Chapter Quiz

Write your answers on a separate sheet of paper.

1. What makes up the universe?
2. Why must scientists use special instruments to study atoms?
3. What is the process of discovery?
4. How do scientists discover new facts?
5. What are three examples of technology in your home?
6. How does technology help people?
7. What do life scientists study?
8. What do physical scientists study?
9. What are two careers in science?
10. Why is it helpful to know about science?

Test Tip
Make sure you understand what each test question is asking. Read a question twice before you answer it.

Research Project

Do research and write a report on a science-related career. You might gather information by using books from the library and using the Internet. You can also set up interviews. The report should describe the career and tell the skills that a person needs to do the job. Also include the amount of education or training needed. Tell about how much the job pays.

Chapter 2 The Process of Discovery

Scientists study practically everything, from rocks to the human body. Can you think of anything that scientists do not study?

Learning Objectives

- Explain the five steps of the scientific method.
- Identify metric units of length, volume, and weight.
- Describe equipment used in a science laboratory.
- Discuss safety rules for work in the laboratory.
- LAB ACTIVITY: Measure the length and volume of objects.
- ON-THE-JOB SCIENCE: Explore the duties of a medical lab technician.

Words to Know

procedure	a plan that is used to complete a task
scientific method	a step-by-step procedure that scientists use to do experiments and make new discoveries
hypothesis	a possible answer to a problem
measurement	the size or the amount of something
unit	an amount that is used by everyone when measuring a particular thing
metric unit	a unit of measurement that is based on the number ten and multiples of ten
meter	the basic metric unit of length
area	the number of square units that is needed to cover a surface
volume	the number of cubic units that is needed to fill a space
liter	a metric unit used to measure volume of a liquid or gas
mass	the amount of matter in something
gram	the basic metric unit of mass
laboratory	a place with equipment that people use to do science
microscope	an instrument used to study very small objects; it makes them appear much larger

2-1 The Scientific Method

Words to Know

procedure	a plan that is used to complete a task
scientific method	a step-by-step procedure that scientists use to do experiments and make new discoveries
hypothesis	a possible answer to a problem

The Five Steps

In ancient times, people thought the sun was a god. Somehow they knew that without the sun's light and heat, life on Earth would be impossible. Today we know that the sun is a star. We also know that stars are big, hot balls of glowing gas. We know these things from the work of scientists.

Remember
The process of discovery includes observing, testing, and drawing conclusions.

Scientists have used the process of discovery to learn about stars. They learned that the sun is about 93 million miles (about 150 million kilometers) away. They also found out that the sun is not a very special star. Its size and temperature are about average.

Scientists use a step-by-step **procedure** to do experiments and make new discoveries. A procedure is a plan that is used to complete a task. This step-by-step procedure is often called the **scientific method.** As you saw earlier, it is also called the science process.

The scientific method has five steps. Each step is listed below and explained on the next page.

1. Describe the problem.
2. Gather information.
3. Suggest an answer.
4. Perform experiments.
5. Draw conclusions and report the results.

1. Describe the problem.

There are many, many problems that can be studied in science, from the common cold to exploding stars.

2. Gather information.

Suppose a scientist wants to find a cure for the common cold. He or she might read books and articles on colds, talk to other scientists, and use the Internet to do research.

3. Suggest an answer.

After doing research, the scientist suggests a **hypothesis,** which is a possible answer to the problem. For example, the scientist might suggest that vitamin C will cure the common cold.

4. Perform experiments.

Now, the scientist must set up an experiment to test the hypothesis. To test the effect of vitamin C, he or she might use twenty people with colds. Ten will be given vitamin C. Ten will be given nothing. Then the scientist observes the people for a certain length of time. This test may be repeated several times. Later, other scientists might repeat the test to see if they get the same results.

5. Draw conclusions and report the results.

Finally, the scientist draws conclusions and writes up the results of the tests that were performed. Charts or graphs may be used to report the results.

