Science

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Sequence	• Captions • Charts • Diagrams • Glossary	Matter

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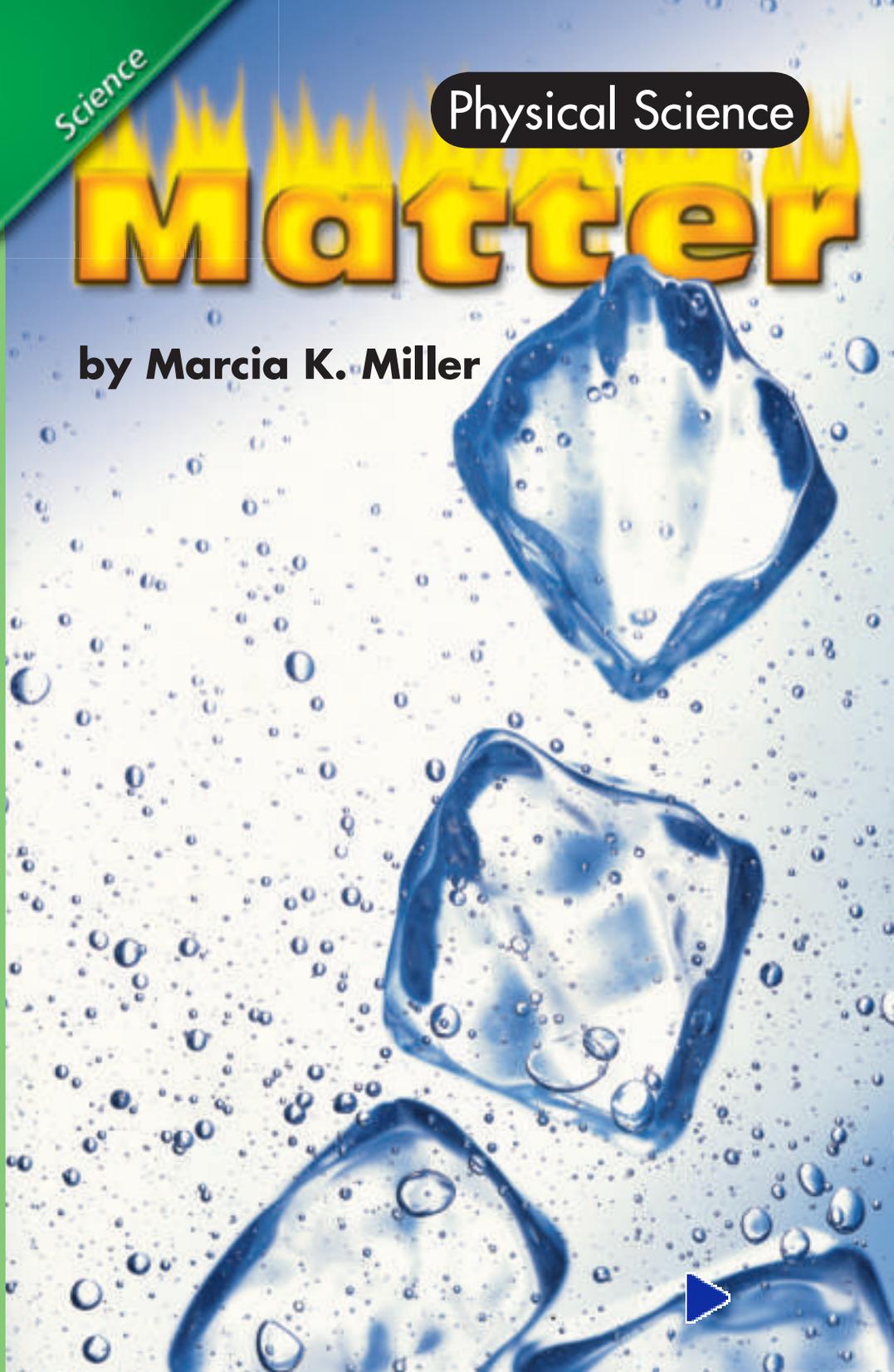
Science

