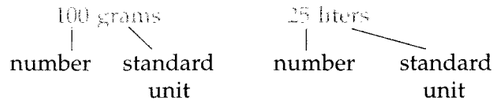
LESSON 1 | How do scientists measure things?

How much do you weigh? What is your height? How many tiles will cover your kitchen floor? How much milk should be added to a cake mix? What is the temperature outside? All of these questions are answered by measurements.

Measuring is an important part of daily life. People use measurements all the time—for shopping, cooking, construction, and deciding how warmly to dress. Measuring also is an important part of science.

A measurement has two parts: a number and a unit. A unit is a standard amount used to measure something.

EXAMPLES



There are many kinds of measurements. The most common are:

MASS and weight are related, but they are not the same. **Mass** is a measure of the amount of matter in an object. **Weight** is a measure of the pull of gravity on an object. The basic unit of mass in the metric system is the kilogram (kg). Mass is measured with a balance.

LENGTH is the distance from one point to another as measured by a ruler. The basic metric unit of length is the meter (m). You can use a meter stick or metric ruler to measure length.

AREA is a measure of surface room—how big something is in two directions. You can find the area of a rectangle by multiplying its length by its width. Area is measured in square units, such as square meters (m^2).

VOLUME is the measure of the amount of space an object takes up—how big an object is in all three directions. The liter (L) is the basic unit of volume in the metric system. A measuring cup or a graduated cylinder is used to measure the volume of liquids.

The volume of a solid can be measured in cubic centimeters (cm^3). You can find the volume of a cube or rectangle by multiplying its length by its width by its height. 1,000 cubic centimeters equals 1 liter.

TEMPERATURE is the measure of how hot or cold an object is. Temperature is measured with a thermometer in degrees Celsius (°C), or degrees Fahrenheit (°F). The Celsius scale usually is used in science.

In the United States people usually use English units of measurement such as ounces, pounds, inches, and feet. Most other countries use metric units. Metric units include the gram, kilogram, meter, and centimeter. Scientists also use the metric system. In science, you will use mostly metric units.

The metric system is based upon units of ten. Each unit is ten times smaller or larger than the next unit. This means that a unit is made larger by multiplying it by 10 and made smaller by dividing by 10. Prefixes describe a unit's value. The prefixes and their meanings are listed below.

	PREFIX		MEANING	
↑ numbers to describe the same amount get larger	kilo- [KILL-uh]	———	one thousand (1,000)	} each unit larger by a multiple of ten
	hecto- [HEC-tuh]	———	one hundred (100)	
	deca- [DEC-uh]	———	ten (10)	
↓ numbers to describe the same amount get smaller	deci- [DESS-ih]	———	one tenth (1/10)	} each unit smaller by a multiple of 1/10
	centi- [SEN-tih]	———	one hundredth (1/100)	
	milli- [MILL-ih]	———	one thousandth (1/1,000)	

Use the chart above to answer the following questions.

1. To change from tens to hundreds, you multiply by _____ (1, 10, 100).
2. To change from hundreds to thousands, you multiply by _____ (1, 10, 100).
3. In the metric system, to change from one unit to the next higher unit, what must you do? _____
4. To change from one unit to the next lower unit, you must divide by _____ (1, 10, 100).
5. Which prefix stands for a greater value?
   - **a)** deca- or kilo-? _____
   - **b)** kilo- or milli-? _____
   - **c)** centi- or milli-? _____
   - **d)** hecto- or kilo-? _____
   - **e)** centi- or deci-? _____
   - **f)** deca- or deci-? _____

MEASURING MASS

1. In the metric system, the unit of mass is the _____ .
   meter, kilogram, pound
2. Mass and weight _____ the same.
   are, are not
3. _____ is a measure of the amount of matter in an object.
   mass, weight

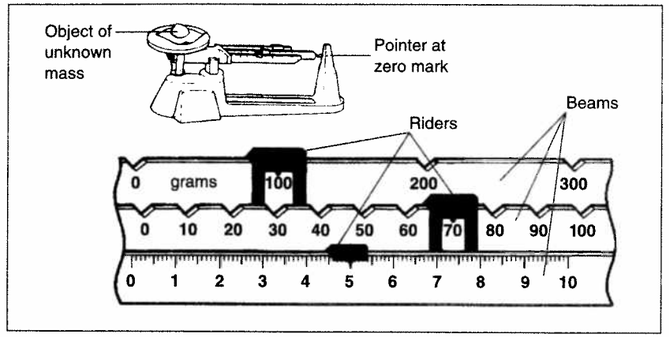


Figure A

4. What instrument is used to measure mass? _____
5. What is the mass of the object shown? _____

TRUE OR FALSE

In the space provided, write "true" if the sentence is true. Write "false" if the sentence is false.

