1 What Is Science?

Reading Preview

Key Concepts

- What skills and attitudes do scientists use to learn about the world?
- What is scientific inquiry?
- How do scientific theories differ from scientific laws?

Key Terms

- science • observing
- inferring • predicting
- scientific inquiry • hypothesis
- controlled experiment
- variable
- manipulated variable
- responding variable • data
- scientific theory • scientific law

Target Reading Skill

Building Vocabulary 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**

How Can Scientists Find Out What's Inside Earth?

1. Your teacher will give you a spherical object, such as a sports ball. You can think of the sphere as a model of Earth.
2. Carefully observe your sphere. What characteristics of the sphere can you observe and measure directly?
3. What characteristics of the sphere cannot be directly observed and measured?

Think It Over

Posing Questions In your notebook, list several questions that you have about Earth. Which of these questions could you answer based on direct observation? Which questions would need to be answered based on indirect evidence?

A helicopter lands near the top of an erupting volcano. With care and speed, a team of scientists get out to do their work. "I've been out there sometimes when lava is shooting out of the ground 100 meters high," says Margaret Mangan, a scientist who studies volcanoes. "The main thing you're struck with is the sound. It's like the roaring of many jet engines. Then there's the smell of sulfur, which is choking. The wind can blow particles from the lava fountain over you, little bits of congealed lava. It feels like a hot sandstorm."

Dr. Mangan has observed many volcanic eruptions of Mount Kilauea in Hawaii. She studies the characteristics of red-hot lava. She wants to know why lava sometimes erupts in huge fountains, but at other times erupts in gently flowing streams.

Thinking Like a Scientist

Watching a volcanic eruption, you might ask yourself questions such as: "What is lava?" and "Where does lava form?" In asking these questions, you are thinking like a scientist—a person who uses science to explore problems and answer questions about the natural world. **Science** is a way of learning about the natural world. Science is also the knowledge gained through that process.

As scientists seek to understand the natural world, they use skills such as observing, inferring, and predicting. Successful scientists also possess certain attitudes, or habits of mind.

Observing Using one or more of your senses to gather information is **observing.** Your senses include sight, hearing, touch, taste, and smell. For example, Dr. Mangan not only saw lava erupting, but she heard the noise it makes, smelled volcanic gases, and felt the lava's heat.

Inferring When you explain or interpret the things you observe, you are **inferring,** or making an inference. Making an inference doesn't mean guessing wildly. An inference is based on reasoning from what you already know. For example, Margaret Mangan inferred that differences in the gas content of the lava result in different types of eruptions. But inferences are not always correct. There could be other factors that affect the strength of a volcanic eruption.

Predicting If Dr. Mangan's inferences are correct, her results may help scientists predict whether a volcanic eruption will be strong or gentle. **Predicting** means making a forecast of what will happen in the future based on past experience or evidence.

Scientific Attitudes As they explore scientific problems, scientists maintain a scientific attitude toward their work. Characteristics that are part of a scientific attitude include curiosity, honesty, open-mindedness, skepticism, and creativity. Curiosity is what drives a scientist to ask questions that no one has thought of before. Honesty requires that scientists report their findings truthfully. Open-mindedness helps a scientist to accept new and different ideas. At the same time, scientists are skeptical—they doubt an idea until it has been fully tested. Creativity helps scientists come up with new ways of solving problems.

Reading Checkpoint **Why is curiosity important to a scientist?**

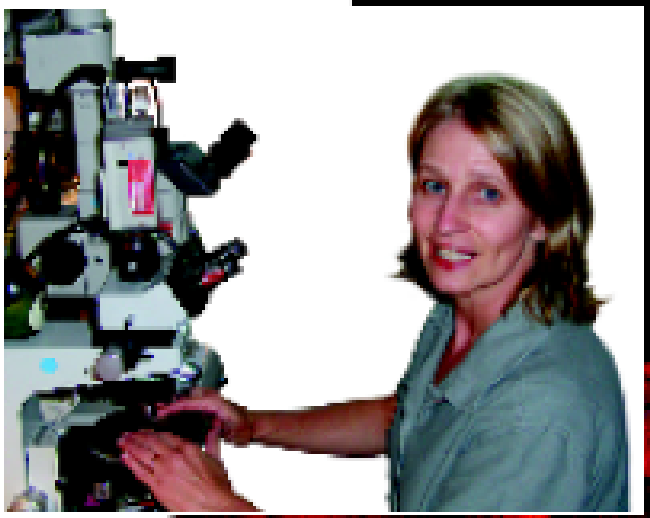

FIGURE 1
Observing Volcanic Eruptions
Margaret Mangan takes samples of lava from Mount Kilauea, Hawaii. In a laboratory, she analyzes the lava to determine its gas content and other characteristics.
Forming Operational Definitions *Based on what you can observe in the photograph, how would you define lava?*

Scientific Inquiry

Thinking and asking questions about what you observe is the start of the **scientific inquiry** process. **Scientific inquiry refers to the many ways in which scientists study the natural world and propose explanations based on the evidence they gather.** Some of the methods of scientific inquiry are described below.

