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.

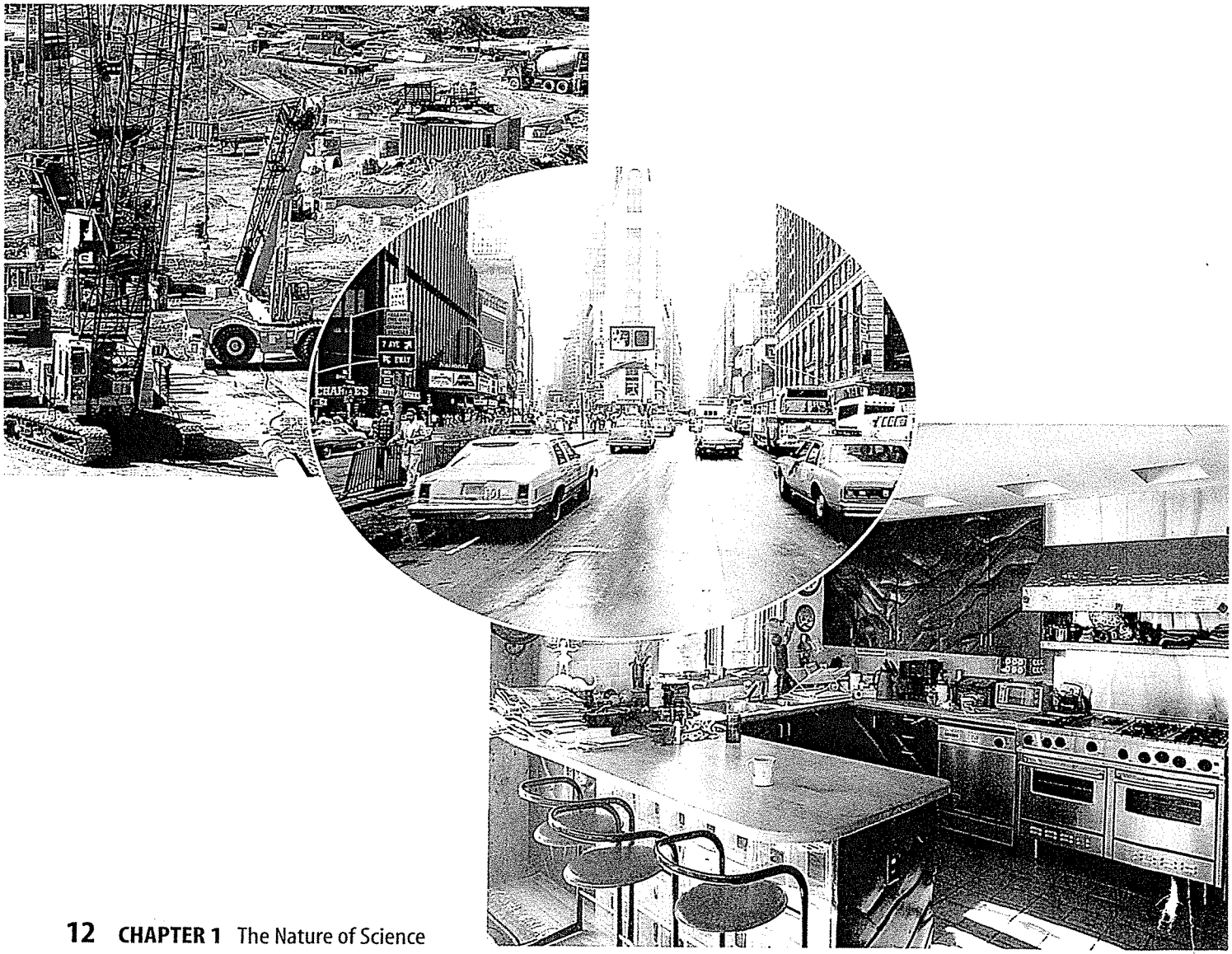


Figure 9 Examples of technology are all around you.
Identify *What are some ways these examples affect your life?*

NATIONAL GEOGRAPHIC VISUALIZING THE HISTORY OF EARTH SCIENCE TECHNOLOGY

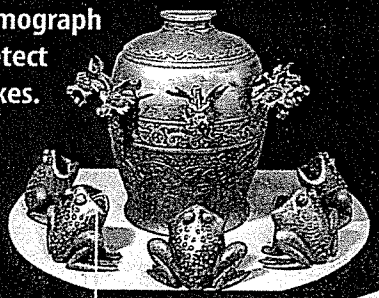
Figure 10

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.

