

## Chapter

# 2

## Methods of Science

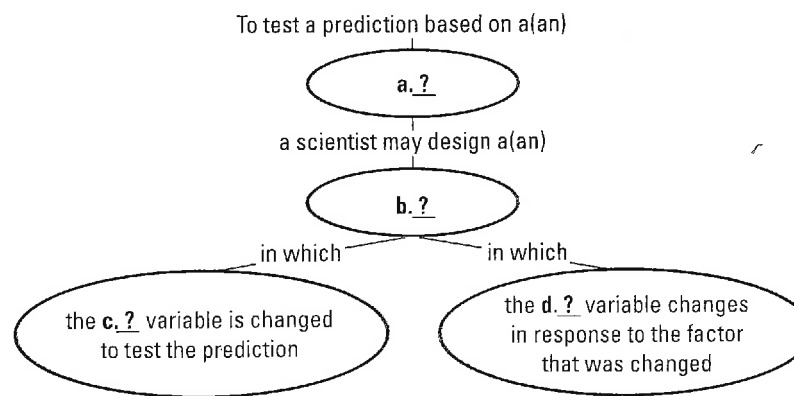
- 2.1 THE NATURE OF SCIENCE
- 2.2 SKILLS AND METHODS
- 2.3 ENVIRONMENTAL SCIENCE



Kilauea volcano on the Big Island of Hawaii erupts in glowing rivers of lava. Here, scientists can observe directly how volcanic eruptions add rock to Earth's lithosphere.

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Copy the concept map about scientific methods into your notebook. As you read, fill in the concept map, then give it a title.



## 2.1 THE NATURE OF SCIENCE

- OBJECTIVES**
- *Explain why there is always uncertainty in science.*
  - *Distinguish between a hypothesis and a guess.*

What is science? What do scientists do? You can probably name different kinds of scientists, such as biologists, chemists, or physicists. Each of these scientists uses different tools and instruments to measure different things, but all scientists have something in common. They all use the scientific method to gather information.

Science is a way of learning about the world. Books contain ideas and information about science. They may also tell how scientists gathered that information. The information itself, however, is not science. Science is the process by which the information was gathered and interpreted.

### Uncertainty in Science

In some ways, the work of a scientist is similar to the work of a detective. The detective cannot go back in time to watch a crime being committed. Instead, the detective must solve a mystery by putting together pieces of evidence. The detective first gathers as much evidence as possible about the crime. Then, based on the evidence, the detective forms a likely explanation. If new evidence is brought to light that disproves the explanation, the detective will have to come up with a new explanation.

In a similar way, a scientist tries to find answers to the mysteries of nature. Just as the detective cannot watch the crime, the scientist often cannot see natural processes at work. Instead, the scientist must make as many observations as possible about the results of those processes. The scientist then forms an explanation for what was observed. A **hypothesis** (hy-POTH-eh-sis) (plural, hypotheses) *is a possible explanation for a set of observations*. A hypothesis is not just a wild guess. It must be based on observations and it must be testable.

If later observations do not fit the hypothesis, the hypothesis can be changed. For example, you may observe that after a hard rain, the gutters on your street fill up with water. You form a hypothesis that all the water in the gutter comes from rain. The next sunny day, a neighbor up the street washes her car, and the gutter fills with water even though there has been no rain. You need to revise your hypothesis. How could you restate your hypothesis about where the water in the gutter comes from?

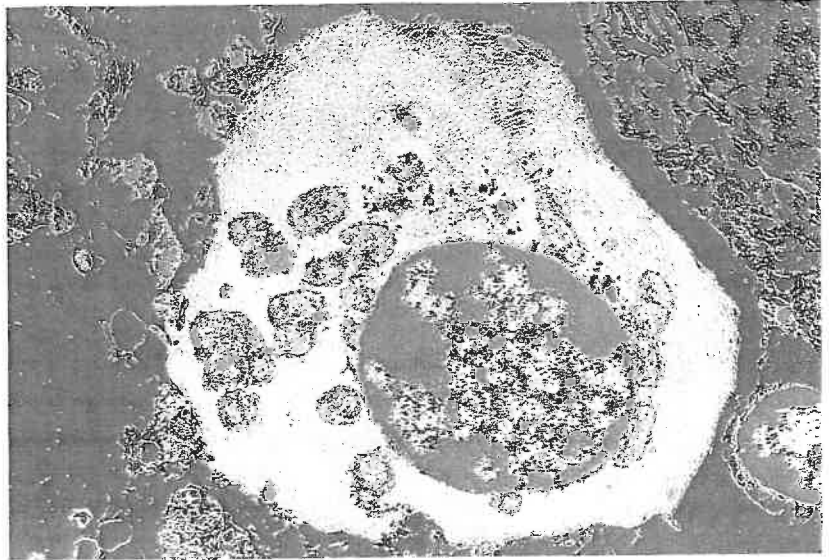
Scientists can never be certain that they have observed everything about a particular subject. A new tool may be invented that allows additional observations. A scientist must always be ready to modify or give up an old hypothesis in favor of a better one. Because new information often causes a scientist to change a hypothesis, change is basic to science.

