section 1

Science All Around

as you read

What You'll Learn

- **Describe** scientific methods.
- **Define** science and Earth science.
- **Distinguish** among independent variables, dependent variables, constants, and controls.

Why It's Important

Scientific methods are used every day when you solve problems.

Review Vocabulary

analyze: to examine methodically

New Vocabulary

- hypothesis
- scientific methods
- science
- Earth science
- variable
- independent variable
- constant
- dependent variable
- control
- technology

Mysteries and Problems

Scientists are often much like detectives trying to solve a mystery. One such mystery occurred in 1996 when Japanese scientists were looking through historical records. They reported finding accounts of a tsunami that had smashed the coast of the island of Honshu on January 27, 1700. That led to the question: What had triggered these huge ocean waves?

The Search for Answers The scientists suspected that an earthquake along the coast of North America was to blame. From the coast of British Columbia to northern California is an area called the Cascadia subduction zone, shown in **Figure 1.** A subduction zone is where one section of Earth's outer, rigid layer, called a plate, is sinking beneath another plate. In areas like this, earthquakes are common. However, one problem remained. Based on the size of the tsunami, the earthquake had to have been an extremely powerful one, sending waves rolling all the way across the Pacific Ocean. That would be a much stronger earthquake than any known to have occurred in the area. Could evidence be found for such a large earthquake?

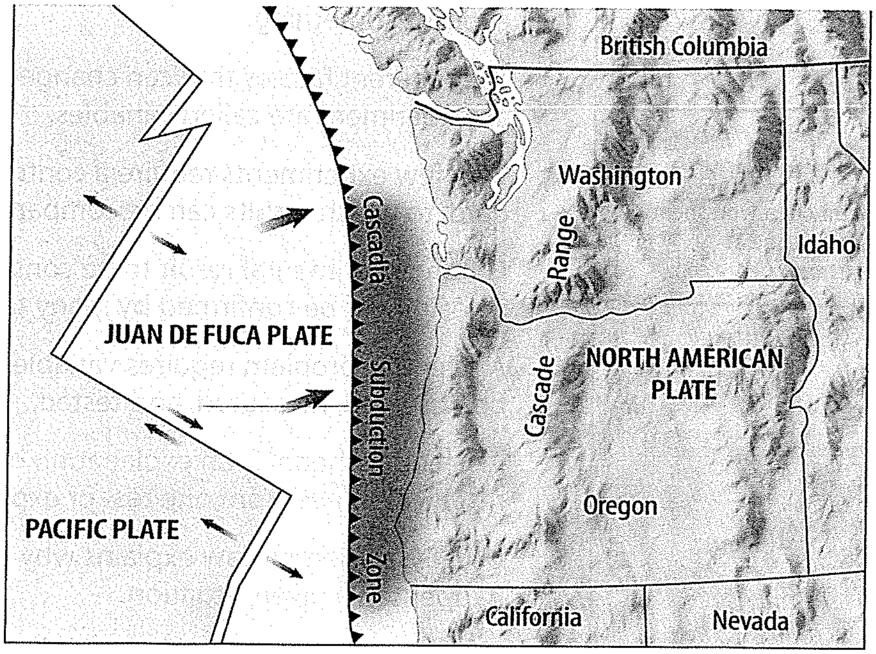


Figure 1 Along the Cascadia subduction zone, the Juan de Fuca Plate is sinking under the North American Plate.

Gathering Evidence Evidence of a large earthquake in the distant past did seem to exist along the coasts of Washington and Oregon. Much of the coast in that area had sunk, submerging coastal forests and killing thousands of trees. However, dating the earthquake to a specific year would be difficult.

A Possible Solution One scientist, whose field of study was tree rings, thought he knew how the earthquake could be dated. He made an educated guess, called a **hypothesis,** that tree rings in the drowned trees could be used to determine when the earthquake occurred.

✓ **Reading Check** *What is a hypothesis?*

The hypothesis was based on what scientists know about tree growth. Each year, a living tree makes a new ring of tissue in its trunk, called an annual growth ring. You can see the annual rings in the cross section of a tree trunk shown in **Figure 2.** Two groups of scientists analyzed the rings in drowned trees along the coast, like the remains of cedar trees shown in **Figure 3.** Their data showed that the trees had died or were damaged after August 1699 but before the spring growing season of 1700. That evidence put the date of the earthquake in the same time period as the tsunami on Honshu.

Importance of Solving the Mystery In addition to solving the mystery of what caused the tsunami, the tree rings also provided a warning for people living in the Pacific Northwest. Earthquakes much stronger than any that have occurred in modern times are possible. Scientists warn that it's only a matter of time until another huge quake occurs.

Figure 2 You can see the growth rings in this tree trunk. **Determine** *How much time does each ring represent?*

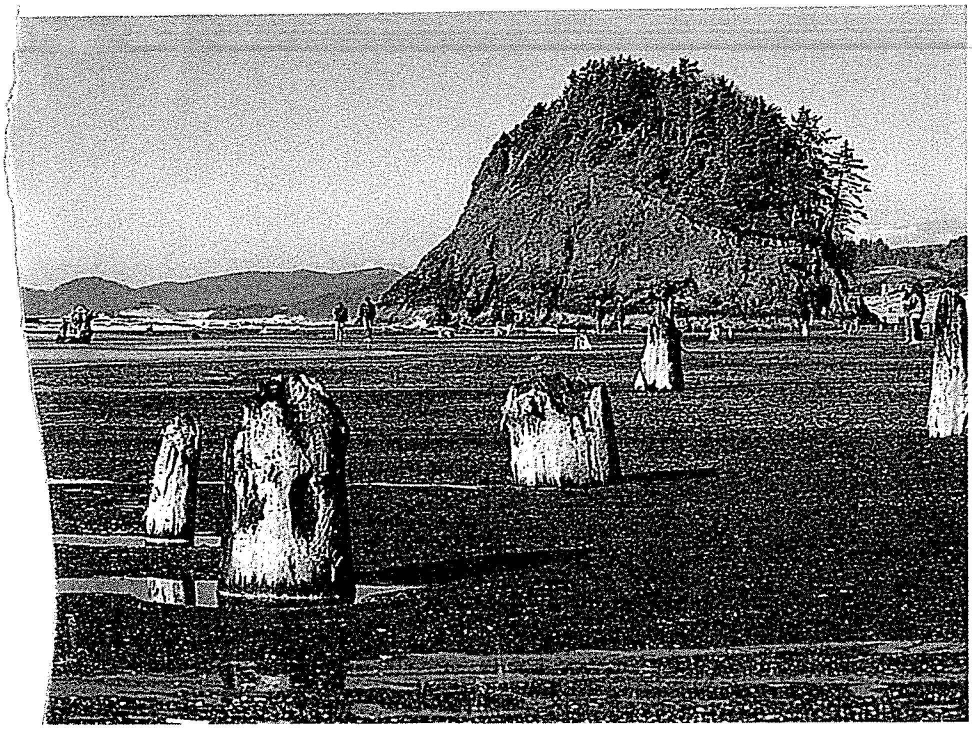


Figure 3 Growth rings from these and other trees linked a huge earthquake along the coast of Washington to a tsunami in Japan that occurred more than 300 years ago.