_____ **1.** Weight is a measure of the pull of gravity on an object.

_____ **2.** Scientists use English units of measurement.

_____ **3.** The prefix centi- stands for one hundredth (1/100).

_____ **4.** A graduated cylinder is used to measure mass.

_____ **5.** The basic unit of length in the metric system is the meter.

_____ **6.** Volume is a measure of the amount of matter in an object.

_____ **7.** One kilogram is less than one gram.

_____ **8.** A measurement has two parts.

_____ **9.** A unit is an amount used to measure something.

_____ **10.** Most countries use the metric system.

MEASURING LENGTH

Length is measured with a metric ruler. Part of a combined metric and inch ruler is shown in Figure B. On the metric side of the ruler the distance between numbered lines is equal to one centimeter. Each centimeter is divided into 10 equal parts. Each one of these parts is equal to one millimeter.

The figure below shows a combined metric and inch ruler.

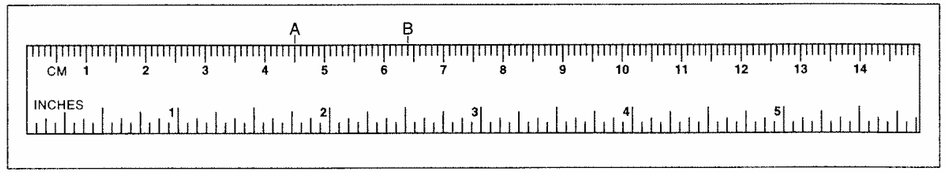


Figure B

1. What value does the prefix milli- stand for? _____
2. What value does the prefix centi- stand for? _____
3. Which is larger, a meter or a millimeter? _____
4. How many millimeters make 1 centimeter? _____
5. The length at A may be written as 45 mm. It may also be written as _____ .
   45 cm, 4.5 cm, 4.5 mm
6. The length at B may be written as _____ mm or _____ cm.

Measure each of the following lengths. Write the lengths on the right in centimeters and millimeters.

7.	_____	**7.** _____ cm _____ mm
8.	_____	**8.** _____ cm _____ mm
9.	_____	**9.** _____ cm _____ mm
10.	_____	**10.** _____ cm _____ mm

To the right of each length listed, draw a line of that length.

a) 92 mm

b) 9.2 cm

c) 43 mm

d) 3.5 cm

MEASURING TEMPERATURE

Temperature is measured with a thermometer. Many thermometers, including the ones you are most familiar with, are made of glass tubes. At the bottom of the tube is a wider part called the bulb. The bulb is filled with a liquid, such as mercury. When the bulb is heated, the liquid in the bulb expands, or gets larger. It rises in the tube. When the bulb is cooled, the liquid contracts, or gets smaller. It falls in the tube.

On the sides of a thermometer are a series of marks. You read the temperature by looking at the mark where the liquid stops.

Write the temperature shown on each Celsius thermometer in the space provided.