**Figure 2.1** The transmission electron microscope (TEM) is a tool that enables scientists to see structures within a cell. Scientists had to change their ideas about some cellular structures when they saw images like this one produced by the TEM.

## Think About It!

Housing starts, or the construction of new homes, are an important indicator of a strong economy. But building homes may also be harmful to the environment. People must make choices when the needs of the economy and the needs of the environment conflict.

1. How can science help people understand the effects of construction on the environment and the economy?
2. How can science help people decide if houses should be built in a particular area?



## Science and Society

The progress of science is often driven by the needs and challenges of society. Feeding a hungry world, curing and preventing the spread of AIDS, and developing new energy sources are just some of the challenges of today's scientists.

Science cannot answer questions of ethics or personal values. Science can find out how well a new AIDS drug will work or how much electricity a new energy source will provide. But it cannot tell which research is more important.

The products of science can be of great benefit to the world. Unfortunately, the products of science also have the potential to do harm. Everyone, not just scientists, must work to make sure that scientific findings are put to good use. As a voter and a consumer of the products of science, you will be involved in making decisions about the impact of science on society. The more you know about the issues, the better prepared you will be to make these decisions.

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## SECTION REVIEW

1. Explain why a hypothesis is not just a wild guess.
2. Why are scientific ideas uncertain by nature?
3. **Apply** The United States government has established recommended daily allowances for many nutrients. The amounts recommended for some nutrients have changed over the years. Why do you think this has happened?

# Searching the Depths

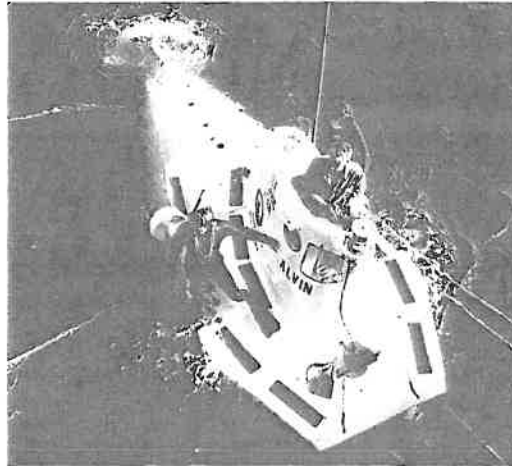
To collect data, scientists often do field research. But in some "fields," conditions make it impossible for humans to visit without special equipment. For instance, as divers go deeper into the ocean, they must deal with decreasing temperatures, diminishing light, and increasing pressure. At depths where pressure is more than the human body can stand, research must be done from within a small submarine, called a submersible.

One such submersible is *Alvin*, operated by Woods Hole Oceanographic Institution. Built in 1964 to reach depths of more than 5000 feet, *Alvin* is carried on a larger research vessel. The submersible is equipped with lights, video cameras, and robot arms. There are instruments to monitor water temperature and depth, plus a communication system for keeping in touch with the research vessel at the surface.

*Alvin* became internationally famous after being used in the expedition that located and photographed the remains of the RMS Titanic in 1986. However, *Alvin's* main purpose is to conduct scientific research.

The years from 1971 to 1976 were spent surveying the bottom of the Atlantic Ocean, doing both geological and biological surveys. As part of the French-American Mid-Ocean Undersea Study, *Alvin* and two French submersibles carried scientists to the Mid-Atlantic Ridge. This was the first time humans saw this geologically active area up close.

In 1988, *Alvin* enabled biologists and oceanographers to conduct detailed studies of several "hot smokers" along the Juan de Fuca Ridge in the Pacific Ocean. These are vents where an active volcano spews lava directly into the ocean at depths of several thousand feet. These vents support surprisingly diverse communities of organisms at depths that are usually lifeless. Using *Alvin's* remote-controlled temperature probe, scientists learned that the temperature inside a vent is greater than 275 °C.



Used for scientific research, *Alvin* can study the ocean at depths of more than 5000 feet.

After more than 3000 dives, *Alvin* has been used for further study of undersea vents and to perform tests on specialized underwater research equipment. *Alvin* has even run errands, making a special dive just to recover a rock drill that was lost by another expedition.

## ✓ Checkpoint

1. What problems of deep-sea research does *Alvin* help scientists overcome?
2. Why is it important that *Alvin* have equipment to measure depth?

## 2.2 SKILLS AND METHODS

**OBJECTIVE** • *Describe the steps involved in conducting a scientific experiment.*

### **Do It!** **Field Activity**

An important skill in detective work is observing and noting details about your surroundings.

1. Using a specific site on the school grounds, make as many observations as you can in 10 minutes, and write them down.
2. Based on your observations, make a list of five questions; for example: What was the color of the car parked on the corner?
3. Exchange your list with that of your classmates and see how well you each observed your surroundings.

There is no single process or set of steps that all scientists use. The scientist must always be prepared to go backward, change direction, and be flexible. The scientist must be prepared for surprising results or unexpected information. One investigation may lead to another, and yet another. The result for the scientist may be a lifetime of investigation and learning. Although the exact steps may vary, good scientific investigations have certain common features. Every investigation begins with an observation.