Posing Questions Scientific inquiry often begins with a problem or question about an observation. The questions may come from observations and inferences that you make, or just from curiosity. For example, you may have wondered, "What is lightning?" You could use scientific inquiry to answer this question. That's what Benjamin Franklin—the American scientist, inventor, and statesman—did in 1752.

Developing a Hypothesis During the mid-1700s, Franklin became interested in electricity. He thought that electricity and lightning were similar. Both electrical sparks and lightning produced a brilliant, white light. Both moved along crooked paths and made crackling noises. Could lightning be a form of electricity? In asking this question, Franklin was developing a hypothesis: Lightning consists of electricity. A **hypothesis** (plural: *hypotheses*) is a possible explanation for a set of observations or answer to a scientific question. In science, a hypothesis must be testable. This means that scientists must be able to carry out investigations and gather evidence that will either support or disprove the hypothesis.

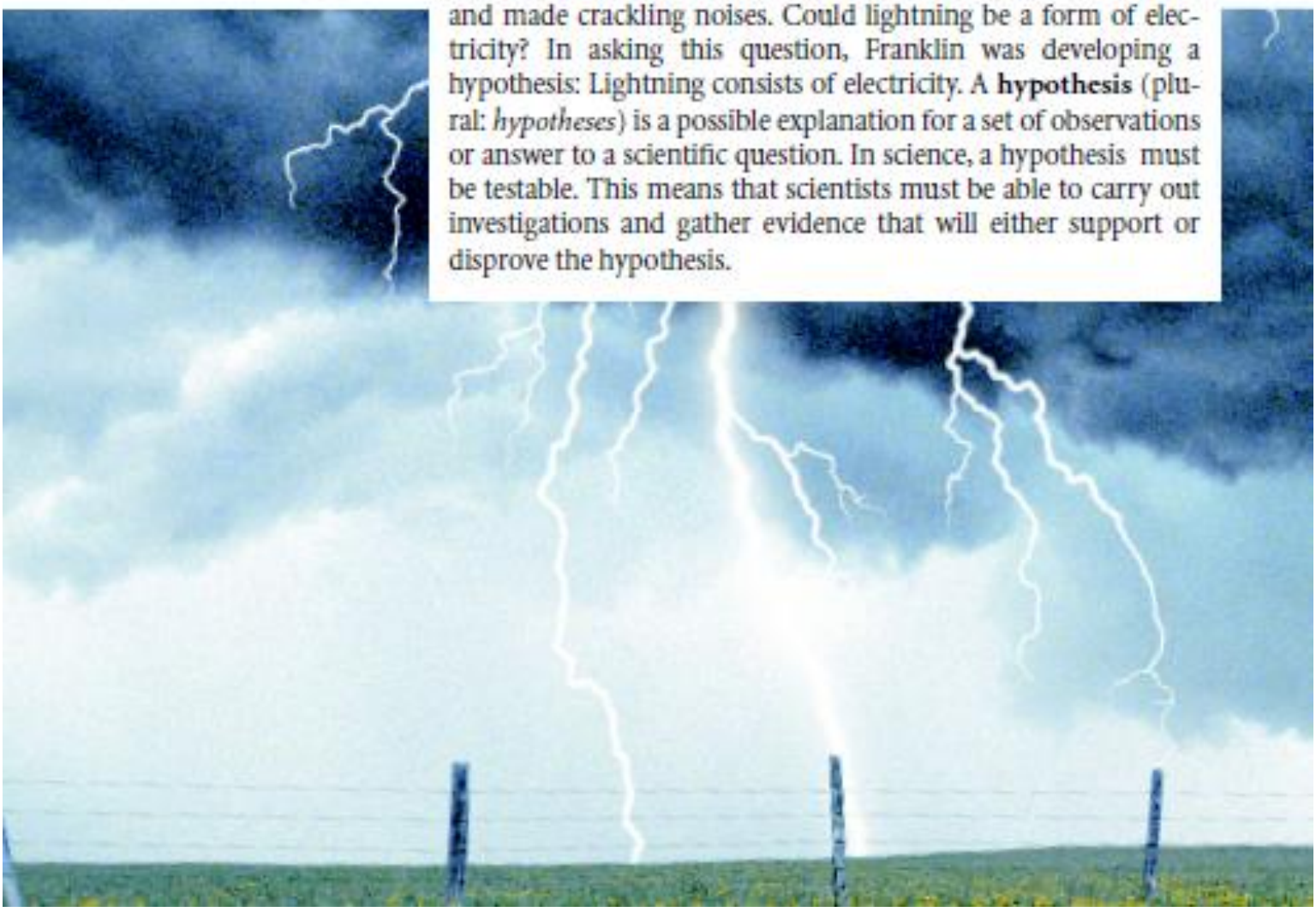

Figure 2
Investigating Lightning
Franklin conducted his famous experiment near Philadelphia in 1752. As the thundercloud passed overhead, electricity was transferred between the cloud and the kite. **Inferring** *Why was Franklin's experiment extremely dangerous?*

