Science

Science

Physical Science

Properties of Matter

by Lillian Duggan

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

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Vocabulary

chemical change
chemical properties
condensation
density
mass
physical change
physical properties
volume
weight

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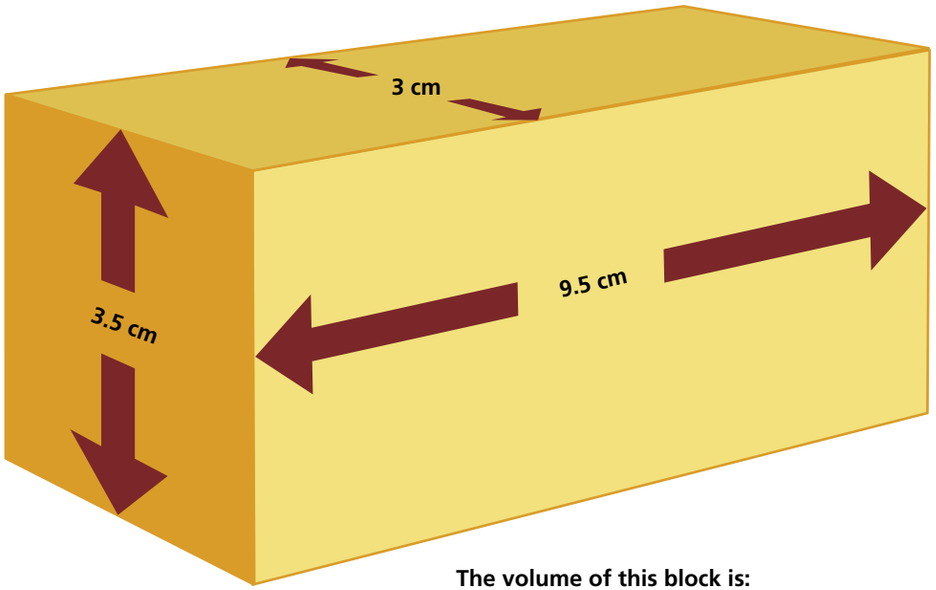
Matter

All matter has physical properties such as volume, mass, density, and boiling point. Matter also has chemical properties that explain how it reacts with other types of matter. Matter can change both physically and chemically.

Measuring Matter

Everything around you, even the air that fills the room, is matter. Matter is anything that has mass and takes up space.

Two properties of matter that can be measured are mass and volume. An object's **mass** is the amount of matter that makes up that object. Mass is measured in grams. **Volume** is the amount of space that something takes up. The volume of a liquid is measured in milliliters. The volume of a solid is measured in cubic units, such as cubic centimeters (cm^3). To find the volume of a solid, multiply its height by its width by its depth.



The volume of this block is:
3.5 cm x 3 cm x 9.5 cm = 99.75 cm^3

Although the feathers take up more space, they still weigh less than the rocks.

Density Differences

Suppose you had two piles the same size—one of feathers and the other of rocks. Would both piles have the same amount of mass? The answer is no. The rocks have more mass. The matter that makes up the rocks is more tightly packed than the matter that makes up the feathers.

Density is a measure of the amount of matter in a given space. Density is also described as mass per unit volume. The rocks have a much higher density than the feathers.

To calculate the density of a substance, all you need to know are its mass and its volume. Use this formula:

density = mass/volume or m/v

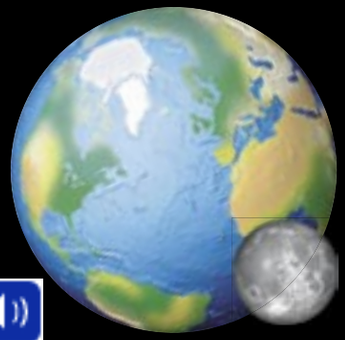
If an object has a mass of 30 grams and a volume of 10 cubic centimeters, what is its density?

density = m/v = 30 g/10 cm^3 = 3 g/cm^3

Mass and Weight

Mass and weight are two different properties of matter. Mass is a measure of the amount of matter in an object. No matter where an object is in the universe, its mass is always the same. Mass can be measured with a balance.