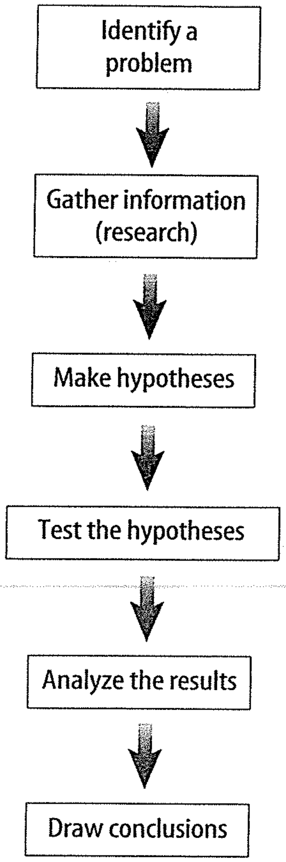


Figure 4 By using scientific methods, you can solve many problems.

Scientific Methods

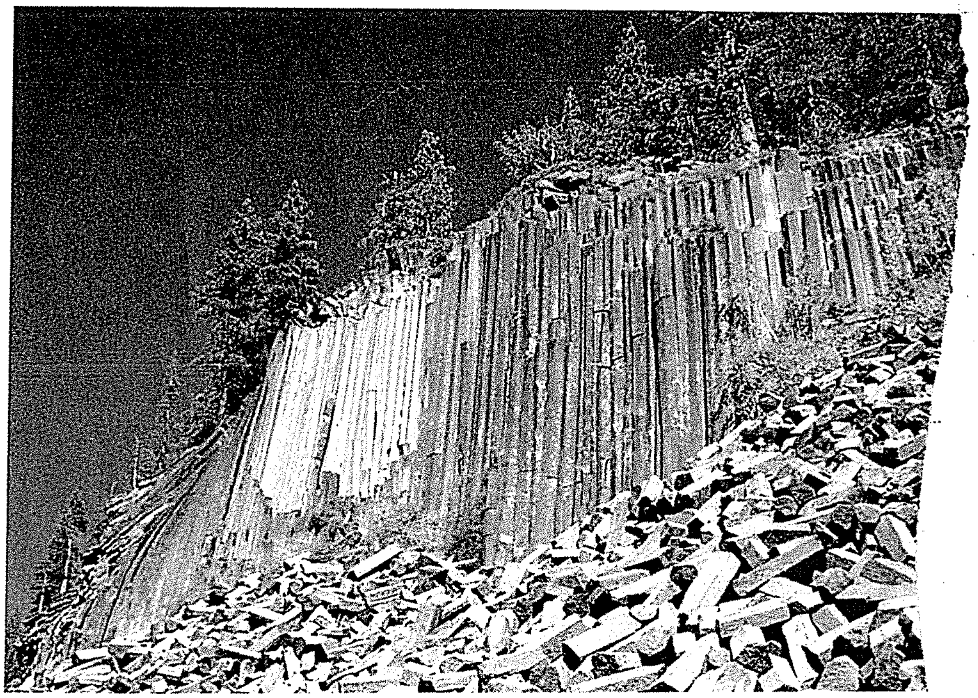
When scientists try to solve a mystery like what caused the tsunami in Japan in 1700, they perform problem-solving procedures called **scientific methods.** As shown in **Figure 4,** some of the scientific methods they use include identifying a problem, gathering information (researching), developing hypotheses, testing the hypotheses, analyzing the results, and drawing conclusions. When you use methods like these, you are solving problems in a scientific way.

Science

Science means "having knowledge." **Science** is a process of observing, studying, and thinking about things in your world to gain knowledge. Many observations can't be explained easily. When people can't explain things, they ask questions. For example, you might observe that the sky appears to be blue during the day but often appears to be red at sunset and sunrise. You might ask yourself why this happens. You might visit or see a picture of Devils Postpile in California, shown in **Figure 5,** and notice that the dark rock is divided into long, thin, six-sided columns. Many fallen columns lie at the base of this mass of rock. You might wonder how and when this strange-looking rock formed. You also might wonder why rocks can be smooth or rough, shiny or dull, and can be so many different colors. Science involves trying to answer questions and solve problems to better understand the world. Every time you attempt to find out how and why things look and behave the way they do, you are performing science.

✓ **Reading Check** *What is science?*

Figure 5 The columns in Devils Postpile rise between 12 m and 18 m from the valley floor. This unusual formation was created when hot lava cooled and cracked.



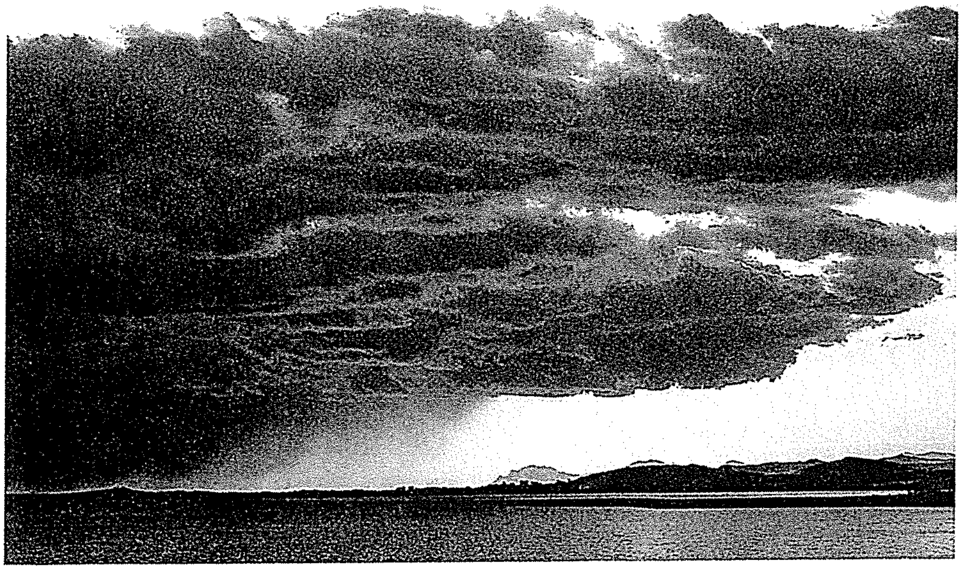


Figure 6 Earth science includes the study of climate, volcanoes, space, and much more.
Identify *Which Earth science topics are represented here?*

Earth Science Science is divided into different areas of study. The kind of science you will learn about this year is Earth science. **Earth science** is the study of Earth and space. Some Earth science topics include rocks, minerals, soil, volcanoes, earthquakes, maps, fossils, mountains, climates, weather, ocean water, and objects in space. Some of these topics are represented in **Figure 6.** Much of the information you'll learn about has been discovered through the ages by people who conducted scientific tests or investigations. However, many unanswered questions remain and much more is waiting to be discovered.

✓ **Reading Check** *What topics do Earth scientists study?*

Working in the Lab

Testing, or experimenting, is an important part of science, and if you really want to learn from an investigation, the experiment must be carefully designed. Suppose that after listening to advertisements for several dishwashing liquids, you want to know which brand of dishwashing liquid cleans dishes the best. To find the answer, you would need to do some library or Internet research on dishwashing liquids. After researching, several thoughts might go through your mind. For example, you might hypothesize that brand X will clean dishes better than any other brand. You also might consider that there might be no difference in how well the different liquids clean.

Next, you would design an experiment that tests the validity of your hypotheses. You would need to think about which dishwashing liquids you would test, the amount of each dishwashing liquid you would use, the temperature of the water, the number of dishes you would wash, the kind and amount of grease you would put on the dishes, and the brand of paper towels you would use. All these factors can affect the outcome.

Science Online

Topic: Earth Science
Visit earth.msscience.com for Web links to information about the different areas of Earth science.

Activity Prepare a collage that illustrates what you learn.

