CONCEPT 1

Matter can be solid, liquid, or gas.

Activity

What Is It?

Working in groups, add 250 mL of cornstarch into a large bowl. Feel the cornstarch with your hand. Then slowly add 85 mL of water and mix the cornstarch as you add the water. Mix the cornstarch with your hands so that you can feel the texture and consistency. Add some food colouring if you wish. Then experiment with the mixture. What happens when you grab a handful of the mixture and try to form a ball with it? Now open up your hand. What happens to the ball? Slap the cornstarch mixture quickly. Now try squeezing it. Is it a liquid? Is it a solid? How do you know?

Matter can exist as a solid, liquid, or gas. What are some examples of liquids and solids in your everyday life? Just this morning, you may have taken a shower in water and used some shampoo and conditioner on your hair: that's three liquids. Perhaps you had a glass of juice or poured some milk on some cereal in a bowl and ate it with a metal spoon. That's two more liquids and four solids. It can be hard to think of gases as matter because many gases are invisible. Although you cannot see them, gases surround us—you can feel gases filling your lungs every time you take a breath. **Figure 2.12** describes examples of solids, liquids, and gases.

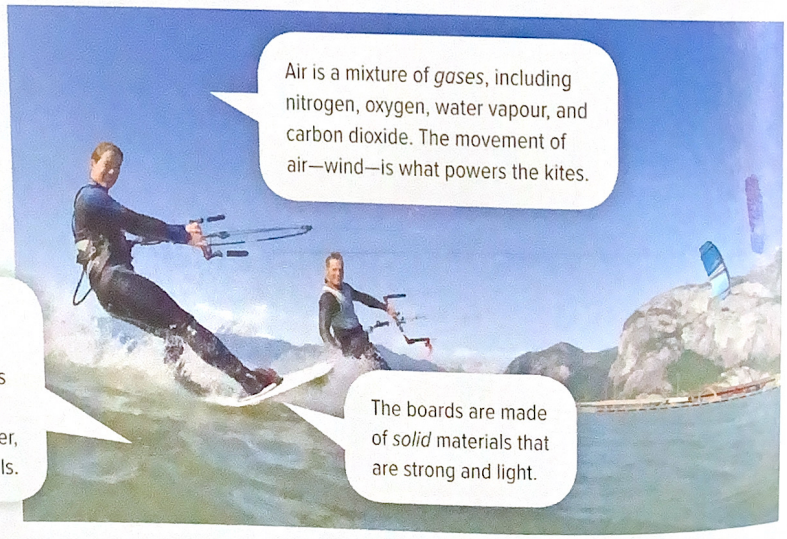
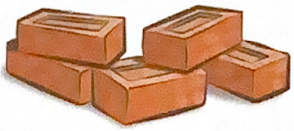


Figure 2.12 Kiteboarders depend on the different properties of solids, liquids, and gases to enjoy their sport. **List three solids shown but not mentioned here and describe their physical properties.**

Properties of the States of Matter

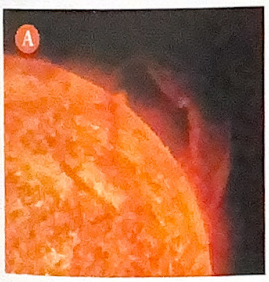
Solids, liquids, and gases have distinct characteristics that can be used to classify them. These characteristics are summarized below in Table 2.2.

Table 2.2 States of Matter

State	Common Characteristics	Examples	
solid	• holds its own shape • has a constant volume		• wood • silver • stone • plastic
liquid	• takes the shape of its container • has a constant volume		• oil • juice • antifreeze • gasoline
gas	• takes the shape and volume of its container • can be compressed		• air • helium • hydrogen

The Fourth State

Solids, liquids, and gases are the most familiar states of matter. But most matter in the universe actually exists as a fourth state of matter called plasma. A plasma is similar to a gas in that it does not have a defined shape and volume, but plasmas have different electrical properties than gases. Some examples of plasmas are shown in Figure 2.13.



