chapter 1

The Nature of Science

section 1 The Methods of Science

What You'll Learn

- how scientists solve problems
- why scientists use variables
- how to compare and contrast science laws and theory

Before You Read

When you hear the word *scientist,* what comes to mind? Brainstorm some words that describe a scientist. Write them on the lines below.

_____

_____

Mark the Text

Identify Highlight each heading that is a question. Use a different color of marker to highlight the answers to the questions.

Read to Learn

What is science?

Science is not just a subject in school. Science is a way of studying the world. The word *science* comes from a Latin word that means "knowledge." Science is a way to learn or gain knowledge by observing and investigating.

Nature follows a set of rules. The rules for understanding how the human body works are complicated. The rules for understanding the pattern of Earth spinning once every 24 h on its axis are simpler. Scientists ask questions to learn about the natural world.

What are the major categories of science?

Science covers many different topics. These topics fall under three main categories: life science, Earth science, and physical science. Life science is the study of living things. Earth science is the study of Earth and space. Physical science is the study of matter and energy. In this book, you will study mainly physical science. You also will learn how these three main categories sometimes overlap.

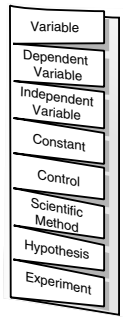
How does science explain nature?

Scientific explanations help explain the natural world. Scientists investigate and use technology to get new information. Sometimes, this new information causes scientific explanations to change. In the 1700s, most scientists thought heat was a fluid. After many studies, they concluded heat is not a fluid.

