3.1 Solids, Liquids, and Gases

Reading Focus

Key Concepts

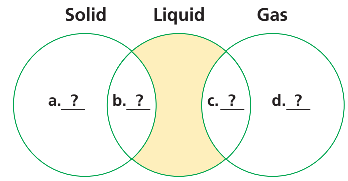
- How can shape and volume be used to classify materials?
- How can kinetic theory and forces of attraction be used to explain the behavior of gases, liquids, and solids?

Vocabulary

- solid
- liquid
- gas
- kinetic energy

Reading Strategy

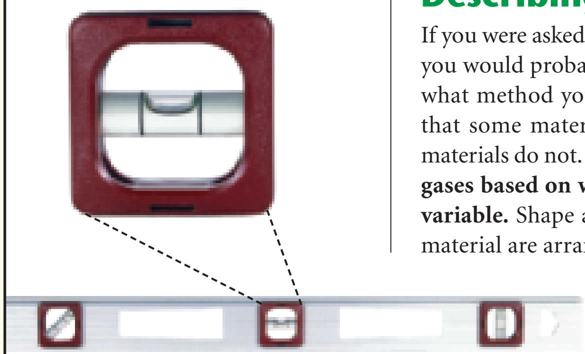
Comparing and Contrasting Copy the diagram. As you read, replace each letter with one of these phrases: *definite volume, definite shape, variable volume,* or *variable shape.*



Do you recognize the object in Figure 1? It is a carpenter's level. A level can be used to see whether a surface is perfectly horizontal. The level has one or more transparent tubes inside a metal or wooden frame. Inside each tube is a clear liquid, such as alcohol, and an air bubble. When a carpenter places the level on a surface that is perfectly horizontal, the air bubble stays in the middle of the horizontal tube. The bubble moves to the high end of the tube if the surface is slanted.

The metal, alcohol, and air in a carpenter's level represent three states of matter. At room temperature, most metals are solids, alcohol is a liquid, and air is a gas. In this chapter, you will learn why the appearance and behavior of solids, liquids, and gases are different.

Figure 1 Carpenters use a level to find out if a surface is perfectly horizontal. In the level shown, three clear plastic tubes are set into an aluminum frame. Each tube contains a liquid and a gas. **Classifying** ***What property could you use to distinguish the liquid or gas from the solids in a level?***



Describing the States of Matter

If you were asked to classify some materials as solids, liquids, or gases, you would probably find the task fairly easy. But could you describe what method you used to classify the materials? You might notice that some materials have a definite shape and volume and some materials do not. **Materials can be classified as solids, liquids, or gases based on whether their shapes and volumes are definite or variable.** Shape and volume are clues to how the particles within a material are arranged.

Section 3.1

1 FOCUS

Objectives

3.1.1 **Describe** the five states of matter.

3.1.2 **Classify** materials as solids, liquids, or gases.

3.1.3 **Explain** the behavior of gases, liquids, and solids, using kinetic theory.

Reading Focus

Build Vocabulary L2

Word Origins Explain to students that a Flemish chemist, Jan Baptista van Helmont (1577–1644), coined the word *gas*. Its origin is the Greek word *khaos*. Point out that the English word *chaos* refers to a disordered state. Relate this definition to the relative disorder of gases.

Reading Strategy L2

a. Definite shape **b.** Definite volume
c. Variable shape **d.** Variable volume

2 INSTRUCT

Describing the States of Matter

Use Visuals L1

Figure 1 Have students look at the magnified portion. Ask, **Why is the air bubble above the liquid in the tube?** *(Air is less dense than the liquid.)* **When might the tube in the middle of the level be used?** *(To see whether a shelf or counter is perfectly horizontal)* **When might the tube on the right be used?** *(To see whether a wall or doorframe is perfectly vertical)* If possible, bring in levels for students to observe and use.
Visual

Section Resources

Print
- ***Laboratory Manual,*** Investigation 3B
- ***Reading and Study Workbook With Math Support,*** Section 3.1
- ***Math Skills and Problem Solving Workbook,*** Section 3.1
- ***Transparencies,*** Chapter Pretest and Section 3.1