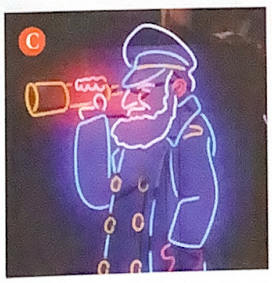


Figure 2.13 The fourth state of matter, plasma, is found on Earth and throughout the universe. (A) All stars, including our Sun, are made up of plasma. (B) The visible fork of a lightning bolt is plasma formed in the air by an electrical current. (C) The glowing gas of a neon sign is actually plasma.

Before you leave this page . . .

1. Give two examples of solids, liquids, and gases.
2. Which state of matter does plasma most resemble and why?

CONCEPT 2

Matter is made of particles in constant motion.

Activity

Musing on Models

What does the term "model" mean to you? Write a brief definition. What are some different examples of models in everyday life? How do you think models are used in science?

model a verbal, mathematical, or visual representation of a scientific structure or process

theory a scientific explanation that has been supported by consistent, repeated experimental results and is therefore accepted by most scientists

The terms "model" and "theory" have a variety of different meanings in different contexts. In science, however, they have very specific meanings.

A **model** consists of words, pictures, physical objects, or mathematical equations that are used to represent and explain complex objects, living things, or events in nature. Models help people analyze and communicate what they observe in the natural world. They also help us visualize processes that cannot be seen with the unaided eye. Some examples of models are shown in Figure 2.14.

A scientific **theory** is an explanation of a phenomenon in the natural world based on many observations and investigations. Theories can be, and often are, modified or discarded if new experimental data arise that contradict the theory or that the

Figure 2.14 These models were made to help people understand or analyze complex systems, organisms, or events. **Do any of these models simplify or distort the organism, item, or system they are representing? If so, how and why?**

theory cannot explain. Theories often lead to new conclusions. A theory is considered successful if it both explains experimental observations and can be used to make accurate predictions. A theory is never considered to be proven, no matter how successful it is. Future experiments may lead to further changes.

Explaining Properties of the States of Matter

The *particle model of matter* is a model that enables people to visualize and understand the structure of matter, even though we cannot see it. According to the particle model of matter, all matter is made up of very small particles. These particles are so small that they cannot be seen even with the help of a light microscope.

Using the particle model of matter, scientists developed a theory to explain the behaviour of gases. This scientific theory, when extended to explain the behaviour of all states of matter, is called the **kinetic molecular theory of matter (KMT)**. An important part of the kinetic molecular theory of matter is the notion of *kinetic energy*—the energy of motion. According to the theory, all particles are constantly moving and therefore have kinetic energy. The kinetic molecular theory successfully explains many observations about matter, including the different properties of the states of matter, as well as the ways in which matter changes state.

kinetic molecular theory of matter (KMT) a scientific explanation of the behaviour of matter based on all matter being made of particles that possess kinetic energy

The Kinetic Molecular Theory of Matter

The key points of the kinetic molecular theory of matter are:

1. All matter is made up of very small particles.
2. The particles exist in empty space.
   - **(a)** In solids, particles are closely packed and held rigidly in place.
   - **(b)** In liquids, particles are also closely packed but can move around.
   - **(c)** In gases, particles have large amounts of empty space between them and are not attracted to one another.
3. Particles are constantly moving.
   - **(a)** The particles in solids vibrate but cannot move around.
   - **(b)** The particles in liquids slip and slide past and revolve around each other but stay close together. They collide with each other and the walls of their container.
   - **(c)** The particles in gases move freely in straight lines, colliding with each other and with the walls of their container.
4. Energy makes particles move. The more energy the particles have, the faster they can move and the farther apart they can get.

