SECTION 4

Focus

Overview

This section explains SI, the International System of Units. (It is called SI and not IS because the official name of the system is French: Le Système International d'Unités.) Students learn about volume and mass. They also learn about derived units, such as area and density. Finally, students consider safety rules and safety icons.

Bellringer

Pose the following to students: "How does a standard system of weights and measures, agreed to and used around the world, make life easier? Give examples."

Motivate

ACTIVITY — BASIC

Vocabulary Flashcards Have pairs of students make flashcards of the vocabulary words with the definitions and an example of each unit on the back. Have partners quiz one another using the cards.

LS Interpersonal/Verbal — English Language Learners

SECTION 4

Tools, Measurement, and Safety

Would you use a spoon to dig a hole to plant a tree? You wouldn't if you had a shovel!

To dig a hole, you need the correct tools. A *tool* is anything that helps you do a task. Scientists use many different tools to help them in their experiments.

READING WARM-UP

Objectives

- Identify tools used to collect and analyze data.
- Explain the importance of the International System of Units.
- Identify the appropriate units to use for particular measurements.
- Identify safety symbols.

Terms to Learn

mass, density, volume, temperature

READING STRATEGY

Brainstorming The key idea of this section is scientific tools and measurements. Brainstorm what tools scientists use in their work and what the tools are used for.

Tools in Science

One way to collect data is to take measurements. To get the best measurements, you need the proper tools. Stopwatches, metersticks, and balances are some of the tools you can use to make measurements. Thermometers can be used to observe changes in temperature. Some of the uses for these tools are shown in **Figure 1.**

After you collect data, you need to analyze them. Calculators are handy tools to help you do calculations quickly. Or you might show your data in a graph or a figure. A computer that has the correct software can help you display your data. Of course, you can use a pencil and graph paper to graph your data.

Reading Check **Name two ways that scientists use tools.** (*See the Appendix for answers to Reading Checks.*)

Making Measurements

Many years ago, different countries used different systems of measurement. In England, the standard for an inch used to be three grains of barley placed end to end. Other units were originally based on parts of the body, such as the foot.

Figure 1 **Measurement Tools**

You can use a stopwatch to measure time.

You can use a spring scale to measure force.

CHAPTER RESOURCES

Chapter Resource File

- Lesson Plan
- Directed Reading A BASIC
- Directed Reading B SPECIAL NEEDS

Technology

Transparencies
- Bellringer
- Common SI Units

Answer to Reading Check

Scientists use tools to take measurements and analyze data.

Table 1 Common SI Units		
Length	**meter (m)**	
	kilometer (km)	1 km = 1,000 m
	decimeter (dm)	1 dm = 0.1 m
	centimeter (cm)	1 cm = 0.01 m
	millimeter (mm)	1 mm = 0.001 m
	micrometer (μm)	1 μm = 0.000 001 m
	nanometer (nm)	1 nm = 0.000 000 001 m
Volume	**cubic meter (m^3)**	
	cubic centimeter (cm^3)	1 cm^3 = 0.000 001 m^3
	liter (L)	1 L = 1 dm^3 = 0.001 m^3
	milliliter (mL)	1 mL = 0.001 L = 1 cm^3
Mass	**kilogram (kg)**	
	gram (g)	1 g = 0.001 kg
	milligram (mg)	1 mg = 0.000 001 kg
Temperature	**Kelvin (K)**	0°C = 273 K
	Celsius (°C)	100°C = 373 K

The International System of Units

In the late 1700s, the French Academy of Sciences set out to make a simple and reliable measurement system. Over the next 200 years, the metric system was formed. This system is now the International System of Units (SI). Because all SI units are expressed in multiples of 10, changing from one unit to another is easy. Prefixes are used to express SI units that are larger or smaller than basic units such as meter and gram. For example, *kilo-* means 1,000 times, and *milli-* indicates 1/1,000 times. The prefix used depends on the size of the object being measured. **Table 1** shows common SI units.

Length

To describe the length of an Olympic-sized swimming pool, a scientist would use meters (m). A *meter* is the basic SI unit of length. Other SI units of length are larger or smaller than the meter by multiples of 10. For example, if you divide 1 m into 1,000 parts, each part equals 1 millimeter (mm). So, 1 mm is one-thousandth of a meter.

