InquiryLab

15 min

Make a Prediction

Making predictions is an important part of scientific thought. To make a prediction, you use observations to foretell what will happen in a given situation. In this lab, you will practice making predictions.

Procedure

1. Open a **Petri dish with agar,** and streak your finger across the agar.
2. Replace the lid, and seal it with **tape.** Label the dish with your name and the number “1.”
3. Seal the **second Petri dish with agar** without removing the lid. Label this Petri dish with your name and the number “2.”
4. Write a prediction about what will happen in each dish. Store your dishes as your teacher directs. Record your observations.

Analysis

1. **Restate** your prediction.
2. **List** the evidence that you can cite to support your prediction.
3. **Explain** whether you would change your testing method or your prediction if you did not obtain the results that you predicted.
4. **Evaluate** the importance of obtaining a result that does not support your prediction.

Scientists rely on tools to make accurate measurements. This tool is called a *Vernier caliper.* It was invented in 1631 by the French scientist Pierre Vernier. Now, there is a street in Paris named after him.

READING TOOLBOX

These reading tools can help you learn the material in this chapter. For more information on how to use these and other tools, see **Appendix: Reading and Study Skills.**

Using Words

Everyday Words in Science Many words that we use every day have special meanings in science. For example, "matter" in everyday use is an issue or problem. In science, matter is the substance of which all things are made.

Your Turn Make a table like the one shown here.

1. Before you read, write in your own words the everyday meaning of the terms in the table.
2. As you read, fill in the science meaning for the terms in the table.

Everyday Words in Science

Word	Everyday Meaning	Science Meaning
theory		
reproduction		
control		
conclude		

Using Language

Hypothesis or Theory? In everyday language, there is little difference between a *hypothesis* and a *theory*. But in science, the meanings of these words are more distinct. A *hypothesis* is a specific, testable prediction for a limited set of conditions. A *theory* is a general explanation for a broad range of data. A theory can include hypotheses that have been tested and can also be used to generate new hypotheses. The strongest scientific theories explain the broadest range of data and incorporate many well-tested hypotheses.

Your Turn Use what you have learned about the difference between a hypothesis and a theory to answer the following questions.

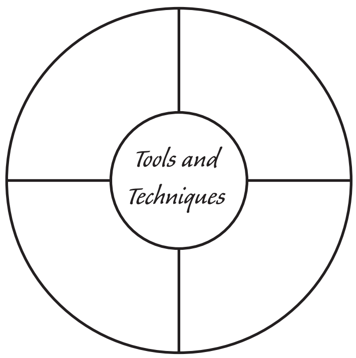
1. What is the difference between a hypothesis and a theory?
2. Propose a testable hypothesis to explain why the chicken crossed the road.

Using Graphic Organizers

Idea Wheel An idea wheel is an effective type of visual organization. Ideas in science can be divided up into topics around a central, or main, idea.

Your Turn Create an idea wheel like the one shown here to help you organize your notes about tools and techniques used in science.

1. Draw a circle. Draw a larger circle around the first circle.
2. Divide the ring between the circles into sections by drawing lines from the center circle to the outer circle.
3. Write the main idea *Tools and Techniques* in the smaller circle.
4. Label each section of the ring with a topic that falls under the main idea.
5. In each section of the ring, include notes about each topic.



Section 1

The Nature of Science

Key Ideas	Key Terms	Why It Matters
❯ How can someone practice scientific thought? ❯ What are universal laws in science? ❯ How do ethics apply to science? ❯ Why should someone who is not planning to become a scientist study science?	skepticism	Thinking like a scientist helps you solve problems and think critically about the world around you.

The goal of science is to help us understand the natural world and improve people's lives. Thinking like a scientist can help you solve problems and think critically about your world.

Scientific Thought

❯ Scientific thought involves making observations, using evidence to draw conclusions, being skeptical about ideas, and being open to change when new discoveries are made.

Questioning Ideas Scientists carefully observe the world. They then ask questions about what they observe. Often, the questions that they ask lead to even more questions. This process is the cornerstone of scientific thought. Scientific thought also requires **skepticism**—a questioning and often doubtful attitude. Scientists question everything. They require evidence, not opinions, to support ideas. Many great discoveries have been made when scientists doubted conventional wisdom. For example, people once thought that stress caused stomach ulcers. However, a group of researchers found the bacteria *Helicobacter pylori* in the stomachs of people with ulcers. Studies confirmed that the bacteria, shown in **Figure 1,** caused ulcers.

skepticism a habit of mind in which a person questions the validity of accepted ideas

Discovery and Change As scientists challenge old claims and make new discoveries, they change the way that people view the world. Many scientific discoveries lead to new technologies and medical treatments. For example, discovering that bacteria cause stomach ulcers led to prescribing antibiotics for patients with ulcers. Through the ongoing cycle of challenge and discovery, scientific knowledge grows.

***Helicobacter pylori* bacterium**

Figure 1 Doctors once thought that stress caused stomach ulcers. However, in 1982, scientists discovered that *Helicobacter pylori* bacteria were the actual cause.

Figure 2 All objects in the universe, from birds to stars, are affected by gravity. Birds must overcome gravity to fly. Stars are formed when gravity pulls a mass of gases together.

Universal Laws

Science is governed by truths that are valid everywhere in the universe. These truths are called *universal laws*. Though branches of science address different aspects of the natural world, universal laws such as the law of gravity, the law of conservation of energy, and the laws of planetary motion apply to all branches of science and to every person. A biologist studying the flight of the bird in **Figure 2** is studying how animals have adapted to overcome the force of gravity. A biologist studying the habits of nocturnal animals is studying the way that animal behavior has adapted to take advantage of the regular pattern of day and night caused by Earth's rotation on its axis.

Academic Vocabulary

aspect the way in which an idea or situation is viewed

Science and Ethics

Ethics are a system of moral principles and values. **Because scientific experimentation and discovery can have serious ethical implications, scientific investigations require ethical behavior.** Scientists performing investigations must report only accurate data and be willing to allow their peers to review their work. All scientists rely on the work of other scientists. If the data or claims of one scientist are misleading or false, many other scientists may waste time and resources conducting investigations that are based on that unethical work.

