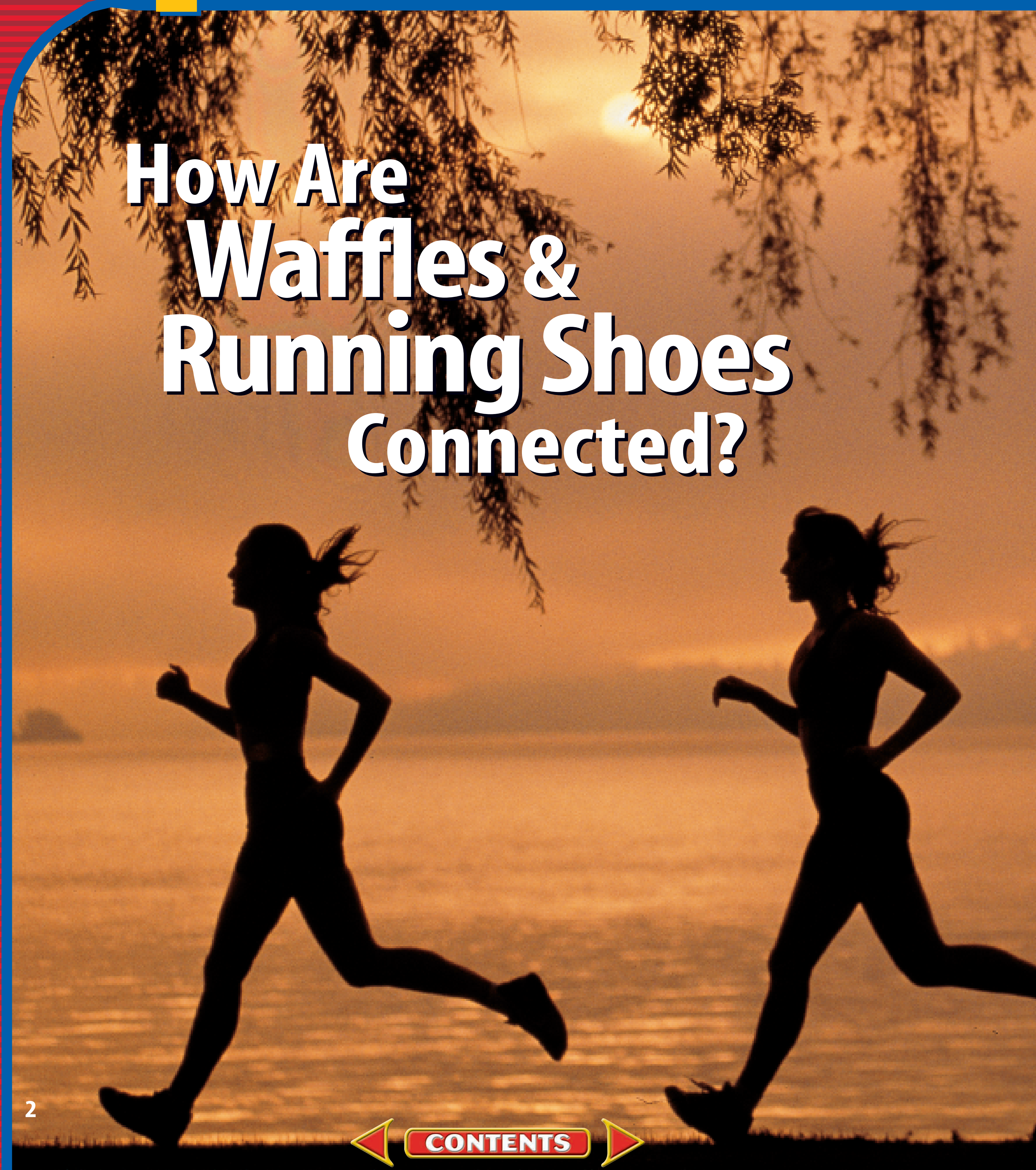
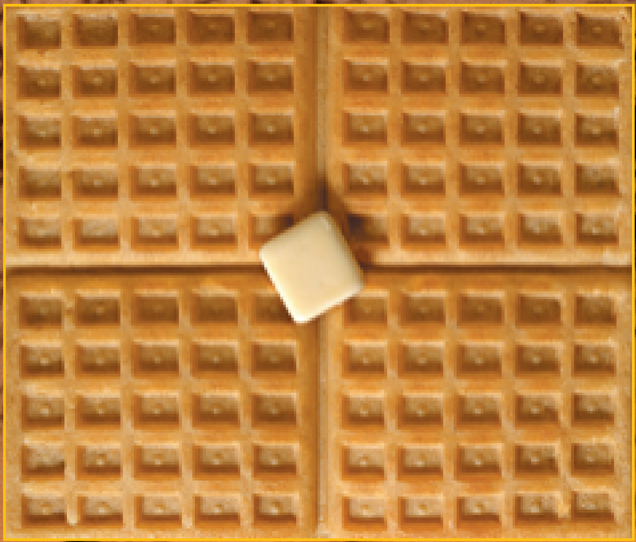
Energy and Motion

How Are Waffles & Running Shoes Connected?





For centuries, shoes were made mostly of leather, cloth, or wood. These shoes helped protect feet, but they didn't provide much traction on slippery surfaces. In the early twentieth century, manufacturers began putting rubber on the bottom of canvas shoes, creating the first "sneakers." Sneakers provided good traction, but the rubber soles could be heavy—especially for athletes. One morning in the 1970s, an athletic coach stared into the waffles on the breakfast table and had an idea for a rubber sole that would be lighter in weight but would still provide traction. That's how the first waffle soles were born. Waffle soles soon became a world standard for running shoes.

SCIENCE CONNECTION

FRICTION Waffle soles improve traction by increasing friction—the force that opposes motion between two surfaces. At school or in a bicycle shop, examine and sketch the treads on different kinds of bicycle tires. Draw conclusions about how each type of tread increases or decreases friction between the tire and the ground. Then create a poster showing three different tire treads with an explanation about how each type of tread might suit a tire to particular riding conditions.

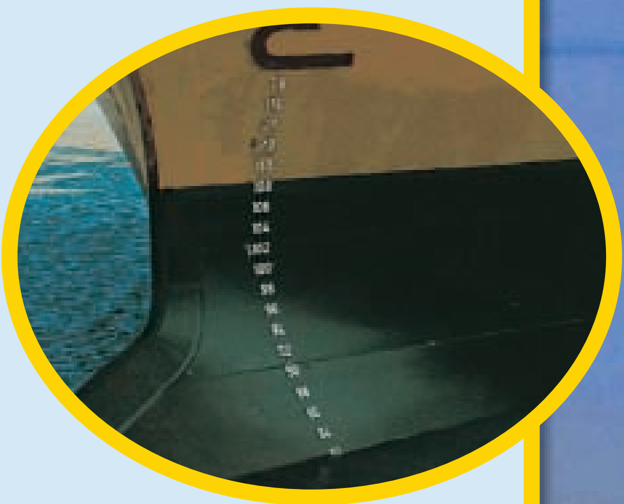
CHAPTER 1

The Nature of Science

Stacy Dragila of the United States won the women's pole vault event at the 2000 summer Olympics. The winner was decided through careful measurement of the jumps. In this chapter, you will learn how measurements are important to scientists. You also will learn about the methods scientists use to conduct their studies and how they communicate findings with graphs.

What do you think?

Science Journal Look at the picture below with a classmate. Discuss what this might be. Here's a hint: *Shipping authorities rely on these numbers for safety reasons.* Write your answer or best guess in your Science Journal.



Explore Activity

During a track meet, one athlete ran 1 mile in 5 min and another athlete ran 5,000 m in 280 s. The two runners used different units to describe their races, so how can you compare them? Do the following activity to explore how choosing different units can make it difficult to compare measurements.

Discover how long a foot is

1. Measure the distance across your classroom using your foot as a measuring device.
2. Record your measurement and name your measuring unit.
3. Now, have your partner measure the same distance using his or her foot as the measuring device. Record this measurement and make up a different name for the unit.

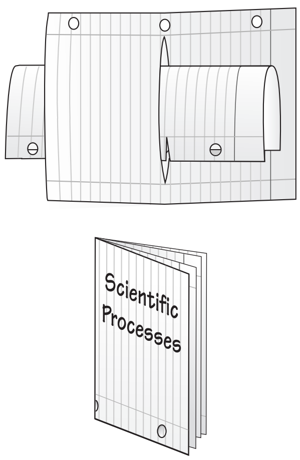
Observe

In your Science Journal, explain why you think it might be important to have standard, well-defined units to make measurements.

Before You Read

Foldables Reading & Study Skills

Making a Question Study Fold **Asking yourself questions helps you stay focused and better understand scientific processes when you are reading the chapter.**



1. Stack two sheets of notebook paper in front of you so the long sides are at the top. Fold both in half from the left side to the right side. Unfold and separate.
2. Cut one sheet along the fold line, from one margin line to the other.
3. Place the second sheet in front of you so the long side is at the top. Cut along the fold line from the bottom of the paper to the margin line and then from the top of the paper to the margin line.
4. Insert the second sheet of paper into the cut of the first paper. Unfold it and align the cuts along the folds.
5. Title your book *Scientific Processes.* Before you read the chapter, write a question about something in your daily life on each page.

SECTION 1

The Methods of Science

As You Read

What You'll Learn

- **Identify** the steps scientists often use to solve problems.
- **Describe** why scientists use variables.
- **Compare and contrast** science and technology.

Vocabulary

scientific method
hypothesis
experiment
variable
dependent variable
independent variable
constant
control
bias
model
theory
scientific law
technology

Why It's Important

Using scientific methods will help you solve problems.

What is science?

Science is not just a subject in school. It is a method for studying the natural world. After all, science comes from the Latin word *scientia*, which means "knowledge." Science is a process that uses observation and investigation to gain knowledge about events in nature.

Nature follows a set of rules. Many rules, such as those concerning how the human body works, are complex. Other rules, such as the fact that Earth rotates about once every 24 h, are simpler. When you study these natural patterns, you are using science.