Figure 7 Wiping each dish in the same manner with a different paper towel is an important constant.
Explain *why it is necessary to have a constant in your experiment.*

INTEGRATE Life Science

Soil Experiment Suppose you wanted to design an experiment to find out what kind of soil is best for growing cactus plants. What would be your variables and constants in the experiment?

Variables and Constants The different factors that can change in an experiment are **variables.** However, you want to design your experiment so you test only one variable at a time. The variable you want to test is the brand of dishwashing liquid. This is called the **independent variable**—the variable that you change. **Constants** are the variables that do not change in an experiment. Constants in this experiment would be the amount of dishwashing liquid used, the amount of water, the water temperature, the number of dishes, the kind and amount of grease applied to each dish, the brand of paper towels that were used, and the manner in which each dish was wiped. For example, you might use 20 equally greasy dishes that are identical in size, soaked in 20 L of hot water (30°C) to which 10 mL of dishwashing liquid have been added. You might rub each dish with a different dry paper towel of the same brand after it has soaked for 20 min and air dried, as the student in **Figure 7** is doing. If grease does not appear on the towel, you would consider the dish to be clean. The amount of grease on the towel is a measure of how clean each dish is and is called the dependent variable. A **dependent variable** is the variable being measured.

Controls Many experiments also need a control. A **control** is a standard to which your results can be compared. The control in your experiment is the same number of greasy dishes, placed in 20 L of hot water except that no dishwashing liquid is added to the water. These dishes also are allowed to soak for 20 min and air dry. Then they are wiped with paper towels in the same manner as the other dishes were wiped.

✓ **Reading Check** *Why is a control used in an experiment?*

Repeating Experiments For your results to be valid or reliable, your tests should be repeated many times to see whether you can confirm your original results. For example, you might design your experiment so you repeat the procedures five times for each different dishwashing liquid and control. Also, the number of samples being tested should be large. That is why 20 plates would be chosen for each test of each dishwashing liquid. The control group also would have 20 plates. By repeating an experiment five times, you can be more confident that your conclusions are accurate because your total sample for each dishwashing liquid would be 100 plates. If something in an experiment occurs just once, you can't base a scientific conclusion on it. However, if you can show that brand X cleans best in 100 trials under the same conditions, then you have a conclusion you can feel confident about.

Testing After you have decided how you will conduct an experiment, you can begin testing. During the experiment, you should observe what happens and carefully record your data in a table, like the one shown in **Figure 8.** Your final step is to draw your conclusions. You analyze your results and try to understand what they mean.

When you are making and recording observations, be sure to include any unexpected results. Many discoveries have been made when experiments produced unexpected results.

Mini LAB

Designing an Experiment

Procedure

1. Design an experiment to test the question: *Which flashlight battery lasts the longest?*
2. In your design, be sure to include detailed steps of your experiment.
3. Identify the independent variable, constants, dependent variable, and control.

Analysis

1. List the equipment you would need to do your experiment.
2. Explain why you should repeat the experiment.

Try at Home

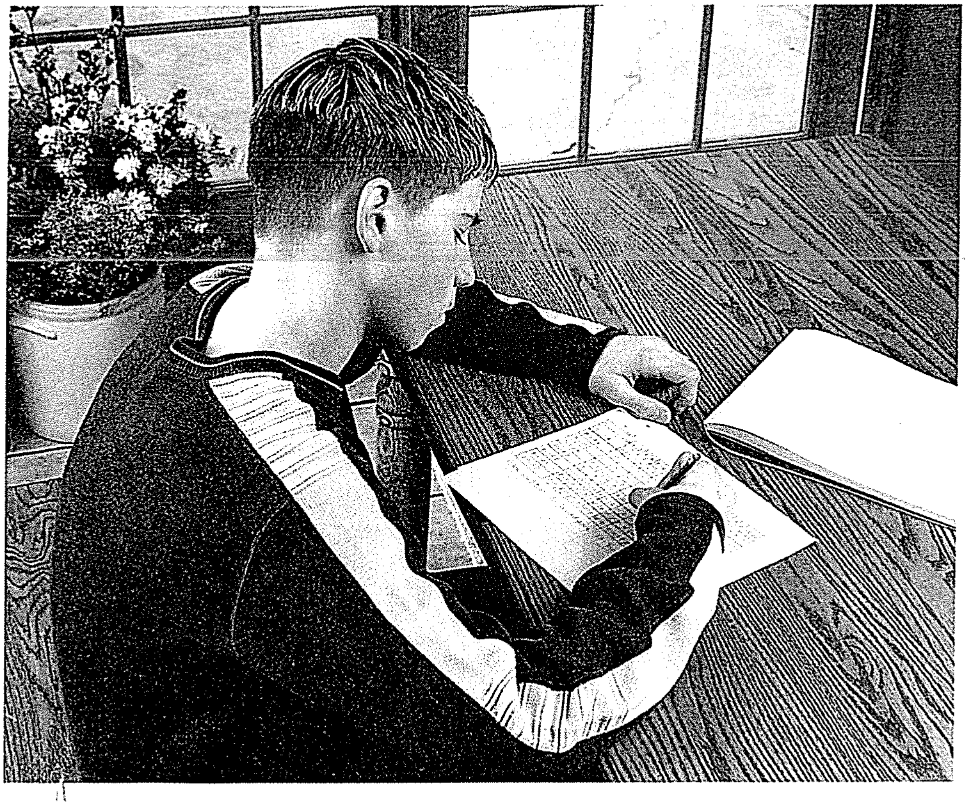


Figure 8 Arranging your data in a table makes the information easier to understand and analyze.

