# 1.2 Using a Scientific Approach

**Reading Focus**

### Key Concepts

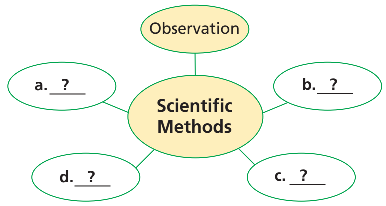
- What is the goal of a scientific method?
- How does a scientific law differ from a scientific theory?
- Why are scientific models useful?

### Vocabulary

- scientific method
- observation
- hypothesis
- manipulated variable
- responding variable
- controlled experiment
- scientific theory
- scientific law
- model

### Reading Strategy

**Using Prior Knowledge** Before you read, copy the web diagram below. Add to the web diagram what you already know about scientific methods. After you read, revise the diagram based on what you have learned.




If you've ever been caught in the rain without an umbrella, your first instinct was probably to start running. After all, the less time you spend in the rain, the less water there is falling down on you. So you might think that running in the rain keeps you drier than walking in the rain over a given distance. However, by running in the rain you run into more raindrops than by walking, thereby wetting more of your face, chest, and legs. Have your instincts been getting you wetter instead of keeping you drier?

You now have a question that you can try to answer with a scientific approach. Which keeps you drier in the rain—walking or running?

## Scientific Methods

In order to answer questions about the world around them, scientists need to gather information. An organized plan for gathering, organizing, and communicating information is called a **scientific method.** Despite the name, a scientific method can be used by anyone, including yourself. All you need is a reason to use it. **The goal of any scientific method is to solve a problem or to better understand an observed event.**

**Figure 6** To run, or not to run: that is the question. **Designing Experiments** *How can you test if running in the rain keeps you drier than walking in the rain over the same distance?*



## Section Resources

**Print**
- ***Reading and Study Workbook With Math Support,*** Section 1.2
- ***Transparencies,*** Section 1.2

**Technology**
- ***Interactive Textbook,*** Section 1.2
- ***Presentation Pro CD-ROM,*** Section 1.2
- ***GoOnline,*** *Science News,* Nature of science

## Section 1.2

## 1 FOCUS

### Objectives

**1.2.1** **Describe** the steps in a scientific method.
**1.2.2** **Compare** and **contrast** facts, scientific theories, and scientific laws.
**1.2.3** **Explain** the importance of models in science.
**1.2.4** **Explain** the importance of safety in science.

**Reading Focus**

### Build Vocabulary L2

**Paraphrase** Tell students to write the vocabulary terms on a sheet of paper and leave enough space to write the definitions. As students read, they should write the definition in their own words.

### Reading Strategy L2

**a.** Forming a hypothesis
**b.** Testing a hypothesis
**c.** Drawing conclusions
**d.** Developing a theory

## 2 INSTRUCT

### Scientific Methods

### Build Reading Literacy L1

**Sequence** Refer to page **290D** in **Chapter 10**, which provides the guidelines for a sequence.

Figure 7 is a flowchart that shows the steps of a scientific method. Remind students to refer to this figure when reading about a particular step to help themselves understand how that step fits into the sequence of steps in a scientific method.
**Visual**

### *Answer to . . .*

**Figure 6** *Possible answer: Take two identical pieces of absorbent cloth and measure the mass of each. Give the cloths to two people to hold at arm's length during a rain storm. One person should walk a fixed distance, and the other should run the same distance. Compare the masses of the wet pieces of cloth.*

## Build Science Skills L2

**Observing**

ACTIVITY

**Purpose** Students observe that as the distance from a light source increases, the brightness decreases.

**Materials** low-wattage incandescent bulb, power source for the bulb

**Class Time** 10 minutes

**Procedure** Darken the room and turn on the bulb. Tell students that its light can be considered to be coming from a single point (a point source). Ask two or three volunteers to walk around the room and observe whether the light from the bulb is visible in all parts of the room. Be sure that volunteers observe the light's brightness at various distances from the bulb.