Major Categories of Science Science covers many different topics that can be classified according to three main categories. (1) Life science deals with living things. (2) Earth science investigates Earth and space. (3) Physical science deals with matter and energy. In this textbook, you will study mainly physical science. Sometimes, though, a scientific study will overlap the categories. One scientist, for example, might study the motions of the human body to understand how to build better artificial limbs. Is this scientist studying energy and matter or how muscles operate? She is studying both life science and physical science. It is not always clear what kind of science you are using, as shown in **Figure 1.**

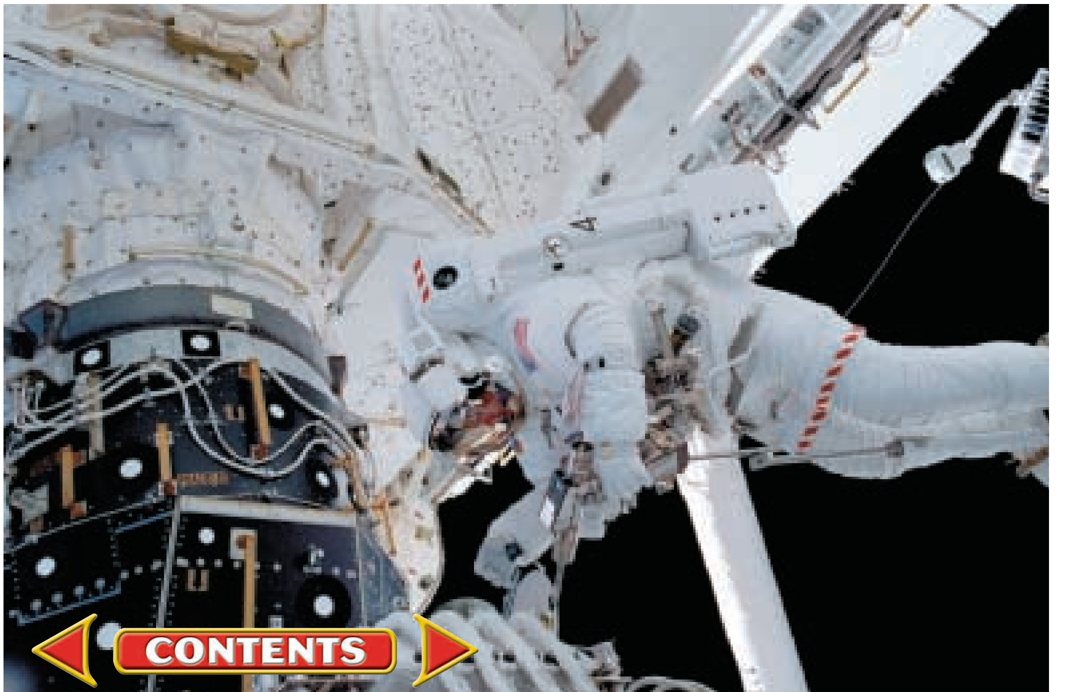


Figure 1
Astronaut Michael Lopez-Alegria uses a pistol grip tool on the *International Space Station.* *What evidence do you see of the three main branches of science in the photograph?*

Science Explains Nature Scientific explanations help you understand the natural world. Sometimes these explanations must be modified. As more is learned about the natural world, some of the earlier explanations might be found to be incomplete or new technology might provide more accurate answers.

For example, look at **Figure 2.** In the late eighteenth century, most scientists thought that heat was an invisible fluid with no mass. Heat seems to flow like a fluid. It also moves away from a warm body in all directions, just as a fluid moves outward when you spill it on the floor.

However, the heat fluid idea did not explain everything. If heat were an actual fluid, an iron bar that had a temperature of 1,000°C should have more mass than it did at 100°C because it would have more of the heat fluid in it. The eighteenth-century scientists thought they just were not able to measure the small mass of the heat fluid on the balances they had. When additional investigations showed no difference in mass was detected, scientists had to change the explanation.

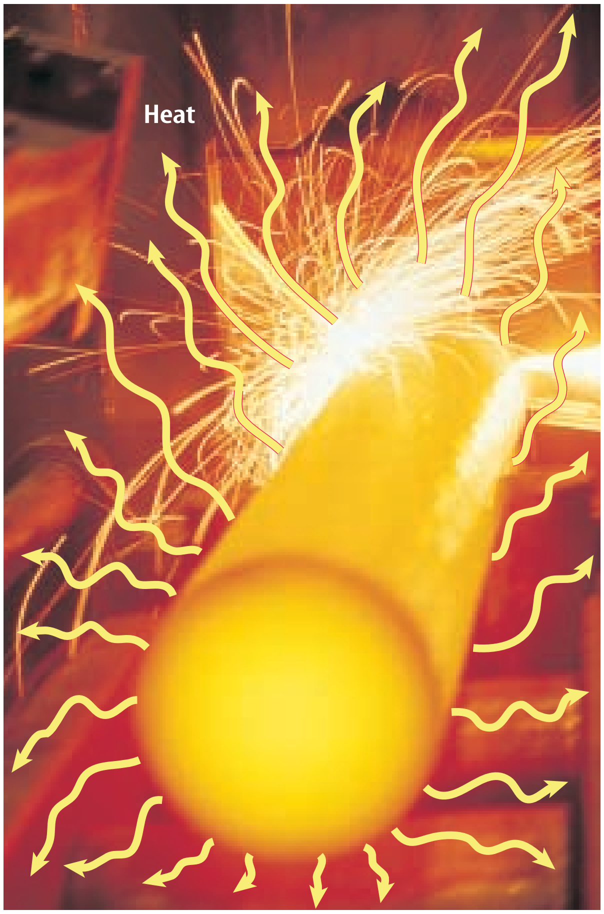


Figure 2
Many years ago, scientists thought that heat, such as in this metal rod, was a fluid. *How does heat act like a fluid?*

Investigations How do scientists learn more about the natural world? Scientists learn new information by performing investigations, which can be done many different ways. Some investigations involve simply observing something that occurs and recording the observations, perhaps in a journal. Other investigations involve setting up experiments that test the effect of one thing on another. Some investigations involve building a model that resembles something in the natural world and then testing the model to see how it acts. Often, a scientist will use something from all three ways when attempting to learn about the natural world.

✔ **Reading Check** *Why do scientific explanations change?*

Scientific Methods

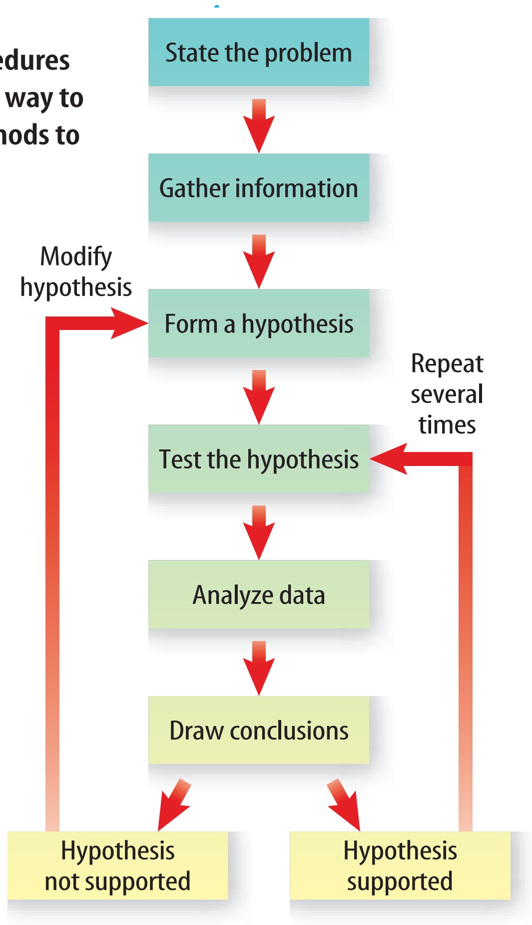
Although scientists do not always follow a rigid set of steps, investigations often follow a general pattern. An organized set of investigation procedures is called a **scientific method.** Six steps often found in scientific methods are shown in **Figure 3.** A scientist might add new steps, repeat some steps many times, or skip other steps altogether when doing an investigation.

CLICK HERE

SCIENCE Online

Research Visit the Glencoe Science Web site at **science.glencoe.com** for information about why leaves change color in the autumn. Make a prediction about why this occurs. Support your answer with evidence.

Figure 3
The series of procedures shown here is one way to use scientific methods to solve a problem.



Stating a Problem Many scientific investigations begin when someone observes that an event in nature repeats itself and wonders why this is true. Then the question of "why" is the problem. Sometimes a statement of a problem arises from an activity that is not working. Some early work on guided missiles showed that the instruments in the nose of the missiles did not always work. The problem statement involved finding a material to protect the instruments from the harsh conditions of flight.

Later, National Aeronautics and Space Administration (NASA) scientists made a similar problem statement. They wanted to build a new vehicle—the space shuttle—that could carry people to outer space and back again. Guided missiles did not have this capability. NASA needed to find a material for the outer skin of the space shuttle that could withstand the heat and forces of reentry into Earth's atmosphere.

Researching and Gathering Information Before testing a hypothesis, it is useful to learn as much as possible about the background of the problem. Have others found information that will help determine what tests to do and what tests will not be helpful? The NASA scientists gathered information about melting points and other properties of the various materials that might be used. In many cases, tests had to be performed to learn the properties of new, recently created materials.

Forming a Hypothesis A **hypothesis** is a possible explanation for a problem using what you know and what you observe. NASA scientists knew that a ceramic coating had been found to solve the guided missile problem. They hypothesized that a ceramic material also might work on the space shuttle.

Testing a Hypothesis Some hypotheses can be tested by making observations. Others can be tested by building a model and relating it to real-life situations. One common way to test a hypothesis is to perform an experiment. An **experiment** tests the effect of one thing on another using controlled conditions.

Variables An experiment usually contains at least two variables. A **variable** is a quantity that can have more than a single value. You might set up an experiment to determine which of three fertilizers helps plants to grow the biggest. Before you begin your tests, you would need to think of all the factors that might cause the plants to grow bigger. Possible factors include plant type, amount of sunlight, water used, room temperature, type of soil, and type of fertilizer.

In this experiment, the amount of growth is the **dependent variable** because its value changes according to the changes in the other variables. The variable you change to see how it will affect the dependent variable is called the **independent variable.**

Constants and Controls To be sure you are testing to see how fertilizer affects growth, you must keep the other possible factors the same for each test, or trial. A factor that does not change when other variables change is called a **constant.** You might set up four trials, using the same soil and type of plant. Each plant is given the same amount of sunlight and water and is kept at the same temperature. These are constants. Three of the plants receive a different type of fertilizer. Fertilizer is the independent variable.

The fourth plant is not fertilized. This plant is a control. A **control** is the standard by which the test results can be compared. Suppose that after several days, the three fertilized plants grow between 2 and 3 cm. If the unfertilized plant grows 1.5 cm, you might infer that the growth of the fertilized plants was due to the fertilizers.