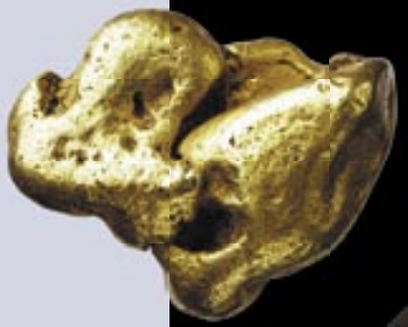
Weight is a measure of the pull of gravity on an object. The force of gravity is different on each of the large bodies in the universe. The larger the body, the greater the pull of its gravity, and the more an object weighs there. You can find the weight of an object by using a spring scale. A spring scale measures weight in units called newtons. On Earth, one newton equals about a quarter of a pound.



The Moon is much smaller than Earth and has only one-sixth the gravity of Earth. A person's weight would be only one-sixth of their weight on Earth.

Densities of Common Materials

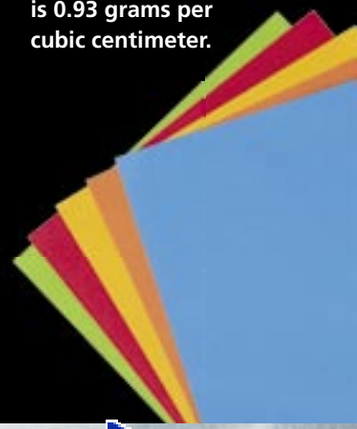
Material	Density (g/cm³)
Gold	19.32
Copper	8.96
Aluminum	2.64
Glass	2.60
Water	1.00
Plastic	0.96
Paper	0.93



The density of gold is 19.32 grams per cubic centimeter.

The density of aluminum is 2.64 grams per cubic centimeter.

The density of paper is 0.93 grams per cubic centimeter.



Using Density

Every substance has a particular density, and that density never changes. For example, the density of copper is 8.96 grams per cubic centimeter, whether the copper is formed into a pipe or a wire. Also, the density of a substance is unique. Rarely do two or more substances have the same density.

Because the density of each substance is different, you can use density to identify an unknown substance. Suppose you have a piece of metal, but you don't know what kind of metal it is. If you measure its mass and its volume, you can use these measurements to calculate its density. Then you can identify the metal by finding its density on a table, such as the one above.