Many other people also rely on scientists to be ethical. For example, if a scientist falsely claims to have discovered a cure for diabetes, people with diabetes may change how they manage their condition to take advantage of the discovery. Because the findings are false, the people relying on the discovery could be in danger.

Scientists must also obey laws and behave ethically with people involved in scientific investigations. Ethical scientists adhere to strict guidelines to ensure that no one involved in medical experiments is coerced, exploited, or involuntarily exposed to a known danger.

Reading Check ***Why is it important that scientific investigations be done ethically? (See the Appendix for answers to Reading Checks.)***

SCILINKS.
www.scilinks.org
Topic: Scientific Discoveries
Code: HX81356

Data

QuickLab

15 min

Evaluate a Scientific Claim

As a consumer, you need to make wise decisions. Often, your buying choices depend on evaluating claims made by the manufacturer. Are the claims accurate? What can you really expect from the products?

Analysis

1. CRITICAL THINKING **Evaluating Conclusions** Suppose that two television commercials claim that their own product is the fastest-acting acne medicine. Design a strategy that could be used to compare the brands. How would you compare their effectiveness?
2. CRITICAL THINKING **Determining the Validity of a Claim** New automobiles are sold with a window sticker displaying the expected miles per gallon. Are these manufacturers' estimates realistic and repeatable by consumers? How would you find out?

Why Study Science?

Scientific thinking is not just for scientists. The same critical-thinking process that scientists use is a tool that you can use in your everyday life. **An understanding of science can help you take better care of your health, be a wiser consumer, and become a better-informed citizen.** For example, you may read an article claiming that riding a bike for 30 minutes a week can lower your blood pressure. How will you know if the claim is accurate? You can investigate the claim by using scientific thought. Ask questions about the claim, be skeptical about what you read, and be ready for discovery and change.

You can also use science to improve the world around you. You may see a problem in your town, such as a struggling recycling program or a dangerous crosswalk. You can investigate these problems with skepticism and creativity to discover helpful solutions. By applying scientific thinking to these problems, you can help yourself and your community.

READING TOOLBOX

Everyday Words in Science In your own words, write the everyday meaning for the word *law*. How does the everyday meaning compare to the science meaning of *law*?

Section 1 Review

KEY IDEAS

1. **Describe** the processes involved in practicing good scientific thought.
2. **Identify** two universal laws.
3. **Explain** how ethics apply to science.
4. **Relate** how science has already helped you in your everyday life.

CRITICAL THINKING

5. **Making Inferences** Most animals have solid bones. However, most birds have bones with hollow spaces. Explain how this feature of birds is related to one of the universal laws.
6. **Evaluating Claims** Two brands of yeast claim to produce a fast-rising dough. Design a strategy that could be used to compare the brands. What would you measure?

WRITING FOR SCIENCE

7. **Persuasive Writing** Write a letter to a younger brother or sister explaining the importance of studying science. Give at least three reasons to support your explanation.

Section
2 Scientific Methods

Key Ideas	Key Terms	Why It Matters
❯ How do scientific investigations begin? ❯ What are two types of experiments that scientists can use to test hypotheses? ❯ What is the difference between a theory and a hypothesis?	observation hypothesis experiment control group theory	Scientific thinking can help you understand and analyze information that you come across in your daily life.

All scientists have a certain way of investigating the world. Studying an actual scientific investigation is an exciting way to learn how science is done. Our story begins with a population of Canada geese.

Beginning a Scientific Investigation

For many years, the number of Canada geese around Chicago, shown in **Figure 3,** had been rising rapidly. Scientist Charles Paine of the Max McGraw Wildlife Foundation was studying this population growth when he noticed that the number of geese was no longer increasing. Why was the population boom over?

Making Observations ❯ **Most scientific investigations begin with observations that lead to questions.** **Observation** is the act of noting or perceiving objects or events by using the senses. Scientists must use both direct and indirect observation to study the world around them. Many things, like the Canada geese, can be seen. This means they can be directly observed. Other things, like the force of gravity, cannot be seen. Gravity is observed indirectly by observing the effects of gravity on objects that can be directly observed.

Formulating a Hypothesis To find out what was happening to the population of Canada geese, Paine needed to form a hypothesis. A **hypothesis** is a possible explanation that can be tested by observation or experimentation. Hypotheses are not guesses. Possible hypotheses to explain Paine's observations included these:

- The geese were being killed by predators.
- Many of the geese had become infertile.
- The geese were migrating out of the area.

Figure 3 Chicago's Canada goose population had risen rapidly for several years. After making observations, Charles Paine discovered that the population was now increasing by only about 1% per year.

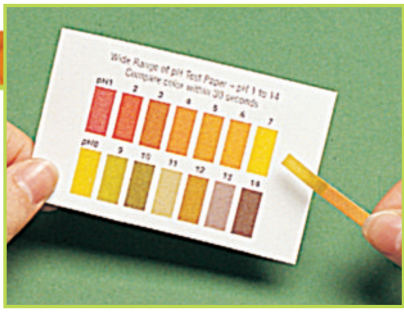
Hands-On

QuickLab

15 min

The pH of Common Substances

You can use pH indicator paper to determine the pH of various solutions. The pH indicator paper changes color when it is exposed to a solution. The change in color indicates how acidic or basic the solution is.



Procedure

1. Make a data table with three columns. Add these headings: “Solution,” “Predicted pH,” and “Measured pH.” Make a row for **five solutions** to be tested.
2. Predict the pH (acid or base) of each solution, and record your predictions in your data table.
3. **Test** each solution with **pH paper,** and record the results in the appropriate row in your data table.

Analysis

1. **Summarize** your findings in two sentences.
2. **Compare** your results with those of the rest of the class. Explain any differences.
3. **List** the scientific methods that you followed in doing this activity.
4. CRITICAL THINKING **Analyzing Results** Were the predictions that you made correct? Explain any differences between your predictions and your results.

