Hypothesis Supported Before it became an accepted theory, Dr. Whipple's hypothesis was subjected to many years of tests and observations. Some of the most important were the 1986 observations of Halley's comet, shown in **Figure 16.** A group of astronomers from the University of Arizona, headed by Dr. Susan Wyckoff, studied the composition of the comet. Dr. Wyckoff observed the comet many times, using giant telescopes in Arizona and Chile in South America. At other times, she studied the observations of other astronomers, including those who studied data collected by the *Giotto* and other spacecrafts. All these observations and data supported Dr. Whipple's original hypothesis. With so much support, Dr. Whipple's hypothesis has become an accepted scientific theory.

Scientific Laws A **scientific law** is a rule that describes the behavior of something in nature. Usually, a scientific law describes what will happen in a given situation but doesn't explain why it happens. An example of a scientific law is Newton's first law of motion. According to this law, an object, such as a marble or a spacecraft, will continue in motion or remain at rest until it's acted upon by an outside force. According to Newton's second law of motion, when a force acts on an object, the object will change speed, direction, or both. Finally, according to Newton's third law, for every action, there is an equal and opposite reaction. This law explains how rockets that are used to launch space probes to study Halley's comet and other objects in space work. When a rocket forces burning gases out of its engines, the gases push back on the rocket with a force of equal strength and propel the rocket forward.

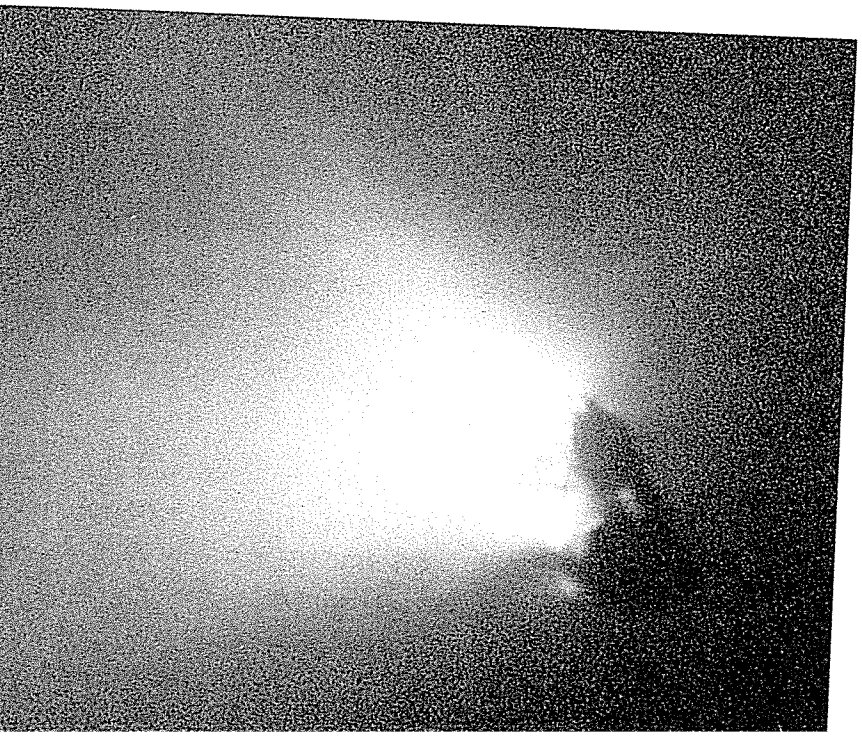


Figure 16 The view of Halley's comet from the *Giotto* spacecraft allowed scientists to determine the size of the icy nucleus, and that the nucleus was covered by a black crust of dust. Jets of gas blasted out from holes in the crust to form the comet's tail.