✓ **What are the five steps of the scientific method?**

Science Fact

Scientists can test how changes in conditions affect an experiment. These changes are called *variables*. To test only certain variables, a *control* group can be set up. For the control group, these variables do not change. Scientists can then compare results of the actual experiment with results from the control group.

Science Fact

Scientists have to make *inferences* from what they observe in an experiment. An inference is how you explain what you observe. Inferences help scientists draw their conclusions.

Continuing the Process

Usually, the results of one experiment lead to another experiment. In the common-cold experiment, ten people were given vitamin C. Most of them got over their colds more quickly than usual. However, some did not get well faster. The scientist now wants to know why taking vitamin C does not work every time.

The scientist repeats the experiment. This time, he or she pays special attention to those people who take vitamin C but do not get better faster. The scientist notices that these people do not sleep much during the experiment. The scientist then performs another experiment to test how sleep affects the common cold.

Figuring out cause and effect is an important part of the scientific method. So are observation, testing, and continuing the process of questioning. There is always more to explore.

✓ **Why does one experiment often lead to another?**

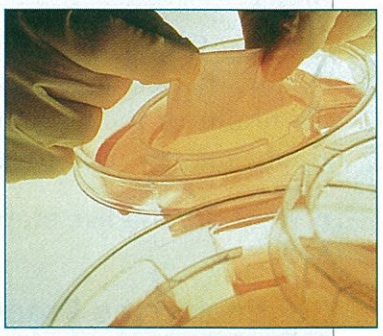
Lesson Review

1. What is the scientific method used for?
2. What step follows making a hypothesis?
3. **CRITICAL THINKING** Why is it important that scientists gather information about a problem?

On the Cutting Edge

ARTIFICIAL SKIN

Scientists use the scientific method to solve problems. One problem they faced was how to help burn victims. People who get severe burns may need *skin grafts*. A skin graft is a piece of healthy skin that is taken from a person's body and used to cover that person's damaged skin. The grafted skin grows with the healthy skin. However, sometimes the burned area is too large for a graft to work. So scientists made artificial skin.



Artificial skin is grown in a dish in a laboratory.

Some artificial skin is made of a protein and human skin cells. When the artificial skin is placed on a wound, it helps the real skin around the wound to grow. Eventually, healthy skin covers the wound, and the artificial skin disappears.

CRITICAL THINKING How is artificial skin better than a skin graft?

2-2 Measuring in Science

Words to Know

measurement	the size or the amount of something
unit	an amount that is used by everyone when measuring a particular thing
metric unit	a unit of measurement that is based on the number ten and multiples of ten
meter	the basic metric unit of length
area	the number of square units that is needed to cover a surface
volume	the number of cubic units that is needed to fill a space
liter	a metric unit used to measure volume of a liquid or gas
mass	the amount of matter in something
gram	the basic metric unit of mass

Measurement

Remember
Experiments help scientists to discover new facts.

You need certain skills to perform science experiments. A very important skill is figuring out how big something is or how much it weighs.

Measurement is used to express the size or the amount of something. Your height and weight are measurements of how much of you there is.

A **unit** is an amount that is used by everyone when measuring a particular thing. For example, when people in the United States drive cars, they measure distance in miles. A mile is a unit.

In most countries, however, people do not measure distance in miles. They do not use feet and inches to measure height. They do not use pounds and ounces to measure weight.

Some road signs give speed limits in both miles and kilometers.

Most people in the world use the metric system to measure things. Each **metric unit** is based on the number ten and multiples of ten, such as 100 and 1,000. Scientists all over the world use metric units. This makes it easier for them to share scientific information, even if they speak different languages.

✓ **What are metric units based on?**

Unit of Length

The basic metric unit of length is called a **meter.** It equals 39.4 inches. Most adults are about 1.5 to 2 meters tall.

You know from using money that the word *cent* means $\frac{1}{100}$. A centimeter is $\frac{1}{100}$ of a meter. The prefix *milli-* means $\frac{1}{1,000}$. A millimeter is $\frac{1}{1,000}$ of a meter.

The prefix *kilo-* means 1,000. A kilometer is 1,000 meters. A kilometer is a little more than half a mile.