Scientific Experiments

An **experiment** is a procedure that is carried out under controlled conditions to test a hypothesis. **Scientists conduct controlled experiments or perform studies in order to test a hypothesis.**

Controlled Experiments A controlled experiment is a procedure that tests one factor at a time and that uses a control group and an experimental group. A **control group** serves as a standard of comparison because the group receives no experimental treatment. Experimental groups are identical to the control group except for one factor, or *variable.* The single factor that scientists change in an experiment is called the *independent variable.* Factors that may change in response to the independent variable are called *dependent variables.* Scientists analyze changes to the dependent variables to understand how the independent variable affects the system that they are studying.

Study Without Experimentation There are often cases in which experiments are not possible or not ethical. For example, researchers are trying to find out if the bacteria that cause dental plaque also contribute to heart disease. It is not ethical to ask a group of people not to brush their teeth for years in order to find out if they will develop heart disease. Instead, researchers look for connections in data gathered from patients who have heart disease. However, many factors can contribute to heart disease. Researchers try to reduce the number of variables that may affect their data. For example, smoking leads to heart disease. If a person who has heart disease smokes and has dental plaque, determining which factor caused the patient’s heart disease is impossible.

observation the process of obtaining information by using the senses

hypothesis a testable idea or explanation that leads to scientific investigation

experiment a procedure that is carried out under controlled conditions to discover, demonstrate, or test a fact, theory, or general truth

control group in an experiment, a group that serves as a standard of comparison with another group to which the control group is identical except for one factor

SCILINKS.
www.scilinks.org
Topic: Scientific Investigations
Code: HX81358

Analyzing Results To test his hypothesis, Paine put radio collars on the adult Canada geese. He tracked the geese and learned that very few of the adult geese were being killed by predators. The results of an experiment may support a hypothesis or prove that a hypothesis is not true. After Paine analyzed his results, he had to change his hypothesis. Paine now hypothesized that the eggs, not the adult geese, were being eaten by predators. He discussed his ideas with his colleague Stan Gehrt, who was studying predators in the Chicago area. Gehrt had recently discovered an amazing fact: Chicago was home to about 2,000 coyotes! Gehrt had observed that coyotes, such as the one in **Figure 4,** sometimes ate the eggs of Canada geese.

theory a system of ideas that explains many related observations and is supported by a large body of evidence acquired through scientific investigation

Drawing Conclusions and Verifying Results Scientists draw conclusions that explain the results of their experiments. Working together, Paine and Gehrt concluded that urban coyotes were controlling the Canada goose population by eating the eggs. How could Paine and Gehrt verify their conclusions? Scientists verify their conclusions by conducting experiments and studies many times. They also check to see if other scientists have found similar results. In this case, urban coyotes have been found in many large cities. Paine and Gehrt could try to find out if these coyotes also eat goose eggs.

READING TOOLBOX

Hypothesis or Theory? List the hypotheses that were proposed to explain the decrease in Canada geese in Chicago. Identify which hypothesis was supported by evidence.

Considering Bias Scientists are human and have particular points of view, or biases. Scientists work hard to prevent bias from affecting their work, but bias can still influence an experiment. Also, a conflict of interest could affect a scientific study. For example, an investigation funded by a company may be biased in favor of that company's products or services. For this reason, you should view all scientific claims in their context and question them. Remember that skepticism is an important part of scientific thought, even when considering research done by qualified scientists.

Figure 4 Coyotes like this one have adapted to city life. **How do coyotes most likely control Chicago's Canada goose population?**

Scientific Theories

When related hypotheses are well supported and explain a great amount of data, these hypotheses may be put together to form a **theory.** **The main difference between a theory and a hypothesis is that a hypothesis is a specific, testable prediction for a limited set of conditions and a theory is a general explanation for a broad range of data.** Some examples of scientific theories include the quantum theory, the cell theory, and the theory of evolution. As you study science, remember that the word *theory* is used very differently by scientists and by the general public. People may say, "It's just a theory," suggesting that an idea is untested, but scientists view a theory as a highly tested, generally accepted principle that explains a vast number of observations and experimental data.

Constructing a Theory **Figure 5** summarizes the steps in the development of a theory. Constructing a theory often involves considering contrasting ideas and conflicting hypotheses. Argument, disagreement, and unresolved questions are a healthy part of scientific research. Scientists routinely evaluate and critique one another's work. Once a scientist completes an investigation, he or she often writes a report for publication in a scientific journal. Before publication, the research report is reviewed by other scientists. These reviewers ensure that the investigation was carried out with the appropriate controls, methods, and data analysis. The reviewers also check that the conclusions reached by the author are justified by the data obtained. Publishing an investigation allows other scientists to use the information to form their hypotheses. They can also repeat the investigations and confirm the validity of the conclusions.

If the results of an experiment can be reproduced many times, the scientific research may help develop a new theory. However, the possibility always remains that future evidence will cause a scientific theory to be revised or even rejected. Challenging old theories is how scientific understanding grows.

Reading Check *How does the scientific use of the word* theory *differ from how it is used by the general public?*