Technology
- ***Interactive Textbook,*** Section 3.1
- ***Presentation Pro CD-ROM,*** Chapter Pretest and Section 3.1
- ***Go Online,*** NSTA SciLinks, Kinetic theory

Solids Think about these familiar objects: a pencil, a quarter, a book, and a cafeteria tray. What do these four objects have in common? They all have a recognizable shape and they all take up a certain amount of space. The materials in these objects are all in the solid state. **Solid** is the state of matter in which materials have a definite shape and a definite volume.

The term *definite* means that the shape and volume of a pencil won't change as you move the pencil from a desk drawer to a pencil case to a backpack. Changing the container doesn't change the shape or volume of a solid. However, the term *definite* doesn't mean that the shape or volume can never change. After all, you can change the shape of a pencil by sharpening it. You can change the shape of a copper wire by bending the wire.

Figure 2 shows the arrangement of atoms in a copper wire. The copper atoms are packed close together and are arranged in a regular pattern. Almost all solids have some type of orderly arrangement of particles at the atomic level.

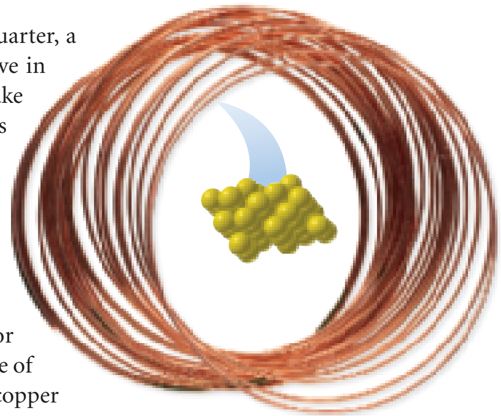


Figure 2 Samples of solid copper have definite volume. Copper atoms are packed close together in an orderly arrangement.

Liquids How good are you at estimating whether the juice remaining in an almost-empty bottle will fit in a glass? If your estimate is not accurate, you will run out of space in the glass before you run out of juice in the bottle.

Appearances can be deceiving. Imagine a narrow glass and a wide bottle side by side. Each contains exactly 350 milliliters of juice (about three quarters of a pint). There will seem to be more juice in the glass because the juice rises almost to the rim of the glass. There will seem to be less juice in the bottle because the juice forms a shallow layer. What can you learn about liquids from this comparison?

A liquid always has the same shape as its container and can be poured from one container to another. **Liquid** is the state of matter in which a material has a definite volume but not a definite shape.

Mercury exists as a liquid at room temperature. The drawing in Figure 3 shows the arrangement of atoms in liquid mercury. Compare this arrangement to the arrangement of copper atoms in Figure 2. The mercury atoms are close together but their arrangement is more random than the arrangement of atoms in copper.

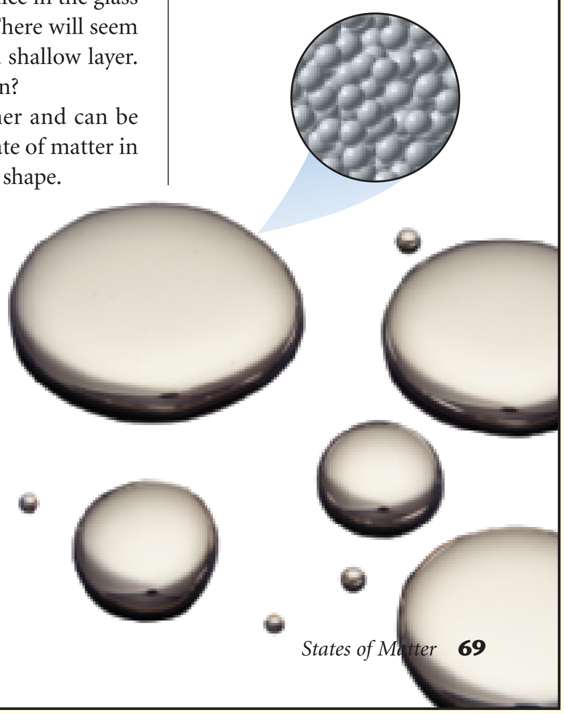


Figure 3 At room temperature, mercury is a liquid. Drops of mercury on a flat, clean surface have a round shape. Mercury in a container has the same shape as its container. Comparing and Contrasting ***Compare the arrangement of atoms in copper and mercury.***