✓ **What is the basic metric unit of length?**

Units of Area and Volume

Area is the number of square units that is needed to cover a surface. This page is about 440 square centimeters, or 68 square inches, in area. The area of the Earth's surface is about 510 million square kilometers. That is about 197 million square miles.

Volume is the number of cubic units that is needed to fill a space. This book is about 870 cubic centimeters, or 53 cubic inches. The **liter** is a metric unit that is used to measure the volume of a liquid or gas. It is a little more than a quart.

Often, scientists work with very small amounts of liquids. They use milliliters to measure small volumes. A milliliter is $\frac{1}{1,000}$ of a liter.

✓ **What metric units are used to measure area and volume?**

Science Fact

To find the area of something, multiply length × width.

To find the volume of a solid, multiply length × width × height.

To find the volume of a liquid, measure using liters.

Unit of Mass

Mass is the amount of matter in something. An object with more mass is heavier, or weighs more, than an object with less mass. For example, a car has more mass than a bike. The basic metric unit of mass is a **gram.** There are about 28 grams in 1 ounce. A kilogram is equal to 1,000 grams, or about 2.2 pounds. One metric ton is equal to 1,000 kilograms, or about 2,200 pounds.

✓ **What metric unit is used to measure mass?**

Units of Temperature and Time

Most people in the United States use the *Fahrenheit* scale to measure degrees of temperature. However, scientists and most people in the world use the metric unit for temperature, which is degrees *Celsius*.

The metric unit of time is the second. You know that 60 seconds make 1 minute and 60 minutes make 1 hour.

✓ **What are the metric units for temperature and for time?**

Getting a Feel for Metric Measurements

Here are some measurements that may help you become more comfortable using metric units:

- A dime is about one millimeter thick.
- Five city blocks are about one kilometer long.
- The button on a push-button telephone is about one square centimeter in area.
- A little less than three cans of soft drink equal one liter.
- One book from an encyclopedia set weighs about one kilogram.
- Room temperature is about 20 degrees Celsius.

✓ **How can you get more comfortable using metric measurements?**

Science Fact

Most people in the United States use the English system of measurement. This system includes units such as the inch and pound. It was developed in England hundreds of years ago. Today, however, England uses the metric system.

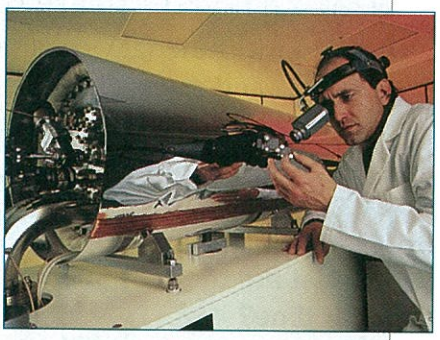
Lesson Review

1. What do measurements tell us?
2. What are meters, liters, and grams?
3. What do the prefixes *centi-*, *milli-*, and *kilo-* mean?
4. **CRITICAL THINKING** Why would you not measure the thickness of a dime in kilometers?

A Closer Look

THE ATOMIC CLOCK

The clocks and watches that most people use are not always correct, or accurate. Batteries run down. Parts wear out. Even changes in temperature may affect their accuracy. So scientists made a clock that does not use batteries. It is not affected by temperature, either. This clock is an atomic clock.



This atomic clock is from the National Institute of Standards and Technology. The long cylinder is the clock.

An atomic clock uses atoms to measure time. It does so by measuring the motion of a certain kind of atom. The speed of an atom's motion changes very little over time. For that reason, an atomic clock may gain or lose only one second of time every million years! Since 1958, scientists have used atomic clocks to measure time.

Today, people can buy wristwatches that are almost as accurate as atomic clocks. These wristwatches receive radio signals from an atomic clock. Radio signals are invisible waves that travel through space. Every day at the same time, the watches reset themselves when they receive the signals.

CRITICAL THINKING Why do scientists use atomic clocks?

2-3 Laboratory Science

Words to Know

laboratory	a place with equipment that people use to do science
microscope	an instrument used to study very small objects; it makes them appear much larger

What Is a Laboratory?