Mass

Mass is the amount of matter in an object. The *kilogram* (kg) is the basic SI unit for mass. The kilogram is used to describe the mass of large objects. One kilogram equals 1,000 g. So, the gram is used to describe the mass of small objects. Masses of very large objects are expressed in metric tons. A metric ton equals 1,000 kg.

MATH PRACTICE

Units of Measure

Pick an object to use as a unit of measure. You can pick a pencil, your hand, or anything else. Find out how many units wide your desk is, and compare your measurement with those of your classmates. What were some of the units used? Now, choose two of the units that were used in your class, and make a conversion factor. For example, 1.5 pencils equal 1 board eraser.

mass a measure of the amount of matter in an object

Is That a Fact!

In 1858, August Ferdinand Möbius invented the Möbius strip, a ribbon of paper with only one edge and one side. This invention was the beginning of the science of topology, a branch of geometry.

Teach

CONNECTION ACTIVITY
Math — GENERAL

Calculations Using SI Units
Have students calculate the following problems:

1. What is the volume of a box that is 1 m long, 0.5 m wide, and 2 m tall? (1.0 m^3)
2. What is the volume of a bar of soap that is 9 cm long, 5 cm wide, and 2 cm high? (90 cm^3)
3. A glass contains about 250 mL of milk. After adding a cookie to the milk, the level is 261 mL. What is the volume of the cookie? (11 cm^3)

LS Logical

Teaching Strategy — GENERAL

Converting to the Metric System The United States is the only industrialized country in the world that does not use the metric system as its predominant system of measurement. Despite encouragement by the federal government, widespread public and private sector transition to the metric system has not occurred. Help familiarize students with some metric measurements by comparing traditional measurements of common items with their metric measurements. Demonstrate to students that a meterstick is a little longer than a yardstick, a liter is a little larger than a quart, and a gram is a little more than the weight of a paper clip. Also, the diameter of a paper clip wire is about 1 mm, the width of a paper clip is about 1 cm, 1 km is a little farther than 1/2 mi, and 1 kg is a little more than 2 lb.

LS Logical/Visual

English Language Learners

Close

Reteaching — BASIC

Guessing Game Have a "Guess the Size" contest. Place signs on several objects of different sizes and masses in your classroom. Ask students to guess the length, area, volume, or mass of each object. Then, have students measure each object. Provide a "Best Guesser" certificate for the student who makes the closest estimates. LS Kinesthetic/Logical

Quiz — GENERAL

1. What does *SI* stand for? (International System of Units)
2. What is the SI unit of length? volume? mass? temperature? (meter, cubic meter, kilogram, kelvin)
3. Name two safety rules of science. (Follow directions, and don't take shortcuts.)

Alternative Assessment — GENERAL

Why Is Safety Important? Have students explain why it is necessary to protect themselves when conducting scientific experiments. Ask students to list the safety symbols in **Figure 3** and to think of at least one situation when the safety rule for each icon should be followed. LS Visual/Logical

volume a measure of the size of an object or region in three-dimensional space

density the ratio of the mass of a substance to the volume of the substance

temperature a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particles in an object

Volume

Imagine that you need to move some lenses to a laser laboratory. How many lenses will fit into a crate? The answer depends on the volume of the crate and the volume of each lens. **Volume** is the amount of space that something occupies.

Liquid volume is expressed in *liters* (L). Liters are based on the meter. A cubic meter (1 m^3) is equal to 1,000 L. So, 1,000 L will fit perfectly into a box that is 1 m on each side. A milliliter (mL) will fit perfectly into a box that is 1 cm on each side. So, 1 mL = 1 cm^3. Graduated cylinders are used to measure the volume of liquids.

Volumes of solid objects are usually expressed in cubic meters (m^3). Volumes of smaller objects can be expressed in cubic centimeters (cm^3) or cubic millimeters (mm^3). To find the volume of a crate—or any other rectangular shape—multiply the length by the width by the height.