### **Observing and Questioning**

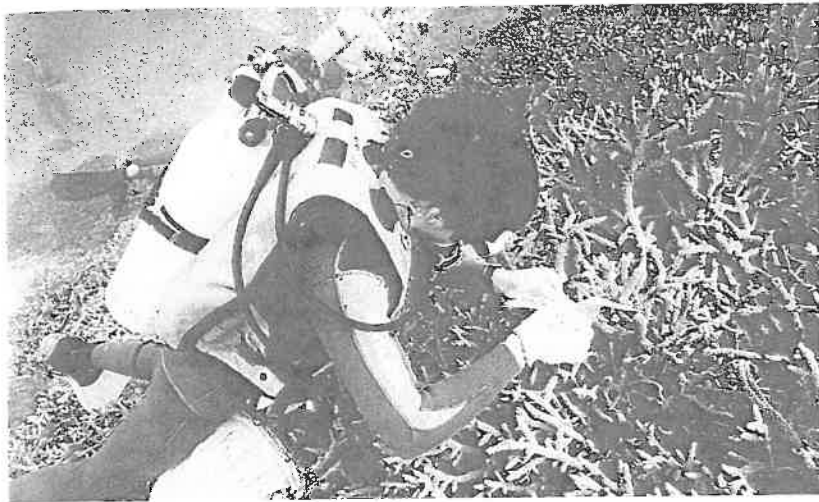
Observations can be made directly with the senses, such as sight or touch. But many observations are made with the help of tools. Some tools are instruments that help extend the senses, allowing more detailed observations and measurements to be made. A balance, for example, enables a scientist to measure the mass of a rock more accurately than by simply holding it. A microscope enables a scientist to view things too small for the unaided eye to see. Other tools enable scientists to measure things that could not otherwise be observed at all. For example, a Geiger counter lets scientists measure radiation that the senses cannot detect.

Observations are followed by a question. The question is based on something that was observed. For example, a scientist may observe that grass does not grow in a certain area, and ask why. A scientist may observe that people who work in a particular building often become sick, and ask why.

### **Researching**

How would you feel if you spent years trying to solve a mystery, only to find that someone else had already solved it? An important step in solving a scientific mystery, or conducting an investigation, is to find out what others have already learned about the topic. Perhaps the earlier work can save you some steps. Perhaps your hypothesis has already been supported or disproven. A trip to the library will help a scientist learn what work has been done on the subject. Scientists also attend meetings to share information about their research.

Sometimes scientists deliberately repeat work that was done by others. Repeating an experiment is an important part of science. If someone repeats your experiment and does not get the same results, there may be a problem with your hypothesis. Experimental results that cannot be repeated are not considered valid.



**Figure 2.2** Much of the data used in environmental science comes from field studies. Field studies take place in any kind of environment, not just fields.

## Hypothesizing

Once the scientist has found out about the work others have done, it is time to determine what direction the investigation will take. This next step is developing a hypothesis. Recall that a hypothesis is a possible explanation for an observation. The scientist should try to think of several hypotheses. From all the possible hypotheses, the scientist then chooses the most likely one. The ability to develop hypotheses and then choose among them is one of the most creative, important parts of a scientist's work.

Suppose a scientist observes that grass does not grow in a certain part of a lawn. The observation may raise a question: Why does grass not grow in this area? The scientist can offer several hypotheses. For example, one hypothesis may be that the area does not receive enough water. Another hypothesis may be that the area is too shady. The presence of a grass disease could be yet another hypothesis to explain the observation. However, only one hypothesis can be investigated in one experiment.

Once a hypothesis has been chosen, the scientist makes a prediction. The prediction states what the results of the experiment will be if the hypothesis is accurate. In the grass example, the scientist may predict that if the area is given more water, grass will grow. Which hypothesis would this prediction support? Suppose the scientist's hypothesis is that a fungus is killing the grass. What prediction could be made to support this hypothesis?

Sometimes a scientist may conduct an experiment without a clear hypothesis. Such an experiment could answer a question that begins with "What would happen if...?" This type of experiment is used to produce further observations that could be used as the basis for a hypothesis later. For such an experiment to be valid, it must be considered part of a larger experiment. For example, you might conduct an experiment to see what would happen if you added bleach to your laundry. You might observe that some clothes

## LINK Literature

The mythology of many ancient cultures, such as the Greeks and Romans, was an attempt to explain observations of nature. Unlike modern science, the ideas put forth in mythology were not tested or testable.