Designing an Experiment Franklin designed an experiment to test his hypothesis about lightning. Franklin attached a metal wire to the frame of a kite. At the end of the kite string was a metal key. As a thunderstorm approached, Franklin launched the kite. Soon, electricity was transferred from the thunderclouds to the metal wire and down the kite string. Sparks leapt from the metal key to objects placed near it.

Franklin's experiment tested his hypothesis. But it was not a controlled experiment. A **controlled experiment** is a test of a hypothesis under conditions established by the scientist. In a controlled experiment, a scientist determines how one particular variable affects the outcome of the experiment. A **variable** is one of the factors that can change in an experiment. For example, a scientist might conduct an experiment to determine if change in temperature affects the rate at which water evaporates. In this case, change in temperature is the variable that determines the outcome of the experiment.

In an experiment, the variable that a scientist changes is called the **manipulated variable.** The variable that changes because of the manipulated variable is the **responding variable**. In the evaporation experiment, temperature is the manipulated variable. The rate of evaporation is the responding variable. In a controlled experiment, scientists control, or keep constant, all other variables. By controlling variables, scientists can eliminate the effects of the other variables as factors in their results.

Reading Checkpoint What is a variable?

Lab zone Skills Activity

Controlling Variables

Suppose you are a scientist studying two types of crystals found on Earth's surface: salt and borax. You are designing an experiment to determine whether salt or borax dissolves more quickly in water. What is your manipulated variable? What is your responding variable? What other variables would you need to control?

Collecting and Interpreting Data If you wanted to investigate the weather in your area, you would need to collect data. **Data** are the facts, figures, and other evidence gathered through observations. A data table provides an organized way to collect and record observations.

After all the data have been collected, they need to be interpreted. One useful tool that can help you interpret data is a graph. Graphs like the one in the Analyzing Data feature on this page can reveal patterns or trends in data.

In Franklin's experiment, his observations were his data. He interpreted these data by comparing what he observed in the kite experiment with his earlier observations of electricity. For example, the sparks from the key tied to the kite string behaved just as electricity from other sources did.

Drawing Conclusions After you have gathered and interpreted your data, you can draw a conclusion about your hypothesis. A conclusion is a decision about how to interpret what you have learned from an experiment. You may decide that the data support the hypothesis. Or you may decide that the data show that the hypothesis was incorrect. Sometimes, no conclusion can be reached and more data are needed.

Franklin decided that lightning behaved exactly as electricity did in his other experiments. Therefore, he concluded that his hypothesis was correct: lightning consists of electricity.

Reading Checkpoint **What is a conclusion?**

Math Analyzing Data

Lightning Through the Year

The graph shows the average number of thunderstorms with lightning in New Mexico. Use the graph to answer the questions.

1. **Reading Graphs** What do the twelve bars on the graph represent?
2. **Reading Graphs** What does the height of each bar represent?
3. **Interpreting Data** When does lightning occur most often? Least often?
4. **Posing Questions** What are some questions that you would want to answer to help you explain the pattern in the graph?