Scientists usually work in a **laboratory**, often just called a lab. A laboratory is a place with equipment that people use to do science. Much of the equipment is for doing experiments, making observations, and taking measurements. For some people, a laboratory is a small room in a hospital. It could also be a tent in the rain forest or even a submarine in the ocean.

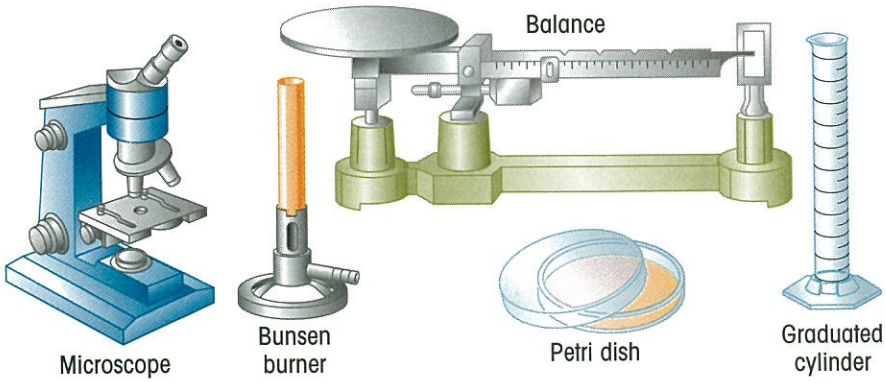


Figure 2-1 *Scientists often use this equipment in laboratories.*

Laboratory equipment includes test tubes, chemicals, and instruments, such as a **microscope.** A microscope is used to study objects that are very small. The microscope makes the objects appear much larger than they are.

✓ **How are laboratories used?**

Safety in the Laboratory

Scientists must be very careful while working in a laboratory. For example, working with fire and certain chemicals can be dangerous.

Here are ten important safety rules you should follow when working in a laboratory.

Safety Rules

1. Read all instructions carefully before beginning an experiment. Look at the list of equipment. Be sure you have everything you need.
2. Keep a very clean work area. Do not have anything out that you do not need for the experiment.
3. Always make sure your equipment is in good condition. Never use chipped glass or torn electrical cords.
4. Know how to put out fires and where to find clean, running water.
5. Never taste or touch any substance in the lab unless told to do so by your teacher or book. Do not chew gum or eat or drink anything in the lab. Keep your hands away from your face.
6. Wear eye goggles whenever you are told to do so.
7. Wear a lab apron when working with chemicals to avoid damaging your clothes.
8. Be careful when working with sharp or pointed objects, such as scissors.
9. Follow all instructions exactly.
10. If an accident occurs, tell your teacher immediately.

Why is it important to follow safety rules in a laboratory?

Safety Alert

Before you begin work in a lab, look for possible dangers and prepare for them. Make sure there is running water and a first-aid kit nearby. Locate a fire extinguisher and fire exit. Post the phone number of a poison control center and nearby hospital. Tell an adult what you are doing. When you are done in the lab, put away all chemicals and lab tools.

Lesson Review

1. What are some kinds of equipment you might find in a lab?
2. How can you protect yourself from fires in a lab?
3. **CRITICAL THINKING** Why is it important not to eat or taste anything while working in a lab?

Great Moments in Science

A LUCKY MISTAKE

In 1928, the British scientist Sir Alexander Fleming was studying tiny living things called *bacteria.* He grew the bacteria in small laboratory dishes. Some bacteria are harmful to people and cause disease. Fleming wanted to discover a way to fight these bacteria.

One day, Fleming made a mistake in the laboratory. He set aside a dish containing bacteria and forgot to throw it away. Some mold grew on the dish. Later, Fleming went to throw the dish away. However, something made him stop and look at the mold more closely. He noticed that no bacteria grew near the mold. The mold was killing the bacteria!

Fleming's Penicillium mold is the large white blob on top. It prevented the spots of bacteria from growing near it.