**Expected Outcome** Students will see that the bulb radiates light in all directions and that as distance from the bulb increases, the bulb's brightness decreases.
**Kinesthetic, Visual, Group**

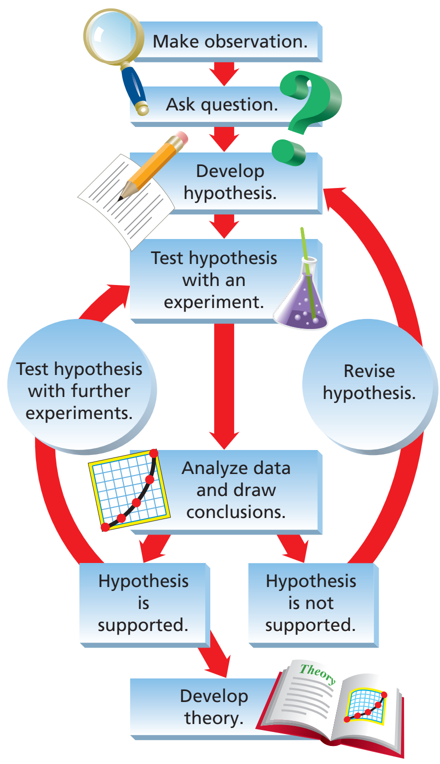



**Figure 7** A scientific method provides a useful strategy for solving problems.
**Inferring** ***Is an observation required in order for you to arrive at a question? What does this tell you about the strictness of the scientific method?***

Figure 7 outlines an example of a scientific method. Each step in the method shown involves specific skills, some of which you will be learning as you read this book. It is important to note that scientific methods can vary from case to case. For example, one scientist might follow the steps shown in Figure 7 in a different order, or another might choose to skip one or more steps.

**Making Observations** Scientific investigations often begin with observations. An **observation** is information that you obtain through your senses. Repeatable observations are known as facts. For example, when you walk or run in the rain, you get wet. Standing in the rain leaves you much wetter than walking or running in the rain. You might combine these observations into a question: How does your speed affect how wet you get when you are caught in the rain?

**Forming a Hypothesis** A **hypothesis** is a proposed answer to a question. To answer the question raised by your observations about traveling in the rain, you might guess that the faster your speed, the drier you will stay in the rain. What can you do with your hypothesis? For a hypothesis to be useful, it must be testable.

**Reading Checkpoint** *What is a hypothesis?*

**Testing a Hypothesis** Scientists perform experiments to test their hypotheses. In an experiment, any factor that can change is called a variable. Suppose you do an experiment to test if speed affects how wet you get in the rain. The variables will include your speed, your size, the rate of rainfall, and the amount of water that hits you.

Your hypothesis states that one variable, speed, causes a change in another variable, the amount of water that hits you. The speed with which you walk or run is the **manipulated variable,** or the variable that causes a change in another. The amount of water that you accumulate is the **responding variable,** or the variable that changes in response to the manipulated variable. To examine the relationship between a manipulated variable and a responding variable, scientists use controlled experiments. A **controlled experiment** is an experiment in which only one variable, the manipulated variable, is deliberately changed at a time. While the responding variable is observed for changes, all other variables are kept constant, or controlled.



## Customize for English Language Learners

**Increase Word Exposure**
Ask students who are learning English to make flashcards for each step of the scientific method shown in Figure 7. Tell students to write the English words describing the steps on an index card. They should also write a brief definition in their first language on the back of each card. Students can make the flashcards as they read the section. Then, have students shuffle their cards and place the steps of the scientific method in the correct order. Students may refer to the definition on the back of the card if they need help. Reinforce that the scientific method shown in Figure 7 is only one of many possible methods.