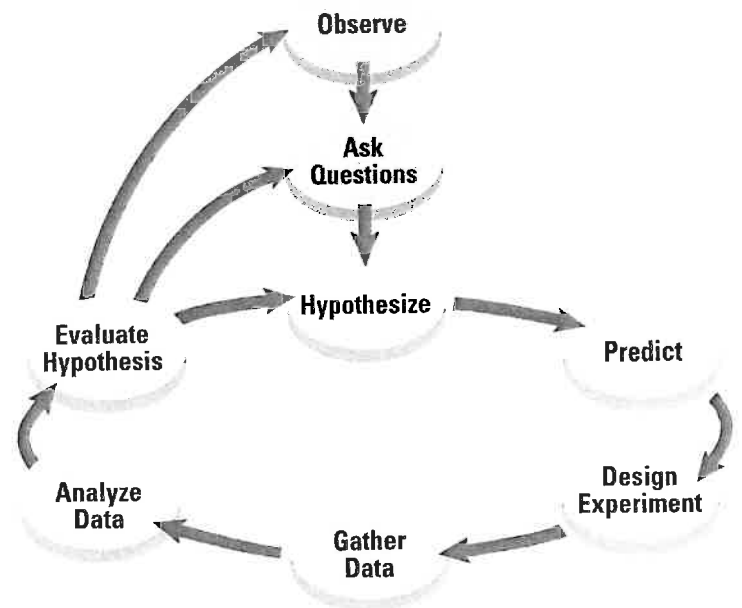
are cleaner, some are faded, and others are not affected at all. From these observations you could develop a hypothesis such as “bleach causes colors to fade on cotton fabric.” You could then predict that if you wash a bright-colored cotton tee shirt with bleach, it will fade. At this point, you would be ready to design an experiment.

## Designing an Experiment

Scientists use experiments to test their hypotheses. If the results of an experiment disprove a hypothesis, the scientist may develop a new hypothesis and design a new experiment. If the results support the hypothesis, the scientist does not say that the hypothesis has been “proven.” Although it is tempting to say so, scientists must be careful not to jump to conclusions. After many experiments have supported the hypothesis, the explanation is said to be valid. This means that the explanation is good. However, there is always a chance that it may be disproven by a better explanation in the future. Designing a good experiment to test a hypothesis is a very important part of scientific studies.

**Variables** A **variable** is any factor that affects the outcome of an experiment. An experiment usually tests one, and only one, variable at a time. Consider once again the problem of grass growth. Variables that could affect the growth of grass include water, sunlight, and diseases. Suppose the scientist exposed the grassless area to more sunlight and gave the area more water. In a few days, new grass grew. The scientist cannot know which variable—the water, the sunlight, or the combination of the two—made the grass grow.

**Figure 2.3** If the data do not support the hypothesis, the scientist may make new observations, ask new questions, or choose a new hypothesis and start the process again.



**Experimental and Control Groups** In designing an experiment, a scientist sets up two groups: an experimental group and a control group. The only difference between the two groups is the one variable to be tested. In the problem of grass growth, the hypothesis is that the grass died because there was no water. The variable to be tested would be the presence of water. The **control group** would have all of the factors that were there when the original observations were made, including the lack of water. The experimental group would be the same, except for the addition of water.

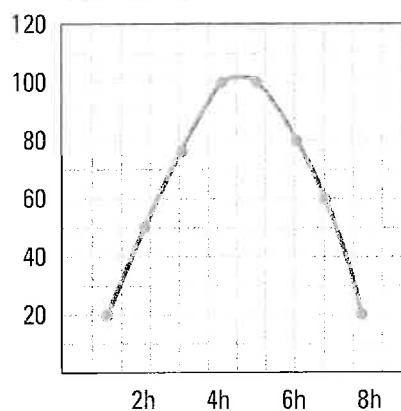
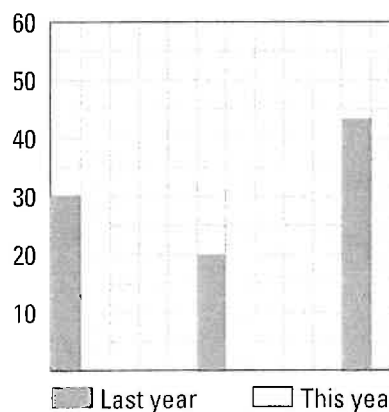
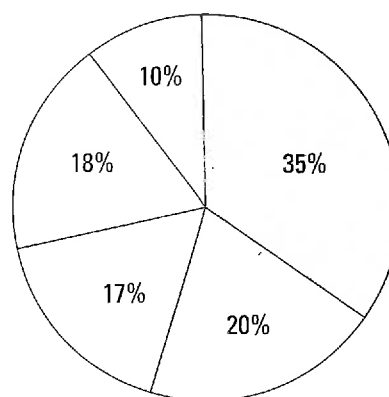
After setting up the experimental and control groups, the scientist predicts how the two groups will compare. The scientist might predict that the grass in the group with water will live and the control grass without water will die. The one variable that is changed to test the prediction is called the *independent variable*. In this experiment, the independent variable is the water. The factor that changes in response to the independent variable is called the *dependent variable*. In this example, the growth of the grass is the dependent variable.

## Collecting, Organizing, and Analyzing Data

Scientists carefully record not only the results of the experiment but also the steps they took to conduct the experiment. Once the data are collected, the scientist must decide what the results mean.

