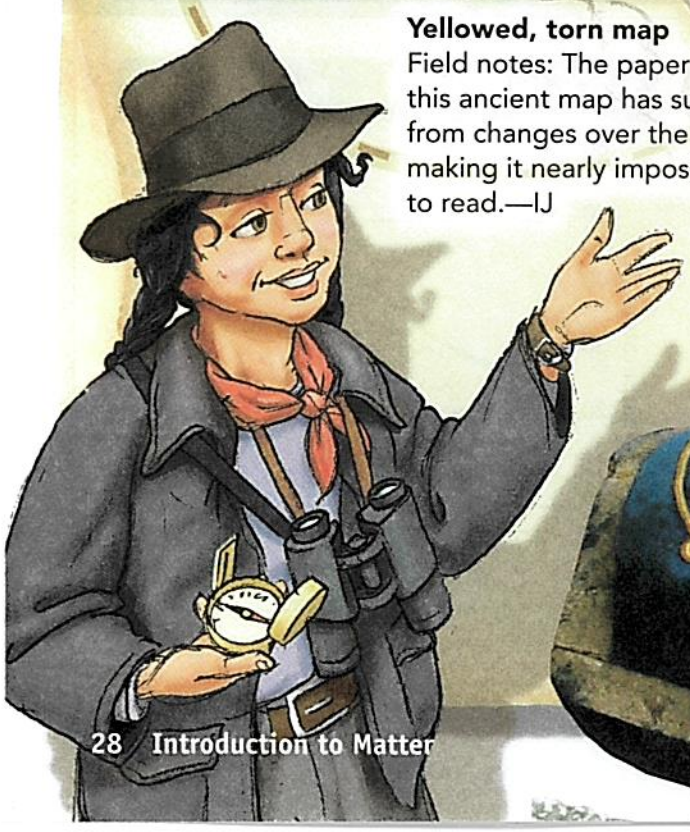
What element are the coins made of?

- ◯ Aluminum (density = 2.7 g/cm^3)
- ◯ Silver (density = 10.5 g/cm^3)
- ◯ Platinum (density = 21.5 g/cm^3)

Arrowhead This arrowhead, most likely carved by an ancient hunter, was discovered in a pile of rocks. **Describe the type of mixture the arrowhead was found in.**

Mummy The mummy we found today is badly decayed, probably because its sarcophagus is not sealed airtight. I translated a scroll found nearby that says the mummy and case originally had a mass of 200 kg. The mass is now 170 kg. **Explain how the mummy and its sarcophagus decreased in mass if the law of conservation of mass must be obeyed.**

Yellowed, torn map Field notes: The paper of this ancient map has suffered from changes over the years making it nearly impossible to read.—IJ



Indiana Jane has to bring all the artifacts back to the museum. Describe each object's properties and the physical or chemical changes it underwent.

Object	Properties	Changes Undergone
1. Clay pot		
2. Coins		
3. Map		

Broken clay pot Field notes: I've come across some clay pots. Many have been broken or cracked over time.—IJ

Wax statue I believe we have found the remains of the famous Carved Dove wax statue. It would have been a valuable artifact, but all that's left is a puddle of liquid.
Describe at least two changes the wax has undergone over time.

Lab zone® Do the Quick Lab *Where Was the Energy?*

Assess Your Understanding

3a. Identify What energy transformation takes place when you exercise?

b. ANSWER THE BIG Q? How is matter described?

got it?

○ **I get it!** Now I know that every chemical and physical change includes

○ I need extra help with

Go to my science coach *online for help with this subject.*