Teacher Demo

Comparing Liquid Volume **L2**

Purpose Students observe that it is difficult to compare the volume of liquids in different containers because liquids take the shape of their containers.

Materials 3 glass jars or bottles with lids, each having a noticeably different diameter but about the same volume; graduated cylinder; water

Advance Prep Before class, use a graduated cylinder to add the same amount of water to each of the three containers. Pick a volume that will almost fill the narrowest container. To avoid evaporation, replace the lids on the containers.

Procedure Have students predict which container has the largest volume of water. Have volunteers use graduated cylinders to measure the amount of water in each container.

Expected Outcome If students' predictions are influenced by the height of the liquids in the containers, they will predict that the container with the narrowest diameter has the greatest volume.
Visual

Build Reading Literacy **L1**

Relate Text and Visuals Refer to page **190D** in **Chapter 7**, which provides the guidelines for relating text and visuals.

Have students compare the drawings of a solid and a liquid in Figures 2 and 3 to the definitions for these states of matter.
Visual, Portfolio

Customize for English Language Learners

Think-Pair-Share
Have students work in pairs to make a table describing solids, liquids, and gases. Remind students that they need to include in their descriptions information about shape, volume, and the arrangement of particles. An example of such a table would have Solids, Liquids, and Gases as column heads and Shape, Volume, and Arrangement of Particles as row heads. Students should title their tables States of Matter. Suggest that students list common examples of each state. Strengthen language skills by having students present their tables to the class.

Answer to . . .

Figure 1 *The liquid and gas have variable shapes.*

Figure 3 *In both copper and mercury, the atoms are close together, but the arrangement of atoms in mercury is less orderly (more random).*

Section 3.1 (continued)

Use Visuals

L1

Figure 4 To help students distinguish a visual model of atoms from actual atoms, point out that the pink spheres represent helium atoms in a balloon. Ask, **Do the size and color of the spheres represent the actual size and color of helium atoms?** *(No, helium atoms are too small to see and helium is a colorless gas.)* Tell students that the actual distance between helium atoms in a balloon is about 10 times the diameter of a helium atom. Have students consider why illustrations cannot accurately represent such distances. **Visual, Logical**

FYI

In this chapter, plasma is not defined as an ionized gas because students are not introduced to ions until Chapter 6.

Gases If you were asked to name a gas, what would you say? Air, which is a mixture of gases, is probably the most obvious example. You might also mention natural gas, which is used as a fuel for heating homes. **Gas** is the state of matter in which a material has neither a definite shape nor a definite volume. (The adjective form of the word *gas* is *gaseous* (GAS e us), as in *gaseous state.*) A gas takes the shape and volume of its container.

The balloons in Figure 4 are filled with helium, a colorless gas that is less dense than air. Two of the balloons are teardrop-shaped and two are disk-shaped. The "shape" of the helium in a balloon is the same as the shape of the balloon itself. The volume of the helium in a balloon is equal to the volume of the balloon.

The helium atoms in a balloon are not arranged in a regular pattern, as shown in the drawing in Figure 4. They are at random locations throughout the balloon. There is more space between two helium atoms in a balloon than between two neighboring atoms in solid copper or liquid mercury.

Because of the space among helium atoms, a large amount of helium can be compressed into a metal cylinder. When helium flows from the cylinder into a balloon, the helium atoms spread out. If 200 balloons are filled from a single cylinder, the total volume of the balloons will be much larger than the volume of the cylinder.

