7.2 Characteristics of Fluids

Fluids have certain characteristics that define them as fluids. For example, fluids do not have a definite shape of their own. Instead, both gases and liquids take the shape of their container (Figure 1). Although liquids do not have a definite shape, they do have a definite volume. If you pour 500 mL of a liquid from a tall, thin container into a short, wide container, its volume is still 500 mL.

LINKING TO LITERACY

Compare and Contrast

Read about liquids and gases in the first two paragraphs. Create a chart to compare and contrast them. Use Liquids and Gases as column headings. In each column, list properties of each. Now, work with a partner to discuss what you have written. How are liquids and gases the same? How are they different?

Figure 1 A key characteristic of fluids is that they take the shape of their container.

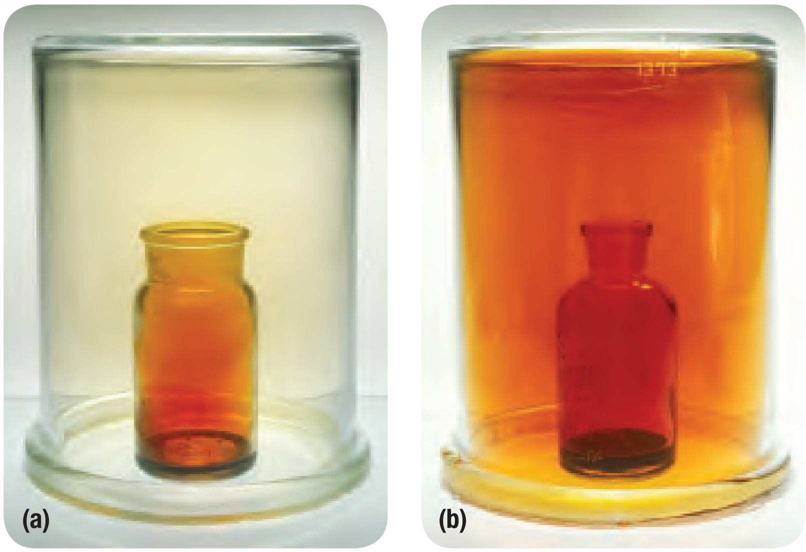

Figure 2 The brown bromine gas in the small bottle slowly moves out of the bottle (a) and fills the large container (b).

Gases, however, will completely fill any empty container they are placed in (Figure 2). Imagine if a frightened skunk entered your classroom. Skunks can spray a very strong-smelling liquid to defend themselves. The liquid quickly evaporates into a gas. Although the spray itself may be only a few millilitres, the smell (which is caused by a gas) quickly fills a room. Very soon, everyone in your school would know by the smell that a skunk is inside. Gases may not have a definite shape or volume, but some have a very definite smell!

The Particle Theory

particle theory of matter: a theory that explains what matter is made of and how it behaves

The **particle theory of matter** helps explain why fluids act the way they do. It states that

- all matter is made of tiny particles
- particles have empty spaces between them
- particles are moving randomly all the time
- particles move faster and spread farther apart when they are heated
- particles attract each other

Solids have a definite shape and volume. Although the particles of a solid are in constant motion, the forces of attraction are so strong that the particles vibrate very small distances around a central point. The particles are more or less locked in place. They cannot slide past one another (Figure 3(a)). This is why solids are generally not fluids.

Particles of liquids are farther apart than particles of solids. They are bound less tightly and are free to move past one another. The forces of attraction among particles of liquids are still strong enough to hold the liquid together (Figure 3(b)).

The particles of a gas are much farther apart, and their force of attraction is extremely small. Gas particles spread out and fill whatever container they are placed in (Figure 3(c)).