Observing a Scientific Law

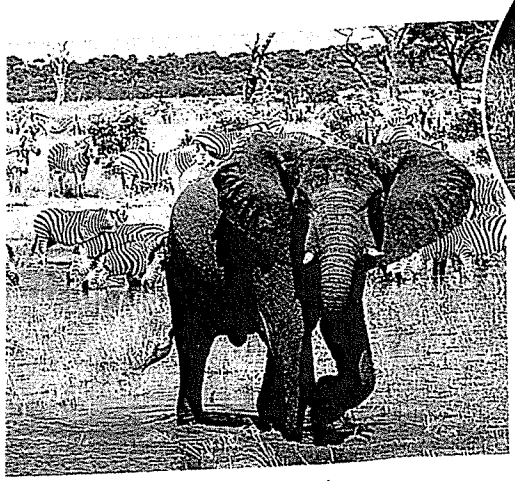
Procedure

1. Cut one end from a **shoe box.**
2. Put the box on the floor. Place a **rubber ball** in the closed end of the box.
3. Pushing on the closed end of the box, move the box rapidly across the floor. Then suddenly stop pushing.

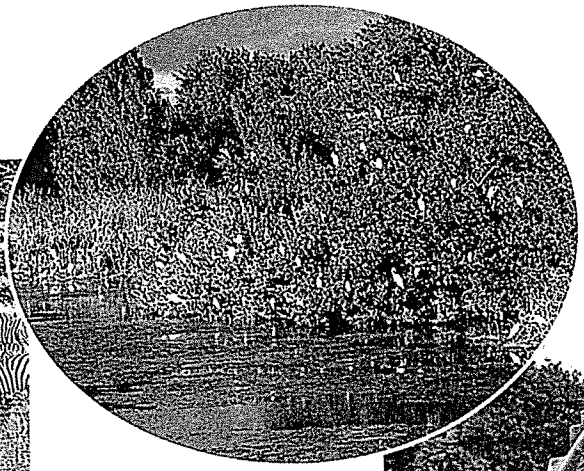
Analysis

1. What happened when the box stopped?
2. How does Newton's first law of motion explain this?

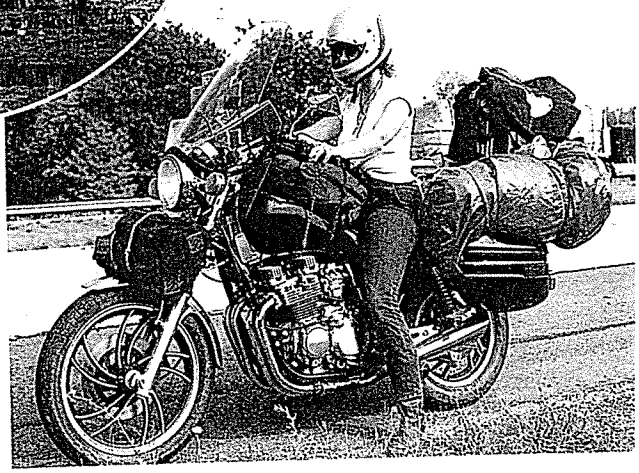
Figure 17 Ethical questions can't be solved by using scientific methods.



These animals live on the African plains.
Form an Opinion *Should they be hunted as trophies?*



Disease-carrying mosquitoes can live in this swamp.
Debate *Should swamps be drained, even if other species lose their habitat?*



Helmets reduce serious head injuries.
Think Critically *Should the government require motorcycle riders to wear helmets?*

Limits of Science

Will science always provide answers to all your questions? No, science doesn't have answers to all the questions and problems in the universe. Science is limited in what it can explain. For a question or problem to be scientifically studied, there must be variables that can be observed, measured, and tested. Problems that deal with ethics and belief systems cannot be answered using these methods. **Ethics** deals with moral values about what is good or bad. Belief systems deal with religious and/or other beliefs. Examples of ethical and belief-system questions that science cannot answer are: Do humans have more value on Earth than other life-forms?, Should the federal government regulate car emissions?, and Should animals be used in medical experiments? Look at **Figure 17.** What's your opinion?

Reading Check ***Why can't science be used to answer ethical questions?***

Doing Science Right

Although ethical questions cannot be answered by science, there are ethical ways of doing science. The correct approach to doing science is to perform experiments in a way that honestly tests hypotheses and draws conclusions in an unbiased way.

INTEGRATE Career

Science Ethics The question of whether or not to use humans in medical research studies is matter of ethics. As a class, discuss and list some pros and cons of using humans as test subjects. Explain why there is no right or wrong answer to this question.

