

CHAPTER 1 The World of Life Science**SECTION****4****Tools, Measurement, and Safety****BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do tools help scientists?
- How do scientists measure length, area, mass, volume, and temperature?

What Tools Do Scientists Use?

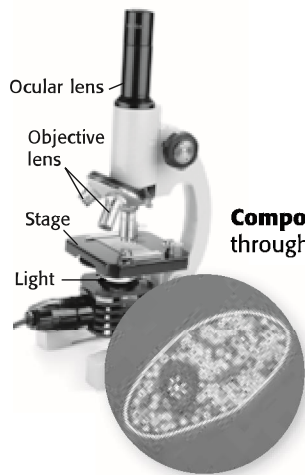
Scientists can use technology to find information and to solve problems. **Technology** is the application of science for practical purposes. New technology can allow scientists to get information that was not available before.

CALCULATORS AND COMPUTERS

Scientists analyze, or examine, data using many different tools. Computers and calculators can help scientists do calculations quickly. Computers are also very important tools for collecting, storing, and studying data.

COMPOUND LIGHT MICROSCOPES

Scientists use microscopes to see things that are very small. One kind of microscope is a compound light microscope. A **compound light microscope** is a tool that magnifies small objects. It has three main parts: a stage, a tube with two or more lenses, and a light. Items are placed on the stage. Light passes through them. The lenses help to magnify the image.



Compound Light Microscope Light passes through a specimen and produces a flat image.



Compare As you read this section, make a table comparing how scientists measure length, area, mass, volume, and temperature. Include the tools and units that scientists use for each type of measurement.

TAKE A LOOK

1. Identify What are the three main parts of a compound light microscope?

SECTION 4 Tools, Measurement, and Safety *continued*

Critical Thinking

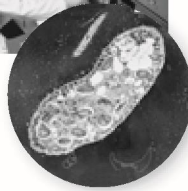
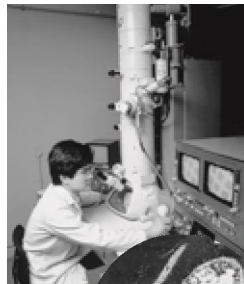
2. Identify A scientist wants to look at a living cell. Should the scientist use a compound light microscope or an electron microscope? Explain your answer.

ELECTRON MICROSCOPES

Electron microscopes use tiny particles called *electrons* to produce magnified images. Electron microscopes make clearer and more detailed images than light microscopes do. However, unlike light microscopes, electron microscopes cannot be used to study things that are alive.

Transmission Electron Microscope Electrons pass through the specimen and produce a flat image.

Scanning Electron Microscope Electrons bounce off the surface of the specimen and produce a three-dimensional (3-D) image.



How Do Scientists Measure Objects?

Scientists make many measurements as they collect data. It is important for scientists to be able to share their data with other scientists. Therefore, scientists use units of measurement that are known to all other scientists. One system of measurement that most scientists use is called the International System of Units.

THE INTERNATIONAL SYSTEM OF UNITS

The *International System of Units*, or *SI*, is a system of measurement that scientists use when they collect data. This system of measurement has two benefits. First, scientists around the world can easily share and compare their data because all measurements are made in the same units. In addition, SI units are based on the number 10. This makes it easy to change from one unit to another.

It is important to learn the SI units that are used for different types of measurements. You will use SI units when you make measurements in the science lab.

Critical Thinking

3. Predict Consequences What could happen if all scientists used different systems of measurement to record their data?

SECTION 4 Tools, Measurement, and Safety *continued***LENGTH**

Length is a measure of how long an object is. The SI unit for length is the *meter* (m). Centimeters (cm) and millimeters (mm) are used to measure small distances. There are 100 cm in 1 m. There are 1,000 mm in 1 m. Micrometers (μm) are used to measure things that are very small, such as cells. There are 1 million μm in 1 m. Rulers and metersticks are used to measure length.

Length tools: ruler or meterstick	SI Unit: meter (m) kilometer (km) centimeter (cm) millimeter (mm)	1 km = 1,000 m 1 cm = 0.01 m 1 mm = 0.001 m 1 μm = 0.000001 m
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AREA

Area is a measure of how much surface an object has. For most objects, area is calculated by multiplying two lengths together. For example, you can find the area of a rectangle by multiplying its length by its width. Area is measured in square units, like square meters (m^2) or square centimeters (cm^2). There are 10,000 cm^2 in 1 m^2 . ✓

There is no tool that is used to measure area directly. However, you can use a ruler to measure length and width. Multiply these measurements to find area.