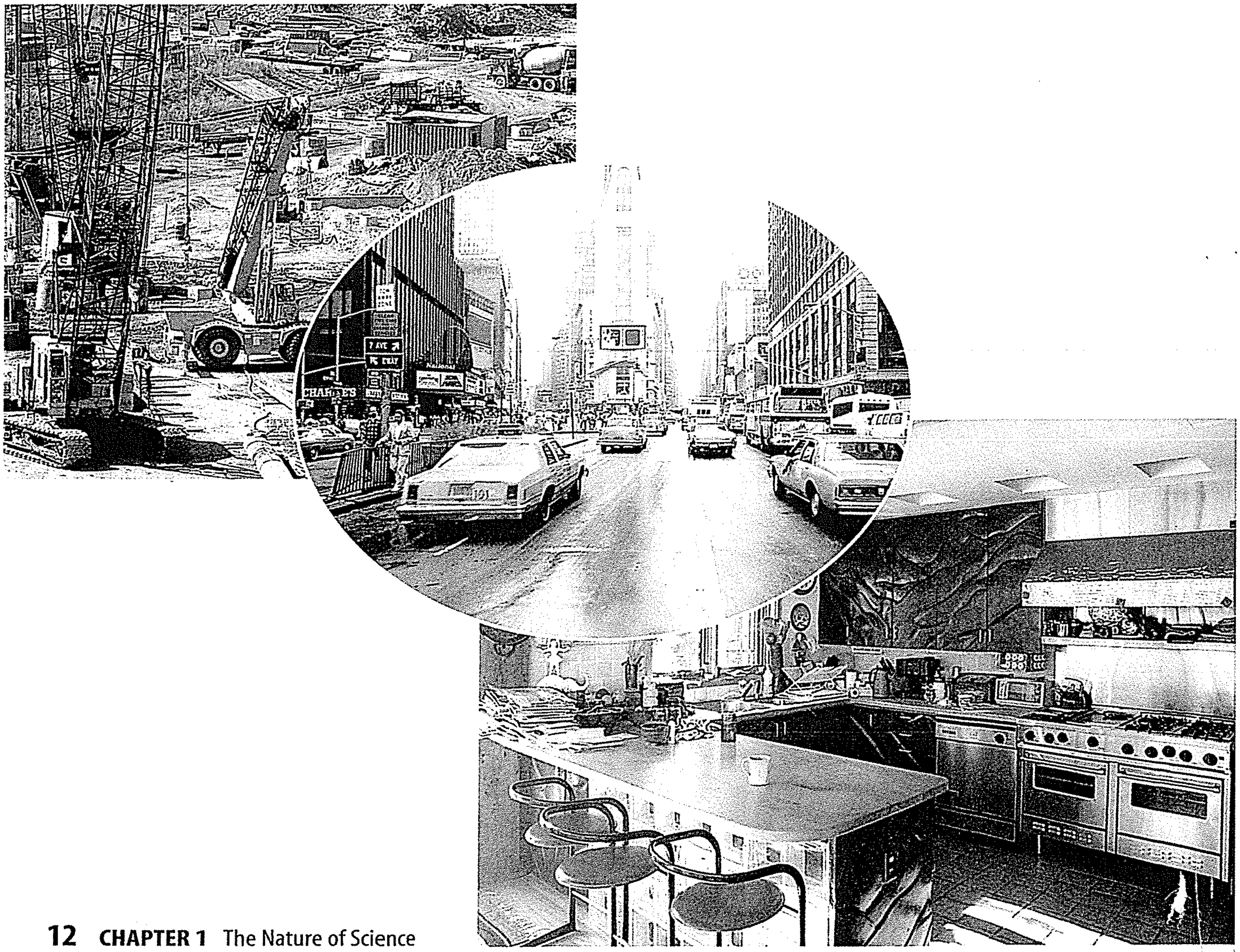
Technology

Science doesn't just add to the understanding of your natural surroundings, it also allows people to make discoveries that help others. Science makes the discoveries, and technology puts the discoveries to use. **Technology** is the use of scientific discoveries for practical purposes.

When people first picked up stones to use as tools or weapons, the age of technology had started. The discovery of fire and its ability to change clay into pottery or rocks into metals made the world you live in possible. Think back to the Launch Lab at the beginning of this chapter. Measuring devices like the metric ruler you used are examples of technology.

Everywhere you look, you can see ways that science and technology have shaped your world. Look at **Figure 9** to see how many examples of technology you can identify in each of the pictures. **Figure 10** shows a time line of some important examples of technology used in Earth science. Notice how different cultures have added to discoveries and inventions over the centuries.

Figure 9 Examples of technology are all around you.
Identify *What are some ways these examples affect your life?*

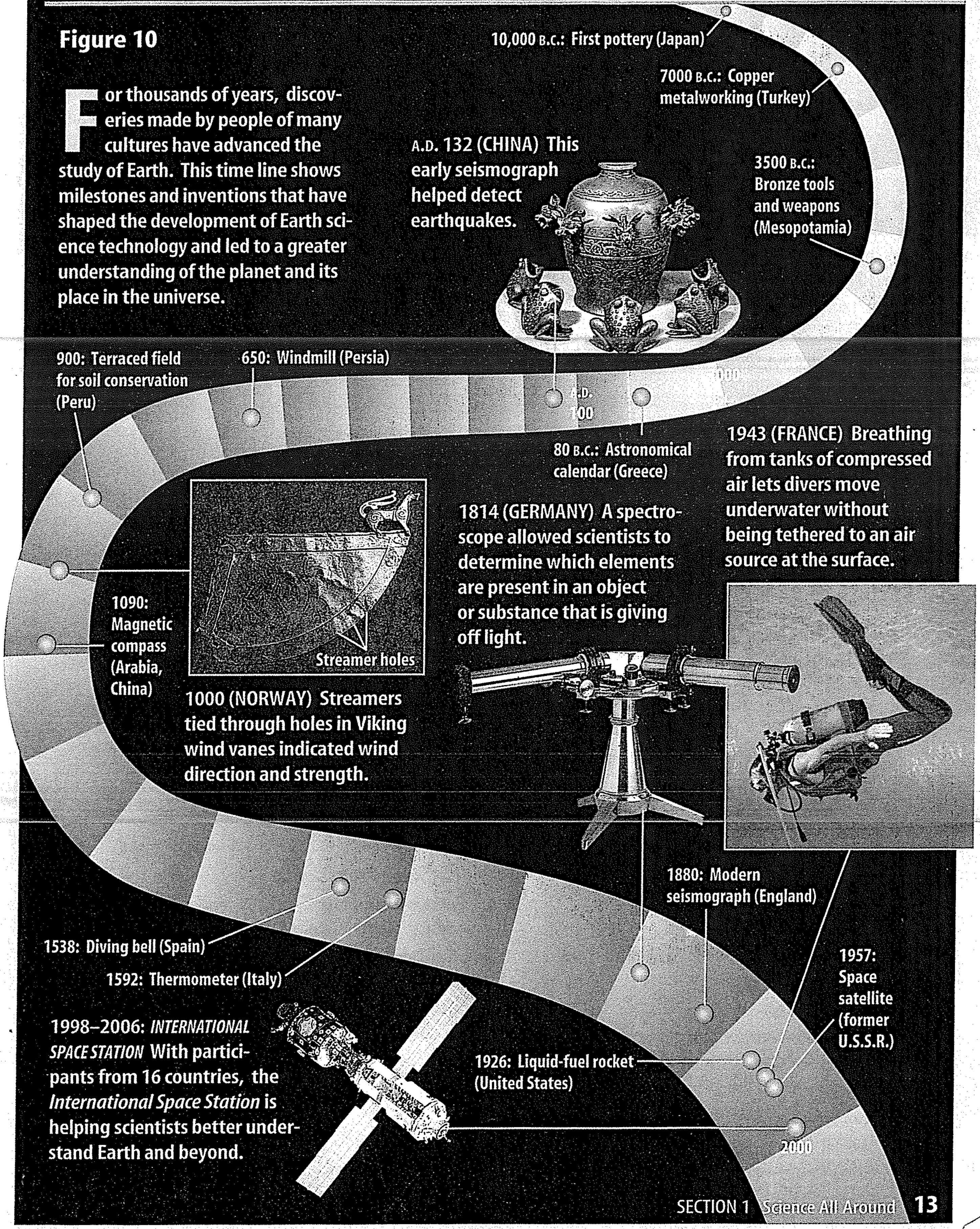


NATIONAL GEOGRAPHIC

VISUALIZING THE HISTORY OF EARTH SCIENCE TECHNOLOGY

Figure 10

For thousands of years, discoveries made by people of many cultures have advanced the study of Earth. This time line shows milestones and inventions that have shaped the development of Earth science technology and led to a greater understanding of the planet and its place in the universe.



A.D. 132 (CHINA) This early seismograph helped detect earthquakes.

1000 (NORWAY) Streamers tied through holes in Viking wind vanes indicated wind direction and strength.

1814 (GERMANY) A spectroscope allowed scientists to determine which elements are present in an object or substance that is giving off light.

1943 (FRANCE) Breathing from tanks of compressed air lets divers move underwater without being tethered to an air source at the surface.

1998–2006: *INTERNATIONAL SPACE STATION* With participants from 16 countries, the *International Space Station* is helping scientists better understand Earth and beyond.