How might the NASA scientists set up an experiment to solve the problem of the damaged tiles shown in **Figure 4?** What are possible variables, constants, and controls?

Reading Check *Why is a control used in an experiment?*

Life Science INTEGRATION

Through observations of living organisms, scientists have designed a classification system. The system groups organisms according to variables such as habits and physical and chemical features. As new organisms are discovered, scientific methods are used to determine their classification.

Figure 4
NASA has had an ongoing mission to improve the space shuttle. A technician is replacing tiles damaged upon reentry into Earth's atmosphere.

Figure 5
An exciting and important part of investigating something is sharing your ideas with others, as this student is doing at a science fair.

Analyzing the Data A part of an experiment includes recording observations and organizing the test data into easy-to-read tables and graphs. Later in this chapter you will study ways to display data. When you are making and recording observations, you should include all results, even unexpected ones. Many important discoveries have been made from unexpected occurrences.

Interpreting the data and analyzing the observations is an important step. If the data are not organized in a logical manner, wrong conclusions can be drawn. No matter how well a scientist communicates and shares that data, someone else might not agree with the data. Scientists share their data through reports and conferences. In **Figure 5** a student is displaying her data.

Drawing Conclusions Based on the analysis of your data, you decide whether or not your hypothesis is supported. When lives are at stake, such as with the space shuttle, you must be very sure of your results. For the hypothesis to be considered valid and widely accepted, the experiment must result in the exact same data every time it is repeated. If your experiment does not support your hypothesis, you must reconsider the hypothesis. Perhaps it needs to be revised or your experiment needs to be conducted differently.

Being Objective Scientists also should be careful to reduce bias in their experiments. A **bias** occurs when what the scientist expects changes how the results are viewed. This expectation might cause a scientist to select a result from one trial over those from other trials. Bias also might be found if the advantages of a product being tested are used in a promotion and the drawbacks are not presented.

Scientists can lessen bias by running as many trials as possible and by keeping accurate notes of each observation made. Valid experiments also must have data that are measurable. For example, a scientist performing a global warming study must base his or her data on accurate measures of global temperature. This allows others to compare the results to data they obtain from a similar experiment. Most importantly, the experiment must be repeatable. Findings are supportable when other scientists perform the same experiment and get the same results.

Reading Check *What is bias in science?*

Visualizing with Models

Sometimes, scientists cannot see everything that they are testing. They might be observing something that is too large, too small, or takes too much time to see completely. In these cases, scientists use models. A **model** represents an idea, event, or object to help people better understand it.

Models in History Models have been used throughout history. One scientist, Lord Kelvin, who lived in England in the 1800s, was famous for making models. To model his idea of how light moves through space, he put balls into a bowl of jelly and encouraged people to move the balls around with their hands. Kelvin's work to explain the nature of temperature and heat still is used today.

High-Tech Models Scientific models don't always have to be something you can touch. Today, many scientists use computers to build models. NASA experiments involving space flight would not be practical without computers. The complex equations would take far too long to calculate by hand, and errors could be introduced much too easily.

Another type of model is a simulator, like the one shown in **Figure 6.** An airplane simulator enables pilots to practice problem solving with various situations and conditions they might encounter when in the air. This model will react the way a plane does when it flies. It gives pilots a safe way to test different reactions and to practice certain procedures before they fly a real plane.

Earth Science INTEGRATION

Meteorology has changed greatly due to computer modeling. Using special computer programs, meteorologists now are able to more accurately predict disastrous weather. In your Science Journal, describe how computer models might help save lives.

Figure 6
Pilots and astronauts use flight simulators for training. *How do these models differ from actual airplanes and spacecraft?*

SCIENCE Online

Research Visit the Glencoe Science Web site at **science.glencoe.com** to find out about Archimedes' principle. Would you classify this principle as a scientific theory or scientific law? Communicate to your class what you learn.

CLICK HERE

Scientific Theories and Laws

A scientific **theory** is an explanation of things or events based on knowledge gained from many observations and investigations. It is not a guess. If scientists repeat an investigation and the results always support the hypothesis, the hypothesis can be called a theory. Just because a scientific theory has data supporting it does not mean it will never change. Recall that the theory about heat being a fluid was discarded after further experiments. A theory accepted today might at some time in the future also be discarded.

A **scientific law** is a statement about what happens in nature and that seems to be true all the time. Laws tell you what will happen under certain conditions, but they don't explain why or how something happens. Gravity is an example of a scientific law. The law of gravity says that any one mass will attract another mass. To date, no experiments have been performed that disprove the law of gravity.

A theory can be used to explain a law. For example, many theories have been proposed to explain how the law of gravity works. Even so, there are few theories in science and even fewer laws.

Reading Check *What is the difference between a scientific theory and a scientific law?*

Figure 7
Science can't answer all questions. *Can anyone prove that you like this artwork? Explain.*

The Limitations of Science

Science can help you explain many things about the world, but science cannot explain or solve everything. Although it's the scientist's job to make guesses, the scientist also has to make sure his or her guesses can be tested and verified. But how do you prove that people will like a play or a piece of music? You cannot and science cannot.

Most questions about emotions and values are not scientific questions. They cannot be tested. You might take a survey to get people's opinions about such questions, but that would not prove that the opinions are true for everyone. A survey might predict that you will like the art in **Figure 7,** but science cannot prove that you or others will.

Using Science—Technology

Many people use the terms *science* and *technology* interchangeably, but they are not the same. **Technology** is the application of science to help people. For example, when a chemist develops a new, lightweight material that can withstand great amounts of heat, this is science. When that material is used on the space shuttle, it is technology. **Figure 8** shows other examples of technology.

Technology doesn't always follow science, however. Sometimes the process of discovery can be reversed. One important historic example of science following technology is the development of the steam engine. The inventors of the steam engine had little idea of how it worked. They just knew that steam from boiling water could move the engine. Because the steam engine became so important to industry, scientists began analyzing how it worked. Lord Kelvin, James Prescott Joule and Sadi Carnot, who lived in the 1800s, learned so much from the steam engine that they developed revolutionary ideas about the nature of heat.

Do science and technology always produce positive results? Some people don't think so. The benefits of some technological advances, such as nuclear technology and genetic engineering, are subjects of debate. Being more knowledgeable about science can help society address these issues as they arise.

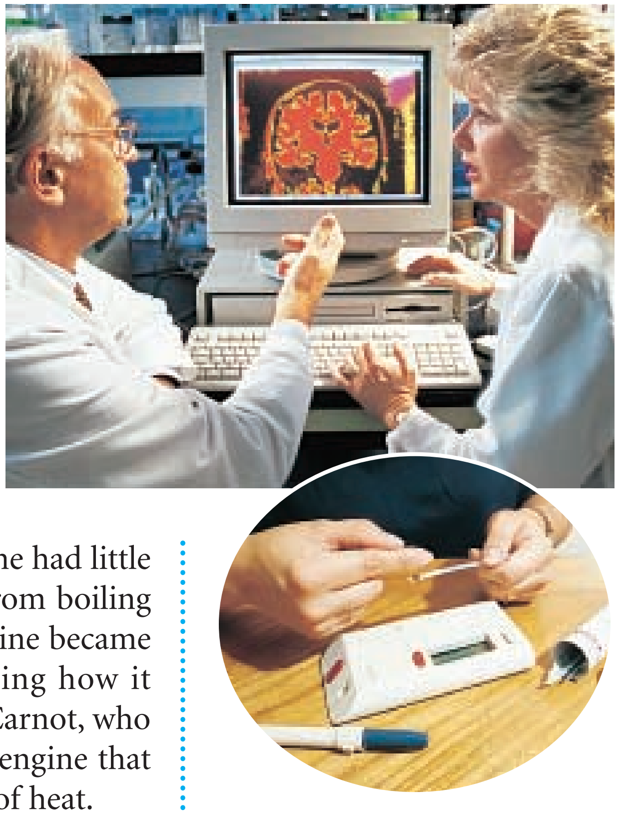


Figure 8
Technology is the application of science. *What type of science (life, Earth, or physical) is applied in these examples of technology?*

Section 1 Assessment

1. What is the first step a scientist usually takes to solve a problem?
2. What is the dependent variable in an experiment that shows how the volume of gas changes with changes in temperature?
3. Explain why a control is needed in a valid experiment.
4. How is science different from technology?
5. **Think Critically** You water your houseplant every Saturday. On Wednesday you notice its leaves are drooping. You give it some water, and the leaves perk up. You conclude you need to water twice a week. Was this a valid experiment? Explain.

Skill Builder Activities

6. **Forming Hypotheses** You don't have enough money to buy the music CD you want. Form a hypothesis about what you could do to solve the problem. How could you test your hypothesis before putting your plan in action? **For more help, refer to the Science Skill Handbook.**
7. **Communicating** You need to design a container to hold a new irregularly shaped device. Write the steps of the method you plan to use to help your team find the solution. **For more help, refer to the Science Skill Handbook.**

SECTION 2

Standards of Measurement

As You Read

What You'll Learn

- **Name** the prefixes used in SI and indicate what multiple of ten each one represents.
- **Identify** SI units and symbols for length, volume, mass, density, time, and temperature.
- **Convert** related SI units.

Vocabulary

standard
SI
volume
density
mass

Why It's Important

By using uniform standards, nations can exchange goods and compare information easily.

Units and Standards

Accurate measurement is needed in a valid experiment. Accuracy depends upon standards. A **standard** is an exact quantity that people agree to use for comparison. Measurements made using the same standard can be compared to each other.

Look at **Figure 9.** Suppose you and a friend want to make some measurements to find out whether a desk will fit through a doorway. You have no ruler, so you decide to use your hands as measuring tools. Using the width of his hands, your friend measures the doorway and says it is 8 hands wide. Using the width of your hands, you measure the desk and find it is 7¾ hands wide. Will the desk fit through the doorway? You can't be sure. What if your hands are wider than your friend's hands? The distance equal to 7¾ of your hands might be greater than the distance equal to 8 of your friend's hands.

What went wrong? Even though you both used hands to measure, you didn't check to see whether your hands are the same width as your friend's. In other words, you didn't use a measurement standard, so you can't compare the measurements.

Figure 9
Hands are a convenient measuring tool, but using them can lead to misunderstanding.

Measurement Systems

Suppose the label on a ball of string indicates that the length of the string is 150. What is the length of the string? It could be 150 feet, 150 m, or 150 cm. In order for a measurement to make sense, it must include a number and a unit.