Area tool: ruler (to measure lengths)	square meter (m^2) square centimeter (cm^2)	1 cm^2 = 0.0001 m^2
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VOLUME

Volume is the amount of space an object takes up. You can find the volume of a box-shaped object by multiplying its length, width, and height together. You can find the volume of objects with many sides by measuring how much liquid they can push out of a container, as shown in the figure on the next page. You can measure the volume of a liquid using a beaker or a graduated cylinder. ✓

Volume is often measured in cubic units. For example, very large objects can be measured in cubic meters (m^3). Smaller objects can be measured in cubic centimeters (cm^3). There are 1 million cm^3 in 1 m^3 . The volume of a liquid is sometimes given in units of liters (L) or milliliters (mL). One mL has the same volume as one cm^3 . There are 1,000 mL in 1 L. There are 1,000 L in one m^3 .

Volume tools: graduated cylinder, beaker	cubic meter (m^3) cubic centimeter (cm^3) liter (L) milliliter (mL)	1 cm^3 = 0.000001 m^3 1 L = 0.001 m^3 1 mL = 1 cm^3
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TAKE A LOOK

4. Identify What is the SI unit for length?

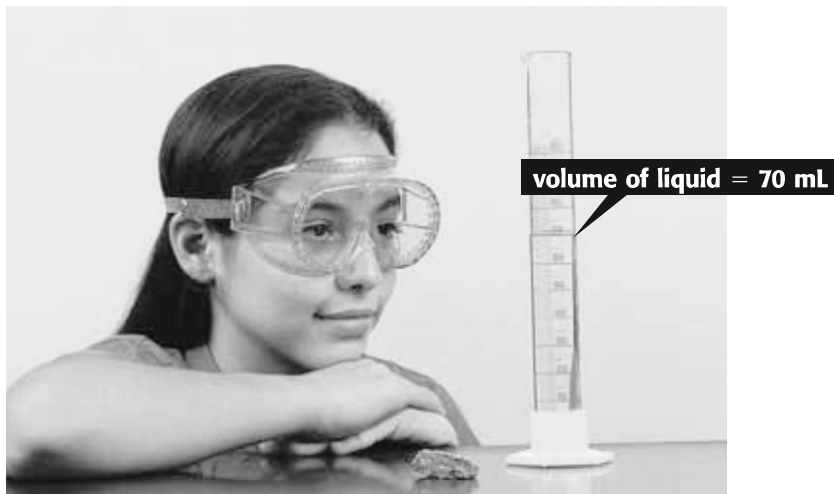
 **READING CHECK**

5. Explain How can you find the area of a rectangle?

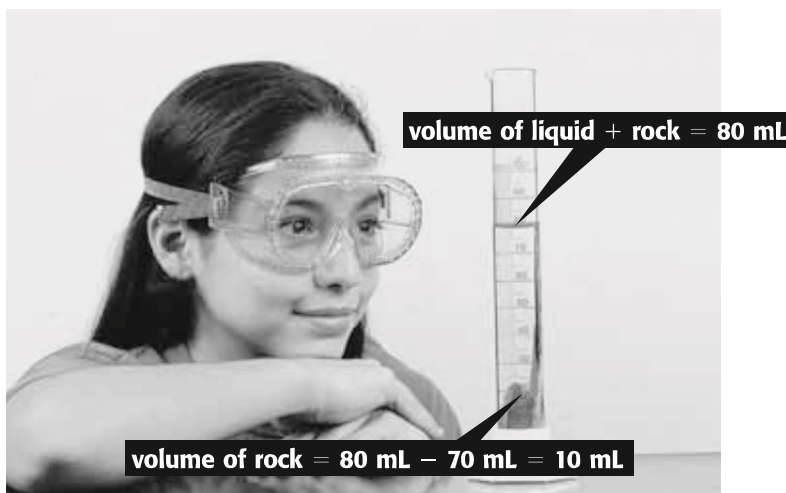
 **READING CHECK**

6. Define What is volume?

SECTION 4 Tools, Measurement, and Safety *continued*



You can find the volume of this rock by measuring how much liquid it pushes out of the way. The graduated cylinder has 70 mL of liquid in it before the rock is added.