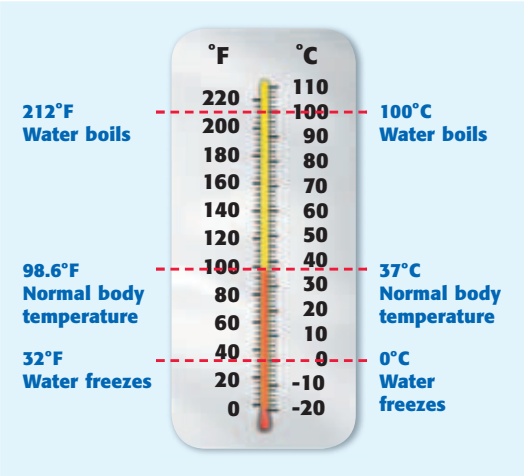
Density

If you measure the mass and the volume of an object, you have the information you need to find the density of the object. **Density** is the amount of matter in a given volume. You cannot measure density directly. But after you measure the mass and the volume, you can calculate density by dividing the mass by the volume, as shown in the following equation:

$$D = \frac{m}{V}$$

Density is called a *derived quantity* because it is found by combining two basic quantities, mass and volume.

Figure 2 *Some common temperature measurements shown in degrees Fahrenheit and degrees Celsius*



Temperature

The **temperature** of a substance is a measurement of how hot (or cold) the substance is. Degrees Fahrenheit (°F) and degrees Celsius (°C) are used to describe temperature. However, the *kelvin* (K), the SI unit for temperature, is also used. Notice that the degree sign (°) is not used with the Kelvin scale. The thermometer in **Figure 2** shows how the Celsius and Fahrenheit scales compare.

Reading Check What is the SI unit for temperature?

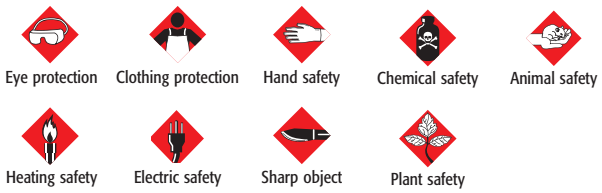
Answer to Reading Check

The SI unit for temperature is the kelvin (K).

Safety Rules

Science is exciting and fun, but it can also be dangerous. Always follow your teacher's instructions. Don't take shortcuts, even when you think there is no danger. Read lab procedures carefully. Pay special attention to safety information and caution statements. **Figure 3** shows the safety symbols used in this book. Learn these symbols and their meanings by reading the safety information at the start of the book. If you are still not sure about what a safety symbol means, ask your teacher.

Figure 3 Safety Symbols



SECTION Review

Summary

- Tools are used to make observations, take measurements, and analyze data.
- The International System of Units (SI) is the standard system of measurement.
- Length, volume, mass, and temperature are types of measurement.
- Density is the amount of matter in a given volume.
- Safety symbols are for your protection.

Using Key Terms

1. Use each of the following terms in a separate sentence: *volume, density,* and *mass*.

Understanding Key Ideas

2. Which SI unit would you use to express the height of your desk?
   a. kilogram **c.** meter
   b. gram **d.** liter
3. Explain the relationship between mass and density.
4. What is normal body temperature in degrees Fahrenheit and degrees Celsius?

Math Skills

5. A certain bacterial cell has a diameter of 0.50 μm. The tip of a pin is about 1,100 μm in diameter. How many of these bacterial cells would fit on the tip of the pin?

Critical Thinking

6. **Analyzing Ideas** What safety icons would you expect to see for a lab activity that asks you to pour acid into a beaker? Explain your answer.
7. **Applying Concepts** To find the area of a rectangle, multiply the length by the width. Why is area called a *derived quantity*?

SCILINKS. NSTA
Developed and maintained by the National Science Teachers Association

For a variety of links related to this chapter, go to www.scilinks.org

Topic: SI Units
SciLinks code: HSM1390

Answers to Section Review

1. Sample answer: Volume is the amount of space taken up by matter. Density is the amount of matter in a given volume. Mass is the amount of matter an object contains.
2. c
3. Sample answer: Mass and density are related because in order to calculate density, the mass and the volume of an object must be known. Density tells how much mass is in a certain volume.
4. 98.6°F; 37°C
5. 2,200 bacterial cells
6. Sample answer: eye protection, clothing protection, hand safety, and chemical safety; Acid is corrosive and will cause severe burns if it comes in contact with eyes, skin, or clothing.
7. Sample answer: Area is called a *derived quantity* because two basic quantities—length and width—must be combined to calculate it.

CHAPTER RESOURCES

Chapter Resource File
- Section Quiz GENERAL
- Section Review GENERAL
- Vocabulary and Section Summary GENERAL
- Critical Thinking ADVANCED

Workbooks

Math Skills for Science
- What Is SI? GENERAL
- Finding Volume GENERAL
- Finding Perimeter and Area GENERAL

Science Skills
- Safety Rules! GENERAL