Your family might buy lumber by the foot, milk by the gallon, and potatoes by the pound. These measurement units are part of the English system of measurement, which is most commonly used in the United States. Most other nations use the metric system, which is a system of measurement based on multiples of ten. The metric system was devised by a group of scientists in the late 1700s.

International System of Units In 1960, an improved version of the metric system was devised. Known as the International System of Units, this system is often abbreviated SI, from the French *Le Systeme Internationale d'Unites*. All **SI** standards are universally accepted and understood by scientists throughout the world. The standard kilogram, which is kept in Sèvres, France, is shown in **Figure 10.** All kilograms used throughout the world must be exactly the same as the kilogram kept in France.

Each type of SI measurement has a base unit. The meter is the base unit of length. Every type of quantity measured in SI has a symbol for that unit. These names and symbols for the seven base units are shown in **Table 1.** All other SI units are obtained from these seven units.

Figure 10
The standard for mass, the kilogram, and other standards are kept at the International Bureau of Weights and Measures in Sèvres, France. *What is the purpose of a standard?*

SI Prefixes The SI system is easy to use because it is based on multiples of ten. Prefixes are used with the names of the units to indicate what multiple of ten should be used with the units. For example, the prefix *kilo-* means "1,000." That means that one kilometer equals 1,000 meters. Likewise, one kilogram equals 1,000 grams. Because *deci-* means "one-tenth," one decimeter equals one tenth of a meter. A decigram equals one tenth of a gram. The most frequently used prefixes are shown in **Table 2.**

Reading Check *How many meters is 1 km? How many grams is 1 dg?*

Table 1 SI Base Units

Quantity Measured	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Temperature	kelvin	K
Amount of Substance	mole	mol
Intensity of Light	candela	cd

Table 2 Common SI Prefixes

Prefix	Symbol	Multiplying Factor
Kilo-	k	1,000
Deci-	d	0.1
Centi-	c	0.01
Milli-	m	0.001
Micro-	µ	0.000 001
Nano-	n	0.000 000 001

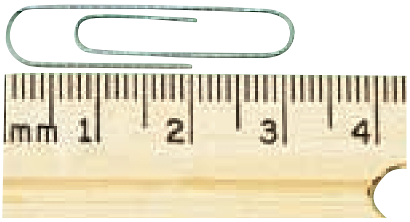


Figure 11
One centimeter contains 10 mm. *How many millimeters long is the paper clip?*

Converting Between SI Units Sometimes quantities are measured using different units. Conversion factors are used to change one unit to another. A conversion factor is a ratio that is equal to one. For example, there are 1,000 mL in 1 L, so 1,000 mL = 1 L. If both sides in this equation are divided by l L, the equation becomes:

$$\frac{1{,}000\ \text{mL}}{1\ \text{L}} = 1$$

The left side of this equation is a ratio equal to one and, therefore, is a conversion factor. You can make another conversion factor by placing 1L in the numerator and 1,000 mL in the denominator. The ratio still is equal to one.

To convert units, you multiply by the appropriate conversion factor. For example, to convert 1.255 L to mL, multiply 1.255 L by a conversion factor. Use the conversion factor with new units (mL) in the numerator and the old units (L) in the denominator.

$$1.255\ \text{L} \times \frac{1{,}000\ \text{mL}}{1\ \text{L}} = 1.255\ \text{mL}$$

The unit L cancels in this equation, just as if it were a number.

Math Skills Activity

Converting Units of Measure

Example Problem

You have a length of rope that measures 3,075 mm. How long is it in centimeters?

1. *This is what you know:* 1 m = 10 dm = 100 cm = 1,000 mm
2. *This is what you need to know:* 3,075 mm = ? cm
3. *This is the equation you need to use:* $? \text{ cm} = 3{,}075 \text{ mm} \times \frac{100 \text{ cm}}{1{,}000 \text{ mm}}$
4. *Cancel units and multiply:* $3{,}075\ \cancel{\text{mm}} \times \frac{1\cancel{00}\ \text{cm}}{10\cancel{00}\ \cancel{\text{mm}}} = 307.5\ \text{cm}$

Check your answer by multiplying your answer by $\frac{1{,}000 \text{ mm}}{100 \text{ cm}}$. *Do you calculate the original length in millimeters?*

Practice Problem

Your pencil is 11 cm long. How long is it in millimeters?

For more help, refer to the Math Skill Handbook.

CONTENTS

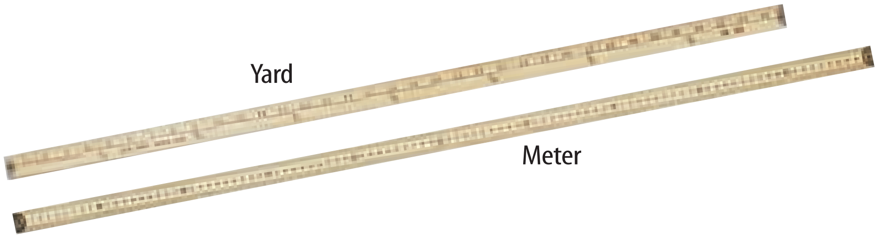


Figure 12
One meter is slightly longer than 1 yard and 100 m is slightly longer than a football field. *Would you expect your time for a 100-m dash to be slightly more or less than your time for a 100-yard dash?*

Measuring Distance

The word *length* is used in many different ways. For example, the length of a novel is the number of pages or words it contains. In scientific measurement, however, length is the distance between two points. That distance might be the diameter of a hair or the distance from Earth to the Moon. The SI base unit of length is the meter, m. A baseball bat is about 1 m long. Metric rulers and metersticks are used to measure length. **Figure 12** compares a meter and a yard.

Earth Science INTEGRATION

The standard measurement for the distance from Earth to the Sun is called the astronomical unit, AU. The distance is about 150 billion (1.5×10^{11}) m. In your Science Journal, calculate what 1 AU would equal in km.

Choosing a Unit of Length As shown in **Figure 13,** the size of the unit you measure with will depend on the size of the object being measured. For example, the diameter of a shirt button is about 1 cm. You probably also would use the centimeter to measure the length of your pencil and the meter to measure the length of your classroom. What unit would you use to measure the distance from your home to school? You probably would want to use a unit larger than a meter. The kilometer, km, which is 1,000 m, is used to measure these kinds of distances.

By choosing an appropriate unit, you avoid large-digit numbers and numbers with many decimal places. Twenty-one kilometers is easier to deal with than 21,000 m. And 13 mm is easier to use than 0.013 m.

Figure 13
The size of the object being measured determines which unit you will measure in. A tape measure measures in meters. The micrometer, shown at the left, measures in small lengths. *What unit do you think it measures in?*

Measuring Volume

The amount of space occupied by an object is called its **volume**. If you want to know the volume of a solid rectangle, such as a brick, you measure its length, width, and height and multiply the three numbers and their units together ($V = l \times w \times h$). For a brick, your measurements probably would be in centimeters. The volume would then be expressed in cubic centimeters, cm^3. To find out how much a moving van can carry, your measurements probably would be in meters, and the volume would be expressed in cubic meters, m^3, because when you multiply you add exponents.

SCIENCE Online

Research Visit the Glencoe Science Web site at **science.glencoe.com** for more information on finding the volume of irregular objects using water displacement. Communicate to your class what you learn.

CLICK HERE

Measuring Liquid Volume How do you measure the volume of a liquid? A liquid has no sides to measure. In measuring a liquid's volume, you are indicating the capacity of the container that holds that amount of liquid. The most common units for expressing liquid volumes are liters and milliliters. These are measurements used in canned and bottled foods. A liter occupies the same volume as a cubic decimeter, dm^3. A cubic decimeter is a cube that is 1 dm, or 10 cm, on each side, as in **Figure 14.**

Look at **Figure 14.** One liter is equal to 1,000 mL. A cubic decimeter, dm^3, is equal to 1,000 cm^3. Because 1 L = 1 dm^3, it follows that:

$$1 \text{ mL} = 1 \text{ cm}^3$$

Sometimes, liquid volumes such as doses of medicine are expressed in cubic centimeters.

Suppose you wanted to convert a measurement in liters to cubic centimeters. You use conversion factors to convert L to mL and then mL to cm^3.

$$1.5 \cancel{\text{L}} \times \frac{1{,}000 \cancel{\text{mL}}}{1 \cancel{\text{L}}} \times \frac{1 \text{ cm}^3}{1 \cancel{\text{mL}}} = 1{,}500 \text{ cm}^3$$

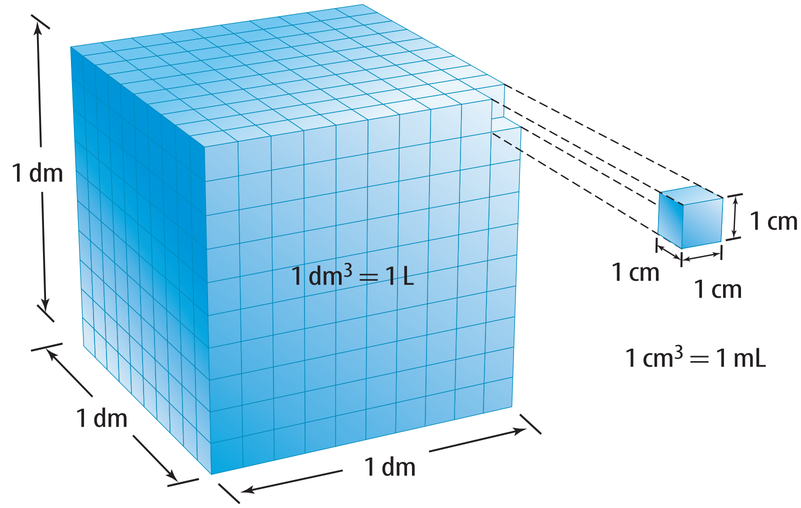


Figure 14
The large cube has a volume of 1 dm^3, which is equivalent to 1 L. *How many cubic centimeters (cm^3) are in the large cube?*

Table 3 Densities of Some Materials at 20°C

Material	Density (g/cm^3)	Material	Density (g/cm^3)
hydrogen	0.000 09	aluminum	2.7
oxygen	0.001 4	iron	7.9
water	1.0	gold	19.3

Measuring Matter

A table-tennis ball and a golf ball have about the same volume. But if you pick them up, you notice a difference. The golf ball has more mass. **Mass** is a measurement of the quantity of matter in an object. The mass of the golf ball, which is about 45 g, is almost 18 times the mass of the table-tennis ball, which is about 2.5 g. A bowling ball has a mass of about 5,000 g. This makes its mass roughly 100 times greater than the mass of the golf ball and 2,000 times greater than the table-tennis ball's mass. To visualize SI units, see **Figure 15** on the following page.