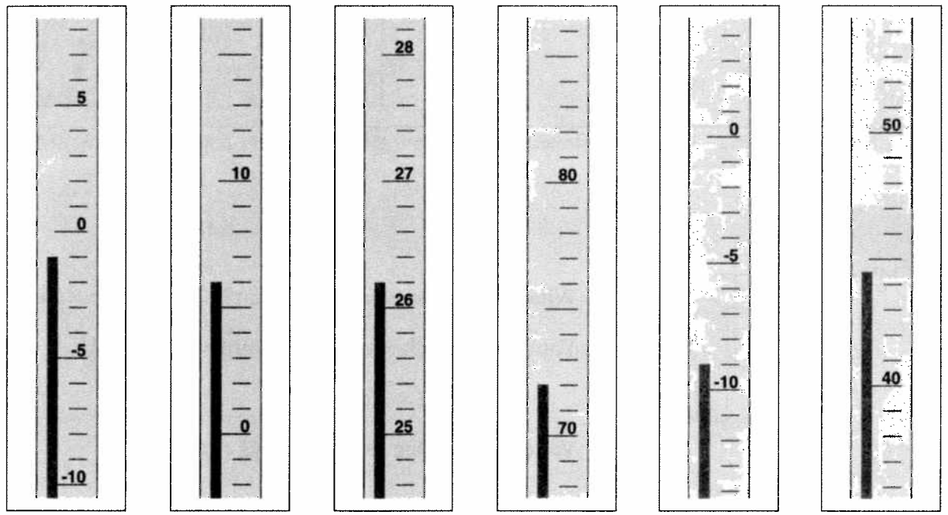


Figure K **Figure L** **Figure M** **Figure N** **Figure O** **Figure P**

_____ _____ _____ _____ _____ _____

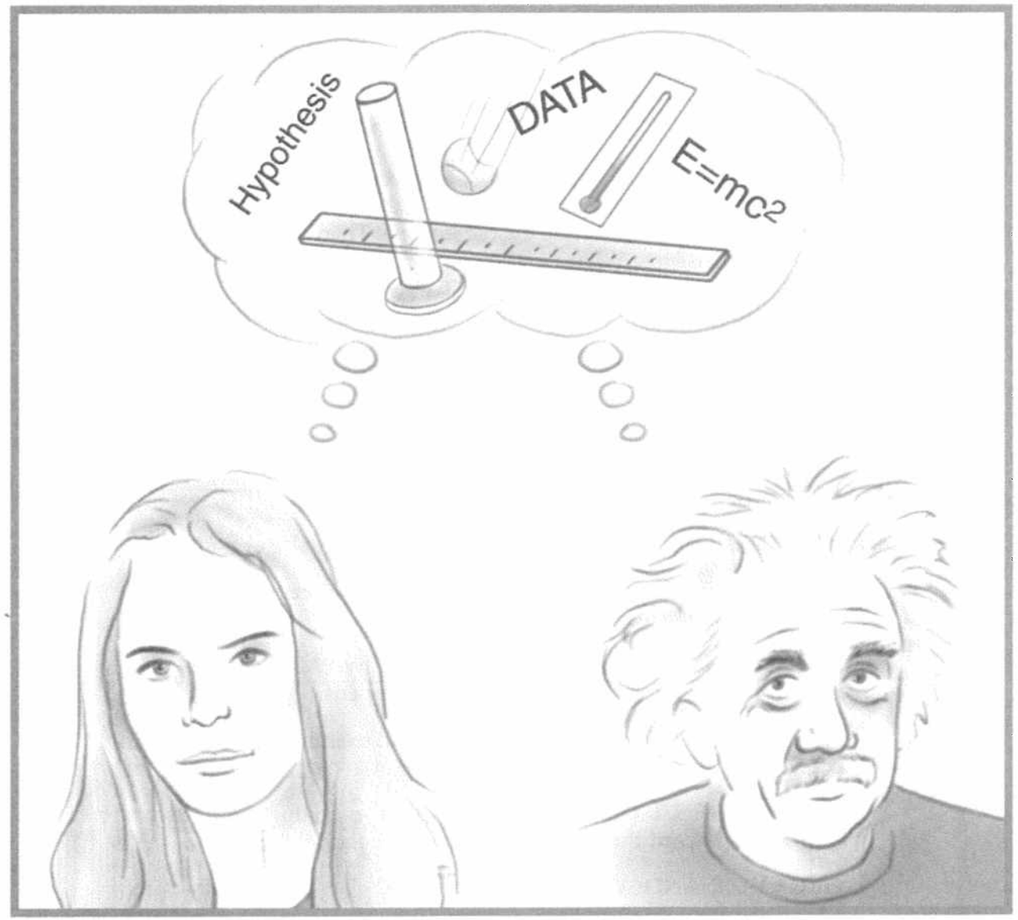
REACHING OUT

One cubic centimeter is equal to one millimeter (mL). How many liters of water can a 1,800 cm^3 pan hold? _____

Scientific Methods

Lesson 2

What is scientific method?