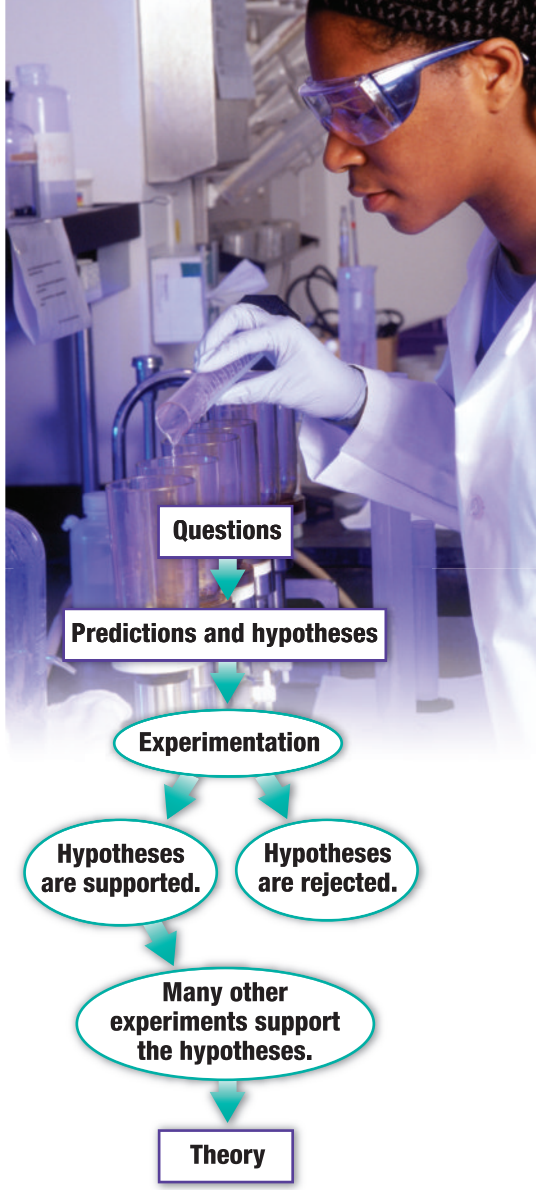


Figure 5 Scientists build theories from questions, predictions, hypotheses, and experimental results. **How can an experiment lead to a theory?**

Section 2 Review

KEY IDEAS

1. **Summarize** the processes that scientists often use when beginning scientific investigations.
2. **Describe** two ways that scientists test hypotheses.
3. **Explain** the difference between a hypothesis and a theory.

CRITICAL THINKING

4. **Analyzing Methods** Provide one example of a case in which an experiment would not be possible and one example in which an experiment would not be ethical.
5. **Forming Hypotheses** A friend notices that her dog is getting thinner even though she has not changed how much she feeds him. Propose three testable hypotheses to explain the dog's weight loss.

METHODS OF SCIENCE

6. **Designing an Experiment** Suppose that Paine had hypothesized that the Canada geese in Chicago were not reproducing at a normal rate. What experiment could he use to test whether the geese in Chicago were less fertile than geese elsewhere?

Section 3

Tools and Techniques

Key Ideas	Key Terms	Why It Matters
Why do scientists use SI units for measurement? What are some tools and techniques that scientists use in the laboratory? What can you do to stay safe during an investigation?	SI	Understanding the tools and techniques that scientists use can help you work safely and effectively in the lab.

Scientists use various units of measurements, tools, and lab techniques to help them make observations and gather and record data.

Measurement Systems

Measurements taken by scientists are expressed in the International System of Units (**SI**), which is the official name of the metric system. **The International System of Units is used by all scientists because scientists need to share a common measurement system. SI is also preferred by scientists because it is scaled in multiples of 10, which makes the system easy to use.** Like the U.S. monetary system, SI is a decimal system, so all relationships between SI units are based on powers of 10. Most SI units have a prefix that indicates the relationship of that unit to a base unit. For example, the SI base unit for length is the meter. The prefix *kilo-* means 1,000. Thus, a kilometer is equal to 1,000 meters. **Figure 6** shows other common SI units.

Reading Check *How are prefixes used in names of SI units?*

go.hrw.com
interact online
Keyword: HX8BIOF6

Figure 6 How many dimes are in a dollar? The question is easy to answer because our monetary system, like SI, is built on powers of 10. **How many pennies are there in $10?**

Common SI Units

Prefix	Factor	Volume	Length	Mass
kilo-	1,000	1 kiloliter = 1,000 L	1 kilometer = 1,000 m	1 kilogram = 1,000 g
—	1	1 liter (L)	1 meter (m)	1 gram (g)
centi-	0.01	1 centiliter = 0.01 L	1 centimeter = 0.01 m	1 centigram = 0.01 g
milli-	0.001	1 milliliter = 0.001 L	1 millimeter = 0.001 m	1 millligram = 0.001 g

Hands-On

QuickLab

15 min

Practice Staining Techniques

The parts (organelles) of a typical cell are mostly transparent. In a technique called *staining,* color is added to cell parts to help identify and distinguish them.

Procedure

1. Use **forceps** to remove a thin layer of **onion skin,** and place it in the center of a **glass slide.** Add a **drop of water,** and place a **coverslip** over the specimen.
2. Examine the onion skin with a **light microscope.** Draw what you see.
3. Place a **drop of iodine stain** along one edge of the coverslip. Touch a piece of **paper towel** to the opposite edge to draw the water. When the skin is stained, examine it with the microscope.

Analysis

1. **Describe** how the stain affected the onion skin.
2. CRITICAL THINKING **Analyzing Information** What is the advantage of using the paper to draw the stain across the field of view?

Lab Techniques

In the lab, scientists always keep detailed and accurate notes and perform precise measurements. Many scientists also use specialized tools, such as microscopes, and specialized procedures, such as sterile technique.

Microscopy Many organisms, such as bacteria, are too small to see with the unaided eye. Microscopes help magnify these organisms. Two common kinds of microscopes are light microscopes and electron microscopes. In a light microscope, light passes through one or more lenses to produce an enlarged image of an object. An electron microscope forms an image of an object by using a beam of electrons to magnify extremely small objects.

Sterile Technique Scientists who study cells need to be able to grow cells in a controlled setting. Because bacteria live everywhere on Earth, scientists must use sterile technique when growing cells. Sterile technique is a method of keeping unwanted microorganisms out of a lab to minimize the risk of contamination. The tools of sterile technique include an autoclave for sterilizing equipment, sterilized dishes and pipets, a laminar-flow hood, and latex gloves.

Collecting Data Remotely As electronic technology has advanced, more tools have become available for scientists to use. Remote tracking devices to attach to released animals, data collected from satellites, and technology based on the global positioning system (GPS) have enabled scientists to conduct investigations that would have been impossible just a few decades ago.

Reading Check *When might sterile technique be used in a lab?*

SI the International System of Units, which is the measurement system that is accepted by scientists worldwide

Academic Vocabulary

technique a way of doing something

SCILINKS.
www.scilinks.org
Topic: History of Standard Units
Code: HX80747

Figure 7 Using proper safety equipment is necessary during every scientific investigation. For example, this scientist must use a special suit to protect his skin from the extreme heat coming from this volcano vent.