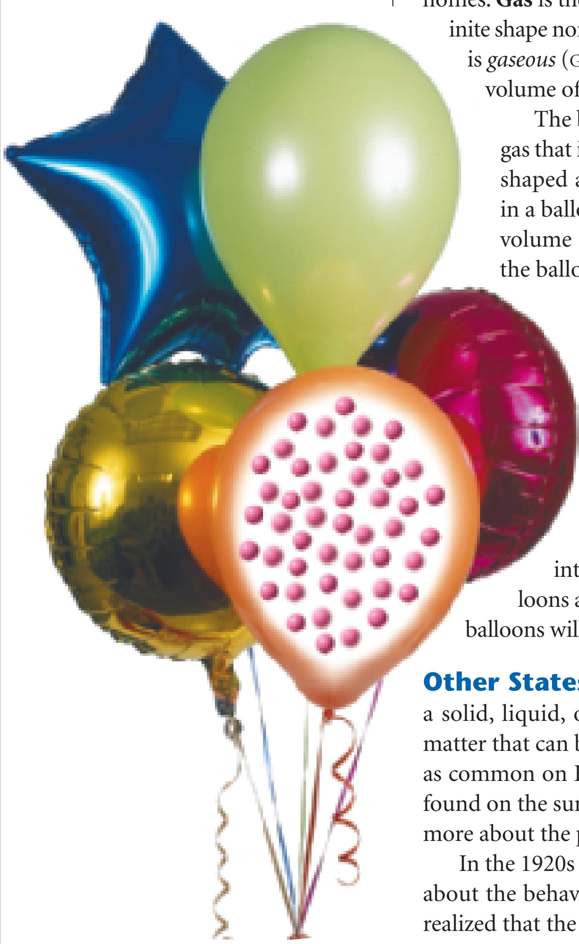


Figure 4 Helium gas takes the volume and shape of its container. **Observing** ***Describe the shape of the helium in the blue balloon.***

Other States of Matter On Earth, almost all matter exists in a solid, liquid, or gaseous state. But ninety-nine percent of all the matter that can be observed in the universe exists in a state that is not as common on Earth. At extremely high temperatures, such as those found on the sun or other stars, matter exists as plasma. You will read more about the properties of plasmas in Chapter 10.

In the 1920s Satyendra Bose, a physicist from India, wrote a paper about the behavior of light. After Albert Einstein read the paper, he realized that the behavior described could apply to matter under certain conditions. Einstein made a bold prediction. He predicted that a fifth state of matter would exist at extremely low temperatures. At temperatures near −273°C, groups of atoms would behave as though they were a single particle. In 1995, scientists produced this fifth state of matter, which is called a Bose-Einstein condensate (or BEC). It behaved as Einstein had predicted decades before.

Reading Checkpoint ***How can atoms behave at temperatures near −273°C?***

Facts and Figures

Bose-Einstein Condensate In 1995, physicists at the University of Colorado at Boulder were the first to produce a BEC. The team of scientists, which included Eric Cornell and Carl Wieman, used lasers and magnets to cool about 2000 rubidium atoms to 20 billionths of a degree above absolute zero (−273.15°C). The rubidium atoms formed a tiny, almost stationary ball, which looked like a cherry pit with a diameter of 20 microns.

In 1997, Steven Chu, William Phillips, and Claude Cohen-Tannnoudji shared the Nobel Prize for Physics for their independent work using lasers to cool atoms. In 1985, Chu and his team had produced "optical molasses," an effect in which the movement of atoms was about one kilometers per hour instead of the expected 4000 kilometers per hour. At that speed the temperature of the sample was close to absolute zero.

Data Analysis

Why Was Mercury Used in Thermometers?

Until recently, mercury thermometers were used in homes and schools. When a thermometer broke, people were exposed to mercury. When broken thermometers were thrown away, they ended up in landfills. Mercury is a toxic substance that can harm humans and other organisms. Schools no longer use mercury thermometers and people are encouraged to replace their fever thermometers.

So why did people continue to use mercury thermometers long after they knew the dangers of mercury? Look at the data table. It lists some densities over a temperature range from 0°C to 150°C. The temperatures are given at 30-degree intervals.