The mold that Fleming observed is called *Penicillium*. It produces a chemical that kills bacteria. The chemical is called *penicillin*. Today, people use penicillin to fight many diseases that are caused by bacteria. Fleming's mistake led to his greatest discovery. It also showed how important it is to make careful observations and to keep asking questions.

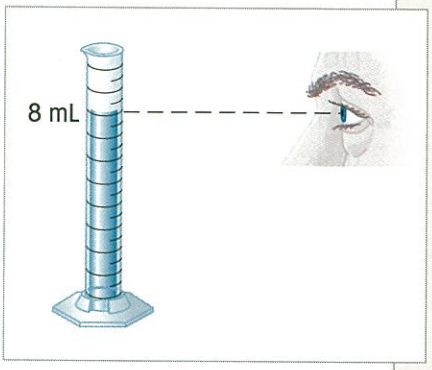
CRITICAL THINKING Why is it important to take careful notes about what happens during an experiment?

LAB ACTIVITY
Metric Measuring

BACKGROUND
Scientists often measure small amounts of things. They may need to measure lengths in millimeters. They may use milliliters for measuring small volumes of liquids.

PURPOSE
You will use a graduated cylinder and a ruler to see the importance of making accurate measurements.

MATERIALS
paper, pencil, metric ruler, book, graduated cylinder, paper cup half filled with water



To measure volume using a graduated cylinder, check what line the water comes to.

WHAT TO DO
1. Copy the chart to record the length of a book and the volume of water in a cylinder.
2. Work in groups of three. Take turns using the ruler to measure the length of the same side of a book in millimeters. Record your measurement. Be sure to include the units.
3. Choose one group member to pour the water from the cup into the graduated cylinder. Record the milliliter line that lines up with the bottom of the water's curve in the cylinder. (See the drawing.) Pour the water back into the cup.
4. Repeat Step 3 two more times so that each group member has a chance to measure the water's volume.

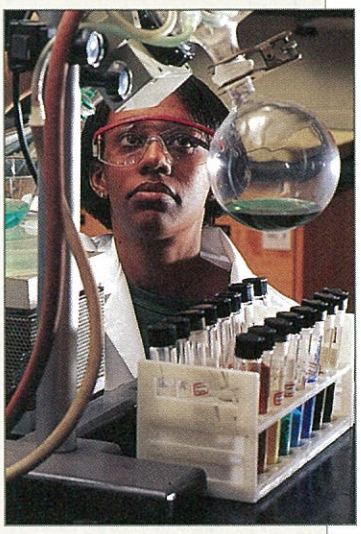
Object	Measurement
Book	
Water	

DRAW CONCLUSIONS
- Compare the measurements that your group members made. Were any of the measurements different? If so, what might have caused the measurements to be different?
- Why is it a good idea to make more than one measurement of an object?

ON-THE-JOB SCIENCE
Medical Lab Technician

Alice is a medical lab technician. She works in a hospital laboratory. Alice uses different kinds of lab equipment to perform tests. She uses chemicals, test tubes, microscopes, and other kinds of instruments.

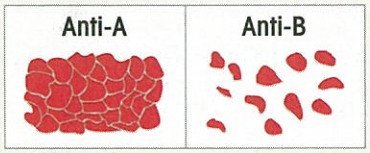
Alice tests the blood and urine of patients. One of the blood tests that Alice performs is called *blood typing*. Every person has one of these types of blood: Type A, Type B, Type AB, or Type O. To find out a person's blood type, Alice mixes a drop of the person's blood with two chemicals called *anti-A serum* and *anti-B serum*. Depending on its type, the blood either clumps or does not clump with each serum. The chart below shows what happens when each type of blood is mixed with each serum.



A medical lab technician performs many kinds of tests.

Look at the microscope slide below.

The slide shows two drops of a person's blood that have been mixed with anti-A serum and anti-B serum.



Clumping *No clumping*

Blood Type	Anti-A Serum	Anti-B Serum
A	Clumping	No clumping
B	No clumping	Clumping
AB	Clumping	Clumping
O	No clumping	No clumping

Critical Thinking

What qualities might a person need in order to be a good medical lab technician?