Safety

As you can see in **Figure 7,** studying science is exciting, but it can also be dangerous. **Scientists must use caution when working in the lab or doing field research to avoid dangers such as chemical burns, exposure to radiation, exposure to infectious disease, animal bites, or poisonous plants.** Here are some guidelines for working safely in the lab:

- Listen carefully to your teacher, and follow all instructions.
- Read your lab procedure carefully before beginning the lab.
- Do not take any shortcuts in your lab procedure.
- Always wear your safety goggles and any other needed safety equipment when working in the lab.
- Measure chemicals precisely.
- Never taste or smell any materials or chemicals that you use in a lab unless your teacher instructs you to do so.
- Do not use any damaged or defective equipment.
- Keep your lab area clean and free from clutter.
- When you place something onto the lab bench, make sure that the object sits securely on the bench and will not fall or tip over.
- Pay attention to where you are walking.
- If you are working outside, be aware of your surroundings. Avoid poisonous plants and animals that live in the area. Wear sunscreen and a hat that shades your neck and ears.

Accidents If an accident does occur, remain calm. Make sure that you are safe and that no one else is in danger. Then, inform your teacher right away. Follow all of the instructions that your teacher gives you. Know the location and proper operation of all lab safety equipment before it is needed. A review of lab safety equipment before labs begin can save valuable time if an accident happens in your lab. For more information about lab safety and how to respond to accidents in the lab, read *Lab Safety* at the front of this book.

Reading Check ***List at least five actions that you can take in the laboratory to ensure your safety.***

READING TOOLBOX

Idea Wheel Complete the idea wheel that you started at the beginning of the chapter. Fill in the outer sections of the wheel with details about the tools and techniques used in science.

Section 3 Review

KEY IDEAS

1. **Explain** why scientists use SI units for measurement.
2. **Describe** two kinds of microscopes.
3. **Summarize** the steps that you should take if an accident occurs in the lab.

CRITICAL THINKING

4. **Inferring Conclusions** In general, measurement systems that are based on powers of 10 are the easiest for people to use. Infer why these systems are easiest to use.
5. **Analyzing Information** Why is reading the lab procedure before starting an experiment considered an important part of lab safety?

MATH SKILLS

6. **Performing Conversions** A scientist pours 3.48 milliliters (mL) of hydrochloric acid into a beaker. How many liters of hydrochloric acid did the scientist pour into the beaker?

Section 4

What Is Biology?

Key Ideas	Key Terms	Why It Matters
❯ What are some of the branches of biology? ❯ What are seven characteristics that all living things share?	biology, reproduction, cell, heredity, homeostasis, evolution, metabolism	All living things on Earth are tied together by common traits and rely on one another for their common survival.

The giant sequoia shown in **Figure 8** is very different from the man standing below it. But both organisms have much in common. Studying living organisms is what the science of biology is all about.

The Study of Life

Biology is the study of life. Life is extremely diverse. It would be impossible for one person to become an expert in all aspects of biology, so scientists specialize. There are many branches of biology. ❯ **Biology includes biochemistry, ecology, cell biology, genetics, evolutionary theory, microbiology, botany, zoology, and physiology.** Biochemistry is the study of the chemistry of life. Ecology is the study of how organisms interact with each other and with their environment. The study of life on the cellular level is called cell biology. Genetics is the study of how organisms pass traits to their offspring. Evolutionary theory is the study of changes in types of organisms over time. The study of microscopic organisms is called microbiology. The study of plants is called botany. Zoology is the study of animals. Physiology is the study of the human body. As you read, you will learn about each of these fields. You will also have the opportunity to practice techniques that are used in careers in each of these fields.

biology the scientific study of living organisms and their interactions with the environment

Figure 8 Both the man and the sequoia tree that he is standing on are living organisms. ❯ **Which branches of biology would study both humans and trees?**

Properties of Life

All living organisms share certain properties. **The seven properties of life are cellular organization, homeostasis, metabolism, responsiveness, reproduction, heredity, and growth.** Life is characterized by the presence of all seven properties at some stage in an organism's life.

Cellular Organization A cell is the smallest unit capable of all life functions. A **cell** is a highly organized, tiny structure that is enclosed in a thin covering called a *membrane*. The basic structure of cells is the same in all organisms.

Why It Matters

Biology in the Wild

A biologist who studies organisms in their natural habitat is called a field biologist. These scientists study life in every kind of habitat. They may tag polar bears near the North Pole or climb into caves deep underground. By studying organisms in their natural habitat, field biologists can learn about life in the wild.

Hanging Around for Science

Sometimes, field biologists hang around in interesting places. Scientists who study the biology of cave-dwelling organisms are called speleologists. This scientist is hanging over a cave called the Well of the Birds. This sinkhole is more than 200 meters deep and growing.

Life Under Water This marine biologist has to go underwater to study manatees in their habitat. Manatees are an endangered species. Scientists hope that by learning about manatees, we may be able to prevent the extinction of this species.

Research Use library or Internet sources to learn more about jobs that are available for field biologists.

Homeostasis All living organisms must maintain a stable internal environment in order to function properly. The maintenance of stable internal conditions in spite of changes in the external environment is called **homeostasis.**

Metabolism Living things carry out many chemical reactions in order to obtain energy. **Metabolism** is the sum of all of the chemical reactions carried out in an organism. Almost all of the energy used by living things originally comes from sunlight. Plants, algae, and some bacteria capture this energy and use it to make molecules. These molecules serve as the source of energy, or food, for other organisms.

Figure 9 These students are responding to the rain by using raincoats. **Can you think of a way that you have responded to your environment today?**

Responsiveness In addition to maintaining a stable internal environment, living organisms also respond to their external environment. Plants bend toward sunlight. Birds fluff their feathers to insulate their bodies during cold weather. Students, shown in **Figure 9,** also respond to their environment.

Reproduction Most living things can reproduce. **Reproduction** is the process by which organisms make more of their own kind from one generation to the next. Because no organism lives forever, reproduction is an essential part of life.