To analyze and interpret data, the scientist chooses a way to display the data. Sometimes the data are organized into a table. A graph is often used to show patterns or trends in the data more clearly. Some types of graphs are shown in Figure 2.4. In bar graphs and line graphs, the independent variable is usually shown on the x-axis. The dependent variable is shown on the y-axis.

Once the data have been collected and analyzed, the scientist communicates the work to others. Sometimes scientists share their work informally through conversations. Scientists publish reports of their experiments in scientific journals and give presentations at meetings. All reports must clearly show how the experiment was conducted, what the results were, and how the results can be interpreted.



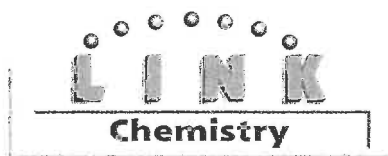
**Figure 2.4** Circle graphs, or pie charts (top), show portions of a whole value. Bar graphs (center) are used to compare quantities. Line graphs (bottom) are used to show how one variable responds to change in another.

## SECTION REVIEW

1. How does an experimental group differ from a control group?
2. Why should a scientist conduct library research before beginning an experiment?
3. **Infer** One of the most important skills a scientist can have is the ability to write well. Why do you think this is so?

## 2.3 ENVIRONMENTAL SCIENCE

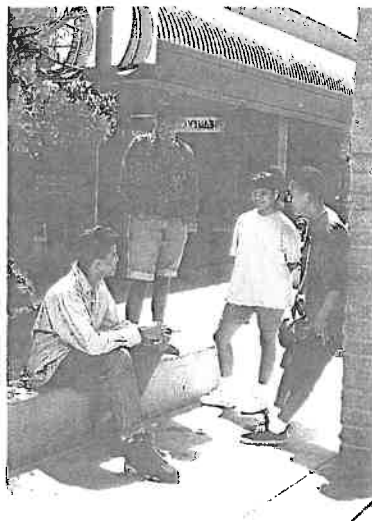
**OBJECTIVES** • **Give** examples of how parts of the environment interact. • **Explain** how science influences decision-making processes.



Matter is defined as anything that takes up space and has mass. Most matter is made up of elements and combinations of elements. All the known elements are listed in the periodic table on page 429.



**Figure 2.5** Every environment has its own set of characteristics. What are the living and nonliving parts of each of the environments shown here?



**Table 2.1 Areas of Study in Environmental Science**

Area	Scientist	Subject
Water	Hydrologist	Flow of Earth's waters
	Oceanographer	Ocean environments
Air	Meteorologist	Weather and the atmosphere
	Climatologist	Global weather patterns
Land	Geologist	Structure and history of Earth
	Seismologist	Movements of Earth's surface
Organisms	Biologist	Structure and behavior of organisms
	Ecologist	Interactions of organisms and their environments
	Paleontologist	Prehistoric life and fossils
	Anthropologist	Structure of human societies

Table 2.1 shows some of the types of scientists that are involved in studying the environment. As you can see from the table, ecologists are scientists that study the interactions between organisms and their environments. What then is the difference between ecology and environmental science? Often the two terms are used to refer to the same thing. Indeed, you cannot study the environment without understanding the principles of ecology. The difference between the two fields of study is the role of human societies.

The principles of ecology do not change simply by including humans in the picture. After all, humans are organisms and are part of the natural world. Unlike other organisms, however, humans have the ability to create and enforce policy, and to affect the environment on a global scale. Environmental science incorporates the impact of human activities, both planned and unplanned, on the environment.

## Parts of the Environment

All the factors that make up the environment can be divided into two categories: living and nonliving. *All the living parts of the environment are called **biotic** (by-OT-ik) **factors**.* Biotic factors in your classroom may include only humans and microbes too small to see. If you were camping, the list of biotic factors in your environment would be longer. The list might include plants, birds, mushrooms, insects, and so on.

*All the nonliving parts of the environment are called **abiotic** (AY-by-OT-ik) **factors**.* Abiotic factors include water, soil, and air, as well as temperature, wind, and sunlight. Some of the abiotic factors in an environment may once have been alive, such as your classroom's wooden chairs, which came from trees. Because the wood is no longer alive, it is therefore not a biotic factor.



### LINK Fine Arts

One way to record observations about your environment is through art. French painter Paul Gauguin (1848–1903) was fascinated with the plants, animals, and people of Tahiti. He made several trips to the islands and painted his impressions of the environment.