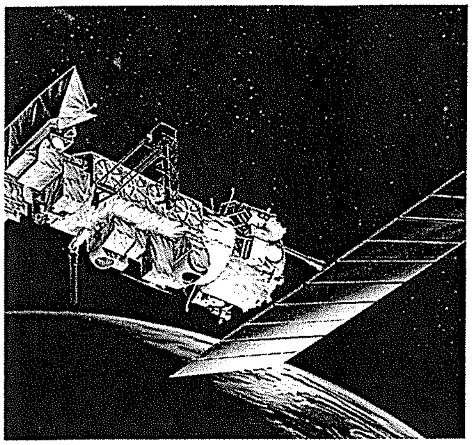


Figure 11 Weather satellites help forecasters predict future storms.

Predict *How might this same technology be used to protect endangered species?*

Using Technology Most people immediately think of complex and exotic inventions when the word *technology* is mentioned. However, the use of scientific knowledge has resulted in such common yet important things as paper, can openers, buckets, aspirin, rubber boots, locks and keys, microfiber clothing, ironing boards, bandages, and scissors. It also has resulted in robots that check underwater oil rigs for leaks and others that manufacture cars. Technology also includes calculators and computers that process information.

Transferable Technology Technology is a natural outcome of using scientific knowledge to solve problems and make people's lives easier and better. The wonderful thing about technology is that it is transferable, which means that it can be applied to new situations. For example, many types of technology that are now common were originally developed for use in outer space.

Scientists developed robotic parts, new fibers, and microminiaturized instruments for spacecraft and satellites. After these materials were developed, many were modified for use here on Earth. Technology that once was developed by the military, such as radar and sonar, has applications in the study of space, weather, Earth's structures, and medicine.

Earth scientists rely on information from weather satellites like the one in **Figure 11** to gather weather data. But biologists also use satellites to track animals. A tiny radio transmitter attached to an animal sends signals up to a satellite. The satellite then sends data on the animal's location to a ground station. Some researchers use the data to track bird migration.

section 1 review

Summary

Mysteries and Problems

- Scientists develop and test hypotheses to explain phenomena they observe.

Scientific Methods

- Scientific methods consist of a series of problem-solving procedures.

Working in the Lab

- Scientists experiment with independent and dependent variables, constants, and controls.

Technology

- Technology uses scientific discoveries for practical purposes.

Self Check

1. **Define** the term *hypothesis.* Why must it be testable?
2. **Define** the term *Earth science.*
3. **Explain** why it is important that scientists perform an experiment more than one time.
4. **Think Critically** Why is it important to use constants in an experiment?

Applying Skills

5. **Communicate** In your Science Journal, write a paragraph about how you would try to describe a modern device such as a TV, microwave oven, or computer to someone living in 1800.

Science Online earth.msscience.com/self_check_quiz

section 2

Scientific Enterprise

A Work in Progress

Throughout time, people have been both frightened by and curious about their surroundings. Storms, erupting volcanoes, comets, seasonal changes, and other natural phenomena fascinated people thousands of years ago, and they fascinate people today. As shown in **Figure 12,** early people relied on mythology to explain what they observed. They believed that mythological gods were responsible for creating storms, causing volcanoes to erupt, causing earthquakes, bringing the seasons, and making comets appear in the sky.

Recording Observations Some early civilizations went so far as to record what they saw. They developed calendars that described natural recurring phenomena. Six thousand years ago, Egyptian farmers observed that the Nile River flooded their lands every summer. Their crops had to be planted at the right time in order to make use of this water. The farmers noticed that shortly before flood time, the brightest star in the sky, Sirius, appeared at dawn in the east. The Egyptians developed a calendar based on the appearance of this star, which occurred about every 365 days.

Later, civilizations created instruments to measure with. As you saw in the Launch Lab, instruments allow for precise measurements. As instruments became better, accuracy of observations improved. While observations were being made, people tried to reason why things happened the way they did. They made inferences, or conclusions, to help explain things. Some people developed hypotheses that they tested. Their experimental conclusions allowed them to learn even more.

as you read

What You'll Learn

- **Explain** why science is always changing.
- **Compare and contrast** scientific theories and scientific laws.
- **Discuss** the limits of science.

Why It's Important

Science helps you understand the world around you.

Review Vocabulary
observation: act of using the senses to gather information

New Vocabulary
- scientific theory
- scientific law
- ethics
- bias

Figure 12 Early Scandinavian and Germanic peoples believed that a god named Thor controlled the weather. In this drawing, Thor is creating a storm. Lightning flashed whenever he threw his heavy hammer.

The History of Meteorology

Today, scientists know what they know because of all the knowledge that has been collected over time. The history of meteorology, which is the study of weather, illustrates how an understanding of one area of Earth science has developed over time.

Weather Instruments As you have read, ancient peoples believed that their gods controlled weather. However, even early civilizations observed and recorded some weather information. The rain gauge was probably the first weather instrument. The earliest reference to the use of a rain gauge to record the amount of rainfall appears in a book by the ruler of India from 321 B.C. to 296 B.C.

It wasn't until the 1600s that scientists in Italy began to use instruments extensively to study weather. These instruments included the barometer—to measure air pressure; the thermometer—to measure temperature, shown in **Figure 13;** the hygrometer—to measure water vapor in the air; and the anemometer—to measure wind speed. With these instruments, the scientists set up weather stations across Italy.

✓ Reading Check *What instruments were used extensively in Italy in the 1600s to study weather?*

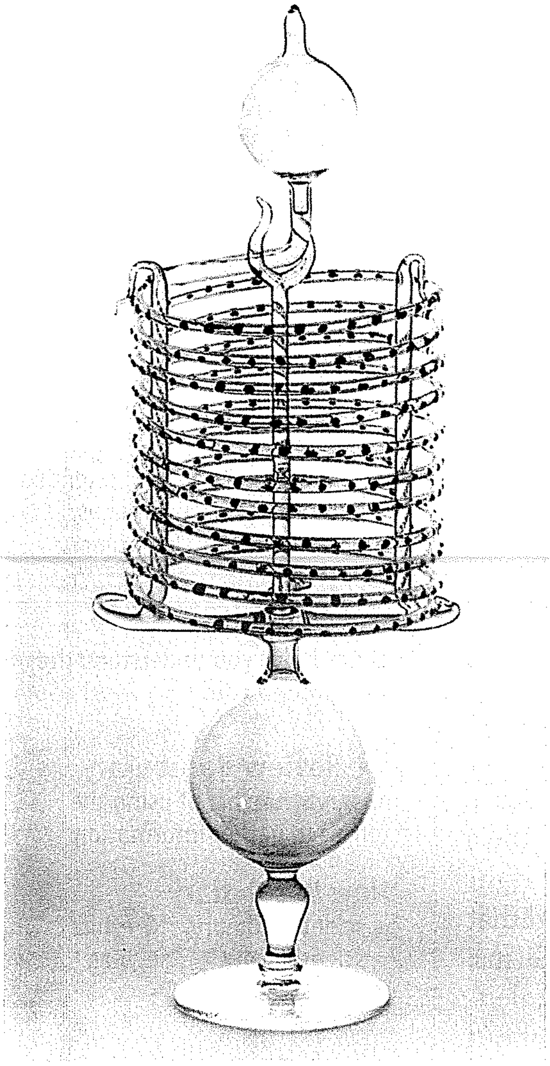


Figure 13 This photo shows a replica of a 1660 Italian alcohol thermometer.

Weather Prediction in the United States

Benjamin Franklin was the first American to suggest that weather could be predicted. Franklin read accounts of storms from newspapers across the country. From these articles, Franklin concluded that severe storms generally move across the country from west to east. He also concluded that observers could monitor a storm and notify those ahead of its path that it was coming. Franklin's ideas were put to practical use shortly after the telegraph was invented in 1837.