Physical Science

Matter

by Marcia K. Miller



Vocabulary

chemical change

chemical property

condensation

density

mass

physical change

physical property

volume

weight

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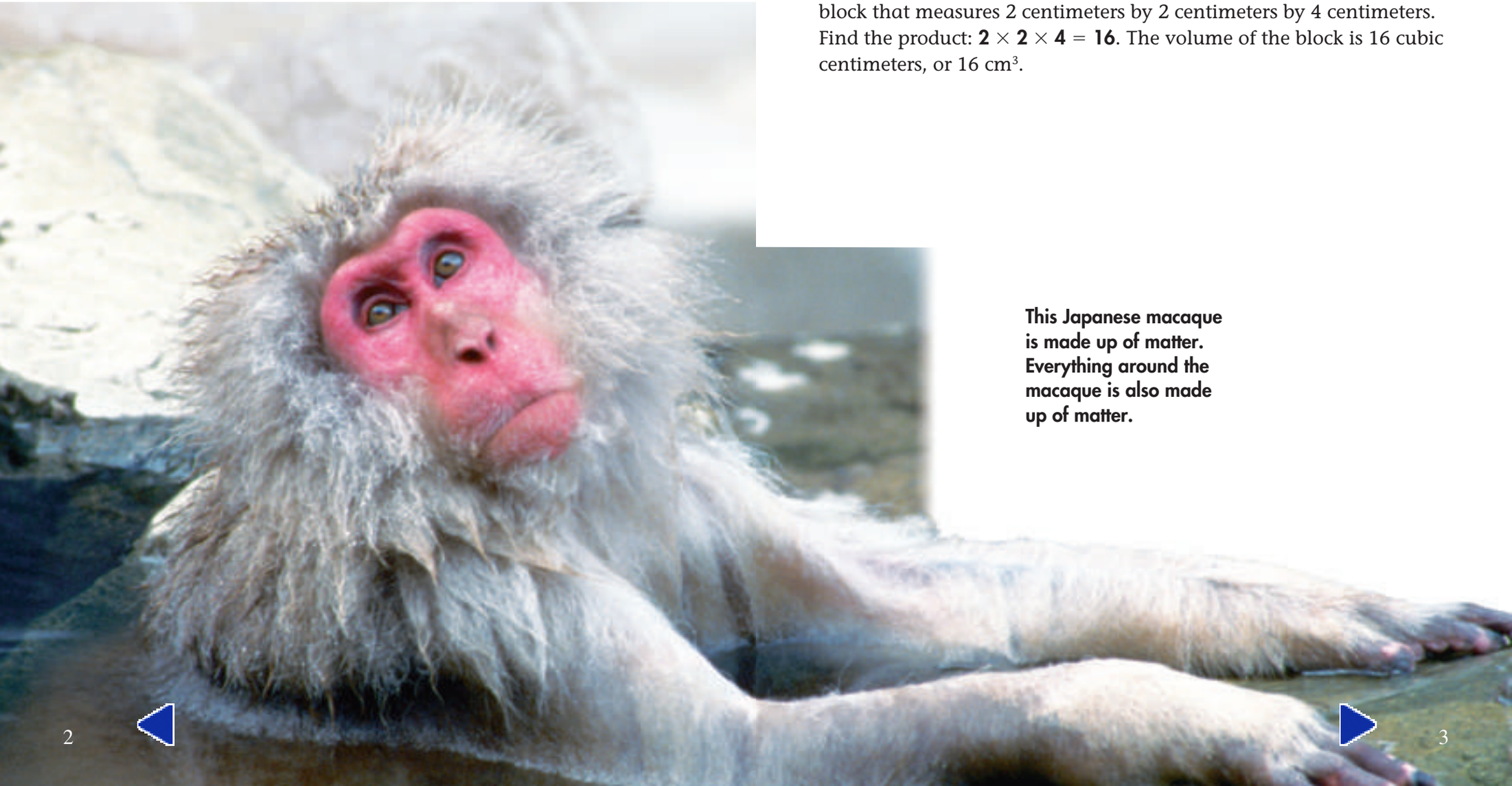
What is matter?

Measuring Matter

The animal in the picture is a macaque. This kind of monkey lives in Japan. You know that the macaque, the rocks, and the water in the picture are made up of matter. Even the air around the macaque is matter. Matter is anything that has mass and takes up space. Almost everything you see is matter. Some matter, such as air, cannot be seen. Matter can be light or heavy, hard or soft, wet or dry.