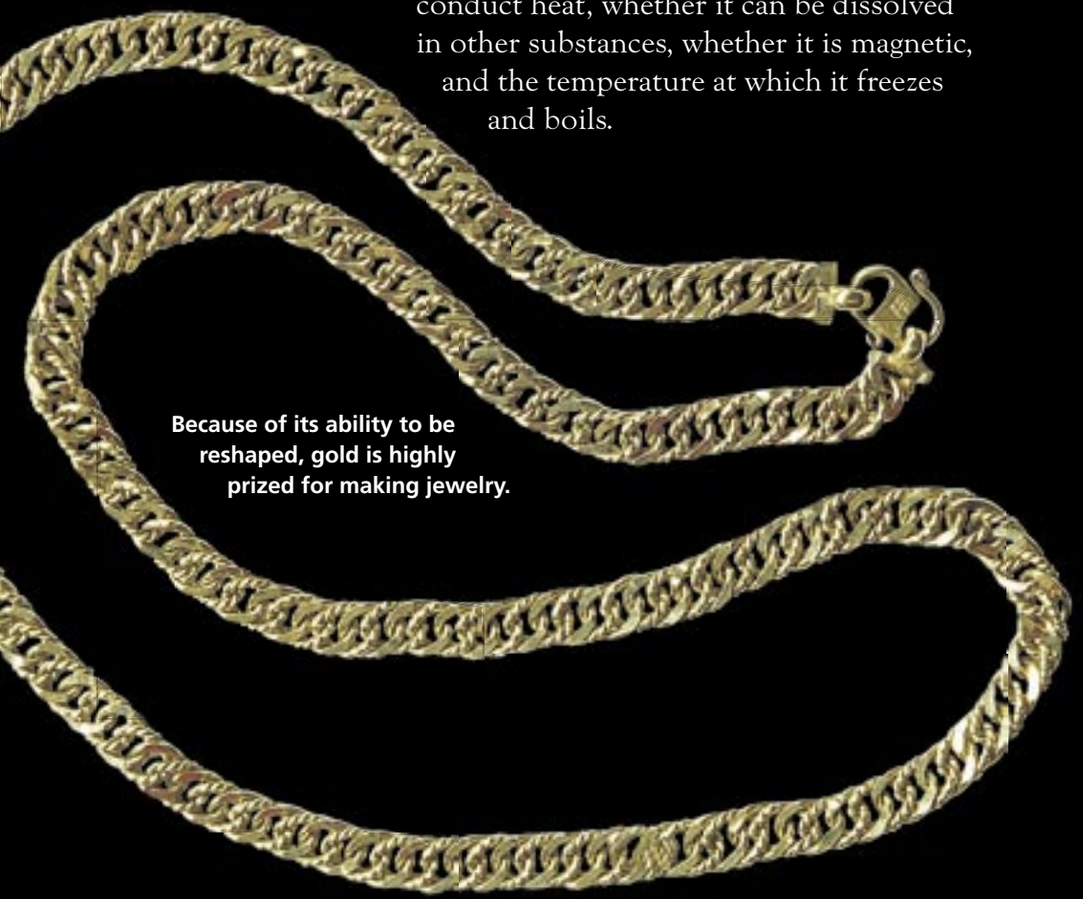
Physical Properties

Physical properties of matter are those that can be seen or measured without changing the substance into something else. Density is one physical property of matter.

Gold has several physical properties that make it unique. Of all the metals, gold is the most malleable, meaning it can be spread or shaped with a hammer or by being pressed through rollers. Gold is also ductile, or easily shaped into wire or thread.

Another physical property of gold is its ability to conduct electricity. It can be used in making electronic equipment.

Other physical properties of matter include whether it can conduct heat, whether it can be dissolved in other substances, whether it is magnetic, and the temperature at which it freezes and boils.



Because of its ability to be reshaped, gold is highly prized for making jewelry.

Properties of Aluminum

Physical Properties	Chemical Properties
• Lightweight silvery-white metal	• Does not corrode
• Reflects light and heat	• Combines with oxygen to form protective coating
• Malleable and ductile	

Some substances are useful to people because they don't form new substances easily. Aluminum doesn't corrode, which is one reason it's used for building airplanes.

Chemical Properties

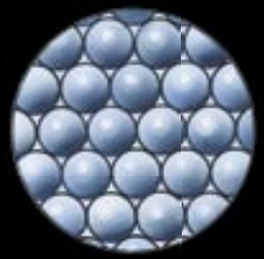
The **chemical properties** of a substance are those that tell how the substance forms new substances when it mixes with something else. Different materials react in different ways when they are combined with other materials. For example, when iron is exposed to oxygen, it forms rust.

A substance's chemical properties can make it useful to people. Wood, for example, is flammable. It burns in the presence of oxygen. The burning of wood produces heat for fireplaces and bonfires.

How Matter Changes

The four states of matter are solid, liquid, gas, and plasma. Matter can change from one state to another. When the state of matter changes, the energy of the particles that make it up changes too.

States of Matter



solid

liquid

gas

The diagrams show the movement of particles in a solid, a liquid, and a gas.

All matter is made up of tiny particles. These particles are constantly in motion. How fast they move and how strongly they are attracted to each other determine whether the matter they make up is a solid, liquid, gas, or plasma.

A solid has a definite shape and volume. The particles that make up a solid move slowly and have a strong attraction to each other.

A liquid has a definite volume, but not a definite shape. Its particles move quickly enough to resist some of the attraction between them. The particles slide past each other, allowing the liquid to take the shape of the container that holds it.

A gas has no particular shape or volume. The particles that make up a gas move quickly and in many directions. A gas fills up and takes the shape of the container that holds it.

Similar to a gas, plasma does not have a definite shape or volume. The particles that make up plasma can conduct electricity.

The Sun is made of plasma. Plasmas are rare on Earth, but scientists think that most of the known matter in the universe is made up of plasma.

Changes of State

If you look around you, you'll see solids, liquids, and gases all existing at the same temperature.