Density A cube of polished aluminum and a cube of silver that are the same size not only look similar but also have the same volume. The mass and volume of an object can be used to find the density of the material the object is made of. **Density** is the mass per unit volume of a material. You find density by dividing an object's mass by the object's volume. For example, the density of an object having a mass of 10 g and a volume of 2 cm^3 is 5 g/cm^3. **Table 3** lists the densities of some familiar materials.

Derived Units The measurement unit for density, g/cm^3, is a combination of SI units. A unit obtained by combining different SI units is called a derived unit. An SI unit multiplied by itself also is a derived unit. Thus the liter, which is based on the cubic decimeter, is a derived unit. A meter cubed, expressed with an exponent—m^3—is a derived unit.

Measuring Time and Temperature

It is often necessary to keep track of how long it takes for something to happen, or whether something heats up or cools down. These measurements involve time and temperature.

Time is the interval between two events. The SI unit for time is the second. In the laboratory, you will use a stopwatch or a clock with a second hand to measure time.

Mini LAB

Determining the Density of a Pencil

Procedure

1. Measure the mass of a **pencil** (unsharpened) in grams.
2. Put 90 mL of **water** into a 100-mL **graduated cylinder.** Lower the pencil, eraser end down, into the cylinder. Push the pencil until it is just submerged. This is known as water displacement. Hold it there and read the new volume to the nearest tenth of a milliliter.

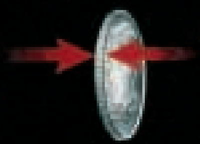
Analysis

1. Calculate the pencil's density by dividing its mass by the change in volume of the water level.
2. Is the density of the pencil greater than or less than the density of water? How do you know?

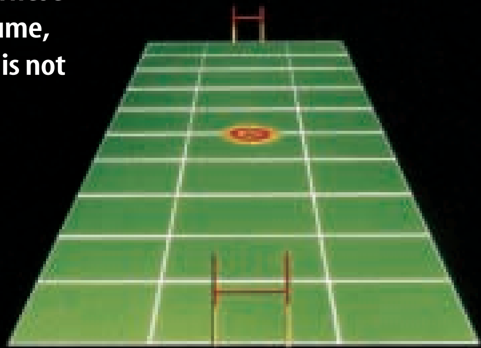
VISUALIZING SI DIMENSIONS

Figure 15

The characteristics of most of these everyday objects are measured using an international system known as SI dimensions. These dimensions measure length, volume, mass, density, and time. Celsius is not an SI unit but is widely used in scientific work.



MILLIMETERS A dime is about 1 mm thick.



METERS A football field is about 91 m long.

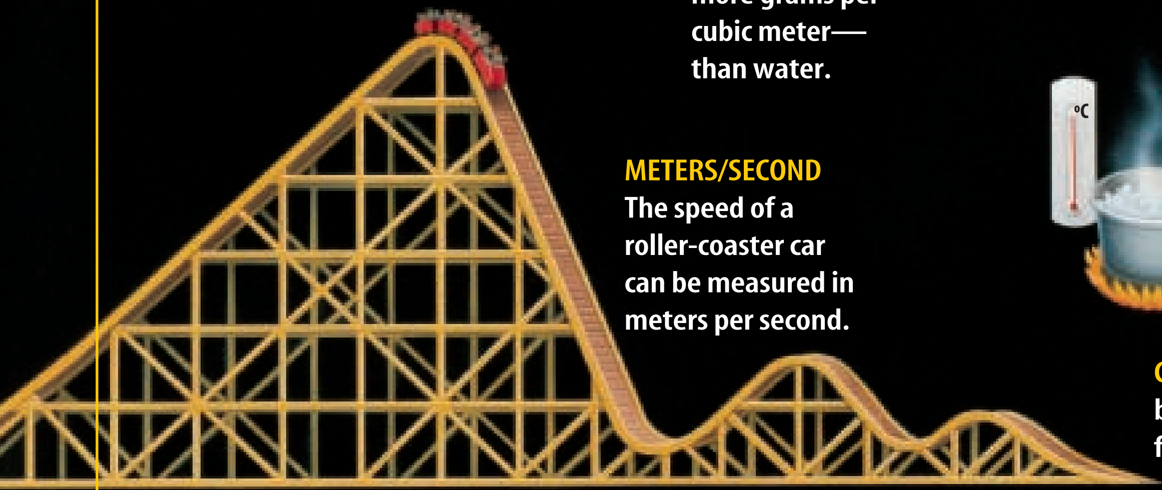
KILOMETERS The distance from your house to a store can be measured in kilometers.

LITERS This carton holds 1.98 L of frozen yogurt.

MILLILITERS A teaspoonful of medicine is about 5 mL.

GRAMS/METER This stone sinks because it is denser—has more grams per cubic meter—than water.

GRAMS The mass of a thumbtack and the mass of a textbook can be expressed in grams.



METERS/SECOND The speed of a roller-coaster car can be measured in meters per second.

CELSIUS Water boils at 100°C and freezes at 0°C.

What's Hot and What's Not You will learn the scientific meaning of the word *temperature* in a later chapter. For now, think of temperature as a measure of how hot or how cold something is.

Look at **Figure 16.** For most scientific work, temperature is measured on the Celsius (C) scale. On this scale, the freezing point of water is 0°C, and the boiling point of water is 100°C. Between these points, the scale is divided into 100 equal divisions. Each one represents 1°C. On the Celsius scale, average human body temperature is 37°C, and a typical room temperature is between 20°C and 25°C.

Kelvin and Fahrenheit The SI unit of temperature is the kelvin (K). Zero on the Kelvin scale (0 K) is the coldest possible temperature, also known as absolute zero. That is equal to −273°C, which is 273° below the freezing point of water.

Most laboratory thermometers are marked only with the Celsius scale. Because the divisions on the two scales are the same size, the Kelvin temperature can be found by adding 273 to the Celsius reading. So, on the Kelvin scale, water freezes at 273 K and boils at 373 K. Notice that degree symbols are not used with the Kelvin scale.

The temperature measurement you are probably most familiar with is the Fahrenheit scale, which was based roughly on the temperature of the human body.

Reading Check *What is the relationship between the Celsius scale and the Kelvin scale?*

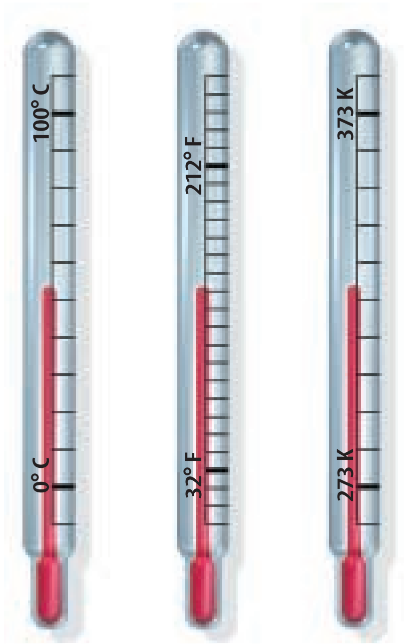


Figure 16
These three thermometers illustrate the scales of temperature between the freezing and boiling points of water. *How do the scales compare at the boiling point?*

Section 2 Assessment

1. Why is it important to have standards of measurement that are exact?
2. What are the SI prefixes for 0.001, 1,000, 0.1, and 0.01?
3. Make the following conversions—100 cm to meters, 27°C to Kelvin, 20 dg to milligrams, and 3 m to decimeters.
4. Explain why density is a derived unit.
5. **Think Critically** What is the density of an unknown metal that has a mass of 158 g and a volume of 20 mL? Use **Table 3** to identify this metal.

Skill Builder Activities

6. **Concept Mapping** Make a network-tree concept map displaying the SI base units used to measure quantities of length, mass, time, and temperature. **For more help, refer to the Science Skill Handbook.**
7. **Solving One-Step Equations** Use a metric ruler to measure a shoe box and a pad of paper. Find the volume of each ($V = w \times l \times h$) in cubic centimeters. Then convert the units to mL. **For more help, refer to the Math Skill Handbook.**

SECTION

3 Communicating with Graphs

As You Read

What You'll Learn

- **Identify** three types of graphs and explain the ways they are used.
- **Distinguish** between dependent and independent variables.
- **Analyze** data using the various types of graphs.

Vocabulary

graph

Why It's Important

Graphs are a quick way to communicate a lot of information in a small amount of space.

A Visual Display

Scientists often graph the results of their experiments because they can detect patterns in the data easier in a graph than in a table. A **graph** is a visual display of information or data. **Figure 17** is a graph that shows a girl walking her dog. The horizontal axis, or the *x*-axis, measures time. Time is the independent variable because as it changes, it affects the measure of another variable. The distance from home that the girl and the dog walk is the other variable. It is the dependent variable and is measured on the vertical axis, or *y*-axis.

Graphs are useful for displaying numerical information in business, science, sports, advertising, and many everyday situations. Different kinds of graphs—line, bar, and circle—are appropriate for displaying different types of information.

Reading Check *What are three common types of graphs?*

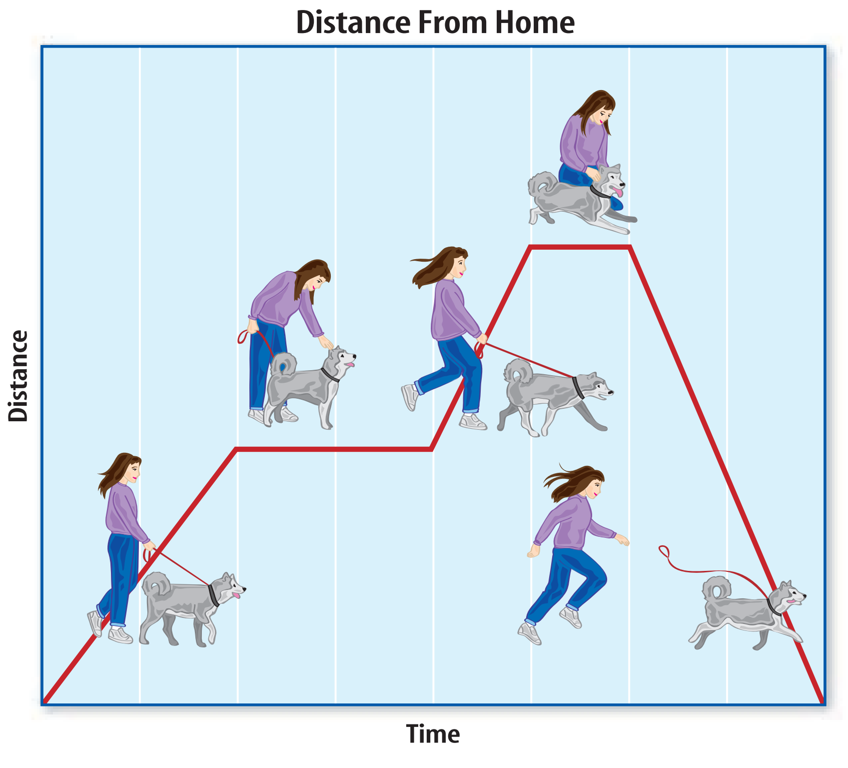


Figure 17
This graph tells the story of the motion that takes place when a girl takes her dog for an 8-min walk.