Heredity When an organism reproduces, it passes on its own traits to its offspring in a process known as **heredity.** Heredity is the reason that children tend to look like their parents. Inherited characteristics change over generations. This process is called **evolution.**

Growth All living organisms grow . Some one-celled organisms only grow briefly, during the time that they are reproducing. Other living things, like the giant sequoia, grow for thousands of years and reach an enormous size. As organisms grow, many change. This process is called *development.* Frogs begin as eggs, develop into tadpoles, and eventually develop into frogs. Development differs from evolution because development refers to change in a single individual during that individual's life.

Reading Check *How is heredity related to evolution?*

cell in biology, the smallest unit that can perform all life processes

homeostasis the maintenance of a constant internal state in a changing environment

metabolism the sum of all chemical processes that occur in an organism

reproduction the process of producing offspring

heredity the passing of genetic traits from parent to offspring

evolution the process of change by which new species develop from preexisting species over time

Section 4 Review

KEY IDEAS

1. **Explain** what biology is.
2. **Describe** nine fields that are part of the science of biology.
3. **Name** the basic unit of life.
4. **Discuss** the seven properties all living organisms share.
5. **Define** homeostasis.

CRITICAL THINKING

6. **Recognizing Verifiable Facts** If you find an object that seems alive, how might you determine if the object is indeed an organism?
7. **Elaborating** Give an example of one way that you are interdependent on another type of organism.
8. **Analyzing Information** Relate five of the characteristics of life to an organism familiar to you.

ALTERNATIVE ASSESSMENT

9. **Interview a Biologist** Choose a field of biology that interests you. Locate a biologist working in that field, and conduct an interview by phone or e-mail. Ask the biologist how he or she became interested in his or her field and what the scientist's work is like. Report your findings to the class.

Skills Practice

Chapter 1 Lab

Objectives

- Express measurements in SI units.
- Read a thermometer.
- Measure liquid volume by using a graduated cylinder.
- Measure mass by using a balance.
- Determine the density (mass-to-volume ratio) of two liquids.

Materials

- graduated cylinder, 100 mL
- sand, light colored, 75 mL
- cups, plastic, (2)
- sand, dark colored, 75 mL
- thermometers, Celsius, alcohol filled (2)
- gloves, heat resistant
- ring stand or lamp support
- light source
- stopwatch or clock
- balance
- corn oil, 25 mL
- water, 25 mL
- cup, clear plastic
- graph paper

Safety

SI Units

Most scientists use SI units for all of the measurements that they take. In this lab, you will practice making measurements in SI units.

Procedure

Measure Sand Temperature

1. In your lab report, prepare a data table similar to the table below.
2. Put on safety goggles, gloves, and a lab apron. Using a graduated cylinder, measure 75 mL of light-colored sand, and pour it into one of the small plastic cups. Repeat this procedure with the dark-colored sand and another plastic cup.
3. Level the sand by placing the cup on your desk and sliding the cup back and forth. Insert one thermometer into each cup.
4. Using a ring stand or lamp support, position the lamp approximately 9 cm from the top of the sand, as shown in the figure. Make sure that the lamp is evenly positioned between the two cups.
5. Before turning on the lamp, record in your data table the initial temperature of each cup of sand.
6. **CAUTION: Wear heat-resistant gloves when handling the lamp. The lamp will become very hot and may burn you.** Note the time or start the stopwatch when you turn on the lamp. The lamp will become hot and warm the sand. Check the temperature of the sand in each container at 1-minute intervals for 10 minutes. In your data table, record the temperature of the sand after each minute.

Sand Temperature

Time (min)		Light-colored sand
1		
2		
3		
4		
5		

Compare the Density of Oil and Water

7. In your lab report, prepare a data table similar to the Density of Two Liquids table.
8. Label one clean plastic cup “Oil,” and label another “Water.” Using a balance, measure the mass of each plastic cup, and record the value in your data table.
9. Put on an apron. Using a clean graduated cylinder, measure 25 mL of corn oil, and pour it into the plastic cup labeled “Oil.” Using a balance, measure the mass of the plastic cup containing the corn oil, and record the mass in your data table.
10. Repeat step 9 with water and the plastic cup labeled “Water.”
11. To find the mass of the oil, subtract the mass of the empty cup from the mass of the cup and the oil together.
12. To find the density of the oil, divide the mass of the oil by the volume of the oil, as shown in the equation below.

$$\textit{Density of oil} = \frac{\textit{mass of oil}}{\textit{volume of oil}} = \underline{\qquad\quad}\ \text{g/mL}$$

13. Repeat steps 11 and 12 to find the mass and density of water.
14. Combine the oil and water in the clear cup, and record your observations in your lab report.
15. Clean up your materials according to your teacher’s instructions. Wash your hands before leaving the lab.

Density of Two Liquids	
a. Mass of empty oil cup	g
b. Mass of empty water cup	g
c. Mass of cup and oil	g
d. Mass of cup and water	g
e. Volume of oil	25 ml
f. Volume of water	25 ml
Calculating Actual Mass	
Oil Item c– Item a =	g
Water Item d – Item b =	g
g. Density of oil	g/ml
h. Density of water	g/ml

Analyze and Conclude

1. **Graphing Data** Use graph paper or a graphing calculator to graph the data that you collected in the first part of the lab. Plot time on the *x*-axis and temperature on the *y*-axis.
2. SCIENTIFIC METHODS **Interpreting Data** Based on your graph, what is the relationship between color and heat absorption?
3. **Inferring Conclusions** How might the color of the clothes that you wear affect how warm you are on a sunny day?
4. SCIENTIFIC METHODS **Making Systematic Observations** In the second part of the lab, what did you observe when you combined the oil and water? Relate your observation to the densities that you calculated.
5. SCIENTIFIC METHODS **Using Evidence to Make Explanations** What could you infer about the value for the density of ice if you observe it floating in water?

Extensions

6. **Understanding Relationships** How would your calculated density values be affected if you misread the volume measurement on the graduated cylinder?
7. **Experimental Design** Pumice is a volcanic rock that has a density less than 1.00 g/cm^3. How would you prove this density if you did not have a balance to weigh the pumice? (Hint: The density of water is 1.00 g/cm^3.)