By 1849, an organized system of weather observation sites was set up and weather reports from volunteer weather observers were sent by telegraph to the Smithsonian Institution. In 1850, Joseph Henry, secretary of the Smithsonian Institution in the United States, began drawing maps from the weather data he received. A large weather map was displayed at the Smithsonian and a weather report was sent to the *Washington Evening Post* to be published in the newspaper.

National Weather Service By the late 1800s, the United States Weather Bureau was functioning with more than 350 observing sites across the country. By 1923, weather forecasts were being carried by 140 radio stations across the United States. In 1970, the bureau's name was changed to the National Weather Service and it became part of the National Oceanic and Atmospheric Administration (NOAA).

Today's weather is forecast using orbiting satellites, weather balloons, radar, and other sophisticated technology. Each day about 60,000 reports from weather stations, ships, aircraft, and radar transmitters are gathered and filed. **Figure 14** shows instruments used to gather data at a weather station. All the information gathered is compiled into a report that is distributed to radio stations, television networks, and other news media.

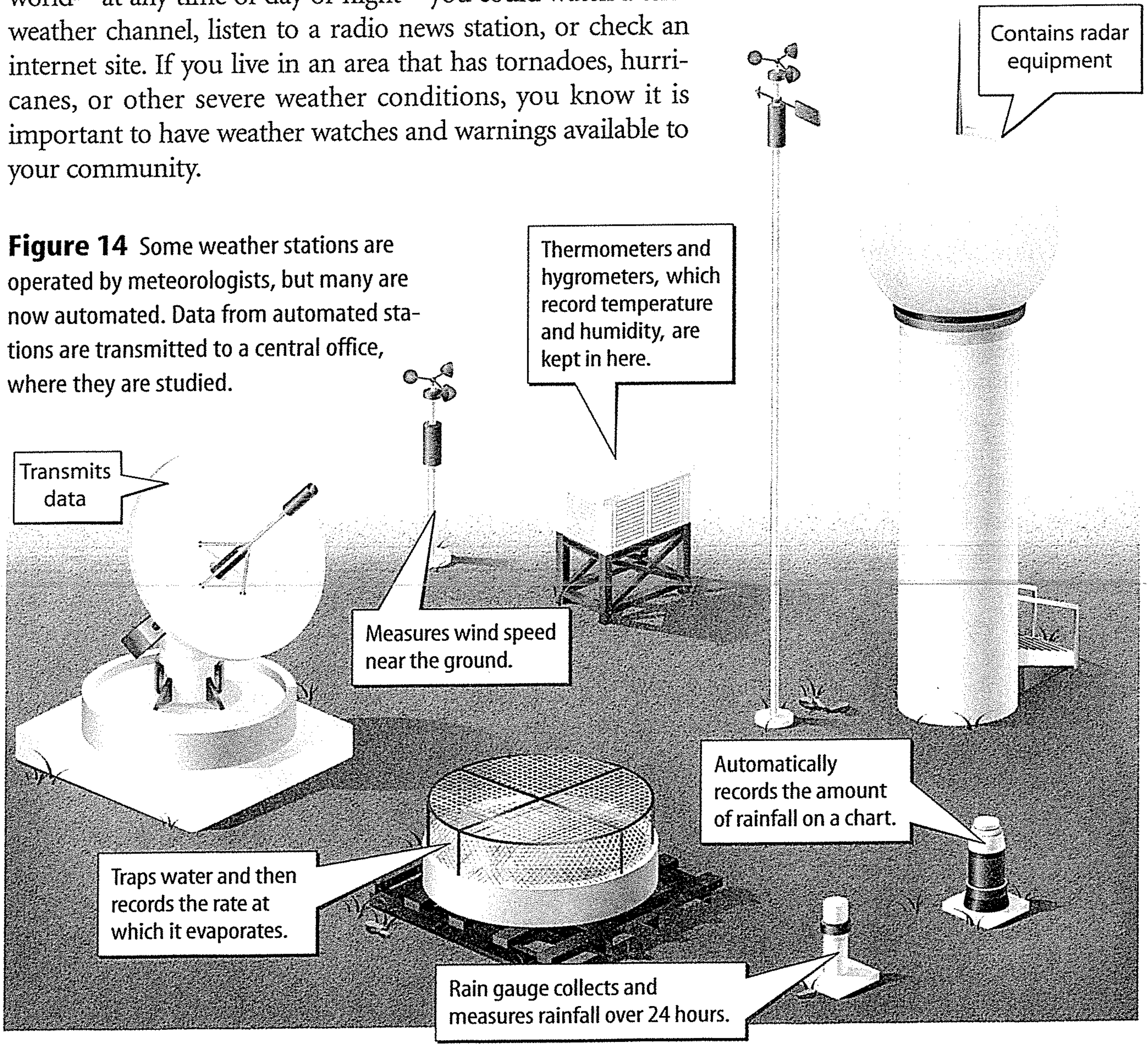
Today, if you want to know about the weather anywhere in the world—at any time of day or night—you could watch a television weather channel, listen to a radio news station, or check an internet site. If you live in an area that has tornadoes, hurricanes, or other severe weather conditions, you know it is important to have weather watches and warnings available to your community.

Science Online

Topic: Weather Forecasting
Visit earth.msscience.com for Web links to information about weather forecasting.

Activity Prepare a detailed forecast for an imaginary snowstorm using information based on the research you have conducted.

Figure 14 Some weather stations are operated by meteorologists, but many are now automated. Data from automated stations are transmitted to a central office, where they are studied.



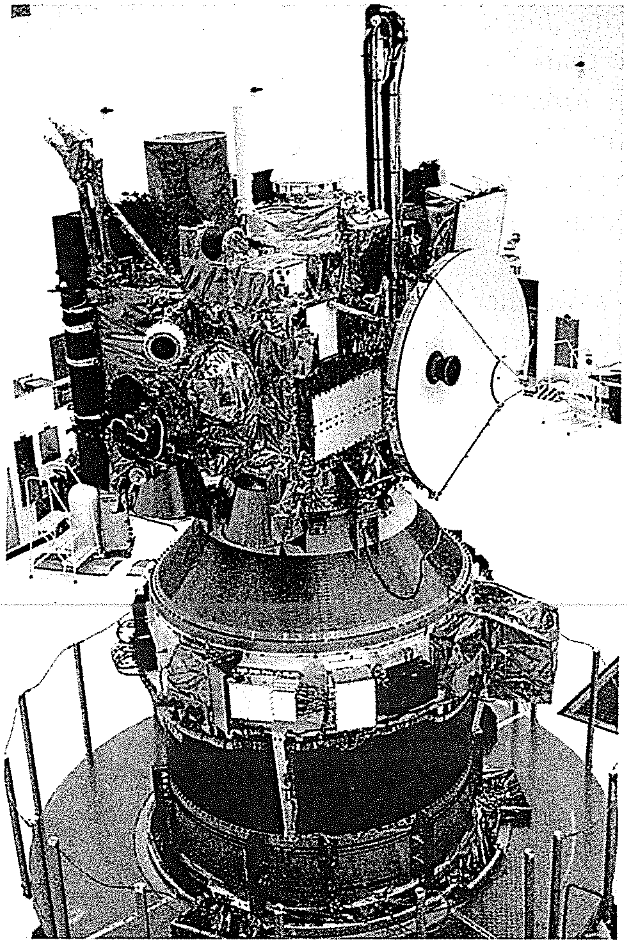


Figure 15 The Global Positioning System (GPS) can pinpoint a person's location on Earth. A radio receiver gets signals from several orbiting *Navstar* satellites like this one. By comparing how far the receiver is from each satellite, the receiver's position can be determined and displayed.