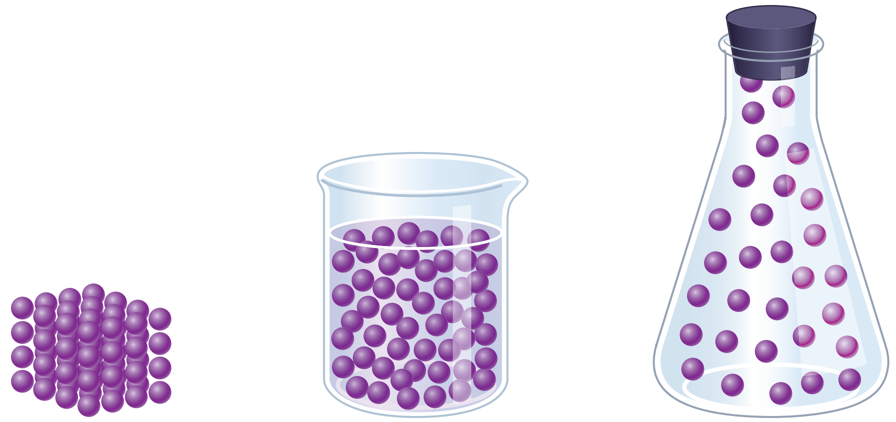

Figure 3 (a) Particles of a solid are tightly packed and locked in place. (b) Particles of a liquid are freer to move about. (c) Gas particles have large spaces between them and are free to spread out to fill their container.

LINKING TO LITERACY

Reading Diagrams

A first look at this diagram may give you little information about particles. The following tips will help you understand this diagram:

- Begin by reading the caption at the bottom of the diagram. The first sentence describes the first picture, a solid. The next sentence describes the second picture, a liquid. And the last sentence describes the third picture, a gas.
- Scan the diagram, left to right, and top to bottom. Make sure you notice all details.
- Reflect: How are the particles different in each picture?
- Make a connection: Think of something that is a solid, something that is a liquid, and something that is a gas. How are particles arranged in each?

TRY THIS: Exploring Goobleck

SKILLS MENU: **performing, observing, analyzing, communicating**

In 1949, Dr. Seuss introduced the mysterious substance Oobleck to the world in his children's book *Bartholomew and the Oobleck*. Today, you will examine an Oobleck-like substance (we will call it Goobleck) and determine whether it is a liquid or a solid. You will also give reasons why there might be some confusion.

Equipment and Materials: measuring cup; medium-sized bowl; graduated cylinder; spoon; cornstarch; water

1. Create your Goobleck by mixing 45 mL of cornstarch with 30 mL of water in the bowl. Stir slowly and well. When the water and cornstarch are thoroughly mixed, you can begin your investigation.
2. Perform the following actions using slow movements. Push your finger into the mixture. Slowly pour it. Let it run between your fingers. Record your observations with each new action.
3. Now perform the following actions using quick movements. Poke your finger into the mixture. Pick some up and squeeze it. Try breaking some in half. Record your observations with each new action.

A. In what ways did your Goobleck behave like a liquid?

B. In what ways did it behave like a solid?

C. Decide whether you think Goobleck is a liquid or a solid. Justify your answer.

Ability to Flow

Fluids have the ability to flow because the particles of liquids and gases are free to move about. The ability to flow through, around, or over something is a key characteristic of fluids (Figure 4). Fluids can flow through pipelines, around wings, and over rocks.

Figure 4 (a) Oil and natural gas flow through pipelines. (b) Air flow holds airplanes aloft. (c) Water flows in rivers.

You might be thinking, "I can pour salt, sugar, or sand. Do some solids also flow?" Some solids can appear to flow, especially when ground into very fine fragments or grains. Salt, for example, can be poured from one container to another and takes the shape of the box or saltshaker (Figure 5(a)). However, if you look closely at such solids you will see that each fragment still has a definite shape (Figure 5(b)). Solids form piles when poured; fluids do not. Imagine trying to make a pile of liquid water or a pile of oxygen!