The rock made the volume of material in the cylinder go up to 80 mL. The rock pushed 10 mL of liquid out of the way. The volume of the rock is 10 mL. Because 1 mL = 1 cm³, the volume of the rock can also be written as 10 cm³.

TAKE A LOOK

7. Explain How do you know that the rock in the figure has a volume of 10 mL?

MASS

Mass is a measurement of the amount of matter in an object. The SI unit for mass is the kilogram (kg). The masses of large objects, such as people, are measured using kg. The masses of smaller objects, such as an apple, are measured in grams (g) or milligrams (mg). There are 1,000 g in 1 kg. There are 1 million mg in 1 kg. Balances are used to measure mass.

Math Focus

8. Convert How many mg are there in 1 g?

Mass tool: balance	SI Unit: kilogram (kg) gram (g) milligram (mg)	1 g = 0.001 kg 1 mg = 0.000001 kg
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SECTION 4 Tools, Measurement, and Safety *continued*

TEMPERATURE

Temperature is a measure of how hot or cold an object is. The SI unit for temperature is the Kelvin (K). However, most people are more familiar with other units of temperature. For example, most people in the United States measure temperatures using degrees Fahrenheit (°F). Scientists often measure temperatures using degrees Celsius (°C). Thermometers are used to measure temperature. ✓

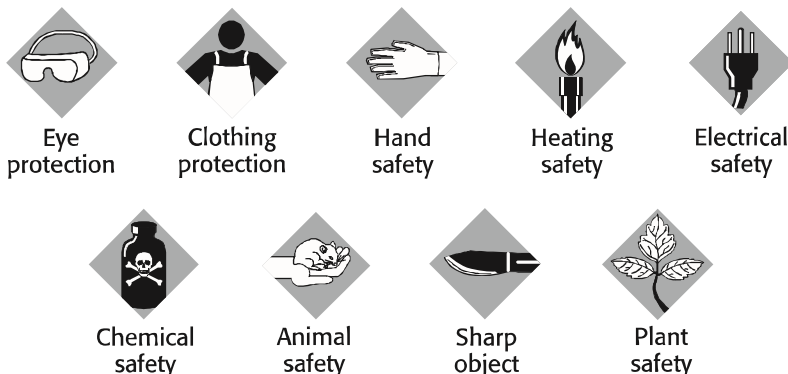
Temperature tool: thermometer	SI Unit: kelvin (K) degrees Celsius (°C)	0°C = 273 K 100°C = 373 K
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It is easy to change measurements in °C to K. To change a temperature measurement from °C to K, you simply add 273 to the measurement. For example, 200 °C = 200 + 273 = 473 K. It is more complicated to change measurements in K or °C into °F. That is why scientists do not measure temperatures in °F. ✓

How Can You Stay Safe in Science Class?

Science can be exciting, but it can also be dangerous. In order to stay safe while you are doing a science activity, you should always follow your teacher’s directions. Read and follow the lab directions carefully, and do not take “shortcuts.” Pay attention to safety symbols, such as the ones in the figure below. If you do not understand something that you see in a science activity, ask your teacher for help.

Safety Symbols



✓ **READING CHECK**

9. Define What is temperature?

✓ **READING CHECK**

10. Explain Why do scientists measure temperature in K or °C instead of °F?

TAKE A LOOK

11. Investigate Look around your classroom for safety symbols like the ones in the figure. Give two examples of places where safety symbols are found in your classroom.

Section 4 Review

SECTION VOCABULARY

<p>area a measure of the size of a surface or a region</p> <p>compound light microscope an instrument that magnifies small objects so that they can be seen easily by using two or more lenses</p> <p>electron microscope a microscope that focuses a beam of electrons to magnify objects</p> <p>mass a measure of the amount of matter in an object</p>	<p>technology the application of science for practical purposes; the use of tools, machines, materials, and processes to meet human needs</p> <p>temperature a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particles in an object</p> <p>volume a measure of the size of a body or region in three-dimensional space</p>
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1. Describe You can find the volume of a box-shaped object by multiplying its length, width, and height together. How can you measure the volume of an object if it is not shaped like a box?

2. Identify Fill in the table to show the tool you would use to carry out each measurement.

Task	Tool
Looking at something that is very small	
Measuring how tall your friend is	
Measuring how much water is in a glass	

3. Identify What are two units that scientists use to measure temperature?

4. Explain How can you stay safe while doing a science activity? Give three ways.