KEY TERMS

scientific method: problem-solving guide

hypothesis: suggested solution to a problem based upon known information

data: record of observations

LESSON 2 | What is scientific method?

You may not realize it, but you do problem-solving every day. You do not always think about how to solve a particular problem. You solve problems in sort of a "natural" way, a way that seems to "make sense." And it usually does.

For example, suppose you put your key into your house door and try to turn it, but it does not budge. You wonder what's wrong. You examine the key to make certain that it is the correct one. Then you try again. The key still does not turn. What next? You might "jiggle" the key. Or, you might pull back on the doorknob as you try to turn the key. One of these approaches might work. If not, you try other methods until the problem is solved.

Without knowing it, you solve problems very much like a scientist does. You use **scientific method.** Scientific method is a guide used to solve problems. It involves asking questions, making observations, and trying things out in an orderly way. Scientists use certain steps to solve problems. The steps of scientific method are:

- **IDENTIFY THE PROBLEM** State it clearly—usually as a question.
- **GATHER INFORMATION** Research; ask questions. Discover what is already known about the problem.
- **STATE A HYPOTHESIS** A **hypothesis** [hy-PAHTH-us-sis] is a suggested solution as to why something happens.
- **TEST THE HYPOTHESIS** Experiment and examine the situation to check the hypothesis.
- **MAKE CAREFUL OBSERVATIONS** Note everything your senses can gather. Record the **data** [DAY-tuh]. Keep careful records.
- **ORGANIZE AND ANALYZE THE DATA** Put the data in order. Scientists often use charts and tables to organize data. Figure out the meaning of the data.
- **STATE A CONCLUSION** Explain the data. State whether or not it supports the hypothesis.

Different problems require different approaches. Not every step in scientific method needs to be used. And the steps can be used in any order.

CHOOSE THE RIGHT CAPTION

Below and on page 12 are eight figures and eight captions. Each caption matches one of the figures. Choose the caption that best describes each figure. Write the correct caption on the line provided.

Choose from these captions:

Identify the problem	Make careful observations
Gather information	Record the data
State a hypothesis	Analyze the data
Test the hypothesis	State a conclusion