Mass is a key property of matter. You can measure mass. The **mass** of an object is the amount of matter that makes up the object. Scientists measure mass in grams. The mass of an object does not depend on its shape. A piece of paper has the same mass whether it is flat, crumpled, or folded into the shape of a boat.

Volume is another property of matter that can be measured. **Volume** is the amount of space that an object takes up. Scientists measure the volume of a liquid in milliliters (mL). They measure the volume of a solid in cubic centimeters (cm^3). You can find the volume of a solid by measuring its height, its length, and its width. Then you multiply the three measurements together. Picture a small block that measures 2 centimeters by 2 centimeters by 4 centimeters. Find the product: $\mathbf{2} \times \mathbf{2} \times \mathbf{4} = \mathbf{16}$. The volume of the block is 16 cubic centimeters, or 16 cm^3.



This Japanese macaque is made up of matter. Everything around the macaque is also made up of matter.

Mass and Weight

People often mix up mass and weight. But these are two different properties of objects. Mass is a measure of the amount of matter in an object. Mass is the same for an object wherever it is in the universe.

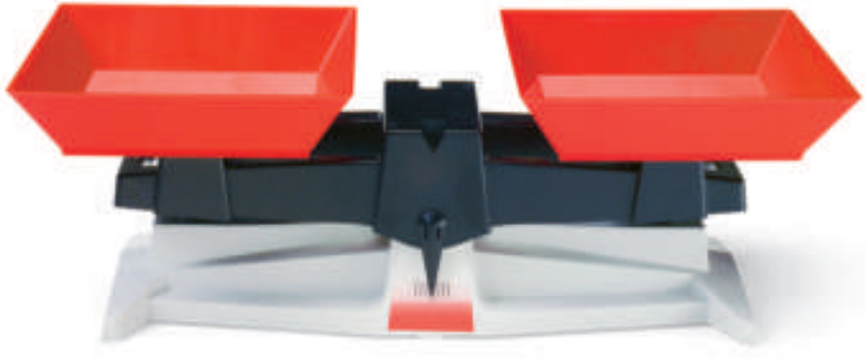
Weight is a measure of the pull of gravity on an object. It is measured using a spring scale in units called newtons. Weight can change if an object moves to a place that has a different force of gravity. You have the same mass whether you are on Earth or on the Moon. But you weigh six times as much on Earth as you would on the Moon!

Spring scale

Density

Here's an old riddle. *Which weighs more—a pound of feathers or a pound of lead?* Do you know?

The feathers and the lead weigh the same amount. Both weigh one pound! But one pound of lead is a lot smaller than one pound of feathers. Why is this?



Balance

The matter that makes up lead is more tightly packed than the matter that makes up feathers. Lead has a greater density. **Density** is a measure of the amount of matter that fills a given space. You can also say that density is mass per unit volume.

Think of density this way. Picture a cube of lead that measures 1 centimeter on each side. Its volume would be 1 cubic centimeter. Its mass would be 11.35 grams. A cube of cork of the same size has the same volume—1 cubic centimeter. But its mass is only 0.24 grams. The particles of matter in the lead are more tightly packed than the particles of matter in the cork are. The lead cube would be heavier.

You can use a formula to find density.

$$\text{density} = \frac{\text{mass}}{\text{volume}} \text{ or } \frac{m}{v}$$

Suppose you have an object with a mass of 30 grams. Its volume is 15 cubic centimeters. What is its density? Follow the steps to find the density.

$$\text{density} = \frac{m}{v} = \frac{30\text{g}}{15\text{cm}^3} = \frac{2\text{g}}{\text{cm}^3}$$

Each cubic centimeter of the substance in that cube has a mass of 2 grams.

The liquid and solid substances in this tube have different densities. A substance with less density floats on top of a substance with more density.

Using Density To Identify Substances

How can it help to know the density of a substance? Every substance has a particular density. So you can use density to figure out what a substance is.

Picture a small cube of lead and a large lead pipe. The density of lead is always the same. It is 11.35 grams per cubic centimeter. This means the lead cube and the lead pipe have the same density even though they are different sizes. The density of one substance is usually different than the density of any other substance.

Suppose you find a piece of metal. You don't know what metal it is, but you want to find out. First, use a balance to find its mass. Then measure it to find its volume. Use those two numbers to find its density. Then look at a table similar to the one at the right. Suppose you calculated a density of 10.50 grams per cubic centimeter. Look for a material that has the same density. Which metal matches?

