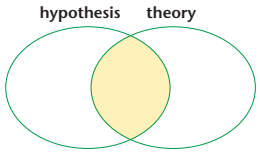
1.5 What Is Scientific Inquiry?

Reading Focus

Key Concepts
- What is a hypothesis?
- What is a theory?

Vocabulary
- hypothesis
- theory

Reading Strategy
Comparing and Contrasting Complete the Venn diagram by listing the ways hypothesis and theory are alike and how they differ.



All science is based on two assumptions. First, the natural world behaves in a consistent and predictable manner. Second, through careful, systematic study, we can understand and explain the natural world's behavior. We can use this knowledge to make predictions about what should or should not be expected. For example, by knowing how oil deposits form, geologists are able to predict the most likely sites for exploration.

The development of new scientific knowledge involves some basic steps. First, scientists collect data through observation and measurement. These data are essential to science and serve as the starting point for the development of scientific theories.

Hypothesis

Once data have been gathered, scientists try to explain how or why things happen in the manner observed. Scientists do this by stating a possible explanation called a scientific hypothesis. Sometimes more than one hypothesis is developed to explain a given set of observations. Just because a hypothesis is stated doesn't mean that it is correct or that the scientific community will automatically accept it.

Before a hypothesis can become an accepted part of scientific knowledge, it must be tested and analyzed. If a hypothesis can't be tested, it is not scientifically useful, no matter how interesting it might seem. Hypotheses that fail rigorous testing are discarded. The history of science is filled with discarded hypotheses. One of the best known is the Earth-centered model of the universe. This hypothesis was based on the apparent movement of the sun, moon, and stars around Earth.

Go Online NSTA SCILINKS

For: Links on scientific methods
Visit: www.SciLinks.org
Web Code: cjn-1015

Section 1.5

1 FOCUS

Section Objectives
1.13 **Define** the terms *hypothesis* and *theory*.

Reading Focus

Build Vocabulary L2
Word Meanings Before they read the section, have students write down definitions for *hypothesis* and *theory*. As they read the section, have them note the scientific definitions of these terms and compare them to their definitions.

Reading Strategy L2
Hypothesis: an idea someone wants to test; Theory: an explanation that is supported by evidence and widely accepted; Similarities: could be proven wrong, can be tested

2 INSTRUCT

Hypothesis

Build Reading Literacy L1
Refer to **p. 446D** in **Chapter 16,** which provides guidelines for sequencing.

Sequence Tell students to create a flowchart showing the steps toward the development of a scientific theory. They should begin the flowchart as they are reading the introduction to this section and should end it at Scientific Methods. *(Sample response: Collect data → Develop hypotheses or models → Test hypothesis (experiment) → Accept, modify, or reject hypothesis → If well tested, the hypothesis becomes a theory.)* Have students check their flowchart against the sequence of steps provided in the Scientific Methods section of the text.
Visual, Verbal

Go Online NSTA SCILINKS

Download a worksheet on scientific methods for students to complete, and find additional teacher support from NSTA SciLinks.

Theory

Address Misconceptions L2

Students often think that a scientific theory is an ultimate truth, and therefore can never be changed. This is not true. A theory is only accepted if a multitude of tests support the theory. However, if even one scientist finds a situation where the theory fails, that theory is again called into question and must be revised or replaced. For this reason, science is constantly changing. One example is medicines or supplements that have been promoted and used for years suddenly being pulled off the shelves after the discovery of unexpected and dangerous side effects.
Verbal

Scientific Methods

Integrate Language Arts L2

Representing Definitions There are many definitions for the word *model*. Have students use a dictionary to write down as many definitions of the word as possible. Then have them draw or cut out pictures representing these definitions. Help students determine which definition is most appropriate in this section.
Visual, Verbal

3 ASSESS

Evaluate Understanding L2

Give students the steps of the scientific method in random order, and have them put the steps in the correct order.

Reteach L1

Have students illustrate each step of the scientific method on the flowchart they created earlier. Help students understand that scientists regularly go back a few steps in the method as they attempt to arrive at a theory.
Visual

Writing in Science

Many scientists repeated the same observations and recorded similar results. These observations were made in many places around the world, yet all had the same basic principles. Advise students that they can find out more about the theory of plate tectonics in Chapter 9.

As the mathematician Jacob Bronowski stated, "Science is a great many things, but in the end they all return to this: Science is the acceptance of what works and the rejection of what does not."

Theory

When a hypothesis has survived extensive testing and when competing hypotheses have been eliminated, a hypothesis may become a scientific **theory.** **A scientific theory is well tested and widely accepted by the scientific community and best explains certain observable facts.** For example, the theory of plate tectonics provides the framework for understanding the origin of continents and ocean basins, plus the occurrence of mountains, earthquakes, and volcanoes.

Scientific Methods

The process of gathering facts through observations and formulating scientific hypotheses and theories is called the scientific method. There is no set path that scientists must follow in order to gain scientific knowledge. However, many scientific investigations involve the following steps: (1) the collection of scientific facts through observation and measurement, (2) the development of one or more working hypotheses or models to explain these facts, (3) development of observations and experiments to test the hypotheses, and (4) the acceptance, modification, or rejection of the hypothesis based on extensive testing.

Section 1.5 Assessment

Reviewing Concepts

1. You have just come up with an explanation to a question that has bothered you for some time. What must you do to have your explanation become a hypothesis?
2. Explain how a hypothesis can become a theory.
3. According to the scientific community, how does the natural world behave?
4. What happens if more than one hypothesis is put forward to explain the same observations?
5. When is a model useful in scientific investigations?