In 1997, two meteorologists conducted a controlled experiment to determine if moving faster keeps you drier in the rain. In the experiment, both scientists traveled 100 yards by foot in the rain. One of them walked; the other ran. By measuring the mass of their clothes before and after traveling in the rain, the scientists were able to measure how much water each had accumulated. One of the controlled variables was size—the two scientists were about the same height and build. Another was the rate of rainfall—the scientists began traveling at the same time during the same rainstorm on the same path. A third was the ability to absorb water—the scientists wore identical sets of clothes.

**Drawing Conclusions** The scientists' rainy-day experiment produced some convincing data. The clothes of the walking scientist accumulated 217 grams of water, while the clothes of the running scientists accumulated 130 grams of water. Based on their data, the scientists concluded that running in the rain keeps you drier than walking—about 40 percent drier, in fact. Now you have scientific evidence to support the hypothesis stated earlier.

What happens if the data do not support the hypothesis? In such a case, a scientist can revise the hypothesis or propose a new one, based on the data from the experiment. A new experiment must then be designed to test the revised or new hypothesis.

**Go Online SCIENCE NEWS**

**For:** Articles on the nature of science
**Visit:** PHSchool.com
**Web Code:** cce-0011

**Developing a Theory** Once a hypothesis has been supported in repeated experiments, scientists can begin to develop a theory. A **scientific theory** is a well-tested explanation for a set of observations or experimental results. For example, according to the kinetic theory of matter, all particles of matter are in constant motion. Kinetic theory explains a wide range of observations, such as ice melting or the pressure of a gas.

Theories are never proved. Instead, they become stronger if the facts continue to support them. However, if an existing theory fails to explain new facts and discoveries, the theory may be revised or a new theory may replace it.

## Scientific Laws

After repeated observations or experiments, scientists may arrive at a scientific law. A **scientific law** is a statement that summarizes a pattern found in nature. For example, Newton's law of gravity describes how two objects attract each other by means of a gravitational force. This law has been verified over and over. However, scientists have yet to agree on a theory that explains how gravity works. **A scientific law describes an observed pattern in nature without attempting to explain it. The explanation of such a pattern is provided by a scientific theory.**

**Figure 8** An environmental scientist collects a sample for a water pollution study. After analyzing the sample, the scientist can draw conclusions about how the water became polluted.



## Scientific Laws

### Build Science Skills L2

**Inferring** Reinforce the difference between a scientific theory and a scientific law. Ask, **How are scientific laws affected by new scientific theories?** *(Scientific laws aren't affected because new theories are new explanations of the observations. Scientific laws are descriptions of patterns in nature; they do not explain. Theories are explanations of patterns observed in nature.)* **If a scientific law were developed in one country, would it apply in a different country? Explain your answer.** *(Scientific laws apply everywhere. Scientific laws are different from legal and political laws, which apply only in specific countries.)* **Logical**

### Address Misconceptions L2

Some students may incorrectly think that every hypothesis becomes a theory and then a law. Help students understand the basic definitions of these three terms. For example, tell students that a hypothesis is a reasonable idea, or reasonable guess, that is often much narrower in scope than a theory. Explain that some ideas or guesses are incorrect, incomplete, or only partially correct. Tell students that a theory is an explanation, and help them realize that some explanations are incorrect. When students thoroughly understand the definitions of these three terms, they will realize that these are not always part of a progression. **Verbal**

**Go Online SCIENCE NEWS**

*Science News* provides students with current information on articles on the nature of science.

### Answer to . . .

**Figure 7** *No, an observation is not required in order for you to be able to pose a question. This tells you that the scientific method should not be thought of as a strict sequence of steps, but rather a flexible set of guidelines for investigating a problem. The flexibility of the scientific method allows for scientists to be creative in their problem solving.*

Reading Checkpoint *A proposed answer to a question*

## Scientific Models

**Teacher Demo**

### Flaps on an Airplane L2

**Purpose** Students observe how models can be used.

**Material** sheet of paper

**Procedure** Tell students that the flaps on airplane wings help control how the plane flies. Point out that because you do not have an airplane in the class, you will use a model to observe how wing flaps can affect an airplane's flight. Fold the sheet of paper into a paper airplane. Throw the plane so the class sees how the plane flies without flaps. On the trailing edge of each wing, cut a flap. Bend the flaps into different positions such as both up, both down, or one up and one down. Throw the plane with different flap positions and observe how the plane flies. Ask students if they think the wing flaps on a real airplane would have the same effect.