FOLDABLES™

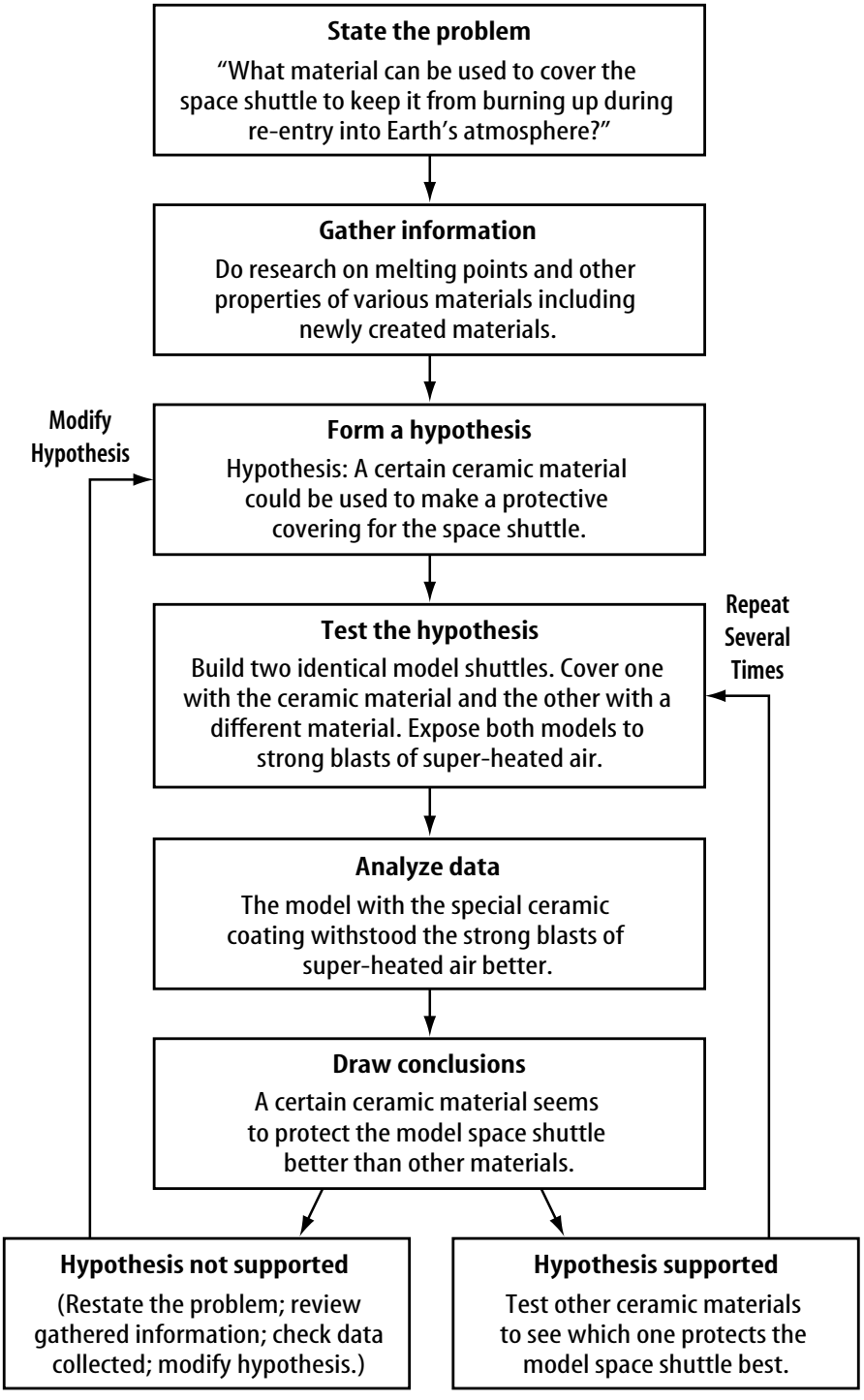
A Build Vocabulary

Make the following Foldable to help you learn key terms from this section. You will need to make more than one Foldable.



Scientific Methods

A **scientific method** is a set of steps used in an investigation. Scientists follow steps similiar to those listed below when doing an investigation. These steps guide the scientist. Some steps may be repeated. Other steps may be skipped. The flowchart below shows six common steps found in various scientific methods.



Think it Over

1. **Draw Conclusions** Why might steps in scientific methods be skipped or changed?

Picture This

2. **Interpret** Why are there two arrows leading to different parts of the chart at the bottom?

Stating a Problem Many scientific investigations begin with a question about how or why something happens in nature. The problem is stated as a "how" or "why" question. Sometimes a question is asked because scientists want to improve upon something. Early work on guided missiles showed that the nose cone instruments needed a material to protect them from heat. Later, National Aeronautic and Space Administration (NASA) scientists wanted to find a material to protect the space shuttle from the heat and forces of re-entry into Earth's atmosphere.

Researching and Gathering Information It is important to study a problem before any testing is done. Sometimes someone has already solved a similar problem. NASA scientists gathered information about melting points and other properties of various materials that might be used. They also performed tests on newly created materials.

Forming a Hypothesis A **hypothesis** is a possible explanation for a question or problem based on what you know and what you observe. A scientist who forms a hypothesis must be certain it can be tested. NASA scientists knew that a certain ceramic material had been used to protect the nose cones of guided missiles. They hypothesized that a ceramic material might also protect the space shuttle.

Testing a Hypothesis Some hypotheses are simply tested by making observations. Building a model may be the best way to test a hypothesis. Scientists may also use an experiment to test a hypothesis. The **experiment** looks at how one thing affects another under controlled conditions. NASA scientists built model space shuttles and covered them with various materials. They tested the models in simulated re-entry environments to see which material gave the best protection.

Variable An experiment usually has at least two variables. A **variable** is a factor that can cause a change in the results of an experiment. Suppose you set up an experiment to see which fertilizer makes plants grow biggest. First, you need to think of all the factors that can make a plant grow bigger. These might include the type of plant, amount of sunlight, amount of water, type of soil, and amount of fertilizer.

In this experiment, the amount of growth is one variable. It is a **dependent variable** because its value changes according to the changes in other variables. The other variable is the amount of fertilizer. The **independent variable** is changed to see how it affects the dependent variable.

Think it Over

3. **Research** List two places where you might find information on the development of the space shuttle.

_____

_____

Reading Check

4. **Define** What are the two kinds of variables that are tested in experiments?

_____

_____

Constants and Controls To keep an investigation fair, all other factors must be the same. A **constant** is a factor in an experiment that does not change. In the fertilizer experiment, the constants are the amount of water and sunlight the plants get and the temperature at which the plants are kept. These are the same for all plants tested. Three plants get different amounts of fertilizer, which is the independent variable.

