Section 2

Scientific Inquiry

Reading Preview

Key Concepts

- What is scientific inquiry?
- What makes a hypothesis testable?
- What attitudes are important in science?

Key Terms

- scientific inquiry
- hypothesis • variable
- controlled experiment
- manipulated variable
- responding variable
- operational definition
- data • communicating

Target Reading Skill

Building Vocabulary A definition states the meaning of a word or phrase by telling about its most important feature or function. After you read this section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

What Can You Learn About Mealworms?

1. Observe mealworms in a tray. Use a magnifying glass to see them more clearly.
2. Watch the mealworms' behavior—for example, how they move.

Think It Over

Posing Questions Write three questions you have about mealworms and their behavior. How could you find out the answers?

"Chirp, chirp, chirp." It is one of the hottest nights of summer and your bedroom windows are wide open. On most nights, the quiet chirping of crickets gently lulls you to sleep, but not tonight. The noise from the crickets is almost deafening!

Why do all the crickets in your neighborhood seem determined to keep you awake tonight? Could the crickets be chirping more because of the heat? How could you find out?

As you lie awake, you are probably not thinking much about science. But, in fact, you are thinking just as a scientist would. You made observations—you heard the loud chirping of the crickets and felt the heat of the summer night. Your observations led you to infer that heat might cause increased chirping. You might even make a prediction: "If it's cooler tomorrow night, the crickets will be quieter."

▼ A snowy tree cricket

The Scientific Process

Although you might not know it, your thinking and questioning can be the start of the **scientific inquiry** process. **Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence they gather.** If you have ever tried to figure out why a plant has wilted, then you have used scientific inquiry. Similarly, you could use scientific inquiry to find out whether there is a relationship between the air temperature and crickets' chirping.

Posing Questions Scientific inquiry often begins with a problem or question about an observation. In the case of the crickets, your question might be: Does the air temperature affect the chirping of crickets? Of course, questions don't just come to you from nowhere. Instead, questions come from experiences that you have and from observations and inferences that you make. Curiosity plays a large role as well. Think of a time that you observed something unusual or unexpected. Chances are good that your curiosity sparked a number of questions.

Some questions cannot be investigated by scientific inquiry. Think about the difference between the two questions below.

- Does my dog eat more food than my cat?
- Which makes a better pet—a cat or a dog?

The first question is a scientific question because it can be answered by making observations and gathering evidence. For example, you could measure the amount of food your cat and dog each eat during a week. In contrast, the second question has to do with personal opinions or values. Scientific inquiry cannot answer questions about personal tastes or judgments.

Developing a Hypothesis How could you explain your observation of noisy crickets on that summer night? "Perhaps crickets chirp more when the temperature is higher," you think. In trying to answer the question, you are in fact developing a hypothesis. A **hypothesis** (plural: *hypotheses*) is a possible explanation for a set of observations or answer to a scientific question. In this case, your hypothesis would be that cricket chirping increases at higher air temperatures.

In science, a hypothesis must be testable. This means that researchers must be able to carry out investigations and gather evidence that will either support or disprove the hypothesis. Many trials will be needed before a hypothesis can be accepted as true.

Reading Checkpoint **What is a hypothesis?**

FIGURE 7 Developing Hypotheses
A hypothesis is one possible way to explain a set of observations. A hypothesis must be testable—scientists must be able to carry out investigations to test the hypothesis. **Developing Hypotheses** *Propose another hypothesis that could explain the observation that crickets seem to be noisier on some nights than others.*

Lab zone Skills Activity

Controlling Variables

Suppose you are designing an experiment to determine whether birds eat a larger number of sunflower seeds or millet seeds. What is your manipulated variable? What is your responding variable? What other variables would you need to control?

Designing an Experiment To test your hypothesis, you will need to observe crickets at different air temperatures. All other **variables,** or factors that can change in an experiment, must be exactly the same. Other variables include the kind of crickets, the type of container you test them in, and the type of thermometer you use. By keeping all of these variables the same, you will know that any difference in cricket chirping must be due to temperature alone.

An experiment in which only one variable is manipulated at a time is called a **controlled experiment.** The one variable that is purposely changed to test a hypothesis is called the **manipulated variable** (also called the independent variable). In your cricket experiment, the manipulated variable is the air temperature. The factor that may change in response to the manipulated variable is called the **responding variable** (also called the dependent variable). The responding variable here is the number of cricket chirps.

Another aspect of a well-designed experiment is having clear operational definitions. An **operational definition** is a statement that describes how to measure a variable or define a term. For example, in this experiment you would need to determine what sounds will count as a single "chirp."

Collecting and Interpreting Data For your experiment, you need a data table in which to record your data. **Data** are the facts, figures, and other evidence gathered through observations. A data table is an organized way to collect and record observations. After the data have been collected, they need to be interpreted. A graph can help you interpret data. Graphs can reveal patterns or trends in data.

Reading Checkpoint **What are data?**

FIGURE 8
A Controlled Experiment
In their controlled experiment, these students are using the same kind of containers, thermometers, leaves, and crickets. The manipulated variable in this experiment is temperature. The responding variable is the number of cricket chirps per minute at each temperature.
Controlling Variables *What other variables must the students keep constant in this experiment?*

Drawing Conclusions A conclusion is a summary of what you have learned from an experiment. In drawing your conclusion, you should ask yourself whether the data support the hypothesis. You also need to consider whether you collected enough data. After reviewing the data, you decide that the evidence supports your original hypothesis. You conclude that cricket chirping does increase with temperature. It's no wonder that you have trouble sleeping on those warm summer nights!