Being Objective When you do scientific experiments, be sure that you design your experiments in such a way that you objectively test your hypotheses. If you don't, your **bias,** or personal opinion, can affect your observations. For example, in the 1940s, Soviet scientist Trofim Lysenko believed that individuals of the same species would not compete with one another. His ideas were based on the political beliefs held in the Soviet Union at that time. Based on his personal opinion, Lysenko ordered 300,000 tree seedlings planted in groups in a reforestation project. He believed that the trees in each group would aid one another in competing against other plant species. However, the area where the trees were planted was extremely dry, and all of the trees were competing for water and nutrients. As a result, many trees died. Lysenko's personal opinion and lack of knowledge turned out to be a costly experiment for the Soviet government.

Suppose you wanted to grow as many plants as possible in a single flowerpot. Would you assume that all of the plants in the pot shown in **Figure 18** could survive, or would you set up an experiment to objectively test this hypothesis? Unless you test various numbers of plants in pots under the same conditions, you could not make a valid conclusion.

Figure 18 These seedlings are crowded into a single pot.
Predict *How many do you think could survive?*

Applying Science

How can bias affect your observations?

Do you think bias can affect a person's observations? With the help of her classmates, Sharon performed an experiment to find out.

Identifying the Problem

Sharon showed ten friends a photograph of an uncut amethyst and asked them to rank the quality of color from 1 to 10. She then wrote the words *Prize Amethyst* on top of the photo and asked ten more friends to rank the quality of color.

Rankings Without Hint		Rankings With Hint	
5	7	7	8
4	5	8	9
6	4	9	8
5	6	10	8
5	3	7	9
Average: 5.0		Average: 8.3	

Solving the Problem

1. Examine the tables. Do you think the hint affected the way Sharon's classmates rated the amethyst? What effect did the hint have on them?
2. Do you think bias could affect the results of a scientific experiment? Explain. How could this bias be prevented?

Figure 19 Scientists take detailed notes of procedures and observations when they do science experiments.
Explain *why you should do the same thing.*

Being Ethical and Open People who perform science in ethical and unbiased ways keep detailed notes of their procedures, like the scientists shown in **Figure 19.** Their conclusions are based on precise measurements and tests. They communicate their discoveries by publishing their research in journals or presenting reports at scientific meetings. This allows other scientists to examine and evaluate their work. Scientific knowledge advances when people work together. Much of the science you know today has come about because of the collaboration of investigations done by many different people over many years.

The opposite of ethical behavior in science is fraud. Scientific fraud involves dishonest acts or statements. Fraud could include such things as making up data, changing the results of experiments, or taking credit for work done by others.

Section 2 Review

Summary

A Work in Progress

- Early people used mythology to explain what they observed.

Continuing Research

- After data are gathered over a long period of time to test a hypothesis, the information might be developed into a scientific theory.
- A scientific law is a rule that describes the behavior of something.

Limits of Science

- Science is limited to what it can explain.
- Scientists need to remain open and unbiased in their research.

Self Check

1. **Explain** why science is always changing.
2. **List** ways a hypothesis can be supported.
3. **Compare and contrast** scientific theory and scientific law.
4. **Determine** What kinds of questions can't be answered by science?
5. **Think Critically** When reading science articles, why should you look for the authors' biases?

Applying Skills

6. **Draw Conclusions** Describe what would have happened if the 1986 observations of Halley's comet had not supported Dr. Whipple's original hypothesis.

Science Online earth.msscience.com/self_check_quiz

Reviewing Main Ideas

Section 1 Science All Around

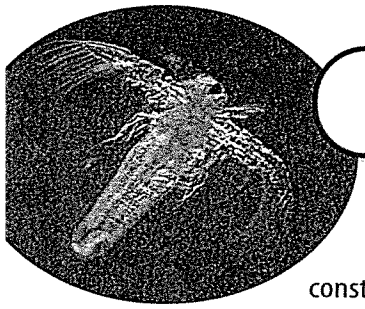
1. Scientific methods include identifying a problem or question, gathering information, developing hypotheses, designing an experiment to test the hypotheses, performing the experiment, collecting and analyzing data, and forming conclusions.
2. Science experiments should be repeated to see whether results are consistent.
3. In an experiment, the independent variable is the variable being tested. Constants are variables that do not change. The variable being measured is the dependent variable. A control is a standard to which things can be compared.
4. Technology is the use of scientific discoveries.