A **control** is used to compare the results of the experiment. One plant is a control and does not get any fertilizer, but does get the same sunlight, water, and temperature as the other plants. Suppose after several days that the control plants grow between 2 and 3 cm. If the unfertilized plant grows only 1.5 cm, you might infer that the greater growth of the fertilized plants was caused by the fertilizer.

Analyze the Data An important part of any experiment is recording observations and organizing information. All results and observations should be recorded during an experiment. Many important discoveries have been made from unexpected results. The information or data should be organized into an easy-to-read table or graph. Later in this chapter, you will learn how to show your data.

Understanding what the data and observations mean is also important. The data must be organized logically. Poorly organized data may lead to a wrong conclusion. Scientists share their data through reports and meetings. Scientists may disagree about certain data, no matter how well the data is presented.

Drawing Conclusions Scientists look at their data and decide if the data support the hypothesis. If the data is the same after many experiments, the hypothesis is supported. If the hypothesis isn't supported, scientists may change it or the experiment.

Sometimes others don't agree with the conclusions, so they design new experiments to test the hypothesis. In time, data will support a valid hypothesis.

Being Objective Scientists must avoid a bias. A **bias** occurs in an experiment when a scientist expects something to happen and lets this influence how the results are viewed. Scientists try to reduce bias whenever they can by doing the experiment many times and keeping careful notes about observations. Also, other scientists repeat the same experiment to see if they get the same results.

Think it Over

5. Classify Is the plant that receives no fertilizer in the plant experiment a variable, a constant, or a control?

_____

Reading Check

6. List two reasons why data must be organized.

_____

_____

_____

Visualizing with Models

Sometimes, scientists cannot see everything they are testing. They might be studying something too large or too small to see. It might even take too much time to see completely. In these cases, scientists use models. A **model** represents an idea, event, or object to help people better understand it. A model may be a physical object such as a scaled-down version of the space shuttle. A model can also be represented by a drawing on paper or by a computer program.

Models in History Models have been used throughout history. Lord Kelvin, a scientist who lived in England in the 1800s, was famous for making models. To model his idea of how light moves through space, he put balls in a bowl of jelly. He asked people to move the balls with their hands. Kelvin's work explaining heat and temperature is still used today.

Reading Check

7. **Explain** What are models?

What are high-tech models?

Scientific models don't have to be something you can touch. Many scientists use computers to build models. Computer models are used to solve difficult mathematical equations. NASA uses computers in experiments with space flights to solve equations that are too hard or would take too long to solve by hand.

Another type of model is a simulator. A simulator can create the conditions found in real life. For example, a flight simulator is a model of an airplane. It can help a pilot pretend to be flying a plane. The pilot can test different ways to solve problems. The simulator reacts the same way a real plane does when it flies, but there is no danger to either the pilot or a plane.

Think it Over

8. **List** three differences between a flight simulator and a real airplane.

Scientific Theories and Laws

A scientific **theory** is a way of explaining things or events based on what has been learned from many observations and investigations. When these observations and investigations have been repeated many times and support the hypothesis, then the hypothesis becomes a theory. New information in the future may change the theory.

A **scientific law** is a statement about what happens in nature and seems to be true all the time. A law explains what will happen under certain conditions, but it does not explain why or how it happens. Theories are used to explain how and why laws work. Gravity is an example of a scientific law. The law of gravity says that any one mass will attract another mass. To date, no experiments have been done that prove this law is not true.

The Limitations of Science

Science is used to explain many things about the world. However, science cannot explain everything. Questions about emotions or values are not questions science can answer. A survey of peoples' opinions would not prove that these opinions are true for everyone. Scientists make predictions when they perform experiments. Then these predictions are tested and verified by using a scientific method.

Using Science—Technology

The words *science* and *technology* often are used in place of each other. However, the two words mean different things. Technology is the application of science to help people. For example, science methods are used when a chemist develops a new material. When this new material is used on the space shuttle, technology is applied.

Sometimes technology comes before science. For example, when the steam engine was invented, no one knew exactly how it worked. Scientists studied it and learned about the steam engine. This led them to discover new ideas about the nature of heat.