Figure A

1. _____

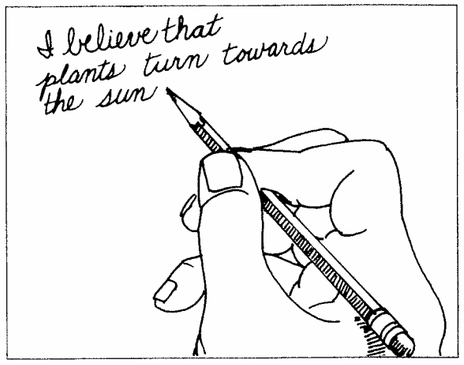


Figure B

2. _____

Figure C

3. _____

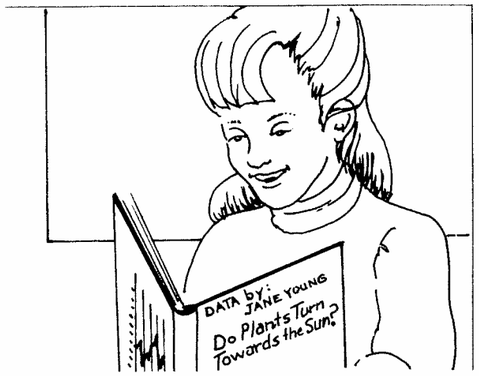


Figure D

4. _____

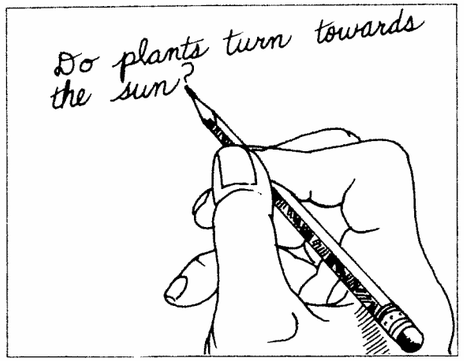


Figure E

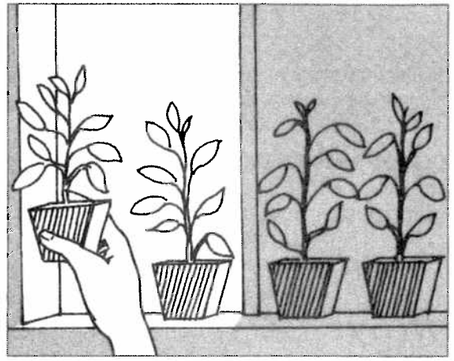


Figure F

5. _____

6. _____

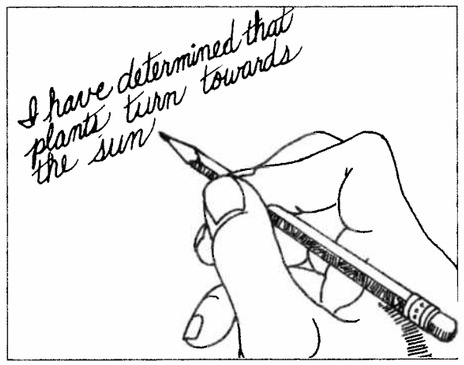


Figure G

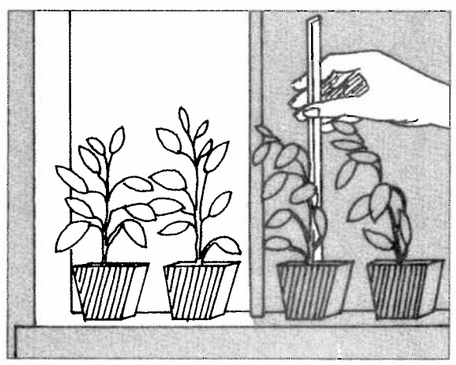


Figure H

7. _____

8. _____

MATCHING

Match each term in Column A with its description in Column B. Write the correct letter in the space provided.

	Column A	Column B
_____	**1.** analyze	**a)** explains the data
_____	**2.** scientific method	**b)** suggested solution
_____	**3.** conclusion	**c)** test the hypothesis
_____	**4.** hypothesis	**d)** guide for solving problems
_____	**5.** experiment	**e)** figure out the meaning

USING YOUR IMAGINATION AND SCIENTIFIC REASONING

Two separate stories are shown in the figures below. However, the figures in each are not in the proper order (sequence). In the table under each set of figures, list the figures in their proper order. Also, explain what is happening in each figure. Finally, write a hypothesis (in question form) and a conclusion.

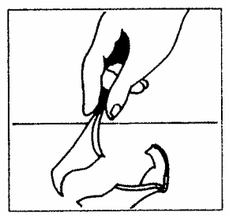


Figure I

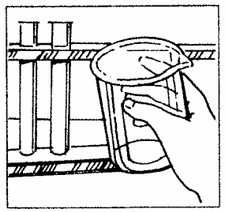


Figure J

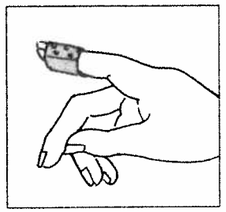


Figure K

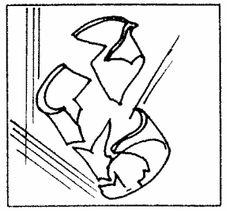


Figure L

Step	Figure	Explanation
1.		
2.		
3.		
4.		

Hypothesis: _____

Conclusion: _____

Figure M

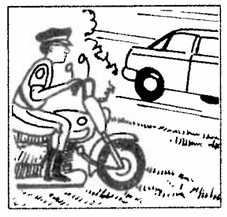


Figure N

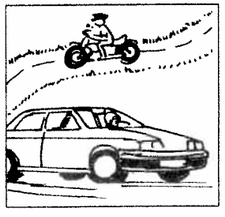


Figure O

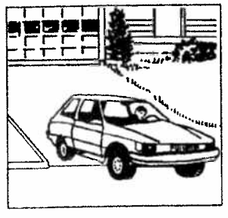


Figure P

Step	Figure	Explanation
1.		
2.		
3.		
4.		