Density of Mercury

Temperature (°C)	Density (g/mL)	Volume of One Gram (mL)
0	13.60	0.07356
30	13.52	0.07396
60	13.45	0.07436
90	13.38	0.07476
120	13.30	0.07517
150	13.23	0.07558

1. **Using Tables** How does the density of mercury change as the temperature increases?
2. **Relating Cause and Effect** How does a change in density affect the volume of a mercury sample?
3. **Calculating** If a thermometer contained a gram of mercury, how much would the volume of the mercury change when the temperature rose from 0°C to 30°C? From 30°C to 60°C? From 60°C to 90°C? From 90°C to 120°C?
4. **Drawing Conclusions** Why was mercury a better choice than water for the liquid in a thermometer? (*Hint:* Between 0°C and 30°C, the volume of a gram of water changes by 0.0042 mL. Between 30°C and 60°C, the volume changes by 0.0127 mL. Between 60°C and 90°C, the volume changes by 0.0188 mL.)
5. **Inferring** Why is the mercury in a thermometer stored in a narrow tube?

Kinetic Theory

Why, under ordinary conditions, is copper a solid, mercury a liquid, and helium a gas? To begin to answer that question, you need to know something about kinetic energy. An object that is moving has kinetic energy. The word *kinetic* comes from a Greek word meaning "to move." **Kinetic energy** is the energy an object has due to its motion.

The faster an object moves, the greater its kinetic energy is. A ball thrown at 85 miles (137 kilometers) per hour by the pitcher in Figure 5 has more kinetic energy than a ball thrown at 78 miles (125 kilometers) per hour. When a baseball is thrown, a batter can see that it is moving. But the batter cannot see that there is also motion occurring within the baseball. According to the kinetic theory of matter, particles inside the solid baseball are moving. Particles in the air that the baseball travels through are moving too.

The kinetic theory of matter says that all particles of matter are in constant motion. The theory was developed in the mid-1800s to explain the behavior of gases. It can also help to explain the behavior of liquids and solids.

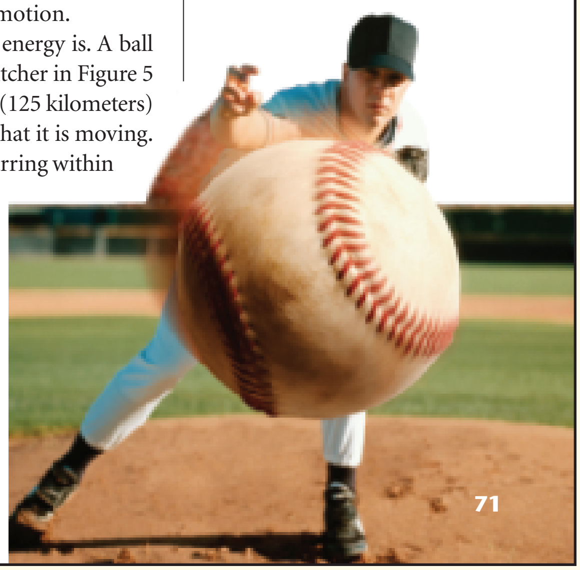


Figure 5 The kinetic energy of a baseball depends on the speed at which the pitcher throws the ball.

Data Analysis

Why Was Mercury Used in Thermometers? L2

Answers

1. The density decreases.
2. As the density decreases, the volume increases.
3. 0.00040 mL; 0.00040 mL; 0.00040 mL; 0.00041 mL
4. Unlike with water, the change in volume for mercury is almost identical for each interval. (The expansion is linear.) Thus, the interval spacing between degree marks is consistent for mercury. (In addition, the liquid range for mercury is broader—from –38.9°C to 356.7°C.)
5. With such a small change in volume per degree, the mercury must be in a narrow tube for the difference in height to be observed and measured.