Section 2 Scientific Enterprise

1. Today, everything known in science results from knowledge that has been collected over time. Science has changed and will continue to change because of continuing research and improvements in instruments and testing procedures.
2. Scientific theories are explanations or models that are supported by repeated experimentation.
3. Scientific laws are rules that describe the behavior of something in nature. They do not explain why something happens.
4. Problems that deal with ethics and belief systems cannot be answered using scientific methods.

Visualizing Main Ideas

Copy and complete the following concept map about variables and constants.



Possible Hypothesis:
The amount of salt in water affects how fast brine shrimp eggs hatch.

the constants are

- Amount of water
- _____
- _____

the independent variable is

- _____

the dependent variable is

- Length of time for eggs to hatch

chapter 1 Review

Using Vocabulary

bias p. 21
constant p. 10
control p. 10
dependent variable p. 10
Earth science p. 9
ethics p. 20
hypothesis p. 7
independent variable p. 10
science p. 8
scientific law p. 19
scientific methods p. 8
scientific theory p. 18
technology p. 12
variable p. 10

Use what you know about the vocabulary words to explain the differences between the words in the following sets. Then explain how the words are related.

1. constant—control
2. dependent variable—independent variable
3. scientific law—scientific theory
4. science—technology
5. hypothesis—scientific theory
6. science—Earth science
7. independent variable—constant
8. variable—control
9. Earth science—technology
10. ethics—bias

Checking Concepts

Choose the word or phrase that best answers the question.

11. Which word means an educated guess?
    A) theory
    B) hypothesis
    C) variable
    D) law

12. The idea that a comet is like a dirty snowball is which of the following?
    A) hypothesis **C)** law
    B) variable **D)** theory

13. Which of the following is the first step in using scientific methods?
    A) develop hypotheses
    B) make conclusions
    C) test hypotheses
    D) identify a problem

14. The statement that an object at rest will remain at rest unless acted upon by a force is an example of which of the following?
    A) hypothesis **C)** law
    B) variable **D)** theory

15. Which of the following questions could NOT be answered using scientific methods?
    A) Should lying be illegal?
    B) Does sulfur affect the growth of grass?
    C) How do waves cause erosion?
    D) Does land heat up faster than water?

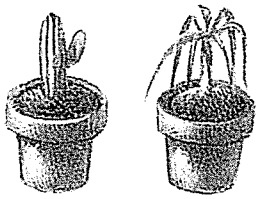
16. Which of the following describes variables that stay the same in an experiment?
    A) dependent variables
    B) independent variables
    C) constants
    D) controls

17. Which of the following is a variable that is being tested in a science experiment?
    A) dependent variable
    B) independent variable
    C) constant
    D) control

18. What should you do if your data are different from what you expected?
    A) Conclude that you made a mistake in the way you collected the data.
    B) Change your data to be consistent with your expectation.
    C) Conclude that you made a mistake when you recorded your data.
    D) Conclude that your expectation might have been wrong.

Thinking Critically

19. **Recognize Cause and Effect** Suppose you had two plants—a cactus and a palm. You planted them in soil and watered them daily. After two weeks, the cactus was dead. What scientific methods could you use to find out why the cactus died?



20. **Think Critically** How have advances in technology affected society?

21. **Explain** what is meant by the statement, *Technology is transferable.*

22. **Evaluate** Why don't all hypotheses become theories?

23. **Identify** some scientific methods you use every day to answer questions or solve problems?

24. **Identify and Manipulate Variables and Controls** How would you set up a simple experiment to test whether salt-crystal growth is affected by temperature?

25. **Form Hypotheses** You observe two beakers containing clear liquid and ice cubes. In the first beaker, the ice cubes are floating. In the second, the ice cubes are on the bottom of the beaker. Write a hypothesis to explain the difference in your observations about the two beakers.

26. **Recognize Cause and Effect** Explain why scientific methods cannot be used to answer ethical questions.