Scientific inquiry usually doesn't end once a set of experiments is done. Often, a scientific inquiry raises new questions. These new questions can lead to new hypotheses and new experiments. Also, scientific inquiry is not a rigid sequence of steps. Instead, it is a process with many paths, as shown in Figure 9.

Communicating An important part of the scientific inquiry process is communicating your results. **Communicating** is the sharing of ideas and experimental findings with others through writing and speaking. Scientists share their ideas in many ways. For example, they give talks at scientific meetings, exchange information on the Internet, and publish articles in scientific journals. When scientists communicate their research, they describe their procedures in full detail so that other scientists can repeat their experiments.

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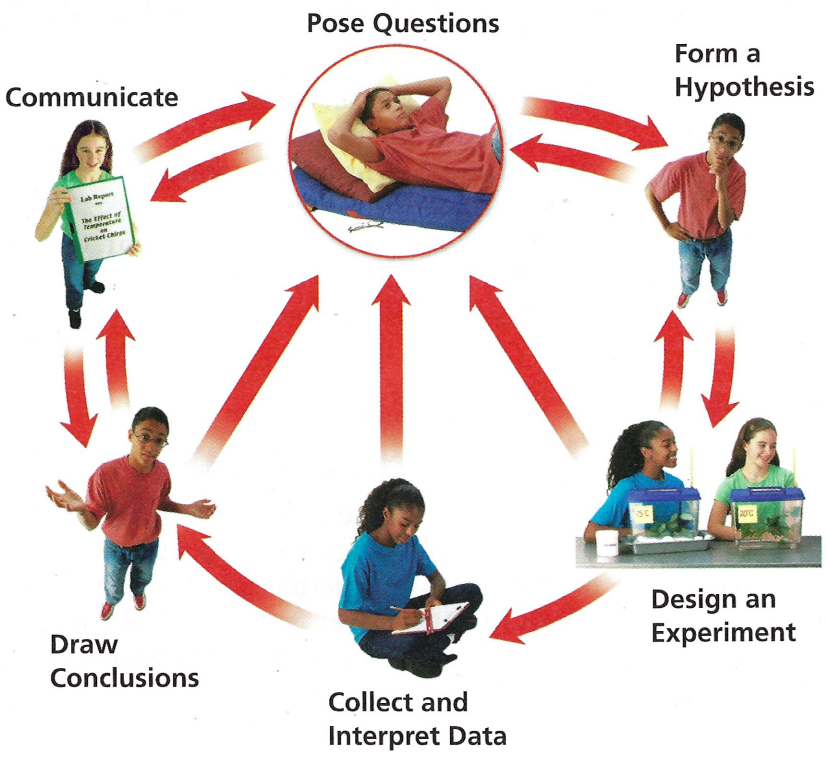

FIGURE 9
Scientific Inquiry
There is no set path that a scientific inquiry must follow. Observations at each stage of the process may lead you to modify your hypothesis or experiment. Conclusions from one experiment often lead to new questions and experiments.

FIGURE 10 **Curiosity**
Curiosity has led Dr. Daphne Soares to study how alligators interact with their environment.

Scientific Attitudes

Why has Jane Goodall been very successful at studying chimps? **Successful scientists possess certain important attitudes, or habits of mind, including curiosity, honesty, open-mindedness, skepticism, and creativity.**

Curiosity An important attitude that drives scientists is curiosity. Successful scientists are eager to learn more about the topics they study. They stick with problems in spite of setbacks.

Honesty Good scientists always report their observations and results truthfully. Honesty is especially important when a scientist's results go against previous ideas or predictions.

Open-Mindedness and Skepticism Scientists need to be open-minded, or capable of accepting new and different ideas. However, open-mindedness should always be balanced by skepticism, which is an attitude of doubt.

Creativity Whether scientists study chimps or earthquakes, problems may arise in their studies. Sometimes, it takes a bit of creativity to find a solution. Creativity means coming up with inventive ways to solve problems or produce new things.

Section 2 Assessment

Target Reading Skill Building Vocabulary
Use your definitions to help answer the questions.

Reviewing Key Concepts

1. a. Defining Define the term *scientific inquiry*.
   b. Explaining A friend claims that pea plants grow faster than corn plants. Could you investigate this idea through scientific inquiry? Explain.
   c. Problem Solving What kind of data would you need to collect to carry out this experiment?
2. a. Reviewing What is meant by saying that a hypothesis must be testable?
   b. Developing Hypotheses Every time you and your friend study for an exam while listening to classical music, both of you do well on the exam. What testable hypothesis can you develop from your observations?
3. a. Identifying What attitudes help scientists succeed in their work?
   b. Explaining Why is it important for scientists to balance open-mindedness and skepticism?
   c. Making Judgments Is it important to be both open-minded and skeptical in your everyday life? Explain.

Writing in Science

Summary Suppose you will be traveling to a convention of cricket scientists from around the world. Write a paragraph describing the results of your cricket experiment. Include questions you'd like to ask other cricket scientists while at the conference.