**Expected Outcome** Students should see that using the paper airplane as a model for a real airplane is appropriate. With both flaps down, the plane descends; with both up, it ascends. With one flap up and the other down, the plane turns in the direction of the flap that is up.
**Visual, Logical**

**Figure 9** Two engineers discuss a computer-aided design, or CAD, of an aircraft component.

## Scientific Models

If you have ever been lost in a city, you know that a street map can help you find your location. A street map is a type of **model,** or representation, of an object or event. **Scientific models make it easier to understand things that might be too difficult to observe directly.** For example, to understand how Earth rotates on its axis, you could look at a globe, which is a small-scale model of Earth. The computer model in Figure 9 represents the interior of an airplane. Other models help you visualize things that are too small to see, such as atoms. As long as a model lets you mentally picture what is supposed to be represented, then the model has done its job.

An example of a mental, rather than physical, model might be that comets are like giant snowballs, primarily made of ice. Scientists would test this model through observations, experiments, and calculations. Possibly they would even send a space probe—a visit to a comet really is planned! If all of these tests support the idea that comets are made of ice, then the model of icy comets will continue to be believed.

However, if the data show that this model is wrong, then it must either be changed or be replaced by a new model. If scientists never challenged old models, then nothing new would be learned, and we would still believe what we believed hundreds of years ago. Science works by making mistakes. The fact that newer models are continually replacing old models is a sign that new discoveries are continually occurring. As the knowledge that makes up science keeps changing, scientists develop a better and better understanding of the universe.

**Reading Checkpoint** *What is a model?*

## Working Safely in Science

Scientists working in the field, or in a laboratory, like those in Figure 10, are trained to use safe procedures when carrying out investigations. Laboratory work may involve flames or hot plates, electricity, chemicals, hot liquids, sharp instruments, and breakable glassware.

Whenever you work in your science laboratory, it's important for you to follow safety precautions at all times. Before performing any activity in this course, study the rules in the Science Safety section of the Skills Handbook. Before you start any activity, read all the steps. Make sure that you understand the entire procedure, especially any safety precautions that must be followed.

The single most important rule for your safety is simple: Always follow your teacher's instructions and the textbook directions exactly. If you are in doubt about any step in an activity, always ask your teacher for an explanation. Because you may be in contact with chemicals you cannot see, it is essential that you wash your hands thoroughly after every scientific activity. Remember, you share responsibility for your own safety and that of your teacher and classmates.

**Figure 10** Safety plays an important role in science. **Interpreting Photos** ***What safety measures are these scientists taking in their laboratory work?***

## Section 1.2 Assessment

### Reviewing Concepts

1. What is the goal of scientific methods?
2. How does a scientific law differ from a scientific theory?
3. Why are scientific models useful?
4. What are three types of variables in a controlled experiment?
5. Does every scientific method begin with an observation? Explain.

### Critical Thinking

6. **Classifying** The scientists who tested the hypothesis on running in the rain performed only one controlled experiment that supported their hypothesis. Can their supported hypothesis be called a theory? Explain.
7. **Designing Experiments** Suppose you wanted to find out how running affects your pulse rate. What would your hypothesis be? Explain how you could test your hypothesis.
8. **Using Models** A scientific model can take the form of a physical object or a concept. List one example of each type of model. How does each one resemble what it is supposed to model?

### Writing in Science

**Descriptive Paragraph** Write a paragraph describing the steps of a scientific method. (*Hint:* Before you write, use a flowchart to arrange your steps in a particular order.)