Not all technology produces something good. Some people question the benefits of some technology, such as nuclear technology. Learning more about science can help society make decisions about these issues.

Reading Check

9. Restate What is a scientific law?

Think it Over

10. Think Critically Give an example of when technology is an application of science.

After You Read

Mini Glossary

bias: what is expected changes how the results are viewed

constant: a condition in an experiment that does not change

control: a standard in an experiment against which the results are compared

dependent variable: the condition in an experiment that results from the changes made to the independent variable

experiment: an investigation that tests a hypothesis by collecting information under controlled conditions

hypothesis: an explanation for a question or a problem that can be tested

independent variable: in an experiment, the condition that is tested

model: anything that represents an idea, event, or object to improve understanding

scientific law: a statement about what happens in nature that seems true all the time

scientific method: the steps a scientist follows when performing an investigation

theory: an explanation that is supported by a large body of scientific evidence obtained from many different investigations and observations

variable: a quantity that can have more than a single value

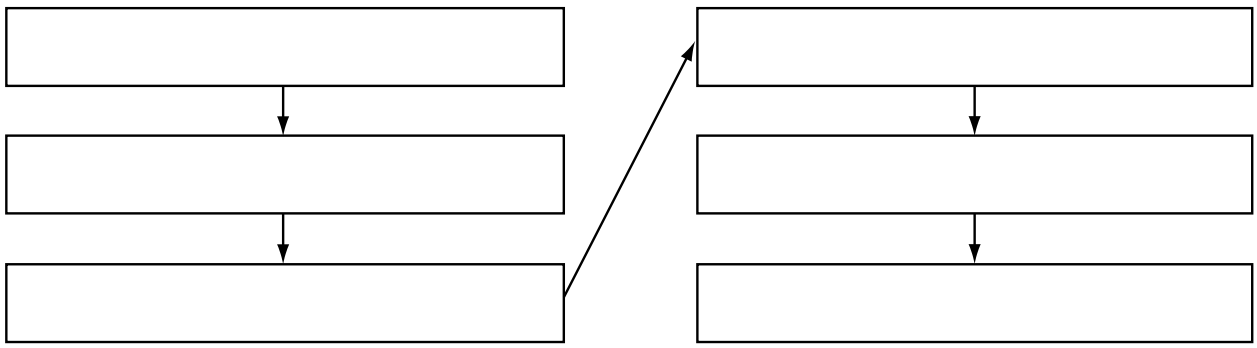
1. Review the terms and their definitions in the Mini Glossary. Write a sentence explaining how bias can influence an experiment.

_____

_____

2. Complete the chart below to organize the information you have learned in this section. Put the following steps for scientific methods in order.

Analyze the data, Test the hypothesis, State the problem, Draw conclusions, Gather information, Form a hypothesis



End of Section

Name _____ **Date** _____

The Nature of Science

Section 1 The Methods of Science

Skim *the headings and bold words in this section. Write four steps scientists might take to solve a problem.*

_____

_____

Review Vocabulary

Define investigation *to show its scientific meaning.*

investigation _____

New Vocabulary

Read the definitions below, then write the key term on the blank in the left column.

_____ variable whose value changes as a result of changes in other variables

_____ standard used to compare the results of the experiment

_____ a factor is a quantity that can have more than one value

_____ a factor in an experiment that does not change

_____ represents an idea, event, or object to help people observe or test it

_____ the variable you change to see how it affects another variable

_____ occurs when a scientist's expectations change how the results are viewed

_____ the general pattern of investigational procedures

_____ a possible explanation of a problem based on observation and prior knowledge

_____ an explanation of things or events using observations and knowledge gained from multiple investigations

_____ a statement about what happens in nature that seems to be true all the time

_____ testing the effect of one thing on another under controlled conditions

Name _____ **Date** _____

Section 1 The Methods of Science (continued)

Main Idea	Details
What is science? *I found this information on page _____.*	**Identify** *the three main categories of science. Summarize the topic studied in each category.* **1.** _____ **2.** _____ **3.** _____
Scientific Methods *I found this information on page _____.*	**Sequence** *the common steps found in scientific methods in the correct order. The first step has been completed for you.* **1.** State the problem **2.** _____ **3.** _____ **4.** _____ **5.** _____ **6.** _____
Visualizing with Models *I found this information on page _____.*	**Organize** *the advantages and disadvantages of a pilot flying a real airplane and flying a simulator.*