Continuing Research

Scientific knowledge continues to change as scientists develop better instruments and testing procedures. As it changes, scientists have a greater understanding of nature. As you saw in **Figure 14,** scientists use a variety of technologies to study weather. Scientists have similar technologies to study Earth's interior, the oceans, environmental problems, and space. How could the technology shown in **Figure 15** be used by Earth scientists?

It is impossible to predict the types of instruments scientists will have in the future. But it is easy to predict that as research continues and instruments improve, knowledge will grow. Perhaps one day you will make a scientific breakthrough that changes people's understanding of the world.

Scientific Theories As you learned earlier, scientists test hypotheses. If data gathered over a long period of time support a hypothesis, scientists become convinced that the hypothesis is useful. They use results from many scientists' work to develop a scientific theory. A **scientific theory** is an explanation or model backed by results obtained from many tests or experiments.

Reading Check *How can a scientific hypothesis become a scientific theory?*

Examine how one hypothesis became a theory. Comets once were believed to be the forecasters of disaster. People often were terrified yet fascinated by the ghostly balls appearing in the sky. Slowly over the years, comets lost much of their mystery. However, from the 1800s until 1949, most scientists hypothesized that comets were made of many particles of different kinds of materials swarming in a cluster. Based on this hypothesis, a comet was described as a swirling cloud of dust.

In 1949, American astronomer Fred L. Whipple proposed a hypothesis that a comet was more like a dirty snowball—that the nucleus of a comet contains practically all of a comet's mass and consists of ice and dust. If a comet's orbit brings it close to the Sun, the heat vaporizes some of the ice, releasing dust and gas, which form the comet's tail. Dr. Whipple's hypothesis was published in the March 1950 *Astrophysical Journal.*

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.

INTEGRATE Physics

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.

Mini LAB

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?

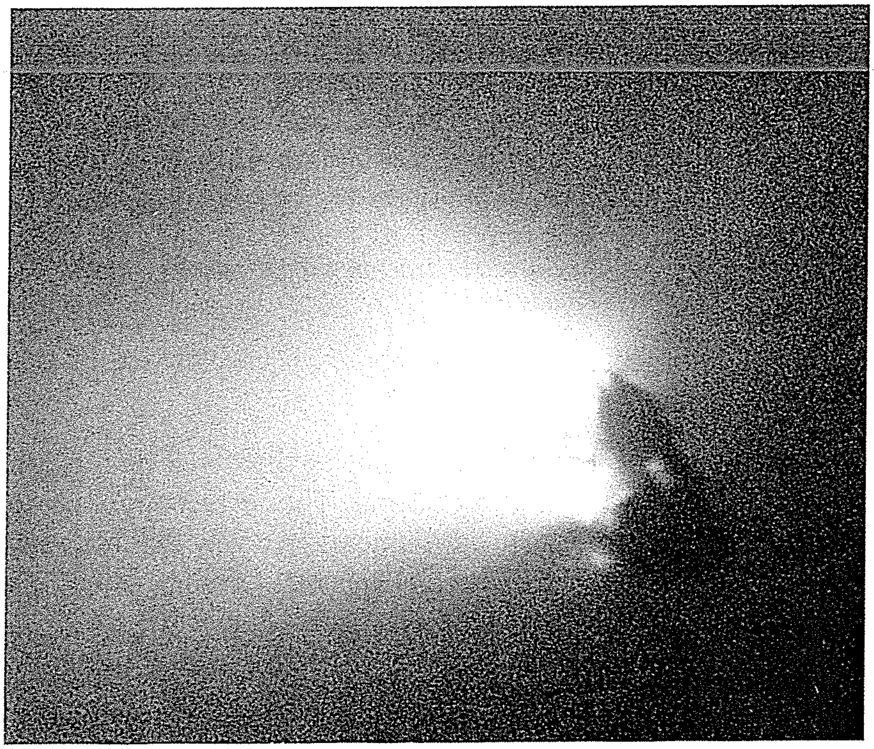
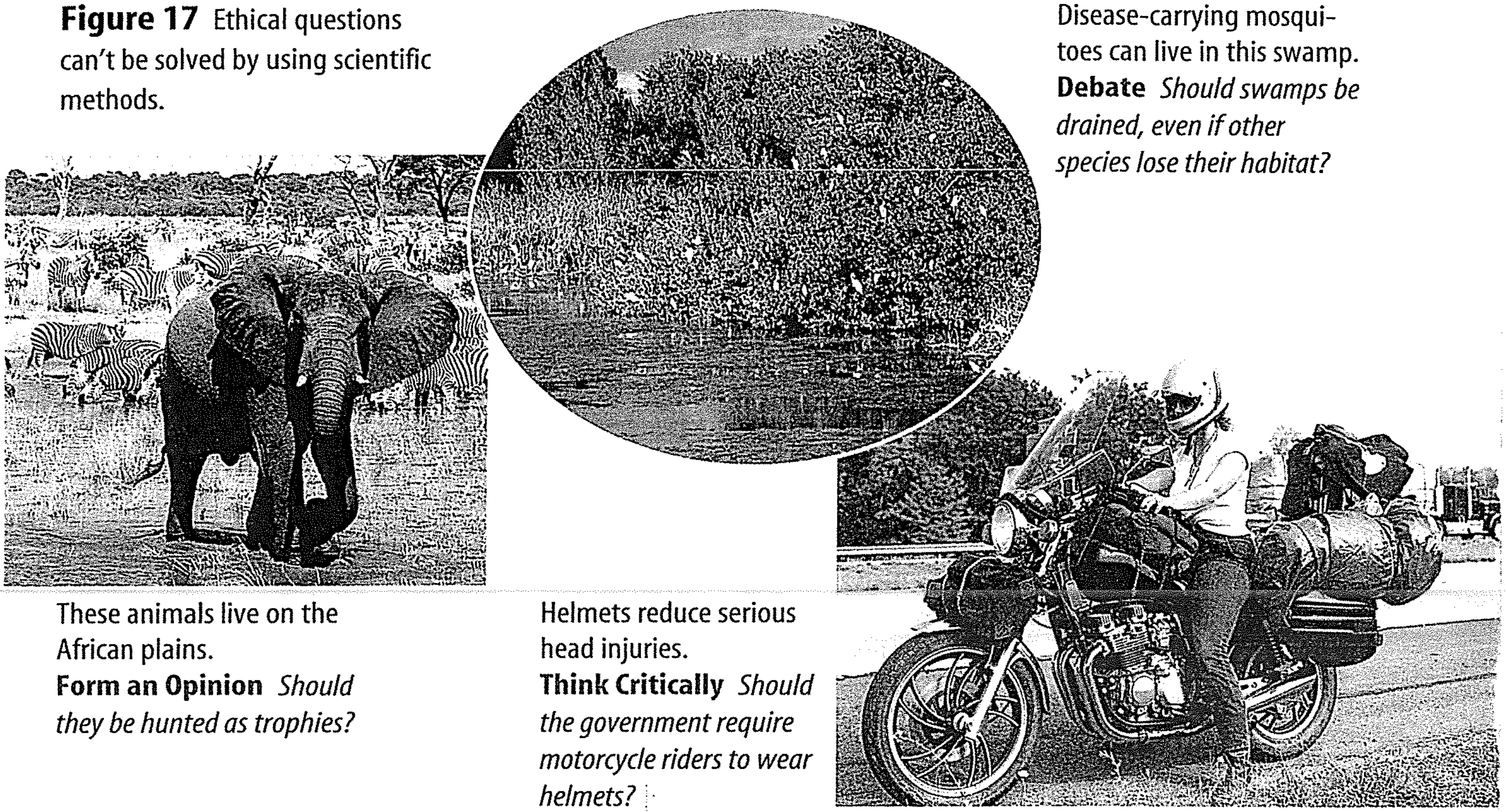


Figure 16 The view of Halley's comet from the *Giotto* spacecraft allowed scientists to determine the size of the icy nucleus, and that the nucleus was covered by a black crust of dust. Jets of gas blasted out from holes in the crust to form the comet's tail.