## Dateline 1970

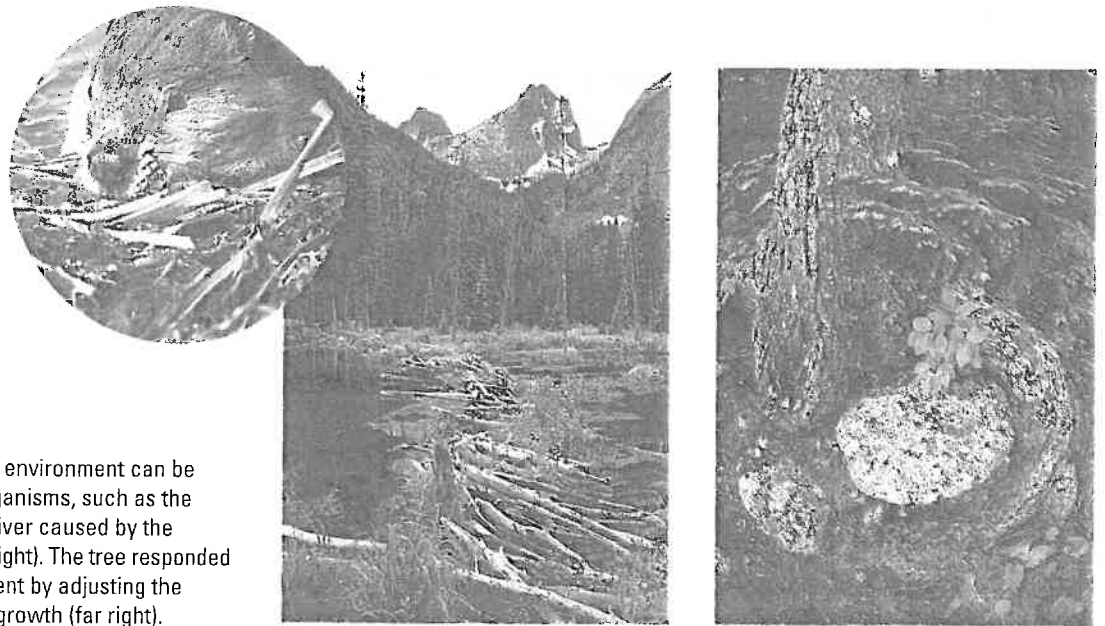
On April 22, 1970, the first Earth Day was established as a day for people to express their desire to protect the environment, and for schools to focus their instruction on environmental protection. The day is now observed internationally on April 22 each year. Earth Day is a day for people to think about how they affect the environment—and how they can help protect it.

## Environmental Interactions

Much of the research that is done in the area of environmental science involves interactions. Organisms interact with the biotic and abiotic factors in the environment. An organism may be affected by changes in the environment, and the environment can be affected by the organism. The change that occurred in the environment may, in turn, have an effect on another organism.

Sometimes it seems easy to predict how a change in the environment will affect other factors. For example, a particular species of butterfly can lay eggs on only one type of lupine flower. It is not difficult to predict what will happen to the butterflies if all the lupine flowers are destroyed. However, it is usually more difficult to predict how a change in one part of the environment will affect other parts. For example, there were once thriving populations of coyotes, deer, wolves, and mountain lions on the north rim of the Grand Canyon. In the early 1900s, the state of Arizona began rewarding hunters for killing the coyotes, mountain lions, and wolves because they were believed to be a danger to settlers and livestock. After 15 years, the hunted animals were almost completely wiped out. But these animals were the natural enemy of the deer, which were not being hunted.

Without wolves, coyotes, and mountain lions, the deer population soon grew to 25 times the size it had been before the hunting began. The deer ate all the available plants in the area. Eventually, the environment could no longer support so many deer, and approximately 60 000 deer died of starvation the following winters. Seventy years later, the plant growth in the area had not yet fully recovered. No one had predicted that the hunting would have such a destructive effect on the environment.



**Figure 2.6** The environment can be changed by organisms, such as the change in the river caused by the beaver's dam (right). The tree responded to its environment by adjusting the direction of its growth (far right).

## ACTIVITY 2.1

### The Capture-Recapture Method

#### PROBLEM

Every year, a team of biologists estimates the population size of a rare species of trout that live in Grass Lake. Grass Lake is polluted, but efforts are being made to clean it up. The biologists make their estimation using the capture-recapture method. The biologists float on rafts and capture fish on baited hooks. The fish are marked, tallied, and thrown back into the water. The biologists repeat the procedure a week later. Imagine you are a biologist on the team trying to answer this question: What is the size of the trout population in Grass Lake?

#### MATERIALS (per class)

- 100 to 200 toothpicks
- Watch or small clock

#### PREDICTION

The capture-recapture method will produce an accurate estimate of a population size.

#### PROCEDURE

1. For the first sampling, go with your class to the designated grass area. The borders of this area represent the shores of Grass Lake.
2. Previously, toothpicks were spread out over Grass Lake. Toothpicks have been cut in half. Each half toothpick represents a trout. Spend 2 minutes capturing toothpicks. Keep the toothpicks you capture in your hand, and return to class with them.
3. Mark the toothpicks in an agreed-upon manner without damaging them. Tally and record the number caught by the entire class. These are the marked trout in the total population.
4. Give your half toothpicks to a designated member of your class. The designated person will throw the marked toothpicks back in Grass Lake. They should be randomly scattered across Grass Lake.
5. Return to Grass Lake with the rest of the class. Again, spend 2 minutes capturing toothpicks, and return to class with them.
6. Some of the toothpicks you've captured will probably be marked, indicating they had been previously captured. Separate these from the unmarked toothpicks.
7. Tally and record the number of toothpicks recaptured by the entire class. These are the marked trout recaptured.
8. Tally and record the total number of toothpicks, marked and unmarked, captured by the class during the second sampling. These are the total trout captured.
9. Return all toothpicks to your teacher.
10. Multiply the number of total trout captured (step 8) by marked trout in total population (step 3). Divide this product by the marked trout recaptured (step 7). The result is an estimate of the trout population in Grass Lake.

$$\frac{\text{Marked trout recaptured}}{\text{Total trout captured}} = \frac{\text{Marked trout in total population}}{X}$$

X = The size of the trout population in Grass Lake

#### ANALYSIS

1. To get an accurate estimate, why is it important that trout caught during the first sampling are returned to the lake unharmed?
2. What are possible sources of error with the capture-recapture method? How can these errors be minimized?
3. Could the capture-recapture method be used to accurately estimate the size of any population? Explain.