Oil is less dense than water. So oil floats on top of water. This is why oil spilled at sea is likely to wash up on a nearby beach.

Densities of Common Materials

Material	Density (g/cm^3)
Gold	19.32
Lead	11.35
Silver	10.50
Copper	8.96
Rubber	1.10
Water	1.00
Cork	0.24
Wood	
White oak	0.68
Balsa	0.16

Physical Properties of Matter

Density is just one property you can use to describe matter. Look at the copper in the picture. How else could you describe it?

You might say that copper is a solid. Or you might say that it shines. These are physical properties of copper. A **physical property** of matter is anything you can see or measure without changing the substance. The physical properties of a substance are always the same.

Copper

Copper has useful physical properties. Copper is malleable. You can pound, roll, or shape it. Copper is also ductile. You can pull it into thin strips, such as wire.

Copper conducts heat and electricity very well. It is often used to make electrical wires and cooking pots. Wood does not conduct heat or electricity well. A wooden spoon lets you stir hot liquid without burning your hand.

Matter has other physical properties. It may dissolve in other substances. It may be magnetic. Different substances may freeze and boil at different temperatures.

The boiling point of a liquid is one of its physical properties.

Water freezes and melts at 0°C. The freezing point of a substance is a physical property.

Chemical Properties Of Matter

Matter can also be described by its chemical properties. A **chemical property** of a substance determines what happens when it mixes with something else. The wood in the photo below is burning. It changes into new substances, ash and gases, as it burns. The ability to burn is called flammability. Wood is flammable. Iron is not.

When placed in acid, the zinc covering the nail goes through a chemical change. The gold in the bracelet is not affected by the acid.

Wood is flammable.

Some Common Properties

Substance	Physical Property	Chemical Property
Wood	Does not conduct electricity	Flammable
Iron	Malleable	Combines with oxygen to form rust
Water	Colorless and odorless	Does not burn
Copper	Conducts electricity	Combines with oxygen to form the mineral cuprite

How can matter change?