For Extra Help L1

Display a copy of the data table on the board. If students are having trouble answering Question 4, have a student record the incremental change in volume (calculated for Question 3) and change in temperature from row to row. This step should make it easier for students to see that the almost constant change in volume corresponds to a constant temperature interval.
Logical

Kinetic Theory

FYI

The kinetic energy of an object is also affected by its mass. The greater the mass of an object, the greater its kinetic energy is. (This effect of mass and speed on kinetic energy is discussed in Section 15.1.)

Facts and Figures

Mercury Thermometer Daniel Fahrenheit invented the alcohol thermometer in 1709 and the mercury thermometer in 1714. He chose mercury because it remains a liquid over a wider range of temperatures than does water. The expansion rate of mercury is fairly uniform, mercury does not adhere to glass, and its color makes it easy to read.

Inhalation of mercury vapor can damage the nervous system and the respiratory system. To prevent mercury vapor from being inhaled when thermometers break, the Environmental Protection Agency, along with state and local agencies, has encouraged consumers to replace mercury fever thermometers. Alternatives to mercury thermometers include digital thermometers that use a change in the resistance in a thermoresistor and thermometers with sensors that detect infrared radiation.

Answer to . . .

Figure 4 *The helium in the blue balloon is star-shaped.*

Reading Checkpoint *Groups of atoms can behave as though they were a single particle.*

Section 3.1 (continued)

Explaining the Behavior of Gases

Teacher Demo

Detecting the Motion of a Gas L2

Purpose Students infer that particles in gases are in constant motion.

Materials spray can of air freshener, 3 stopwatches

Procedure Spray the air freshener at a distant corner of the room. Have students located in various parts of the room time how long it takes before they smell the gas. (The mist from the spray will evaporate.) Ask students to explain the results.

Expected Outcome Students will detect odor several moments after the air freshener is sprayed. Students should explain that they could smell the air freshener because the particles in a gas are in constant, random motion. That motion carried particles from the corner of the room to the students' locations.
Kinesthetic, Logical

Use Visuals L1

Figures 6 and 7 Have students compare the models of collisions shown in Figures 6 and 7. Ask, **How are the paths of billiard balls and helium atoms the same?** *(The paths of both are straight lines.)* **How is the motion of billiard balls different from the motion of helium atoms?** *(The motion of billiard balls is not constant or random.)* **What is a weakness of the model of helium atoms shown in Figure 7?** *(There are only two atoms to represent the billions of atoms that would be in such a jar.)*
Visual

Figure 6 This photograph of billiard balls was taken just after the cue struck the white ball, which began to move. The white ball moved in a straight line until it collided with the dark blue ball. The collision caused the dark blue ball to start moving. The motion of billiard balls can be compared to the motion of particles in a gas.

Explaining the Behavior of Gases

You can compare the motion of the particles in a gas to the movement of balls during a game of billiards. When a cue strikes a billiard ball, as shown in Figure 6, the ball moves in a straight line until it strikes the side of the billiard table or another ball. When a moving ball strikes a ball at rest, the first ball slows down and the second ball begins to move. Kinetic energy is transferred during those collisions.

Motion in Gases Unlike billiard balls, the particles in a gas are never at rest. At room temperature, the average speed of the particles in a sample of gas is about 1600 kilometers per hour. The use of the term *average* is a clue that not all particles are moving at the same speed. Some are moving faster than the average speed and some are moving slower than the average speed.

Figure 7 shows the possible paths of two helium atoms in a container of helium gas. Notice that each atom moves in a straight line until it collides with the other atom or with a wall of the container. During a collision, one atom may lose kinetic energy and slow down while the other atom gains kinetic energy and speeds up. However, the total kinetic energy of the atoms remains the same.

The diagram in Figure 7 does not accurately compare the volumes of the atoms and the container. The volume of a helium atom is extremely small compared to the volume of its container. If there were a billion times a trillion helium atoms in a liter bottle, there would still be a large amount of space in the bottle.

Between collisions, why doesn't one particle in a gas affect the other particles in the gas? **There are forces of attraction among the particles in all matter.** If the particles are apart and moving fast, as in a gas, the attractions are too weak to have an effect. Under ordinary conditions, scientists can ignore the forces of attraction in a gas.