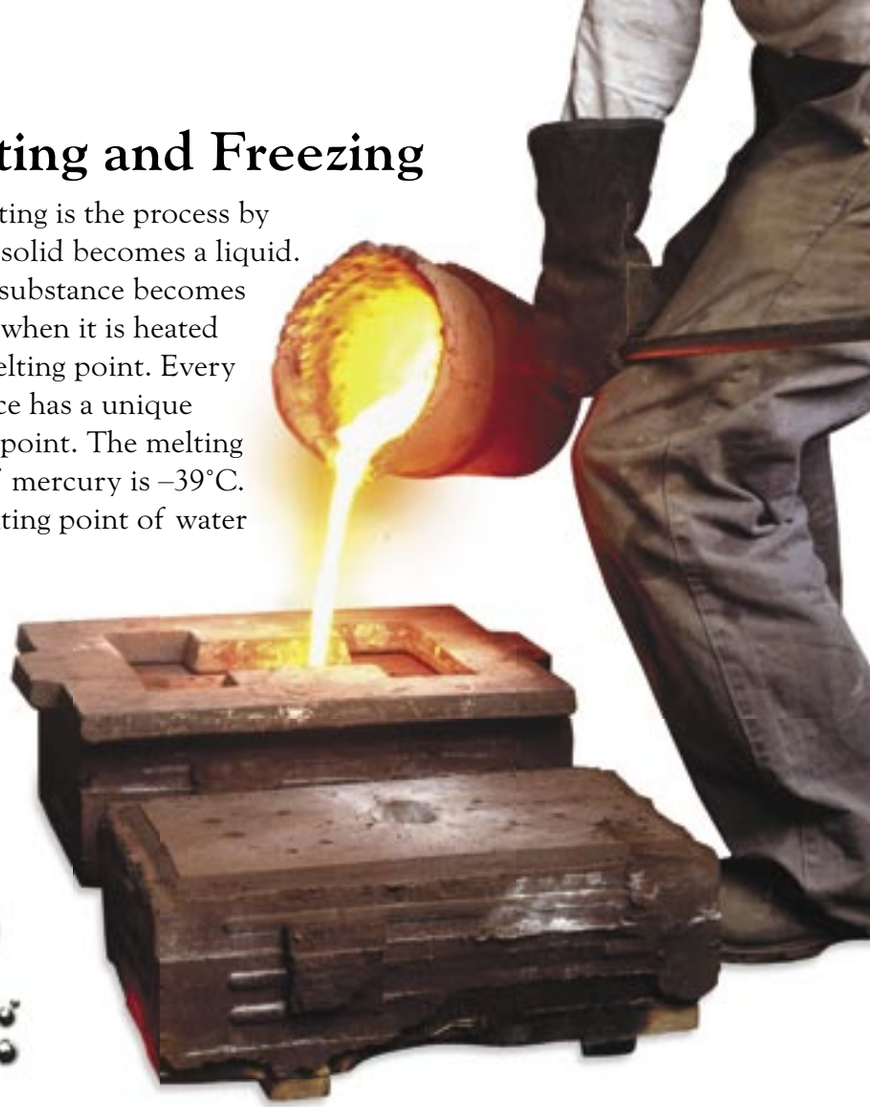
Some types of matter have particles that are more strongly attracted to each other than the particles of other types. The particles that make up a drinking glass have a stronger attraction than the particles that make up the orange juice inside.

The temperature of a substance affects the force of attraction between the particles that make it up. Adding heat to a substance gives its particles energy, causing them to move faster and break the forces of attraction. If you heat a solid to a high enough temperature, it will become a liquid. Heat it even more, and it will become a gas.

Why is water a liquid and wood a solid? The attraction between the particles that make up wood is stronger than the attraction between the particles that make up water.

Melting and Freezing

Melting is the process by which a solid becomes a liquid. A solid substance becomes a liquid when it is heated to its melting point. Every substance has a unique melting point. The melting point of mercury is –39°C. The melting point of water is 0°C.



Before iron can be shaped into items such as tools, it must be heated to its melting point of 1,535°C.

Mercury has a melting point of –39°C.

When a substance loses heat, it freezes. Freezing happens because the particles that make up a substance slow down and hold their attractions to each other. The temperature at which a substance freezes is called its freezing point. The freezing point and melting point of a substance are the same.

Water boils at 100˚C.

Boiling

When a liquid is heated, its particles speed up. With enough added heat, the particles will move fast enough to escape their attraction to each other. A substance reaches its boiling point when it gains enough energy to change from a liquid to a gas.

When water is boiled on the stove, the air surrounding the pan becomes moist. This happens because water is slowly turning to water vapor and escaping from the pan. Later, if the water vapor in the air cools, it loses energy. The particles slow down again and move closer together, returning to a liquid state. The change of state from a gas to a liquid is called **condensation.**

Adding and removing heat are not the only ways to cause a substance to change its state. Changing the air pressure around the substance has similar effects. Normally water does not freeze at room temperatures. But if the air pressure was ten thousand times higher than normal, water would turn to solid ice. Under very low air pressure, water could change to a gas without being heated.