	Advantages	Disadvantages
Real airplane		
Simulator		

Name _____ **Date** _____

Section 1 The Methods of Science (continued)

Main Idea	Details
Scientific Theories and Laws *I found this information on page _____.*	**Distinguish** *between a* scientific theory *and a* scientific law.
The Limitations of Science *I found this information on page _____.*	**Complete** *the paragraph about the* limitations of science. Science _____ explain or solve everything. A scientist has to make sure his or her guesses can be _____ and _____. Science cannot answer questions about _____ and _____. For example, a _____ of people's opinions about such questions would not prove that the opinions are true for everyone. **Create** *your own real-world example of how the application of a scientific discovery has helped create a new technology.*

CONNECT IT **Summarize the steps a scientist might take to determine if a new drug works in cancer patients.**

- **1.**_____ is a process that uses observation and investigation to gain knowledge about the regularities in nature.
    A. Measurement
    B. Science
    C. Graphing
    D. Hypothesizing

- **2.**_____ science deals with matter and energy.
    A. Life
    B. Physical
    C. Earth
    D. Social

- **3.**_____ science deals with living things
    A. Earth
    B. Physical
    C. Life
    D. Human

- **4.**_____ science investigates Earth and space.
    A. Life
    B. Physical
    C. Astrology
    D. Earth

- **5.**A(n) _____ is a well-organized procedure that tests an idea.
    A. hypothesis
    B. method
    C. theory
    D. experiment

- **6.**A(n) _____ is a prediction or explanation that can be tested by experimentation.
  - A. theory
  - B. hypothesis
  - C. scientific law
  - D. method

- **7.**A(n) _____ is something that represents an idea or object to help people better understand it.
  - A. theory
  - B. method
  - C. model
  - D. observation

- **8.**Factors that remain constant from experiment to experiment are the _____
  - A. independent variables
  - B. controls
  - C. dependent variables
  - D. models

- **9.**Which variable in an experiment is specifically changed by the scientist?
  - A. dependent variable
  - B. control
  - C. independent variable
  - D. standard

- **10.**Which of the following questions is legitimate for science to consider?
  - A. Which type of orchid flower is most beautiful?
  - B. How many seals can a killer whale consume per day?
  - C. Is competition good or evil?
  - D. When is religion better than philosophy?

- **11.**How are a hypothesis and a theory similar?
  - A. A hypothesis and a theory cannot be revised.
  - B. Theories and hypotheses are produced by experts.
  - C. They are about equally true.
  - D. They are attempts to explain natural phenomena.

- **12.**An experiment is a specific test of a _____.
  - A. theory
  - B. variable
  - C. control
  - D. hypothesis

- **13.**In an experiment, what is affected by the independent variable?
  - A. control
  - B. dependent variable
  - C. standards
  - D. experimental design

- **14.**Explanations of natural phenomena supported by large amounts of data are called _____.
  - A. hypotheses
  - B. experiments
  - C. data
  - D. theories

- **15.**Which of the following is NOT useful for showing patterns in data?
  - A. procedure
  - B. table
  - C. graph
  - D. chart

- **16.**What occurs when the expectations of a scientist change how the results of an experiment are viewed?
  - A. data
  - B. conclusion
  - C. bias
  - D. revision

- **17.**A(n) _____ is a rule that describes a pattern in nature.
  - A. theory
  - B. scientific law
  - C. hypothesis
  - D. observation

- **18.**_____ is the application of science to help people.
  - A. Scientific law
  - B. Technology
  - C. Knowledge
  - D. Data

- **19.**A(n) _____ is an exact quantity that people agree to use for comparison.
  - A. control
  - B. theory
  - C. standard
  - D. dependent variable

- **20.**In a controlled experiment, the single factor manipulated by the researcher is the _____ variable and the responding factor that is measured is the _____ variable
  - A. independent, dependent
  - B. dependent, independent
  - C. controlled, uncontrolled
  - D. controlled, common