Chapter 1 Summary

go.hrw.com
SUPER SUMMARY
Keyword: HX8BIOS

Key Ideas	Key Terms
1 The Nature of Science	

1 The Nature of Science

- Scientific thought involves making observations, using evidence to draw conclusions, being skeptical about ideas, and being open to change when new discoveries are made.
- Science is governed by truths that are valid everywhere in the universe. These truths are called *universal laws*.
- Scientific investigations require ethical behavior.
- An understanding of science can help you take better care of your health, be a wiser consumer, and become a better-informed citizen.

Key Terms: **skepticism** (4)

2 Scientific Methods

- Most scientific investigations begin with observations that lead to questions.
- Scientists can conduct controlled experiments and qualitative studies in order to test a hypothesis.
- The main difference between a theory and a hypothesis is that a hypothesis is a specific, testable prediction for a limited set of conditions and a theory is a general explanation for a broad range of data.

Key Terms: **observation** (10), **hypothesis** (10), **experiment** (11), **control group** (11), **theory** (13)

3 Tools and Techniques

- The International System of Units (SI) is used by all scientists because scientists need to share a common measurement system. SI is scaled in multiples of 10, which makes the system easy to use.
- In the lab, scientists always keep detailed and accurate notes and perform precise measurements. Many scientists also use specialized tools, such as microscopes, and specialized procedures, such as sterile technique.
- Scientists must use caution when working in the lab or doing field research to avoid dangers such as chemical burns, exposure to radiation, exposure to infectious disease, animal bites, or poisonous plants.

Key Terms: **SI** (14)

4 What Is Biology?

- Biology includes biochemistry, ecology, cell biology, genetics, evolutionary theory, microbiology, botany, zoology, and physiology.
- The seven properties of life are cellular organization, homeostasis, metabolism, responsiveness, reproduction, heredity, and growth.

Key Terms: **biology** (17), **cell** (18), **homeostasis** (19), **metabolism** (19), **reproduction** (19), **heredity** (19), **evolution** (19)

Chapter 1 Review

READING TOOLBOX

1. **Hypothesis or Theory?** Write a statement that summarizes the difference between a hypothesis and a theory.

2. **Concept Mapping** Make a concept map that outlines scientific investigations in biology. Try to include the following words: ***biology, observation, communication, hypotheses, predictions, experiments,*** and ***theories.***

Using Key Terms

Use each of the following terms in a separate sentence.

3. *skepticism*

4. *control group*

For each pair of terms, explain how the meanings of the terms differ.

5. *hypothesis* and *theory*

6. *homeostasis* and *metabolism*

7. *reproduction* and *heredity*

Understanding Key Ideas

8. To support claims, scientists require
   - **a.** evidence.
   - **b.** opinions.
   - **c.** technology.
   - **d.** photographs.

9. Though scientists study the world from differing perspectives, what must all scientists take into account?
   - **a.** universal laws
   - **b.** animal behavior
   - **c.** temperature differences
   - **d.** the importance of biology

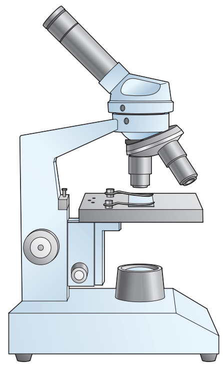
10. Which of the following observations is qualitative, described in words rather than numbers?
    - **a.** surveying the size of the goose population
    - **b.** observing the nocturnal behavior of coyote populations
    - **c.** recording the date when goose migration begins every year
    - **d.** counting the number of goose nests that are robbed of eggs in an area

11. What is true of all hypotheses?
    - **a.** They are true.
    - **b.** They are false.
    - **c.** They are testable.
    - **d.** They are indisputable.

12. In an experiment, what happens to the control group?
    - **a.** It receives no experimental treatment.
    - **b.** It receives experimental treatment last.
    - **c.** It receives experimental treatment first.
    - **d.** It receives more experimental treatments than the other groups.

13. Which of the following units of measure would be most appropriate for determining the mass of an apple?
    - **a.** gram
    - **b.** kilogram
    - **c.** milligram
    - **d.** centigram

14. How does a microscope help scientists observe objects?
    - **a.** It measures objects.
    - **b.** It magnifies images.
    - **c.** It performs calculations.
    - **d.** It stains transparent objects.



15. Some toads that live in a hot, dry environment bury themselves in the soil during the day. What characteristic of living things does this behavior describe?
    - **a.** heredity
    - **b.** reproduction
    - **c.** metabolism
    - **d.** responsiveness

Explaining Key Ideas

16. **Summarize** the four key steps to practicing good scientific thought.

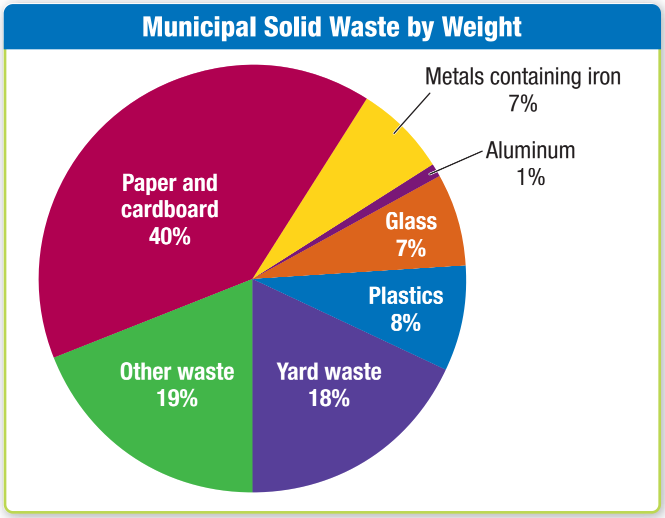
17. **Explain** why the study of science is important.

18. **Infer** why scientists try to limit the number of independent variables in an experiment.

19. **Identify** 10 things that you can do to stay safe during scientific investigations.

Using Science Graphics

This diagram shows a breakdown of the types of municipal solid waste, by weight, generated in the United States. Use the chart and your knowledge of science to answer the following questions.