## Working Safely in Science

### Use Visuals L1

**Figure 10** Emphasize that students must study the safety rules before they do lab activities. Ask, **Why are these scientists wearing goggles?** *(Because when a liquid is poured or heated, it could splash into their eyes.)* **Visual**

## 3 ASSESS

### Evaluate Understanding L2

Ask students to name scientific laws. If they name a theory instead of a law, help them understand why what they chose is a theory and not a law.

### Reteach L1

Use Figure 7 to review the scientific method. Point out that when scientists learn new information, they may go back to an earlier step in the method.

**Writing in Science**

A scientific method can begin with an observation that leads to a question and a hypothesized answer. Next, the hypothesis is tested either by making further observations or by performing an experiment. Conclusions are then drawn from the data.

**Interactive Textbook** If your class subscribes to the Interactive Textbook, use it to review key concepts in Section 1.2.

### *Answer to . . .*

**Figure 10** *They are wearing goggles, gloves, lab coats, and hair nets.*

**Reading Checkpoint** *A representation of an object or event*

## Section 1.2 Assessment

**1.** The goal of scientific methods is to solve a problem or to better understand an observed event.
**2.** A scientific law describes an observed pattern in nature without attempting to explain it. The explanation of such a pattern is provided by a scientific theory.
**3.** Scientific models make it easier to understand things that might be too difficult to observe directly.
**4.** Three types of variables in a controlled experiment are manipulated variables, responding variables, and controlled variables.
**5.** No. The order of the steps within a scientific method can vary from case to case.
**6.** Although the data from the meteorologists' experiment supported their hypothesis, the scope of their investigation is too narrow to be considered a theory. A scientific theory explains a broad set of observations and/or supported hypotheses—not just a single hypothesis.
**7.** Students will likely hypothesize that running increases one's pulse rate. Students can test their hypotheses by performing a controlled experiment in which the manipulated variable is speed (e.g., running, walking, or standing still) and the responding variable is pulse rate.
**8.** Possible answer: A globe, a physical model of Earth, has the same shape as Earth. The quantum mechanical model of the atom describes the behavior of electrons around the nucleus.

CONCEPTS in Action

## Forensic Science L2

### Background

Forensic science is any aspect of science that relates to law. It includes methods for identifying, collecting, and analyzing evidence that may be related to a crime. At a crime scene, data is often identified and collected. Data collection may include taking fingerprints; collecting hair, blood, or tissue samples; or making plaster casts of tire prints or footprints. Depending on the nature of the crime and the crime scene, investigators may also collect samples of soil, pollen, fibers from clothing, or other materials at the crime scene. In the laboratory, technicians study and analyze the samples so that they can provide investigators with accurate information. Data analysis can shed light on what happened, where it happened, and even who might have committed the crime.

### Build Science Skills L2

**Analyzing Data** ACTIVITY

**Purpose** Students compare tire tracks to determine which ones were made by the same toy car.

**Materials** modeling clay, at least 5 different toy cars with similar-sized tires that have different tread, cooking oil, magnifying glass

**Class Time** 30 minutes

**Preparation** Flatten a piece of clay for each group of students. Lightly oil the tread of all the tires on the toy cars. Choose a car and roll the tire across each piece of clay to make an impression.

**Safety** Students who are allergic to corn or olives should wear plastic gloves and dispose of them carefully.

**Procedure** Tell students that they are forensic scientists and they must find out which car was at the scene of a crime based on a tire track from the scene. Give students a piece of clay with a tire track and another piece of unmarked clay. Have students use the clay to test each car's tires and, as needed, use the magnifying glass to find a match. Ask each group to write a short paragraph stating what they did and why they think they have identified the car that made the tracks.