Hypothesis: _____

Conclusion: _____

FILL IN THE BLANK

Complete each statement using a term or terms from the list below. Write your answers in the spaces provided.

supports	observe	different
problems	question	already known
data	scientific method	senses
steps		

1. To test a hypothesis, scientists may _____ natural events.
2. When scientists research, they may find out what is _____ about a problem.
3. Your _____ gather information.
4. A conclusion states whether or not data _____ a hypothesis.
5. A problem is usually stated as a _____ .
6. Scientists use certain _____ to solve problems.
7. You solve _____ much like scientists do.
8. Different problems can be solved in _____ ways.
9. A guide used to solve problems is called _____ .
10. Scientists use charts to put _____ in order.

REACHING OUT

Jennifer has never eaten asparagus. She is afraid that it might make her sick. At dinner, she eats some. She likes the taste, but soon she suffers from nausea. Jennifer concludes that asparagus makes her sick.

1. Why might Jennifer's conclusion be incorrect? _____

_____

_____

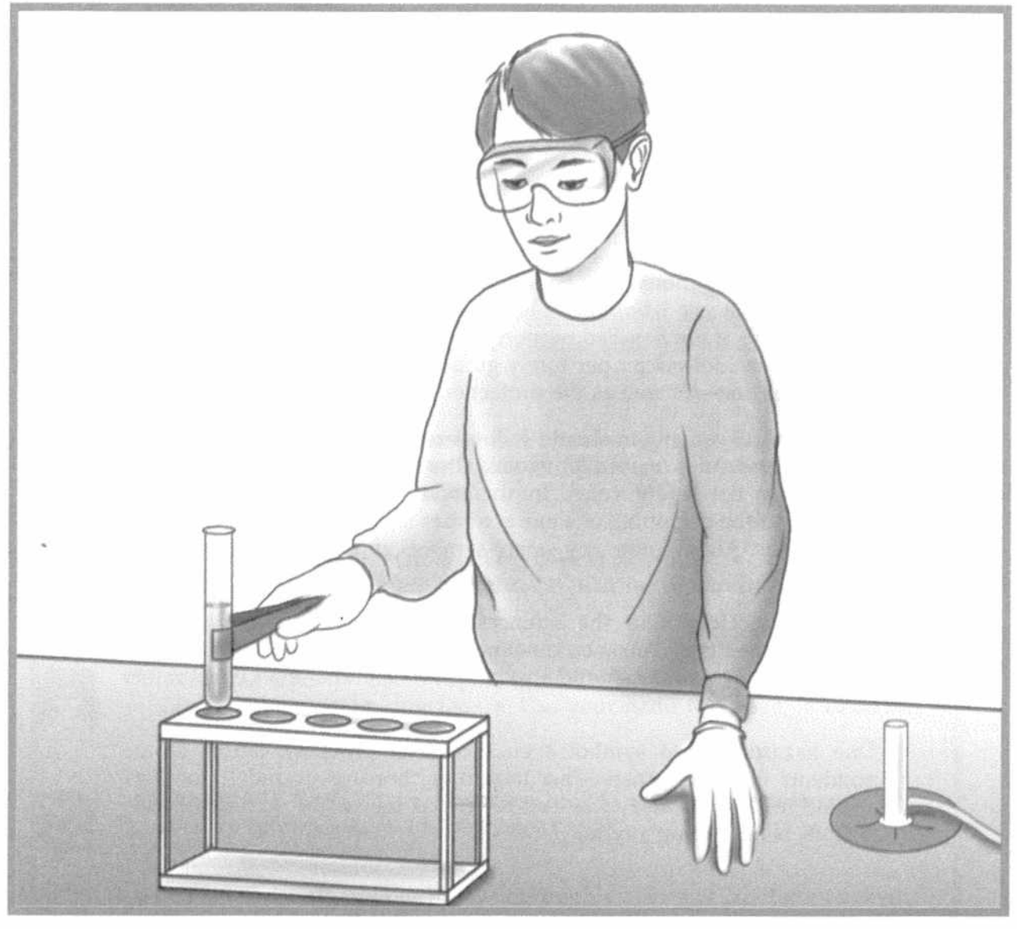
2. What might be done to further test her conclusion? _____

_____

_____

Lesson 3

How are experiments done safely?