Line Graphs

A line graph can show any relationship where the dependent variable changes due to a change in the independent variable. Line graphs often show how a relationship between variables changes over time. You can use a line graph to track many things, such as how certain stocks perform or how the population changes over any period of time—a month, a week, or a year.

You can show more than one event on the same graph as long as the relationship between the variables is identical. Suppose a builder had three choices of thermostats for a new school. He wanted to test them to know which was the best brand to install throughout the building. He installed a different thermostat in classrooms A, B, and C. He set each thermostat at 20°C. He turned the furnace on and checked the temperatures in the three rooms every 5 min for 25 min. He recorded his data in **Table 4.**

The builder then plotted the data on a graph. He could see from the table that the data did not vary much for the three classrooms. So he chose small intervals for the *y*-axis and left part of the scale out (the part between 0° and 15°). See **Figure 18.** This allowed him to spread out the area on the graph where the data points lie. You can see easily the contrast in the colors of the three lines and their relationship to the black horizontal line. The black line represents the thermostat setting and is the control. The control is what the resulting room temperature of the classrooms should be if the thermostats are working efficiently.

Table 4 Room Temperature

Time*	Classroom Temperature (°C) A	B	C
0	16	16	16
5	17	17	16.5
10	19	19	17
15	20	21	17.5
20	20	23	18
25	20	25	18.5

*minutes after turning on heat

Figure 18
The room temperatures of classrooms A, B, and C are shown in contrast to the thermostat setting of 20°C. *Which classroom had the most efficient thermostat?*

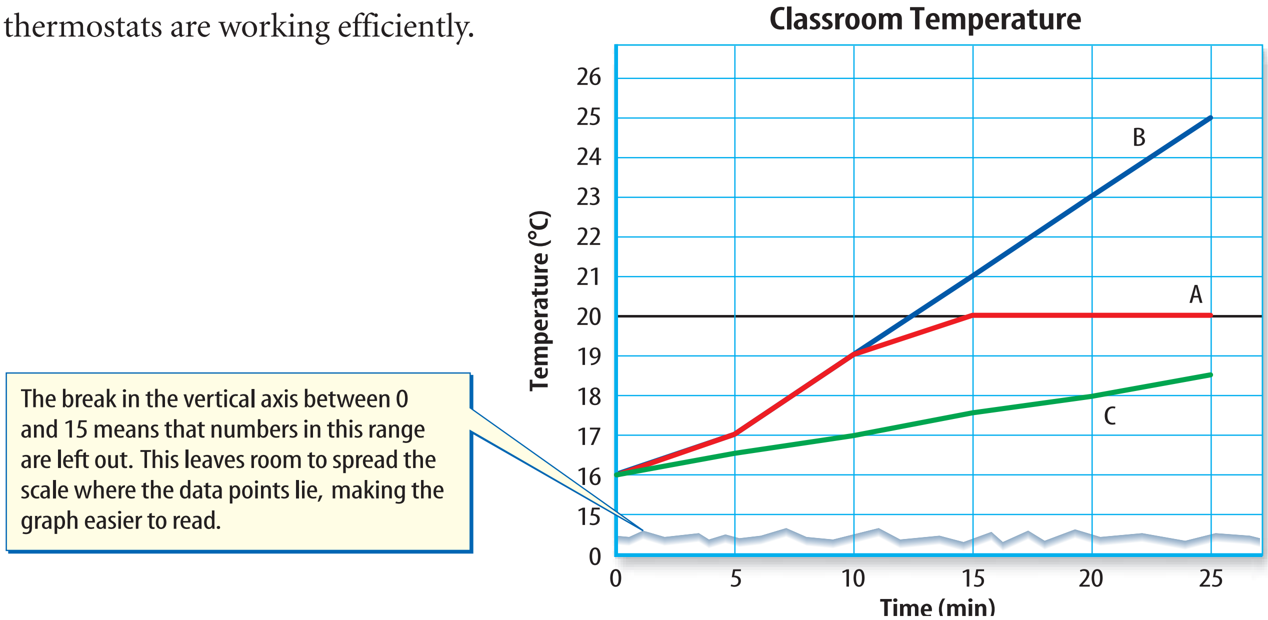


Figure 19
Graphing calculators are valuable tools for making graphs.

Building Line Graphs Besides choosing a scale that makes a graph readable, as illustrated in **Figure 18,** other factors are involved in building useful graphs. The most important factor in making a line graph is always using the *x*-axis for the independent variable. The *y*-axis always is used for the dependent variable. Because the points in a line graph are related, you connect the points.

Another factor in building a graph involves units of measurement. For example, you might use a Celsius thermometer for one part of your experiment and a Fahrenheit thermometer for another. But you must first convert your temperature readings to the same unit of measurement before you make your graph.

In the past, graphs had to be made by hand, with each point plotted individually. Today, scientists use a variety of tools, such as computers and graphing calculators like the one shown in **Figure 19,** to help them draw graphs.

Math Skills Activity

Line Graphing

Example Problem

In an experiment, you check the air temperature at certain hours of the day. At 8 A.M., the temperature is 27°C; at noon, the temperature is 32°C; and at 4 P.M., the temperature is 30°C. Graph the results of your experiment.

Solution

1 *This is what you know:* independent variable = time
dependent variable = temperature

2 *Set up your graph:* Graph time on the *x*-axis and temperature on the *y*-axis. Mark the increments on the graph to include all measurements.

3 *Graph:* Plot each point on the graph by finding the time on the *x*-axis and moving up until you find the recorded temperature on the *y*-axis. Place a point there. Then connect the points from left to right.

Practice Problem

As you train for a marathon, you compare your previous times. In year one, you ran it in 5.2 h; in year two, you ran it in 5 h; in year three, you ran it in 4.8 h; in year four, you ran it in 4.3 h; and in year five, you ran it in 4 h. Graph the results of your marathon races.

For more help, refer to the Math Skill Handbook.

CONTENTS

Bar Graphs

A bar graph is useful for comparing information collected by counting. For example, suppose you counted the number of students in every classroom in your school on a particular day and organized your data as in **Table 5.** You could show these data in a bar graph like the one shown in **Figure 20.** Uses for bar graphs include comparisons of oil, or crop productions, costs, or as data in promotional materials. Each bar represents a quantity counted at a particular time, which should be stated on the graph. As on a line graph, the independent variable is shown on the x-axis and the dependent variable is plotted on the y-axis.

Recall that you might need to place a break in the scale of the graph to better illustrate your results. For example, if your data were 1,002, 1,010, 1,030, and 1,040 and the intervals on the scale were every 100 units, you might not be able to see the difference from one bar to another. If you had a break in the scale and started your data range at 1,000 with intervals of ten units, you could make your comparison more accurately.

Reading Check *Describe possible data where using a bar graph would be better than using a line graph.*

TRY AT HOME Mini LAB

Observing Change Through Graphing

Procedure

1. Place a **thermometer** in a **plastic foam cup** of hot, but not boiling, **water.**
2. Measure and record the temperature every 30 s for 5 min.
3. Repeat the experiment with freshly heated water. This time, cover the cup with a **plastic lid.**

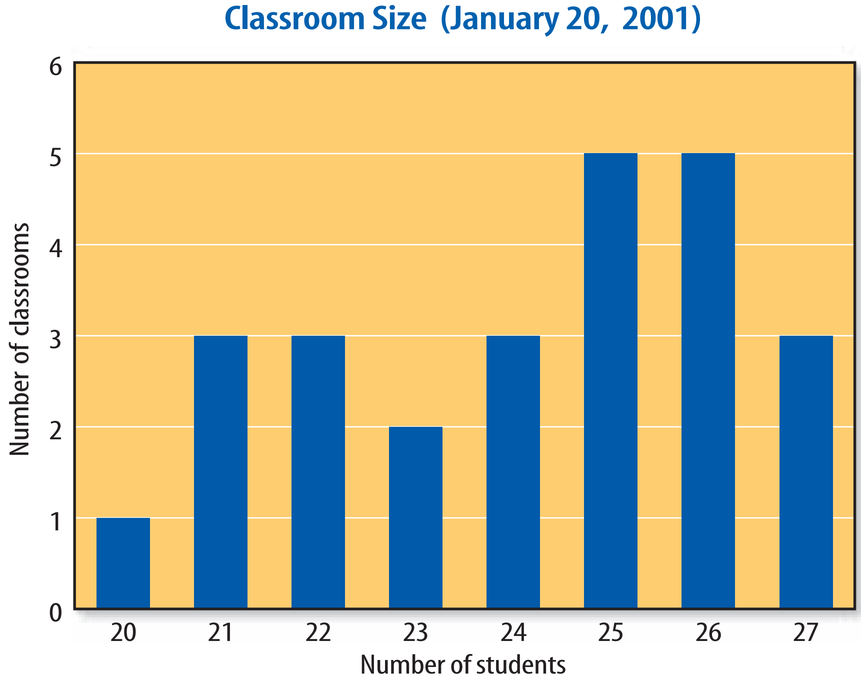
Analysis

1. Make a line graph of the changing temperature from step 2, showing time on the *x*-axis and temperature on the *y*-axis. Then plot the changing temperature from step 3 on the same graph.
2. Use the graph to describe the cooling process in each of the trials.

Table 5 Classroom Size

Number of Students	Number of Classrooms
20	1
21	3
22	3
23	2
24	3
25	5
26	5
27	3

Figure 20
The height of each bar corresponds to the number of classrooms having a particular number of students.