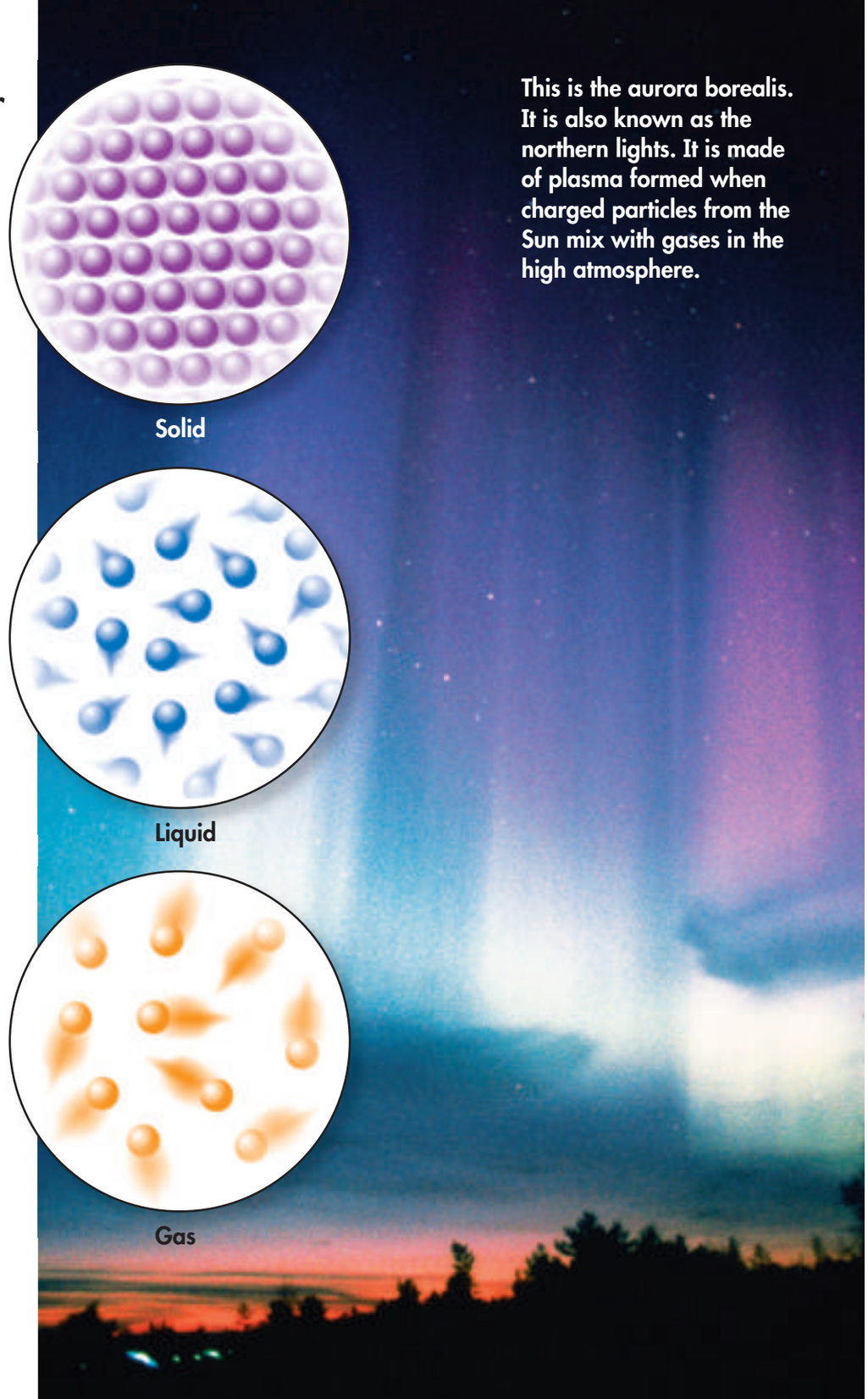
States of Matter

Is your desk moving? You'll probably say no. But the matter that makes up your desk is moving.

All matter is made up of tiny particles. You cannot see them without a microscope. The particles always move and bump into each other. Their speed and how strongly they attract each other is what makes matter a solid, a liquid, a gas, or plasma. These are called the states of matter.

Solids

The shape and volume of the four states of matter show their differences. A solid has a definite shape and volume. Its particles are very close together. They don't move quickly. A strong attraction holds them together. A solid keeps its shape and volume even if you move it around. Your chair, the floor, and the hair on your head are all solids.



This is the aurora borealis. It is also known as the northern lights. It is made of plasma formed when charged particles from the Sun mix with gases in the high atmosphere.

Liquids

Liquids have definite volume but no definite shape. The particles of a liquid move fast enough to break some of the attraction between them. They can slide past each other. So a liquid takes the shape of the container that holds it. You can pour a carton of juice into a cup. The shape of the juice changes, but its volume stays the same.

Gases

A gas has no particular shape or volume. Its particles move quickly. They break away from one another and move in many different directions. A gas takes the shape of the container it is in. The air you breathe is made up of gases that fill and take the shape of the room you are in.

Plasma

Plasma has no definite shape or volume, yet it is not a gas. Its particles have electric charges. Plasmas are not common on Earth. They are found in lightning, fire, and neon lights. Scientists think that 99 percent of the known matter in the universe is made up of plasma.

Changes of State

Look at the matter around you. Many things are solids. Some are liquids. Others are gases. We know oxygen is a gas. We are used to seeing iron as a solid and mercury as a liquid. Why does matter at the same temperature exist in different states?

You have read that the particles in matter attract one another. These attractions can be strong or weak. For example, iron particles are strongly attracted to each other. Oxygen particles in air are less strongly attracted. That is why iron is a solid and oxygen is a gas at normal temperature.

Temperature affects the force of attraction. Heating a substance causes its particles to gain energy. They move faster. With enough added heat, the particles will gain enough energy to break some of their attraction. A solid becomes a liquid. Add even more heat and the particles will break free of all their attraction. A liquid becomes a gas.