1. What blood type does the person have?

2. How do you know?

Chapter

2 Review

Summary

Scientists use the scientific method to make new discoveries. This process includes making measurements. Scientists use equipment in labs to gather information.

Lesson 2.1

The five steps in the scientific method are: describing what the problem is, gathering information, suggesting a hypothesis, performing experiments, and drawing conclusions and reporting the results.

Lesson 2.2

Measurement is used to express the size or the amount of something. Most people in the world, and all scientists, use metric units of measurement.

Lesson 2.3

Safety in the laboratory is very important. Always read all the instructions before beginning an experiment. Follow safety rules.

Vocabulary Review

scientific method
volume
procedure
area
meter
liter
gram
microscope

Complete each sentence with a term from the list.

1. The basic metric unit of length is the ____.
2. Scientists use the five steps of the ____ to make new discoveries.
3. A ____ is equal to about one quart.
4. The ____ of an object is the number of square units needed to cover its surface.
5. A ____ is the metric unit that is used to tell how much something weighs.
6. The number of cubic units needed to fill a space is its ____.
7. The scientific method is a step-by-step ____.
8. Scientists use a ____ to look at very small objects.

Chapter Quiz

Write your answers on a separate sheet of paper.

1. What procedure do scientists use to make new discoveries?
2. What are two ways that scientists gather information?
3. Why do scientists perform experiments after suggesting an answer to a problem?
4. Why do all scientists use metric units?
5. How many times larger is a centimeter than a millimeter?
6. How many meters are in a kilometer?
7. What fraction of a gram is a milligram?
8. What equipment would you expect to find in a laboratory?
9. Before beginning an experiment, what should you do with the instructions you have been given?
10. What should you do if an accident occurs in the school laboratory?

Test Tip
Reread your answer to a question before going on to the next question. You may find a way to improve your answer.

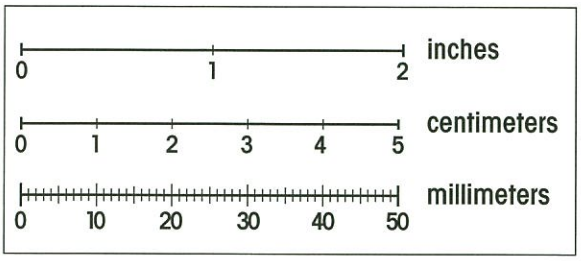
Research Project

Research the Celsius scale. You can find information on the Internet at *http://lamar.colostate.edu/~hillger/temps.htm*. Make a chart that compares Celsius temperatures with Fahrenheit temperatures. Then use your chart to give that day's temperature in your area in degrees Celsius and Fahrenheit. Finally, find out the average temperature in the Arctic and near the equator in degrees Celsius and Fahrenheit. Include this information in your chart.

Unit 1 Review

Choose the letter for the correct answer to each question.

Use the diagram to answer Questions 1 to 3.



1. An inch is equal to about how many centimeters?

- **A.** 1
- **B.** 2.5
- **C.** 20.5
- **D.** 4

2. How many millimeters make up one centimeter?

- **A.** 2.5
- **B.** 10
- **C.** 100
- **D.** 1,000

3. About how many millimeters make up one inch?

- **A.** 25
- **B.** 2.5
- **C.** 10
- **D.** 1,000

4. What are the two parts of science?

- **A.** earth science and life science
- **B.** research and technology
- **C.** experimenting and recording results
- **D.** facts and the process of discovery

5. What is physical science mostly the study of

- **A.** plants and animals
- **B.** rocks and chemicals
- **C.** weather and climate
- **D.** matter and energy

6. Which of the following is not a step of the scientific method?

- **A.** Perform experiments.
- **B.** Describe the problem.
- **C.** Study in the lab.
- **D.** Suggest an answer.

7. Which of the following is an example of technology?

- **A.** an atom
- **B.** a star
- **C.** a television
- **D.** the weather

Critical Thinking

Why is it important to check all equipment before beginning an experiment?