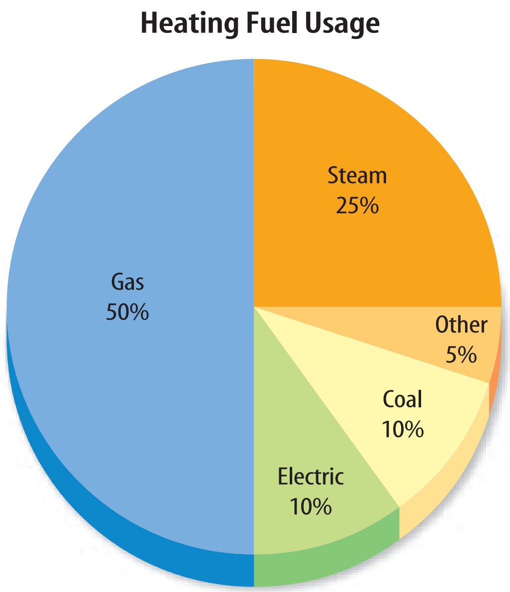


Figure 21
A circle graph shows the different parts of a whole quantity.

Circle Graphs

A circle graph, or pie graph, is used to show how some fixed quantity is broken down into parts. The circular pie represents the total. The slices represent the parts and usually are represented as percentages of the total.

Figure 21 illustrates how a circle graph could be used to show the percentage of buildings in a neighborhood using each of a variety of heating fuels. You easily can see that more buildings use gas heat than any other kind of system. What else does the graph tell you?

To create a circle graph, you start with the total of what you are analyzing. **Figure 21** starts with 72 buildings in the neighborhood. For each type of heating fuel, you divide the number of buildings using each type of fuel by the total (72). You then multiply that fraction (percent) by 360° to determine the angle that the fraction makes in the circle. Eighteen buildings use steam. Therefore, $18 \div 72 \times 360° = 90°$ on the circle graph. You then would measure 90° on the circle with your protractor to show 25 percent.

When you use graphs, think carefully about the conclusions you can draw from them. You want to make sure your conclusions are based on accurate information and that you use scales that help make your graph easy to read.

Section 3 Assessment

1. What is the purpose of each of the three common types of graphs?
2. Which type of variable is plotted on the *x*-axis? The *y*-axis?
3. What kind of graph would best show the results of a survey of 144 people where 75 ride a bus, 45 drive cars, 15 carpool, and 9 walk to work?
4. Why are points connected in a line graph?
5. **Think Critically** Describe one way that a bar graph is different from a circle graph and one way that a bar graph is similar to a circle graph.

Skill Builder Activities

6. **Making and Using Graphs** Find a graph in a newspaper or magazine. Identify the kind of graph you found and write an explanation of what the graph shows. **For more help, refer to the Science Skill Handbook.**
7. **Using an Electronic Spreadsheet** Some computer programs make creating data tables and making graphs an easier task. Use a spreadsheet and a graphing program to make a data table and a line graph of the data you collected in the Try at Home MiniLAB. **For more help, refer to the Technology Skill Handbook.**

Activity

Converting Kitchen Measurements

Look through a recipe book. Are any of the amounts of ingredients stated in SI units? Chances are, English measurements are used. How can you convert English measurements to SI measurements?

What You'll Investigate

How do kitchen measurements compare with SI measurements?

Safety Precautions

Materials

balance
100-mL graduated cylinder
measuring cup
measuring teaspoon
measuring tablespoon
corn meal
dried beans
dried rice
potato flakes
water
vinegar
salad oil

Goals

- **Determine** a relationship between two systems of measurements.
- **Calculate** the conversion factors for converting English units to SI units.

Procedure

1. Copy the data table into your Science Journal.
2. Use the appropriate English measuring cup or spoon to measure the amounts of each ingredient shown in the table.
3. Use a balance to measure the mass in grams of each dry ingredient. Use a graduated cylinder to measure the volume in milliliters of each liquid ingredient.
4. Record each SI equivalent in your data table.

English to SI Conversions

Ingredient	English Measure	SI Measure
Water	$^{1}/_{2}$ cup	
Corn Meal	2 cups	
Salad Oil	4 tablespoons	
Dried Rice	$^{1}/_{2}$ cup	
Potato Flakes	3 cups	
Vinegar	1 teaspoon	
Dried Beans	3 cups	

Conclude and Apply

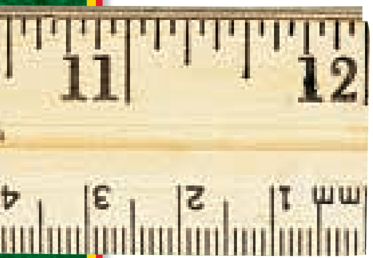
1. **Calculate** the number of grams in one cup of each dry ingredient. Calculate the number of milliliters in one cup, one teaspoon, and one tablespoon of each liquid ingredient.
2. **Write** conversion factors that will convert each English unit to an SI unit for each ingredient.
3. **Calculate** how many milliliters you would measure if a recipe called for three tablespoons of salad oil.
4. **Compare and Contrast** your conversion factors for the dry ingredients and your conversion factors for the liquid ingredients.
5. **Explain** the benefits and problems of changing all recipes to SI units.

Communicating Your Data

Write a recipe used in your home converting all the English units to SI units.

Activity
Design Your Own Experiment

Setting High Standards for Measurement



To develop the International System of Units, people had to agree on set standards and basic definitions of scale. If you had to develop a new measurement system, people would have to agree with your new standards and definitions. In this activity, your team will use string to devise and test its own SI (String International) system for measuring length.

Recognize the Problem

What are the requirements for designing a new measurement system using string?

Form a Hypothesis

Based on your knowledge of measurement standards and systems, state a hypothesis about how exact units help to keep measuring consistent.

Possible Materials

string
scissors
marking pen
masking tape
miscellaneous objects for standards

Safety Precautions

Goals

- **Design** an experiment that involves devising and testing your own measurement system for length.
- **Measure** various objects with the string measurement system.

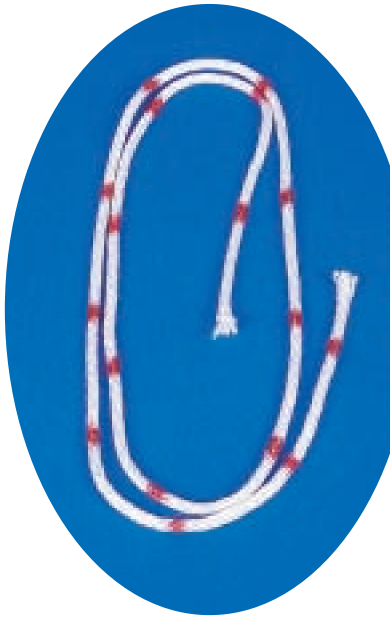
Test Your Hypothesis

Plan

1. As a group, agree upon and write out the hypothesis statement.
2. As a group, list the steps that you need to take to test your hypothesis. Be specific, describing exactly what you will do at each step.
3. Make a list of the materials that you will need.
4. **Design** a data table in your Science Journal so it is ready to use as your group collects data.
5. As you read over your plan, be sure you have chosen an object in your classroom to serve as a standard. It should be in the same size range as what you will measure.
6. Consider how you will mark scale divisions on your string. Plan to use different pieces of string to try different-sized scale divisions.
7. What is your new unit of measurement called? Come up with an abbreviation for your unit. Will you name the smaller scale divisions?
8. What objects will you measure with your new unit? Be sure to include objects longer and shorter than your string. Will you measure each object more than once to test consistency? Will you measure the same object as another group and compare your findings?

Do

1. Make sure your teacher approves your plan before you start.
2. Carry out the experiment as it has been planned.
3. **Record** observations that you make and complete the data table in your Science Journal.



Analyze Your Data

1. Which of your string scale systems will provide the most accurate measurement of small objects? Explain.
2. How did you record measurements that were between two whole numbers of your units?

Draw Conclusions

1. When sharing your results with other groups, why is it important for them to know what you used as a standard?
2. **Infer** how it is possible for different numbers to represent the same length of an object.

Communicating Your Data

Compare your conclusions with other students' conclusions. **For more help, refer to the** **Science Skill Handbook.**

Science and Language Arts

Thinking in Pictures: and other reports from my life with autism[1]

By Temple Grandin

Respond to the Reading

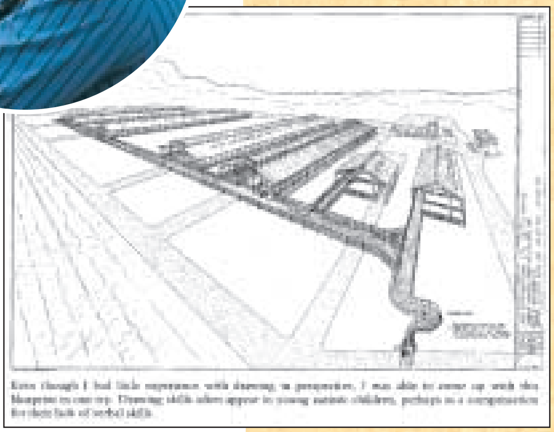
1. How do people with autism think differently than other people?
2. What did the author use to see from a cow's point of view?
3. What did the author use for models to design things when she was a child?

Temple Grandin is an animal scientist and writer who also happens to be autistic. People with autism are said to think in pictures. For instance, an autistic person might think of a "dog" by visualizing a specific dog that he or she has seen rather than the word "dog."

I think in pictures. Words are like a second language to me. I translate both spoken and written words into full-color movies, complete with sound, which run like a VCR tape in my head. When somebody speaks to me, his words are instantly translated into pictures. Language-based thinkers often find this phenomenon difficult to understand, but in my job as equipment designer for the livestock industry, visual thinking is a tremendous advantage.

. . . I credit my visualization abilities with helping me understand the animals I work with. Early in my career I used a camera to help give me the animals' perspective as they walked through a chute for their veterinary treatment. I would kneel down and take pictures through the chute from the cow's eye level. Using the photos, I was able to figure out which things scared the cattle.

Every design problem I've ever solved started with my ability to visualize and see the world in pictures. I started designing things as a child, when I was always experimenting with new kinds of kites and model airplanes.



The author drew this blueprint of a cattle barn in one try.

[1] Autism is a complex developmental disability that usually appears during the first three years of life. Children and adults with autism typically have difficulties in communicating with others and relating to the outside world.

Understanding Literature

Identifying the Main Idea The most important idea expressed in a paragraph or essay is the main idea. The main idea in a reading might be clearly stated, but sometimes the main idea is implied. In other words, sometimes the reader has to summarize the contents of a reading in order to determine its main idea. What do you think is the main idea of the passage? Look closely at the contents of the first and third paragraphs to help you summarize and determine the main idea.