States of Matter and the Kinetic Molecular Theory

To use the kinetic molecular theory as a tool for explaining observations about the states of matter, it can help to visualize the particles for each state, as shown in Figure 2.15. Note that the particles in a gas are actually much farther apart than is suggested by the diagram.

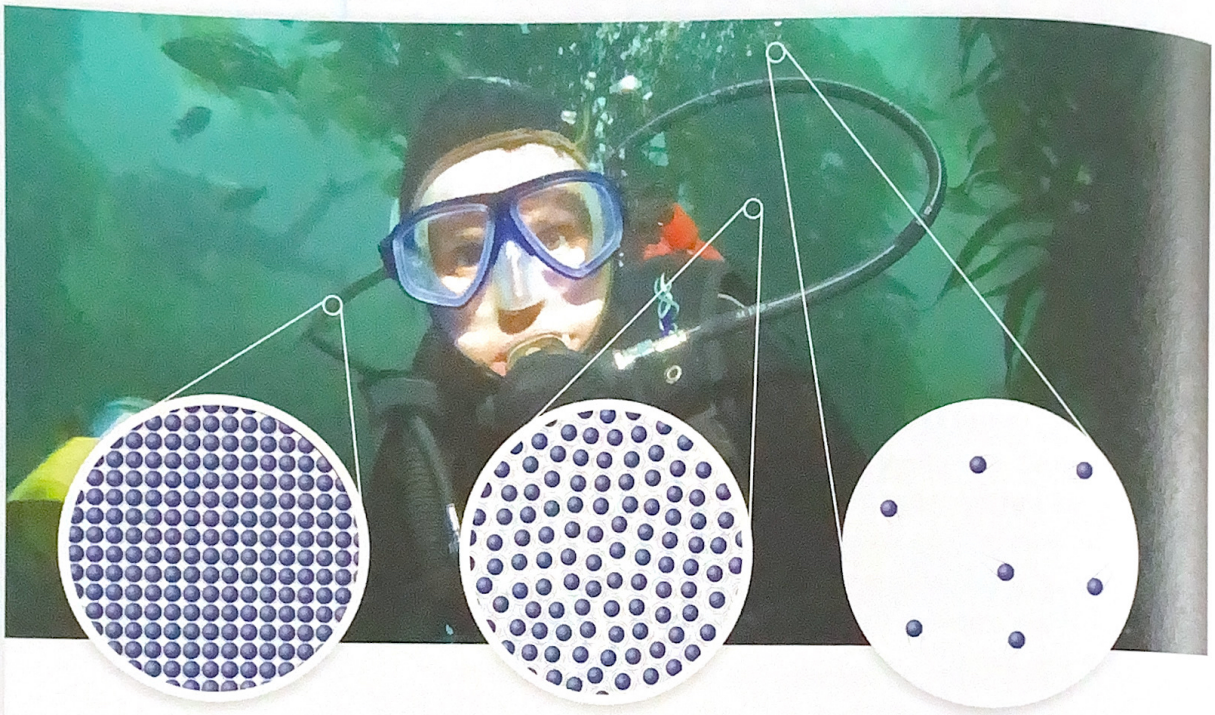


Figure 2.15 The kinetic molecular theory explains the properties of solids, liquids, and gases based on how their particles are arranged and how they move.

Particles in a Solid

- very close together
- vibrate but do not move around
- attract one another strongly in a rigid structure

Particles in a Liquid

- very close together
- slip and slide past and revolve around one another
- attract one another less strongly than in solids

Particles in a Gas

- very far apart compared to their size
- move randomly and quickly in straight lines
- attraction to one another is effectively zero

Before you leave this page . . .

1. In what ways does a model differ from a theory?
2. Summarize the kinetic molecular theory of matter.
3. Describe the particles of the three states of matter in terms of how they move and the spaces between them.
4. It is easy to compress (reduce the volume of) a gas, but solids and liquids cannot be compressed very much. Use the KMT to explain why.