**Expected Outcome** Students should correctly identify the car by the similar tire patterns. **Logical, Visual, Group**



CONCEPTS in Action

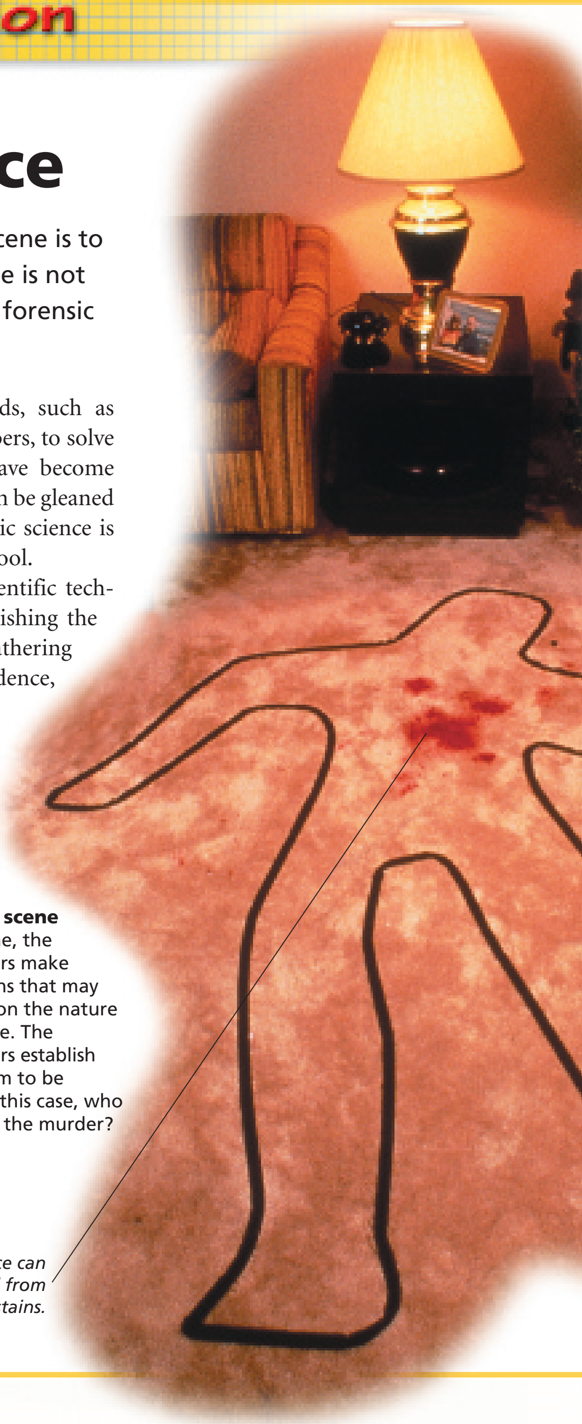
# Forensic Science

The first job of police officers at a crime scene is to seal off the area so that potential evidence is not disturbed. Such evidence will be sent to a forensic science laboratory for examination.

Forensic science is the use of scientific methods, such as fingerprint matching or the analysis of clothing fibers, to solve crimes. As techniques in analytical chemistry have become more advanced, the amount of information that can be gleaned from tiny crime-scene samples has grown. Forensic science is becoming ever more powerful as a crime-solving tool.

Criminal investigators need to use several scientific techniques. They include making observations, establishing the problem to be solved, collecting evidence and gathering information, forming hypotheses, analyzing evidence, testing hypotheses, and drawing conclusions.

**Collecting evidence and forming a hypothesis**
Forensic scientists take photographs and collect materials from the crime scene. Investigators use all of the information gathered to formulate hypotheses about how and why the crime took place.