Melting and Boiling Points

Substance	Melting/Freezing Point (˚C)	Boiling Point (˚C)
Hydrogen peroxide	-2	158
Water	0	100
Lead	328	1740
Silver	962	2212

Ice melts quickly at room temperature.

Hydrogen peroxide will gradually evaporate if left in an open container.

The relatively low melting point of lead makes it useful for welding together pieces of metal.

Silver has a very high melting point.

Physical Changes

Melting, freezing, and boiling points are all physical properties. When a substance melts, freezes, or boils it changes its state, but it is still the same substance. A change of state, such as from a liquid to a gas, is a physical change. During a **physical change,** the appearance of a substance changes but it does not change into a different substance.

A physical change involves changing the size, shape, or state of a substance. Slicing bread is a physical change—the bread is still bread, but it's in a different shape. Melting butter or carving wood are also physical changes.

Some physical changes cause substances to change their appearance completely. You can't see the salt dissolved in seawater. But when the water is left to evaporate in the Sun, salt crystals are left behind.

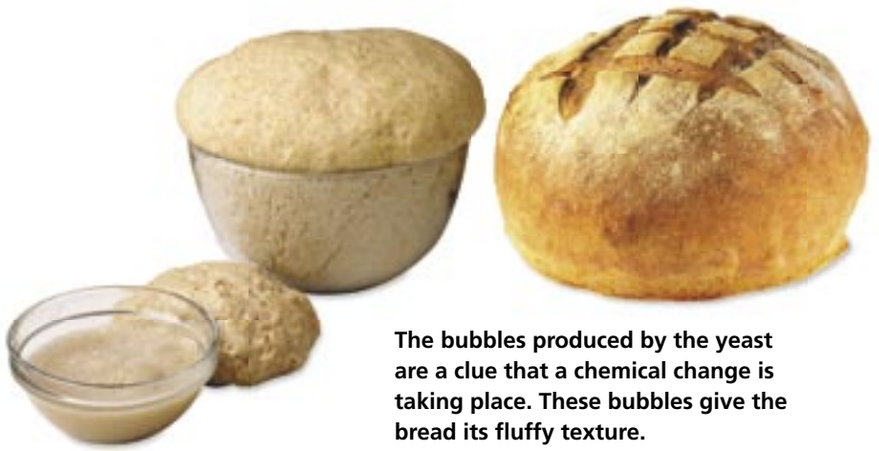
Evaporating water to get salt from it causes a physical change.

Chemical Changes

A loaf of bread rises because of a chemical change. During a **chemical change,** substances change into new substances with different properties.

One of the most important ingredients in bread is yeast. Yeast is a living organism that needs moisture, air, and food to grow. First, the yeast is mixed with sugar and water. It eats the sugar and gives off bubbles of carbon dioxide. Then the yeast mixture is added to flour and water to make dough. The carbon dioxide bubbles cause the dough to expand. When the bread is baked in the oven, the heat kills the yeast.

Baking bread involves a chemical change caused by the yeast. The yeast uses up sugar and gives off a new substance—carbon dioxide.



The bubbles produced by the yeast are a clue that a chemical change is taking place. These bubbles give the bread its fluffy texture.

Everything we know in nature is made up of matter. Matter is anything in the universe that has mass and occupies space. Matter changes all the time. The changes can be physical changes or chemical changes. Matter has properties that can be measured, such as mass, volume, and density. Think about all the different kinds of matter you see every day, and how it changes!

Glossary

chemical change a change in which a substance changes into a new substance with different properties

chemical properties qualities of a substance that tells how the substance 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 in a given space

mass a measure of the amount of matter in an object

physical change a change in which the appearance of a substance changes but its properties stay the same

physical properties qualities of a substance that can be seen or measured without changing the substance into something else

volume the amount of space that something takes up

weight a measure of the pull of gravity on an object

What did you learn?

1. Suppose you have a substance with a mass of 26 grams and a volume of 10 cm^3. Figure out its density and use the density table on page 5 to identify the substance.

2. Potassium burns when it comes in contact with water. Is this a chemical property or a physical property?

3. Write about a physical change that you observed or made happen recently.

4. **Writing in Science** Mass and weight are two different properties of matter. Write to explain the differences between the two. Use information from the book to support your answer.

5. **Sequence** Use sequence words—*first*, *next*, *after*, and *finally*—to describe how condensation forms on a pan of boiled water.