Thinking Critically

6. **Applying Concepts** Why do most scientists follow a set order of steps when carrying out a scientific investigation?
7. **Designing Experiments** While carrying out an investigation, a scientist observes some unexpected results. What are the scientist's next steps?
8. **Understanding Concepts** Why is it necessary to use careful and systematic methods when carrying out scientific investigations?

Writing in Science

Explanatory Paragraph It took a long time for the scientific community to accept the theory of plate tectonics. Write a paragraph suggesting how the use of proper scientific methods helped the theory gain acceptance.

Section 1.5 Assessment

1. Test and analyze the hypothesis.
2. A hypothesis can become a theory once it has survived extensive testing and when competing hypotheses have been eliminated.
3. in a consistent and predictable manner
4. They are all tested and analyzed.
5. A model can be used at any point in the process such as testing a hypothesis or explaining a theory.
6. If an orderly set of steps is followed, the observations and results are more reliable. The experiment can be conducted again using the same procedure.
7. Sample answer: The scientist should record his or her observations and any numerical results that can be recorded. The scientist should continue carrying out the experiment and reanalyze the hypothesis to see if it can be adjusted to accommodate the new results.
8. To be accepted by the scientific community, all experiments must be able to be conducted repeatedly with the same results obtained and with a minimal amount of error. By using systematic methods, this can be done.

understanding EARTH

Studying Earth From Space

Scientific facts are gathered in many ways, such as laboratory studies, field observations, and field measurements. Satellite images like the one in Figure 23 are another useful source of data. Such images provide perspectives that are difficult to get from more traditional sources. The high-tech instruments aboard many satellites enable scientists to gather information from remote regions where data are otherwise scarce.

The image in Figure 23 makes use of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). Because different materials reflect and give off energy in different ways, ASTER can provide detailed information about the composition of Earth's surface. Figure 23 is a three-dimensional view looking north over Death Valley, California. The data have been computer enhanced to exaggerate the color variations that highlight differences in types of surface materials.

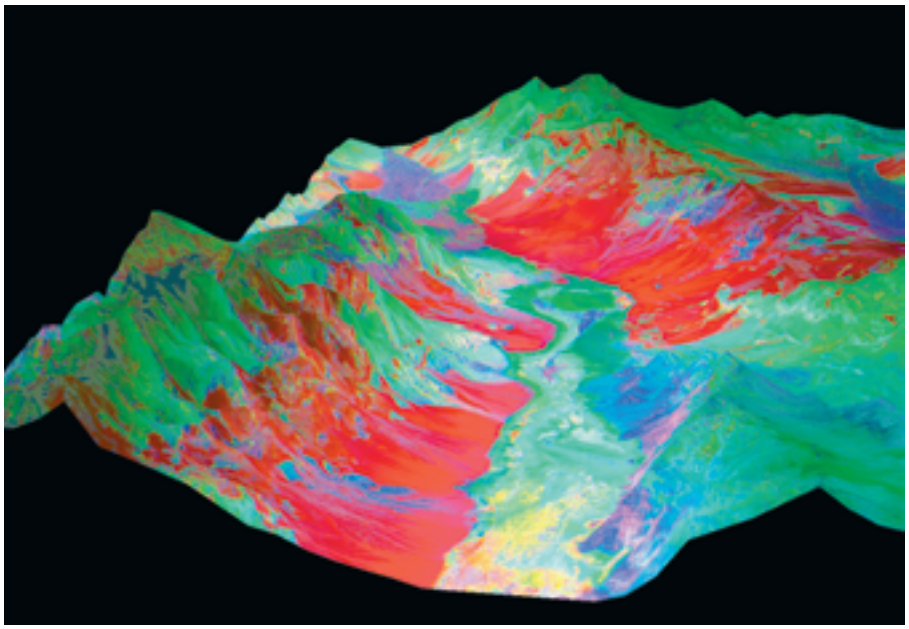


Figure 23 This satellite shows detailed information about the composition of surface materials in Death Valley, California. It was produced by superimposing nighttime thermal infrared data, acquired on April 7, 2000, over topographic data from the U.S. Geological survey. (Image courtesy of NASA)

Salt deposits on the floor of Death Valley appear in shades of yellow, green, purple, and pink. These indicate the presence of carbonate, sulfate, and chloride minerals. The Panamint Mountains to the west and the Black Mountains to the east are made up of sedimentary limestones, sandstones, shales, and metamorphic rocks. The bright red areas are dominated by the mineral quartz, found in sandstone; the green areas are limestone. In the lower center of the image is Badwater, the lowest point in North America.

understanding EARTH

Studying Earth From Space L2

Background ASTER is an imaging instrument that obtains detailed maps of land surface temperature. It flies on a satellite called Terra, which was launched in 1999. ASTER is part of NASA's Earth Observing System (EOS), which is a series of satellites, a science component, and a data system. EOS will help scientists develop a deeper understanding of Earth as an integrated system—the interactions among the biosphere, hydrosphere, lithosphere, and atmosphere.

Teaching Tips

- As students read the feature and look at Figure 23, have them identify on the image the various regions described in the text.
- Explain to students that this image does not show the true colors of Death Valley as seen from space. Instead, the colors were inserted by scientists to indicate differences in surface composition. Ask: **What do you think this image would look like in true color?** *(Since Death Valley is a desert, it would be mostly tan in color.)* **Based on the information given on what the colors indicate, what is the composition of the most distant mountains in the image?** *(mostly limestone, with some sandstone and a little bit of salt)*
- Have students research ASTER and EOS on NASA's web site and prepare a report to the class.

Visual, Logical