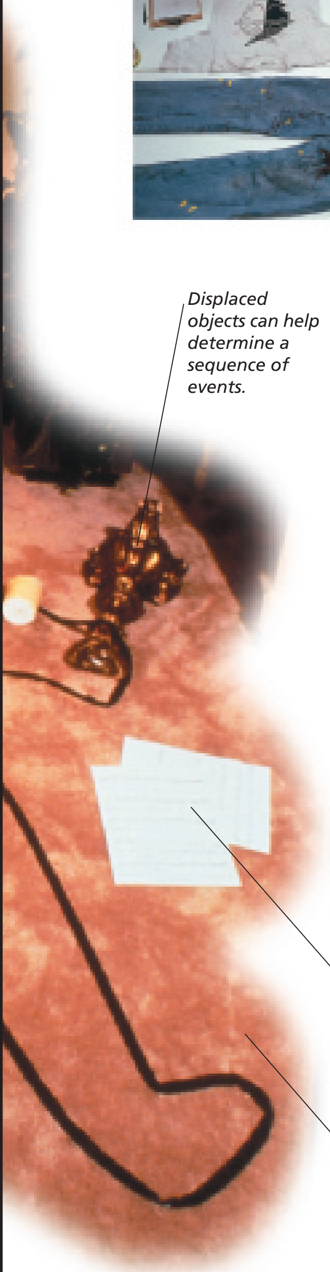


**The crime scene**
At the scene, the investigators make observations that may shed light on the nature of the crime. The investigators establish the problem to be solved—in this case, who committed the murder?

*DNA evidence can be obtained from blood stains.*

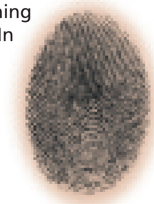
**Analyzing the evidence**
Much of the physical evidence must be analyzed in a laboratory. With a blood sample, for example, DNA is extracted and analyzed and the blood type is established.

**Forensic blood sampling** *Articles from a crime scene, such as the blood-stained clothing and the hatchet shown here, may match DNA to a suspect.*



*Displaced objects can help determine a sequence of events.*

**Testing hypotheses against the evidence**
Investigators now test hypotheses on who committed the crime—looking for matches in DNA, fingerprints, or clothing fibers, for example. In some cases, this testing excludes a suspect. In other cases it strengthens the case against a particular person.



**Drawing conclusions**
To build a convincing case against a suspect, various pieces and types of evidence may be needed. Evidence might include a fingerprint match, a piece of clothing left at the crime scene, or a connection to the murder weapon.

*Documents may provide evidence for a motive.*

*Fibers can link a suspect to a crime scene.*

## Going Further

- Describe how criminal investigators use scientific methods to solve their cases. (*Hint:* start by creating a flowchart of a scientific method. Then identify how criminal investigators carry out each step.)
- Take a Discovery Channel Video Field Trip by watching "Cracking the Case."

Discovery Channel School **Video Field Trip**



## Going Further

A scientific method can include the following steps: observing, posing questions, formulating a hypothesis, testing the hypothesis, and drawing conclusions. When criminal investigators arrive at a crime scene, they make observations and collect evidence. The questions they pose might include, "Who committed the crime?" or "How was the crime committed?" Investigators may then form hypotheses concerning possible suspects and the methods used to commit the crime. By analyzing the evidence obtained (e.g., fingerprint or DNA analysis), they can test their hypotheses. The results of these analyses may allow investigators to draw conclusions about the criminal's identity and methodology.
**Logical**

Discovery Channel School

## Video Field Trip

***Cracking the Case***

After students have viewed the Video Field Trip, ask them the following questions: **What is the main goal of forensic science?** *(To analyze clues to reconstruct past events)* **What discovery led to the use of fingerprinting in forensic science?** *(The discovery that no two people had the same fingerprints)* **What do forensic scientists look for in the pattern of a fingerprint so that they can identify who the fingerprint belongs to?** *(The tiny imperfections such as ridges that end abruptly, ridges that split, and ridges that form little dots; also where these are located with respect to one another)* **How do detectives find fingerprints on an object?** *(The old method involved spreading powder on the area. The powder adhered to traces of sweat left behind by contact with the fingers. The powder was then lifted off with transparent tape, showing the pattern. Newer methods use fluorescent powder and high intensity lasers to find prints that could otherwise be missed.)* **Name two things police detectives and forensic scientists might do to track down the identity of a car that left a suspicious tire track at a crime scene.** *(Student answers may include measure and photograph the area, make a mold of the tire track, and look for irregularities in the mold of the tire tread that are unique to that tire.)*