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



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

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

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	
5	7
4	5
6	4
5	6
5	3
Average: 5.0	

Rankings With Hint	
7	8
8	9
9	8
10	8
7	9
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

chapter 1 Study Guide

Reviewing Main Ideas

Section 1 Science All Around

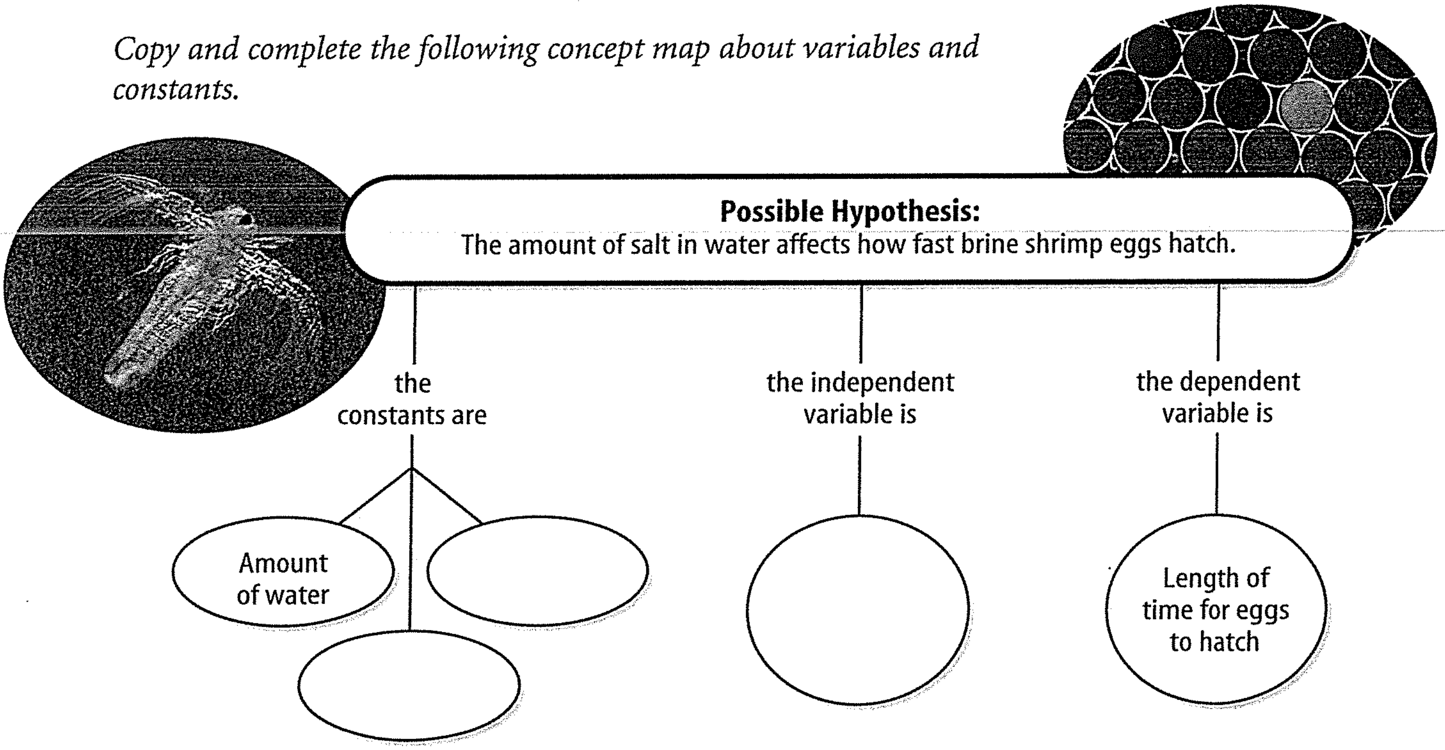
1. Scientific methods include identifying a problem or question, gathering information, developing hypotheses, designing an experiment to test the hypotheses, performing the experiment, collecting and analyzing data, and forming conclusions.
2. Science experiments should be repeated to see whether results 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.



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
B) variable
C) law
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
B) variable
C) law
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

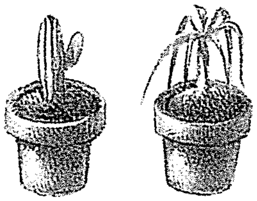
17. Which of the following is a variable that is being tested in a science experiment?
A) dependent variable
B) independent variable
C) constant
D) control

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.

ScienceOnline **earth.msscience.com/vocabulary_puzzlemaker**

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?



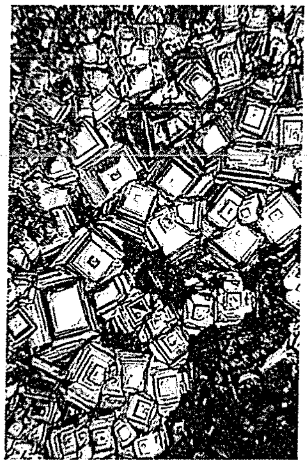
20. **Think Critically** How have advances in technology affected society?

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.

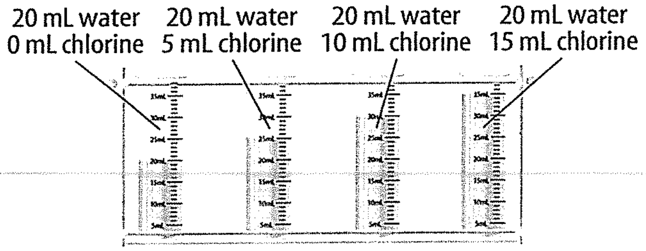
30. **Variables** Identify the independent variables and the dependent variables of the experiment.

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

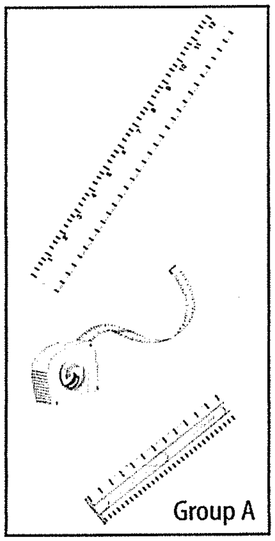
3. Which of these is a factor to which experimental results can be compared?
- **A.** independent variable
- **B.** dependent variable
- **C.** control
- **D.** constant

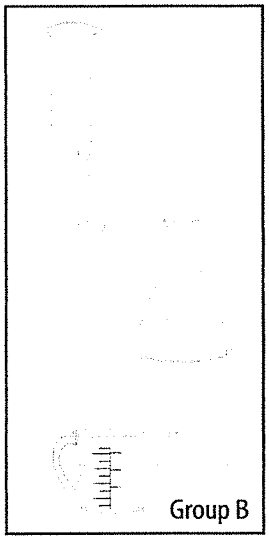
4. What is the use of scientific discoveries for practical purposes?
- **A.** bias
- **B.** scientific methods
- **C.** science
- **D.** technology

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

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

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

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