20. According to the diagram, which makes up the greatest proportion of waste?

a. paper and cardboard
b. metals containing iron
c. yard waste, glass, and plastics
d. other waste

21. If each type of solid waste were recycled, which type would have the biggest impact on conserving trees?

a. aluminum
b. glass
c. plastics
d. paper and cardboard

22. Which of these types of waste could be turned into compost?

a. glass
b. plastics
c. yard wastes
d. metal containing iron

Critical Thinking

23. Forming Reasoned Opinions The law of conservation of matter states that matter cannot be created or destroyed. How does this universal law relate to biology?

24. Recognizing Relationships The development of science and technology is closely linked. Explain how the invention of the microscope led to the development of the sterile technique. List at least one other technology that most likely resulted from the invention of the microscope.

25. Inferring Relationships The most rigorous form of peer review is blind peer review, in which the scientists reviewing the work do not know the identity of the scientists who authored the work. Why might blind peer review be more rigorous than other forms of peer review?

Technology Skills

26. Computer Presentation Find out more about the differences between theories, laws, and hypotheses. Create a computer presentation that uses examples and illustrations to show the differences between each.

Methods of Science

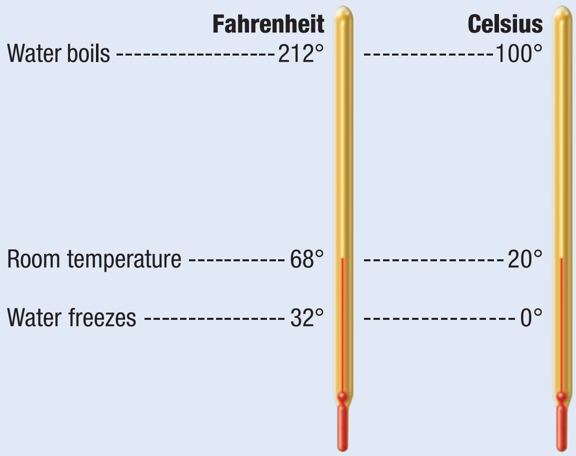
27. Analyzing Methods Scientists collect both quantitative and qualitative data. Quantitative data can be expressed in numbers. Qualitative data must be expressed in words. If you were observing a pride of lions, what are some examples of quantitative and qualitative data that you could collect?

Alternative Assessment

28. Homeostasis Display Research five ways that your body maintains homeostasis. Then, create a poster-board display that illustrates how each of these responses functions.

Math Skills

29. Estimating The diagram below shows the relationship between the Fahrenheit and the Celsius temperature scales. If the air temperature is 60°F, estimate the air temperature in Celsius.



Chapter 1 Standardized Test Prep

TEST TIP When faced with similar answers on multiple-choice questions, define the answer choices and then use that definition to narrow down the choices.

Science Concepts

1. A scientist is investigating a new treatment for a disease that affects thousands of people. Many people with this disease volunteer to be part of the study. Which of the following is an ethical concern that the scientist must address before conducting the study?

- **A** The scientist must ensure that the treatment will be effective.
- **B** The scientist must ensure that the study's results will not be shared with other scientists.
- **C** The scientist must inform the volunteers about the potential dangers of participating in the study.
- **D** The scientist must demonstrate the treatment on him or herself.

2. Which of the following is an example of scientific skepticism?

- **F** A scientist investigates how a universal law affects many fields of study.
- **G** A scientist falsely claims to have discovered a cure for diabetes.
- **H** A scientist conducts an experiment that supports the conclusions of another scientist.
- **J** A scientist questions another scientist's conclusions and develops an experiment to test an alternative hypothesis.

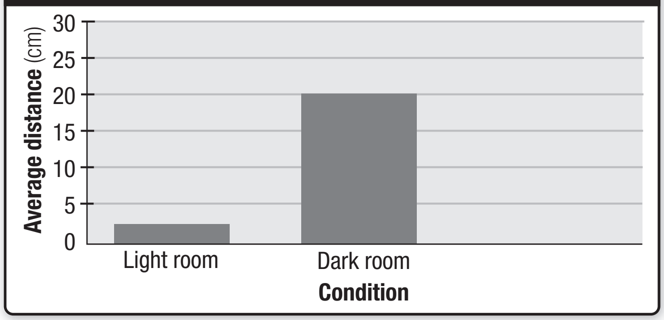
Math Skills

3. Calculate The strength of a light microscope is determined by multiplying the strength of the eyepiece by the strength of the objective lens. Light microscopes often have several objective lenses. Suppose that a microscope has an eyepiece that magnifies by 10 and two objective lenses, one that magnifies by 10 and one that magnifies by 40. Calculate the total magnification for each objective lens used with the eyepiece.

Using Science Graphics

Use the diagram to answer the following question.

Owl Strike Distance from Target in Different Conditions



4. In which room does an owl strike a target most accurately?

- **A** dark room
- **B** light room
- **C** heated room
- **D** dark and lighted room

Use the diagram to answer the following question.

SECTION
NEWS 2
BUSINESS 8
METRO 12
ARTS 20
CLASSIFIEDS 25

The City

THE HOMETOWN GAZETTE · Monday

Weather Watch
Sunny during the day.
Much darker at night.

Detective Has Theory on How Computers Were Stolen from Warehouse

The warehouse on Runny Creek Road was broken into Sunday night between the hours of 10:00 p.m. and midnight. More than $50,000 worth of computer equipment was taken. One arrest has been made based on the testimony of a witness who said he had seen two men in the area on Sunday afternoon. The man arrested was picked out of a lineup by the witness. The suspect says he was at home several miles away when the crime took place. The burglars broke out a window to gain access to the warehouse. Apparently, the burglar cut himself on a piece of the glass. Blood found on the glass is being used for DNA testing which will prove conclusively the innocence or guilt of the arrested man. The suspect has been released on $10,000 bond. One other person is being sought as a possible accomplice.

5. Which of the following words most accurately reflects the use of the term *theory* in the newspaper headline above?

- **F** law
- **G** fact
- **H** hypothesis
- **J** experiment

Writing Skills

6. Evaluating Statements Write a short paragraph that expresses your opinion on the following statement: "The lengthy drug-approval process costs hundreds of lives every year. Doctors have a moral obligation to provide potentially life-saving drugs to terminally ill patients, even if the drugs have not been scientifically tested."