#### CONCLUSION

What is your estimate of the trout population in Grass Lake? Show the calculations you performed to obtain your estimate.



**Figure 2.7** Citizens can voice their opinions by voting. Sometimes people express themselves by joining together in interest groups or by attending demonstrations to make their voices heard.

## Making Decisions

Many changes taking place in the biosphere are the result of human activities. Some of these changes could cause environmental damage if they are allowed to continue. It may seem obvious that people should stop doing things that damage the environment. Unfortunately, deciding what needs to be done, and how to do it, are not such easy tasks.

The interactions that take place in the biosphere are very complex. As you have learned, it is not always possible to predict how one change will affect other parts of the environment. An organism may interact with its environment in ways scientists are not aware of. Whenever a public policy regarding the environment is put into effect, the government must try to predict what the impact of the policy will be. To do this, the government usually employs a team of researchers to study the interactions that will be affected.

In addition to a policy's impact on the environment, the government must also consider the economic effect the policy may have on society. Regulations that protect the environment may cost people their jobs. For example, efforts in the northwestern United States to protect old-growth forests and the organisms that live there have conflicted with the local economic concerns. The economy in the area depends heavily on the lumber industry, which would suffer from protection of the forest. In developing nations where food and fuel are scarce, the conflict between environmental issues and the needs of people are even more difficult to resolve.

Who should decide how, where, and when the environment is to be protected? Who will determine the steps that are to be taken in the future? One essential key to making good decisions is an understanding of the environment and its interactions. This includes thorough scientific research and well-informed citizens. The more people know about how their activities affect the environment, the better prepared they will be to protect the biosphere.

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## SECTION REVIEW

1. Why do governments need to study the environment?
2. Which parts of the environment respond to the activities of organisms, the biotic factors or the abiotic factors?
3. **Infer** Mosquito fish feed on young mosquitoes that can carry malaria. The young mosquitoes feed on tiny floating plants in ponds. Turtles feed on plants at the bottom of the ponds. These plants need sunlight from the surface. What might happen to the turtles if mosquito fish are brought into a pond?

## CHAPTER 2 REVIEW

### KEY TERMS

hypothesis 2.1  
variable 2.2

control 2.2  
environment 2.3

biotic factor 2.3  
abiotic factor 2.3

### CHAPTER SUMMARY

**2.1** Science is a way of learning about the natural world. Science is uncertain and changeable. Science is responsive to the needs of society, and voters are involved in making decisions about the impact of science on society.

**2.2** A scientific investigation follows a series of steps that result in the support or rejection of a hypothesis. An experiment has a control group

and an experimental group. In the control, the variable being tested is absent.

**2.3** Environmental science is an integrated science, one that draws from many fields of science. The environment includes biotic and abiotic factors. Biotic and abiotic factors interact with one another, but it can be difficult to predict what the results of such interactions will be.

### MULTIPLE CHOICE

Choose the letter of the word or phrase that best completes each statement.

1. Science is (a) a collection of information; (b) based on facts; (c) random; (d) uncertain.
2. Science cannot answer questions that are (a) testable; (b) observable; (c) based on ethics; (d) based on observations.
3. Observations should be made (a) before an experiment is designed; (b) while an experiment is being conducted; (c) before and during an experiment; (d) after the experiment is completed.
4. A prediction is usually made (a) before making observations; (b) before developing a hypothesis; (c) after developing a hypothesis; (d) after the experiment is conducted.
5. The part of an experiment in which the variable being tested is not present is called the (a) experimental group; (b) variable group; (c) dependent group; (d) control group.
6. If you wanted to compare the rainfall this month with the rainfall last month in various locations, you could best represent the data in a (a) circle graph; (b) bar graph; (c) line graph; (d) pie chart.
7. The abiotic factors in an environment include (a) plants; (b) animals; (c) water; (d) microbes.
8. Interactions in the environment are usually (a) complex; (b) predictable; (c) easily observed; (d) well understood.

### TRUE/FALSE

Write true if the statement is true. If the statement is false, change the underlined word to make it true.

1. A scientist who studies movements of land is a paleontologist.
2. A prediction is a statement of what will happen during an experiment if the hypothesis is valid.
3. All the environments in which organisms live make up the biosphere.
4. A wooden chair may be one of the biotic factors in your environment.
5. It is difficult to predict the results of changes in the biosphere because interactions are simple.
6. Environmental protection policies often have economic impact.