Figure 7 A helium atom travels in a straight line until it collides with another helium atom or the side of its container.
Relating Cause and Effect ***What can happen to the kinetic energy of two helium atoms when the atoms collide?***

Facts and Figures

Mean Free Path The distance a particle of gas travels between collisions is called its mean free path. This distance varies with temperature and pressure. At 1 atmosphere of pressure and 25°C, the mean free path for a hydrogen molecule is 12.6×10^{-8} meters. For a nitrogen molecule, it is 6.76×10^{-8} meters. At 1 atmosphere of pressure and 25°C, a hydrogen molecule will collide with another molecule about 7.1×10^{11} times per second, while a nitrogen molecule will collide with another molecule about 1.42×10^{10} times per second. The shorter the mean free path is, the greater the number of collisions per second.

Kinetic Theory of Gases The kinetic theory explains the general properties of a gas. **The constant motion of particles in a gas allows a gas to fill a container of any shape or size.** Think about air in a tire. The walls of the tire keep the air contained. What if there is a hole in the tire? Because the particles in the air are in constant motion, some of the particles would travel to the hole and move out of the tire. The kinetic theory as applied to gases has three main points.

- Particles in a gas are in constant, random motion.
- The motion of one particle is unaffected by the motion of other particles unless the particles collide.
- Forces of attraction among particles in a gas can be ignored under ordinary conditions.

Reading Checkpoint ***Describe the motion of particles in a gas.***

Explaining the Behavior of Liquids

The particles in liquids also have kinetic energy. So why does a liquid such as mercury have a definite volume at room temperature instead of expanding to fill its container? The average speed of a mercury atom is much slower than the average speed of a helium atom at the same temperature. A mercury atom has about 50 times the mass of a helium atom. This greater mass is only partly responsible for the slower speed. What other factor is responsible?

The particles in a liquid are more closely packed than the particles in a gas. Therefore, attractions between the particles in a liquid do affect the movement of the particles. A mercury atom in liquid mercury is like a student in the crowded hallway in Figure 8. The student's path may be blocked by students moving in the other direction. The student's ability to move is affected by interactions with other students.

In a liquid, there is a kind of tug of war between the constant motion of particles and the attractions among particles. This tug of war explains the general behavior of liquids. **A liquid takes the shape of its container because particles in a liquid can flow to new locations. The volume of a liquid is constant because forces of attraction keep the particles close together.** Because forces of attraction limit the motion of particles in a liquid, the particles in a liquid cannot spread out and fill a container.

Go Online NSTA SCILINKS

For: Links on kinetic theory
Visit: www.SciLinks.org
Web Code: ccn-1031

Go Online PLANETDIARY

For: Activity on mercury in the enviroment
Visit: PHSchool.com
Web Code: ccc-1031

Figure 8 Particles in a liquid behave like students moving through a crowded hallway.

Explaining the Behavior of Liquids

Build Science Skills L2

Using Analogies Have students think of analogies for the motion of particles in a liquid other than the analogy shown in Figure 8. Possible answers include dancers on a dance floor or bumper cars at an amusement park. Be sure students understand that the objects representing particles in the analogy should be in a confined space.
Logical

Address Misconceptions L2

Students may think that the particles in gases have more kinetic energy than the particles in liquids or solids. Students are confusing an increase in the ability of particles to move freely with an increase in average speed. Challenge this misconception by explaining that the particles in all substances at a given temperature have, on average, similar amounts of kinetic energy. Ask, **Why don't particles in a solid move as freely as particles in a gas at room temperature?** *(Strong forces of attraction among particles in the solid keep the particles vibrating around fixed locations within the solid.)*
Logical

Go Online NSTA SCILINKS

Download a worksheet on kinetic theory for students to complete, and find additional teacher support from NSTA SciLinks.

Go Online PLANETDIARY

Find links to additional activities and have students monitor phenomena that affect Earth and its residents.

Answer to . . .