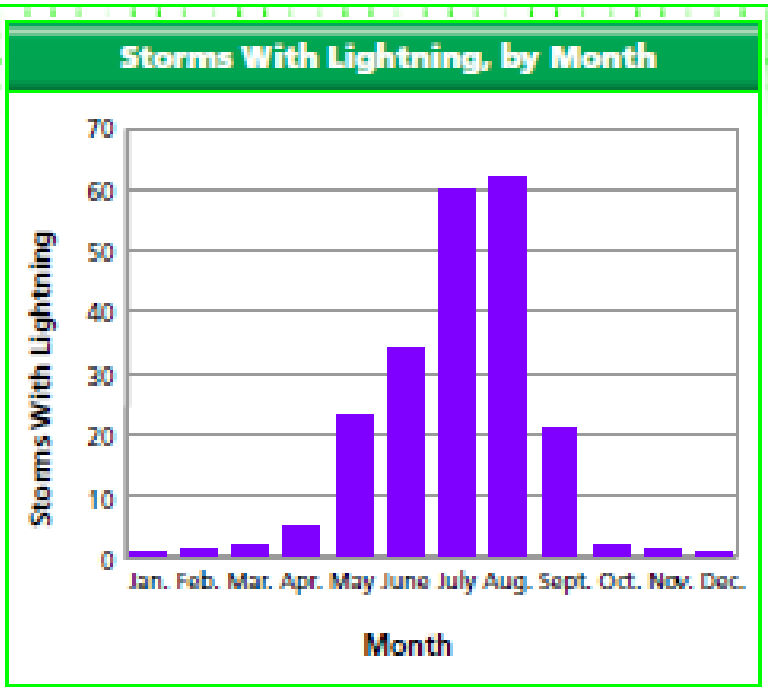

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FIGURE 3
The Nature of Inquiry
There is no set path that a scientific inquiry must follow. Observations at each stage of the process may lead you to modify your hypothesis or experiment.
Applying Concepts *Why is observation important as you design and conduct an experiment?*

Even after you have drawn a conclusion from one experiment, scientific inquiry usually doesn't end. Other scientists may repeat the experiment to determine if its results were correct. Often, the results of an experiment suggest new questions. These new questions can lead to new hypotheses and new experiments.

Communicating An important part of scientific inquiry is communicating the 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, or publish articles in scientific journals.

Benjamin Franklin communicated the details of his kite experiment by writing letters to other scientists. In these letters, Franklin was the first scientist to describe electricity using the terms positive, negative, charge, and conductor.

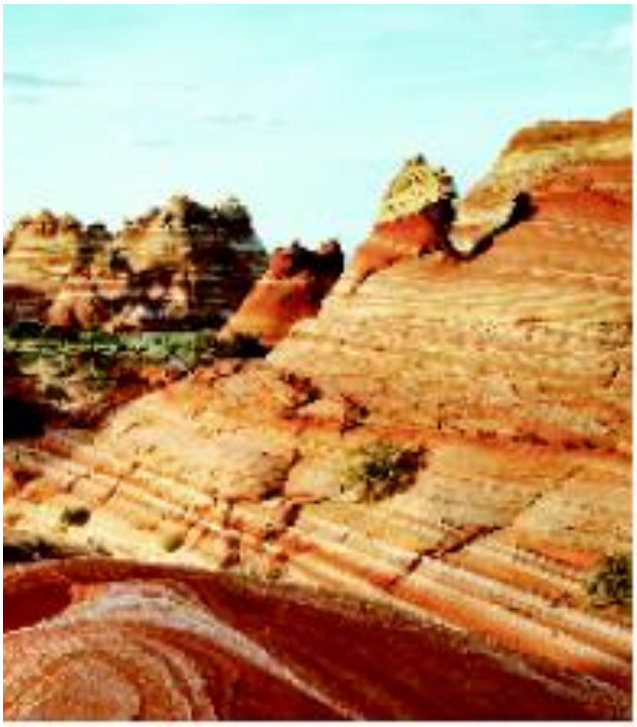

FIGURE 4
Law of Superposition
These colorful layers of sandstone in Utah illustrate the law of superposition.
Inferring *Where are the youngest rock layers in the photograph?*

Scientific Theories and Laws

As scientists study the natural world, they do more than just collect facts. Their goal is to develop concepts that explain their observations. These concepts are called scientific theories. A **scientific theory** is a well-tested scientific concept that explains a wide range of observations. An accepted theory has withstood repeated tests. But if tests fail to support a theory, scientists change the theory or abandon it.

When scientists repeatedly observe the same result in specific circumstances, they may arrive at a scientific law. **Unlike a theory, a scientific law describes an observed pattern in nature, but does not provide an explanation for it.** A **scientific law** is a statement that describes what scientists expect to happen every time under a particular set of conditions. For example, the law of superposition states that in horizontal rock layers, the oldest layer is at the bottom. Scientists have repeatedly tested this law and found it to be true.

Reading Checkpoint **What is a scientific law?**

Section 1 Assessment

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

Reviewing Key Concepts

1. a. **Reviewing** What is science?
   b. **Explaining** Explain three main skills that scientists use.
   c. **Applying Concepts** Can you make an inference without having made any observations? Explain your answer.
2. a. **Defining** Define the term *scientific inquiry*.
   b. **Explaining** You may have heard the saying "Red sky at morning, sailors take warning." This means that stormy weather may follow if the sky looks red around sunrise. Could you investigate this observation using scientific inquiry? Explain.
   c. **Problem Solving** To determine whether the saying in Question (b) is true, what kind of data would you need to collect?
3. a. **Defining** What is a scientific theory? What is a scientific law?
   b. **Comparing and Contrasting** How do scientific theories differ from scientific laws?

Writing in Science

Weather Inquiry With a partner, think of a question about the weather in your area that you would like to answer. Write your question in your notebook. List anything you already know about the topic of your question that might help you answer it. Then state your question as a hypothesis.