To hear an audio clip about a new form of matter,
Go to Nelson Science

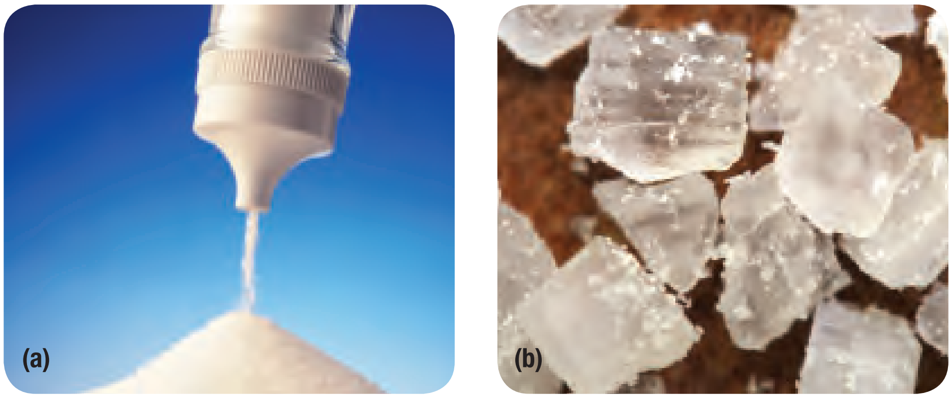

Figure 5 Solids in fine granular form may appear to flow (a), but on close inspection we can see their definite shape (b).

Figure 6 The ice in glaciers can "flow" over long periods of time.

Some solids—such as the ice in glaciers (Figure 6)—are considered fluids. These solids will exhibit fluid-like behaviour when subjected to strong forces over long periods of time. The smooth surface on some glaciers shows that the glaciers are moving (flowing) slower than glaciers with a rough surface. The ability to flow is more commonly discussed with respect to liquids and gases. Fluid solids are very uncommon in everyday life on Earth's surface.

Types of Flow

Fluid flow can be divided into two main patterns—laminar flow and turbulent flow. **Laminar flow** is smooth and regular; **turbulent flow** is choppy and irregular (Figure 7).

laminar flow: a smooth pattern of flow

turbulent flow: an irregular, mixing flow pattern

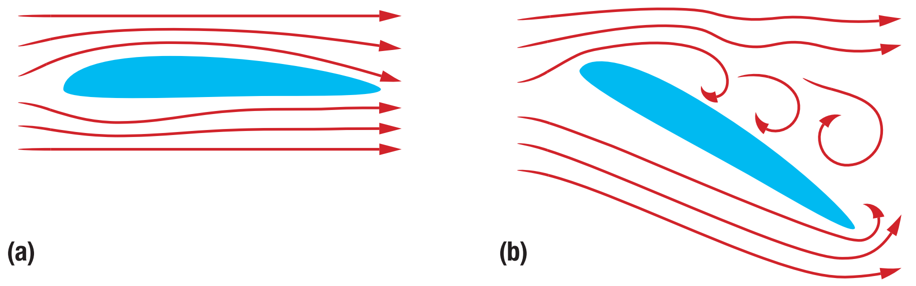

Figure 7 (a) Laminar flow around an airplane wing. (b) As the wing tilts more, the airflow becomes more turbulent.

LINKING TO LITERACY

Reading Diagrams

To understand the diagrams on this page:

- Read the text above the diagrams.
- Read the definitions in the margin.
- Next, read the caption at the bottom of the diagrams.
- Scan the diagrams, making sure to notice all the details.
- Follow the arrows to see how they flow around a tilted wing.

Laminar flow is when fluids move in orderly lines or along smooth pathways. In pipes and hoses, laminar flow allows fluids to move quickly with more energy. For objects such as cars, boats, and planes that move through fluids, laminar flow along the vehicle reduces resistance, or drag. Reduced drag makes the vehicle more efficient, since it needs less energy to push through the air.