Figure 7 *One atom may gain kinetic energy and speed up while the other atom loses kinetic energy and slows down.*

Reading Checkpoint *Particles in a gas are in constant, random motion.*

Section 3.1 (continued)

Explaining the Behavior of Solids

Build Science Skills L2

Using Models Fill a clear plastic box or tray with enough marbles to fill the bottom of the box. Gently move the box back and forth. Ask, **What state of matter does this model represent?** *(Solid)* **How are the particles in a solid like the marbles in this model?** *(Both the marbles and the particles in a solid are in fixed locations. They can only move back and forth.)* The marbles do not move until the box is shaken. **How well does this part of the model represent the behavior of particles in a solid?** *(Not well, because particles in a solid are constantly moving.)*
Visual

3 ASSESS

Evaluate Understanding L2

Have each student write a paragraph explaining how kinetic theory can be used to explain the general characteristics of solids, liquids, and gases.

Reteach L1

Review the properties of solids, liquids, and gases. Use Figure 1 to encourage students to think of practical applications in which the state of matter is important. For example, molten metals can be shaped in a mold, but a metal must be solid to be shaped by hammering.

Connecting Concepts

In a liquid, there is a tug of war between the motion of the particles and attractions among particles. With liquids at the same temperature, the deciding factor would be the strength of the attractive forces. An increase in these forces would decrease a liquid's ability to flow and increase its viscosity.

Interactive Textbook If your class subscribes to the Interactive Textbook, use it to review key concepts in Section 3.1.

Answer to . . .

Figure 9 *People remain in the same seats, but the positions of their bodies change.*

Figure 9 These photographs of an audience in a movie theater were taken at different times on the same day. The behavior of the audience can be compared to the behavior of particles in a solid. **Observing** ***What stayed the same and what changed between the photographs?***

Explaining the Behavior of Solids

You might compare the particles in a solid to a polite audience in a movie theater. While the movie is running, people stay in their seats. Although people move around in their seats, as shown in Figure 9, each person remains in essentially the same location during the movie. They have "fixed" locations in a total volume that does not change.

Solids have a definite volume and shape because particles in a solid vibrate around fixed locations. Vibration is a repetitive back-and-forth motion. Look back at the orderly arrangement of copper atoms in Figure 2. Strong attractions among the copper atoms restrict their motion and keep each atom in a fixed location relative to its neighbors. Each atom vibrates around its location but it does not exchange places with a neighboring atom.

Section 3.1 Assessment

Reviewing Concepts

1. How are shape and volume used to classify solids, liquids, and gases?
2. What does the kinetic theory say about the motion of atoms?
3. How is a gas able to fill a container of any size or shape?
4. Use kinetic theory and attractive forces to explain why a liquid has a definite volume and a shape that can vary.
5. Explain why a solid has a definite shape and volume.
6. How does the arrangement of atoms in most solids differ from the arrangement of atoms in a liquid?

Critical Thinking

7. **Using Analogies** Explain how the behavior of popcorn in a popcorn popper can be used as an analogy for the motion of gas particles.
8. **Applying Concepts** A hazardous chemical is leaking from a tank truck. Rescue workers need to evacuate people who live near the accident. Why are more people likely to be affected if the chemical is a gas, rather than a liquid?

Connecting Concepts

Viscosity Review the description of viscosity in Section 2.2. Use the tug of war between forces of attraction and kinetic energy to explain differences in viscosity among liquids at the same temperature.

Section 3.1 Assessment

1. Materials can be classified as solids, liquids, or gases based on whether their shapes and volumes are definite or variable.
2. All particles of matter are in constant motion.
3. The constant motion of gas particles allows a gas to fill a container of any shape and size.
4. Particles in a liquid can flow to new locations, but forces of attraction keep the particles close together.
5. The particles in a solid vibrate around fixed locations.
6. The atoms in most solids have a more orderly arrangement than the atoms in liquids, which are not restricted to fixed locations.
7. While popping occurs, the motion of the individual popcorn kernels is random and fairly continuous.
8. The particles of a gas have greater freedom of movement and will reach a wider area more quickly.