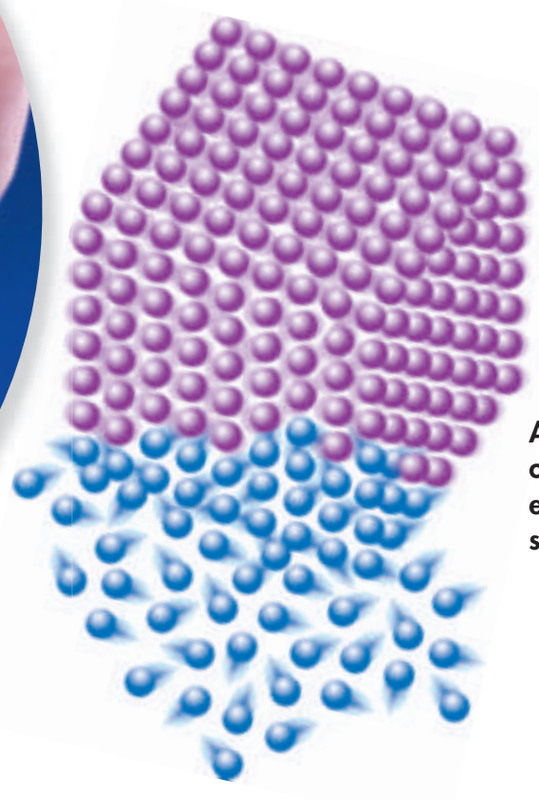
The melting point of the metal gallium is so close to human body temperature that it melts in the hand!

Melting and Freezing

What might happen if you heated solid iron to a high temperature? It would turn into liquid iron. This process of a solid becoming a liquid is called melting. A substance turns into a liquid when it is heated to its melting point. Lead melts at 327.5°C. This is far higher than water's melting point of 0°C.

A substance must gain heat in order to melt. But when a substance loses heat, its particles slow down. They form a solid. This process is called freezing. The temperature at which a substance freezes is its freezing point. A freezing point is the same temperature as the melting point.

A substance will melt more slowly if it is insulated. Insulation slows the movement of heat.



As the particles of a solid gain energy, the solid melts.

Boiling

Air near a pan of boiling water is more humid than the rest of the air in the kitchen. Water particles speed up as the water heats up. The particles in water start to break apart from each other. At its boiling point water has enough heat to become a gas. The gas is called water vapor.

Water vapor particles in the air lose energy as they cool. They slow down and move closer together. Their attraction causes them to form a liquid when they get close enough. This change of state from a gas to a liquid is called **condensation.**

A change in air pressure around a substance can cause a change in energy. This change can make a substance boil or melt at different temperatures. You might think that water never freezes at room temperature. But it would if the air pressure were 10,000 times as high as normal! What if the air pressure were very low? Then water could change from liquid to gas without being heated.

The outside of this can is colder than the air around it. Water vapor turns from a gas to drops of water on the can.

Physical Changes

The physical properties of a substance do not change when it melts, freezes, or boils. During a **physical change,** a substance may look different, but its properties stay the same. Water is water whether it is a solid, a liquid, or a gas. A change of state is not a change of properties. Sawing doesn't change wood. A sliced potato is still a potato.

Shredding the potato is a physical change. Each bit of potato is the same as the original vegetable. But cooking is a chemical change.

Chemical Changes

Look at the candles in the photo. Wax melting is a physical change. But what about the burning wick? It is undergoing a chemical change. In a **chemical change,** one or more substances change into new substances that have different properties.

The wick and oxygen in the air undergo a chemical change during burning. Three new substances form: ash, carbon dioxide, and water vapor. None of these has the properties of the wick or the oxygen.

There are often signs that a chemical change is occurring. Heat, light, sound, and/or color change often mean a chemical change is happening.

Glossary

chemical change a change in which one or more substances change into new substances that have different properties

chemical property a property of a substance that tells how it forms new substances when it mixes with something else

condensation the change of state from a gas to a liquid

density a measure of the amount of matter that fills a given space

mass the amount of matter that makes up a substance

physical change a change that may affect a substance's appearance without changing its physical properties

physical property a property of a substance that can be seen or measured without changing the substance

volume the amount of space that an object takes up

weight a measure of the pull of gravity on an object

What did you learn?

1. What do you measure when you measure an object's mass?
2. How do particles differ in the four states of matter?
3. When water boils, it changes to water vapor. Is this a physical or a chemical change? Explain.
4. **Writing in Science** You drop a cork and a copper penny into a bowl of water. Write to explain what you think will happen and why. Use details from the book to support your answer.
5. **Sequence** Use the sequence words *first, next, after,* and *finally* to tell how to find the density of a substance.