Now imagine a fast-flowing river rushing down a slope. Different currents and pathways in the water can be seen in the white foam that is churned up as the water mixes with air. Turbulent flow in rivers and streams adds oxygen to the water, which is needed by fish, insects, and other organisms. Whitewater rafters, canoeists, and kayakers enjoy turbulent flow for the thrill it provides (Figure 8). For safety's sake, these thrill-seekers spend time and energy learning to "read" the river to understand the patterns that exist even within turbulent flow. For example, as water flows past rocks in the river, some of it curls back behind the rocks to form a much calmer flow called an **eddy**. Canoeists and kayakers rest in these eddies while planning the next stage of their run down the river (Figure 9).

eddy: an area of slower-moving fluid that occurs behind an obstacle

Figure 8 This kayaker understands how the turbulent flow of the river can be used to increase the thrill of the ride.

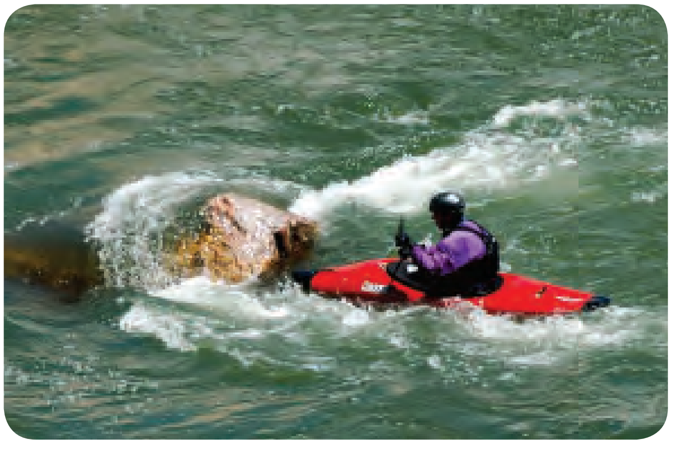

Figure 9 Knowing the patterns that exist within turbulent flow allows this kayaker to find a quiet eddy behind a rock.

Turbulence is not only found in water and air. It can also occur in a person's bloodstream. In a healthy person, blood normally flows smoothly through veins and arteries. However, over time, material called plaque can build up in arteries. Plaque buildup narrows arteries and causes additional friction, which can create turbulence in the blood flow. Turbulent blood flow and plaque may then cause blood clots to form. If the clot gets big enough, or if it moves and becomes lodged in a small artery, it can completely block the artery. This can cause heart attacks and strokes. Understanding turbulence in blood flow helps doctors and medical researchers save lives.

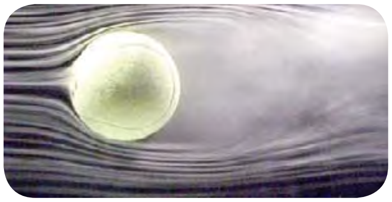

Figure 10 Wind tunnels and smoke trails can be used to investigate patterns of fluid flow around objects like this tennis ball.

streamlined: a smooth shape designed to decrease resistance to fluid flow

To learn more about streamlining and turbulence,
Go to Nelson Science

Taming Turbulence

Scientists and engineers use their knowledge of flow patterns to reduce or eliminate turbulence so that fluids flow more smoothly. Engineers and designers often use wind tunnels and smoke trails to study air flow around objects (Figure 10). Objects that are **streamlined** have shapes that reduce turbulence and create more laminar flow.

Managing fluid flow can create problems as well as solve them. During heavy rains, the increased volume of water can cause turbulent flow in rivers and streams, which can result in erosion of the riverbanks. Concrete linings have been used to create more laminar flow along some waterways (Figure 11). The linings also help prevent soil erosion. What problems can you think of that might be created by this solution? What other solutions might there be?

Figure 11 (a) To create a more laminar flow, this waterway is lined with concrete. (b) Concrete baffles help release some of the water's energy by creating more turbulent flow.

CHECK YOUR LEARNING

1. State two characteristics of all fluids.
2. State the particle theory.
3. Use the particle theory to explain why fluids can flow while solids cannot.
4. Draw diagrams to represent the arrangement of particles of a solid, a liquid, and a gas.
5. (a) What is the difference between laminar flow and turbulent flow?
   (b) Give one advantage and one disadvantage each for laminar flow and turbulent flow.
6. In your own words, explain streamlining.