KEY TERMS

safety alert symbols: signs that warn of hazards or dangers

caustic: able to burn and irritate the skin

LESSON 3 | How are experiments done safely?

"Hands-on" experiences are part of many school activities. Science, especially, is suited to "learning by doing." You investigate; you make things happen; you learn from what you do.

Science investigations can be exciting. However, they can also be dangerous. Science laboratories have equipment and materials that can be dangerous if not handled properly. For this reason, it is important for you to always follow proper safety guidelines. Safety rules are for your own protection—as well as the protection of everyone around you.

The safety rules that you should follow are listed on page 17. Read over these safety rules carefully. Notice the **safety alert symbols** that accompany the safety rules. In this book, safety alert symbols are included at the beginning of some activities to make you aware of safety precautions. Always note any safety symbols and caution statements in an activity.

To avoid accidents in the science laboratory, always follow your teacher's directions. You should not perform activities without directions from your teacher. You should also never work in the science laboratory alone.

One hazard has no symbol even though it probably causes more accidents than any others. That hazard is "horsing around." Horsing around in the laboratory can lead to serious injury—or even death. So THINK before doing anything foolish.

SAFETY ALERT SYMBOLS

CLOTHING PROTECTION • A lab coat protects clothing from stains. • Always confine loose clothing.

EYE SAFETY • Always wear safety goggles. • If anything gets in your eyes, flush them with plenty of water. • Be sure you know how to use the emergency wash system in the laboratory.

FIRE SAFETY • Never get closer to an open flame than is necessary. • Never reach across an open flame. • Confine loose clothing. • Tie back loose hair. • Know the location of the fire extinguisher and fire blanket. • Turn off gas valves when not in use. • Use proper procedures when lighting any burner.

POISON • Never touch, taste, or smell any unknown substance. Wait for your teacher's instructions.

CAUSTIC SUBSTANCES • Some chemicals can irritate and burn the skin. If a chemical spills on your skin, flush it with plenty of water. Notify your teacher without delay.

HEATING SAFETY • Handle hot objects with tongs or insulated gloves. • Put hot objects on a special lab surface or on a heat-resistant pad—never directly on a desk or table top.

SHARP OBJECTS • Handle sharp objects carefully. • Never point a sharp object at yourself—or anyone else. • Cut in the direction away from your body.

TOXIC VAPORS • Some vapors (gases) can injure the skin, eyes, and lungs. Never inhale vapors directly. • Use your hand to "wave" a small amount of vapor toward your nose.

GLASSWARE SAFETY • Never use broken or chipped glassware. • Never pick up broken glass with your bare hands.

CLEAN UP • Wash your hands thoroughly after any laboratory activity.

ELECTRICAL SAFETY • Never use an electrical appliance near water or on a wet surface. • Do not use wires if the wire covering seems worn. • Never handle electrical equipment with wet hands.

DISPOSAL • Discard all materials properly according to your teacher's directions.

PUTTING SAFETY RULES TO USE

Answer the following questions in complete sentences.

1. Jean has long hair. What should she do before working near an open flame? _____

2. A glass tube has broken. How should you pick up the pieces? _____

3. Why should you always wear safety goggles during every lab activity? _____

4. What else should you wear? Why? _____

5. A chemical spills on your hand. You are pretty sure that it is harmless. But you are not certain. What should you do? _____

IDENTIFYING SAFETY ALERT SYMBOLS

Six safety alert symbols are shown below. Match them with their meanings. Write the correct letter next to each description.

a. b. c. d. e. f.

_____ **1.** electrical safety

_____ **2.** fire safety

_____ **3.** heating safety

_____ **4.** clothing protection

_____ **5.** sharp objects

_____ **6.** glassware safety

REACHING OUT

In the box at the right, design a NO HORSING AROUND symbol. Either draw it or describe it, or both. Perhaps you can think up more than one.

Lesson 4

Is it matter or energy?

KEY TERMS

energy: ability to do work; ability to make things move

matter: anything that has mass and takes up space

property: characteristic; used to describe a substance

characteristic: distinguishing trait, feature, or quality; property