Science Connection In this chapter you learned that models are important tools for scientists. Models enable scientists to see things that are too big, too small, or take too much time to see completely. Scientists might build models of DNA, atoms, airplanes, or other equipment. Temple Grandin excels at building models because she is a visual thinker. Her visual thinking and ability to make models enables her to predict how things will work when they are put together.

Linking Science and Writing

Summarizing Research a magazine or newspaper article about the use of a scientific model. The model can be a blueprint design like that of Temple Grandin's. Write a paragraph that summarizes what you learned. Your summary should organize the information you learned by stating the main ideas and listing supporting details.

Career Connection

Astronaut

John Glenn, Jr. made history twice. In 1962 he became the first American to orbit Earth. In 1998, at age 77, he became the oldest person to fly in space. During Glenn's first mission, NASA learned how to place a craft into Earth's orbit and track its location. This mission also taught NASA the basics about how the human body reacts to weightlessness. On his second mission, Glenn studied the similarities between the effects of space flight and the effects of aging. After his retirement from the Marine Corps in 1965, Glenn went on to serve four terms as U.S. Senator from Ohio.

CLICK HERE

SCIENCE *Online* To learn more about a career as an astronaut, visit the Glencoe Science Web site at **science.glencoe.com**

Chapter 1 Study Guide

Reviewing Main Ideas

Section 1 The Methods of Science

1. Science is a way of learning about the natural world through investigation.
2. Scientific investigations can involve making observations, testing models, or conducting experiments. *What do you observe about hurricanes from the photo?*

3. Scientific experiments investigate the effect of one variable on another. All other variables are kept constant.
4. Scientific laws are repeated patterns in nature. Theories attempt to explain how and why these patterns develop.

Section 2 Standards of Measurement

1. A standard of measurement is an exact quantity that people agree to use as a basis of comparison.
2. When a standard of measurement is established, all measurements are compared to the same exact quantity—the standard. Therefore, all measurements can be compared with one another.
3. The most commonly used SI units include: length—meter, volume—liter, mass—kilogram, and time—second.
4. In SI, prefixes are used to make the base units larger or smaller by multiples of ten. *The Petronas Twin Towers in Malaysia is the world's tallest building, standing at 45,190 cm. Use a conversion factor to find out how many meters this is. How many kilometers?*

5. Any SI unit can be converted to any other related SI unit by multiplying by the appropriate conversion factor.

Section 3 Communicating With Graphs

1. Line graphs show continuous changes among related variables. Bar graphs are used to show data collected by counting. Circle graphs show how a fixed quantity can be broken into parts.
2. In a line graph, the independent variable is always plotted on the horizontal *x*-axis. The dependent variable is always plotted on the vertical *y*-axis.

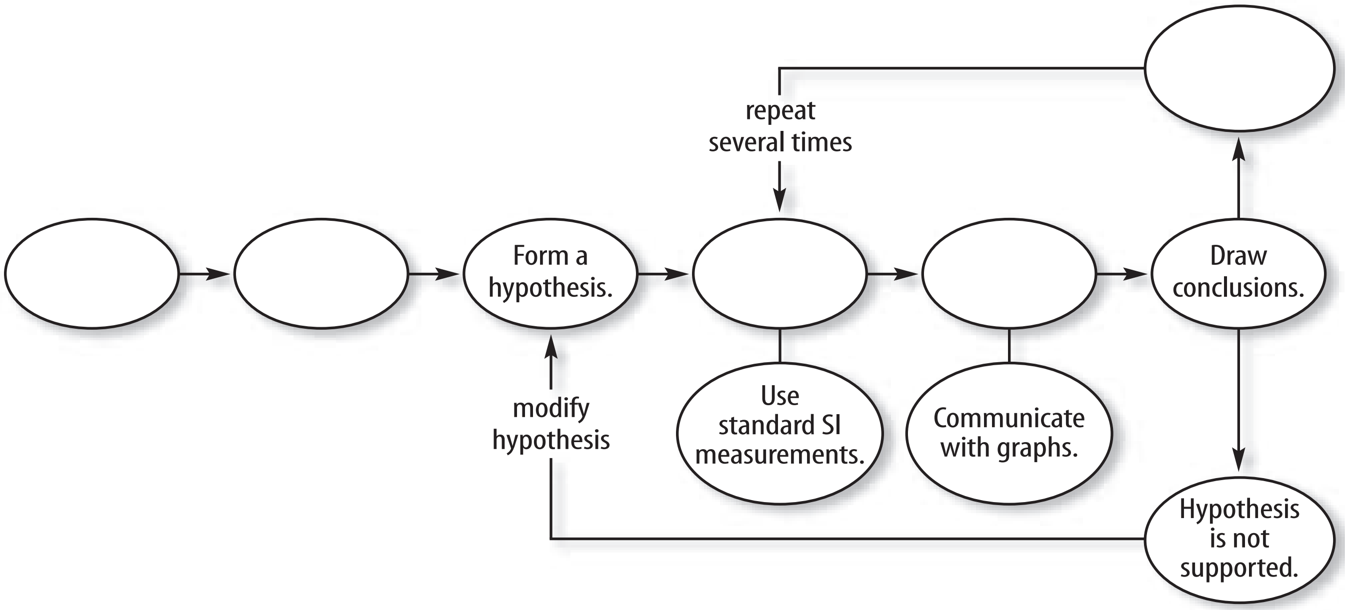
FOLDABLES Reading & Study Skills

After You Read

Using the information in this chapter, determine if the questions on your Question Study Fold can be answered by scientific processes. Then review your questions on the foldable and write the answers.

Visualizing Main Ideas

Complete the following concept map on scientific methods.



Vocabulary Review

Vocabulary Words

a. bias
b. constant
c. control
d. density
e. dependent variable
f. experiment
g. graph
h. hypothesis
i. independent variable
j. mass
k. model
l. scientific law
m. scientific method
n. SI
o. standard
p. technology
q. theory
r. variable
s. volume

Study Tip

THE PRINCETON REVIEW

If you're not sure of the relationship between terms in a question, try making a concept map of the terms and see how they fit together.

Using Vocabulary

Match each phrase with the correct term from the list of vocabulary words.

1. the modern version of the metric system
2. the amount of space occupied by an object
3. an agreed-upon quantity used for comparison
4. the amount of matter in an object
5. a variable that changes as another variable changes
6. a visual display of data
7. a test set up under controlled conditions
8. a variable that does NOT change as another variable changes
9. mass per unit volume
10. an educated guess using what you know and observe

Chapter 1 Assessment

Checking Concepts

Choose the word or phrase that best answers each question.

1. Which of the following questions CANNOT be answered by science?
   A) How do birds fly?
   B) Is this a good song?
   C) What is an atom?
   D) How does a clock work?

2. Which is an example of an SI unit?
   A) foot **C)** pound
   B) second **D)** gallon

3. Which system of measurement is used by scientists around the world?
   A) SI **C)** English system
   B) Standard system **D)** Kelvin system

4. Which of the following is SI based on?
   A) inches **C)** English units
   B) powers of five **D)** powers of ten

5. One one-thousandth is expressed by which prefix?
   A) kilo- **C)** centi-
   B) nano- **D)** milli-

6. What is the symbol for deciliter?
   A) dL **C)** dkL
   B) dcL **D)** Ld

7. What does the symbol µg stand for?
   A) nanogram **C)** microgram
   B) kilogram **D)** milligram

8. Which is the distance between two points?
   A) volume **C)** mass
   B) length **D)** density

9. Which of the following is NOT a derived unit?
   A) dm^3 **C)** cm^3
   B) m **D)** g/ml

10. Which of the following is NOT equal to 1,000 mL?
    A) 1 L **C)** 1 dm^3
    B) 100 cL **D)** 1 cm^3

Thinking Critically

11. Make the following conversions.
    a. 1,500 mL to L **c.** 5.8 dg to mg
    b. 2 km to cm **d.** 22°C to K

12. Standards of measurement used during the Middle Ages often were based on such things as the length of the king's arm. What would you say to convince people to use a different system of standard units?

13. List the SI units of length you would use to express the following. Refer to **Table 2** in Section 2.
    a. diameter of a hair
    b. width of your classroom
    c. width of a pencil lead
    d. length of a sheet of paper

14. Suppose you set a glass of water in direct sunlight for 2 h and measure its temperature every 10 min. What type of graph would you use to display your data? What would the dependent variable be? The independent variable?

15. What are some advantages and disadvantages of adopting SI in the United States?

Developing Skills

16. **Comparing and Contrasting** Compare and contrast the ease with which conversions can be made among SI units versus conversions among units in the English system.

17. Forming Hypotheses A metal sphere is found to have a density of 5.2 g/cm^3 at 25°C and a density of 5.1 g/cm^3 at 50°C. Propose a hypothesis to explain this observation. How could you test your hypothesis?

18. Measuring in SI Not all objects have a volume that is measured easily. If you were to determine the mass, volume, and density of your textbook, a container of milk, and an air-filled balloon, how would you do it?

19. Interpreting Scientific Illustrations The illustrations show the items needed for an investigation. Which item is the independent variable? Which items are the constants? What might a dependent variable be?

Performance Assessment

20. Making Observations and Inferences In the one-page activity, suppose you needed to measure five times the quantities. Compare the difficulty of multiplying the English measurements five times with multiplying the SI measurements five times.

TECHNOLOGY

Go to the Glencoe Science Web site at **science.glencoe.com** or use the **Glencoe Science CD-ROM** for additional chapter assessment.

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THE PRINCETON REVIEW

Test Practice

A student made measurements of several items using units from the English system of measurement and the SI system of measurement to determine how units of the two systems were related. Using these data, the student determined unit conversion factors that allow one unit to be converted into another. These conversion factors and their related units are shown below.

Measurement Units

Measurement	English System Unit	SI Unit	Conversion Factor
Length	Foot	Meter	1 foot = 0.305 m
Mass	Slug	Kilogram	1 slug = 14.6 kg
Volume	Gallon	Liter	1 gallon = 3.78 L
Time	Second	Second	N/A

Study the table and answer the following questions.

1. According to this table, about how many liters are in a gallon?

A) 1/4 **C)** 3/2
B) 3 3/4 **D)** 2/3

2. How many kilograms are equal to two slugs?

F) 42.8 **H)** 30.4
G) 11.6 **J)** 29.2

3. Which unit is the same in the English and SI systems of measurement?

A) meter **C)** gallon
B) slug **D)** second