27. **Draw Conclusions** A laboratory tests a hypothesis through an experiment and publishes its findings that confirm the hypothesis is true. Ten other laboratories attempt to duplicate the findings, but none are able to prove the hypothesis true. Give a possible explanation why the labs' results did not agree.

Performance Activities

28. **Poster** Research an example of Earth science technology that is not shown in Figure 10. Create a poster that explains the contribution this technology made to the understanding of Earth science.

Applying Math

Use the table below to answer questions 29–30.

Color and Heat Absorption

Color	Beginning Temperature (°C)	Temperature (°C) after 10 minutes
Red	24°	26°
Black	24°	28°
Blue	24°	27°
White	24°	25°
Green	24°	27°

29. **A Color Experiment** A friend tells you that dark colors absorb more heat than light colors do. You conduct an experiment to determine which color of fabric absorbs the most heat. Analyze your data below. Was your friend correct? Explain.

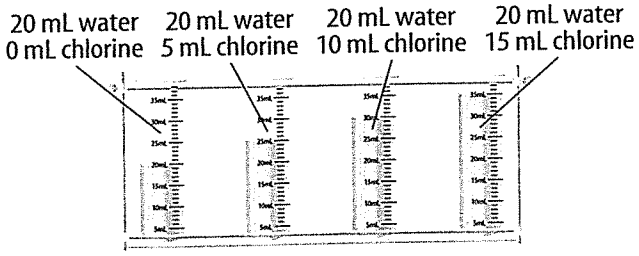
30. **Variables** Identify the independent variables and the dependent variables of the experiment.

chapter 1 Standardized Test Practice

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the illustration below to answer question 1.



1. The test tubes were left at room temperature for a week to see if algae would grow. Which variable is being investigated?
   - **A.** the volume of water used
   - **B.** the temperature of the test tube's contents
   - **C.** the amount of chlorine present
   - **D.** the amount of algae present

2. Which of the following is the study of Earth and space?
   - **A.** life science
   - **B.** Earth science
   - **C.** physical science
   - **D.** chemical science

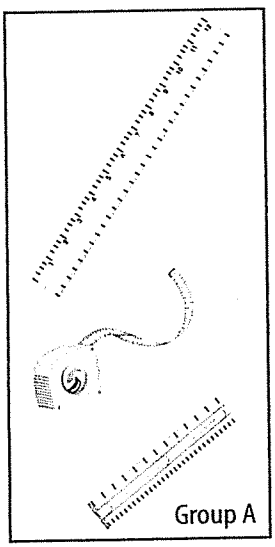
3. Which of these is a factor to which experimental results can be compared?
   - **A.** independent variable
   - **B.** dependent variable
   - **C.** control
   - **D.** constant

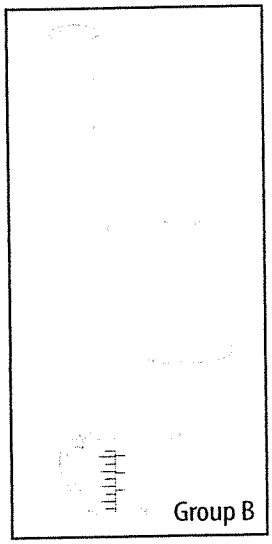
4. What is the use of scientific discoveries for practical purposes?
   - **A.** bias
   - **B.** scientific methods
   - **C.** science
   - **D.** technology

5. Which of the following is an explanation or model that is supported by many experiments and observations?
   - **A.** hypothesis
   - **B.** law
   - **C.** theory
   - **D.** estimate

6. Which is a rule that describes the behavior of something in nature?
   - **A.** hypothesis
   - **B.** law
   - **C.** estimate
   - **D.** theory

Use the illustrations below to answer questions 7–9.





7. Which quality can be measured using the tools in group A?
   - **A.** distance
   - **B.** weight
   - **C.** volume
   - **D.** mass

8. Which quality can be measured using the tools in group B?
   - **A.** distance
   - **B.** weight
   - **C.** volume
   - **D.** mass

9. Which of the following belongs in group B above?
   - **A.** spring scale
   - **B.** thermometer
   - **C.** beaker
   - **D.** stopwatch