## CHAPTER 2 REVIEW

### CONCEPT REVIEW

Write a complete response to each of the following.

1. How are graphs useful in a scientific investigation?
2. Why is it important that scientists communicate the results of their experimentation to other scientists?
3. How has the invention of new tools, such as the electron microscope, influenced the progress of science?
4. A hypothesis can be considered an educated guess. Explain how this is different from a wild guess.
5. Why is it necessary for people who do not plan to have careers in science to be informed about the environment?

### THINK CRITICALLY

1. Suppose there is a tree growing in your backyard, and the roots of the tree have damaged the pipes that bring water into the house. To restore the water, the tree must be removed. But the tree is home to a rare bird. Would you cut down the tree? Why or why not?
2. Suppose the tree in the above example is growing in someone else's yard, and recent studies have shown that the rare bird produces a chemical that may cure cancer. Would your opinion change? Explain your answer.
3. A friend is upset because the fish in his aquarium have been dying. He raises the temperature of the water and increases the amount of available food. The fish continue to die, so your friend decides that neither temperature nor food is responsible. What is

- wrong with your friend's approach to solving the problem? Is the conclusion valid?
4. Suppose you had lived near the Grand Canyon in the early 1900s. Do you think you would have supported the policy of rewarding hunters for killing wolves, coyotes, and mountain lions? Explain.

**Computer Activity** In 1980, the flowers in a particular field were made up of 40 percent daisies, 30 percent lupines, 15 percent daffodils, and 15 percent buttercups. In 1990, the combination of flowers in the same field was 35 percent daisies, 25 percent lupines, 25 percent daffodils, and 15 percent buttercups. Use a graphing program to represent the change of flowers as a circle graph and as a bar graph.

### WRITE CREATIVELY

What do you think your neighborhood looked like 200 years ago? Write a story about an animal that fell asleep 200 years ago and just woke

up. In your story, describe the changes that have taken place in the animal's environment.

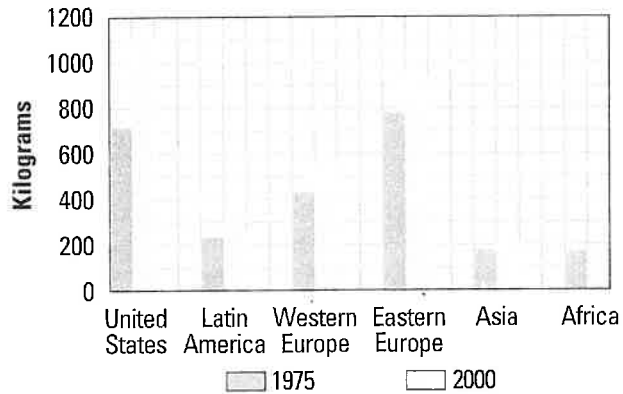
### PORTFOLIO

1. People used to believe that life could arise from nonliving things. Research the experiments of Francesco Redi and Louis Pasteur that disproved this idea. What were the variables and controls in each experiment? Prepare a presentation describing how each scientist followed the steps of a scientific experiment.
2. Each area of specialization in science uses specific types of tools to gather data. Choose one of the areas in Table 2.1. Find out what tools are used, and the type of data that each tool provides.

## GRAPHIC ANALYSIS

Use the figure to answer the following.

1. The graph represents the amount of grain consumed per person per year in various parts of the world. The graph shows consumption in 1975 and expected consumption in the year 2000. Which type of graph is shown?
2. In what part of the world is consumption not expected to rise?
3. In what part of the world was grain consumption greatest in 1975? What part of the world is expected to be the greatest grain consumer in 2000?
4. Could this information be presented in a different form? Explain your answer.



## ACTIVITY 2.2

### PROBLEM

How is a hypothesis tested and evaluated?

### MATERIALS

- 6 radish seeds
- 2 Petri dishes
- 6 lima bean seeds
- wax marking pencil
- 2 sponges

### HYPOTHESIS

Water is needed for seeds to germinate.

### PROCEDURE



1. To test the hypothesis, place a wet sponge in one Petri dish. Pour a small amount of water in the dish. The top of the sponge should be moist but not submerged. Label this dish *experimental*.
2. Place a dry sponge in the other dish. Do not allow this sponge to get wet. Label this dish *control*.
3. Place 3 radish seeds and 3 lima bean seeds on top of each sponge. **Caution:** Wash your hands after handling the seeds because they are often coated with chemicals.

4. Keep the two dishes close together at all times. Keep all conditions, except moisture, the same for each setup. Be sure to keep the wet sponge moist.
5. Examine the seeds over the next few days.
6. Record the number of seeds that germinated from each setup in a data table.

### ANALYSIS

1. Describe an observation of nature that might lead someone to develop the original hypothesis.
2. What factors did you control in this experiment?
3. What was the tested variable? Why is it important to test only one variable in an experiment? Do your observations support or reject the previously stated hypothesis? If necessary, restate your hypothesis.

### CONCLUSION

Why is evaluating your hypothesis an important part of a good scientific experiment?