10,000 B.C.: First pottery (Japan)

7000 B.C.: Copper metalworking (Turkey)

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



3500 B.C.: Bronze tools and weapons (Mesopotamia)

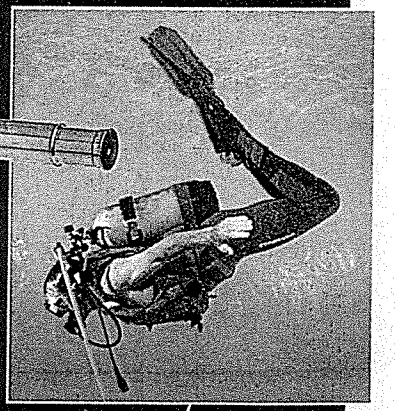
900: Terraced field for soil conservation (Peru)

650: Windmill (Persia)

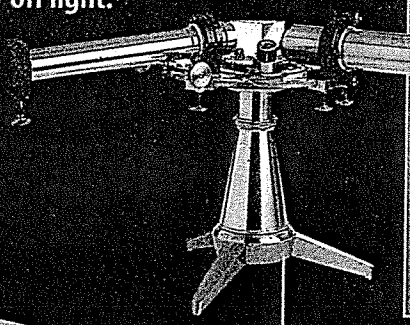
A.D. 100

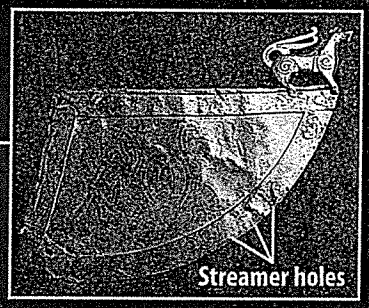
80 B.C.: Astronomical calendar (Greece)

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



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





1090: Magnetic compass (Arabia, China)

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

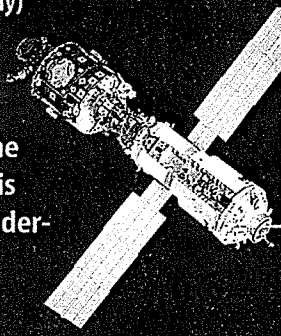
1880: Modern seismograph (England)

1538: Diving bell (Spain)

1592: Thermometer (Italy)

1957: Space satellite (former U.S.S.R.)

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



1926: Liquid-fuel rocket (United States)

2000

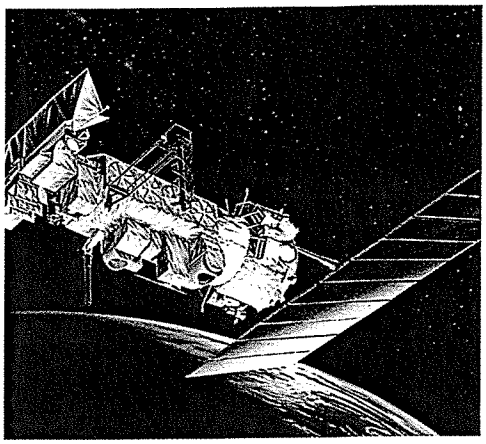


Figure 11 Weather satellites help forecasters predict future storms.
Predict *How might this same technology be used to protect endangered species?*

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.

ScienceOnline 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.

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.

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

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?*

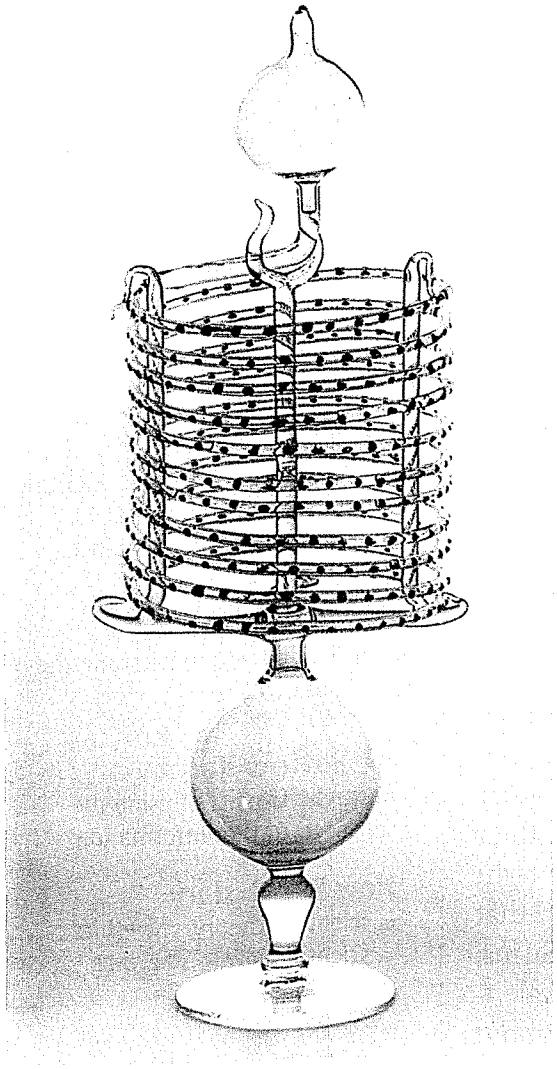


Figure 13 This photo shows a replica of a 1660 Italian alcohol thermometer.

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.

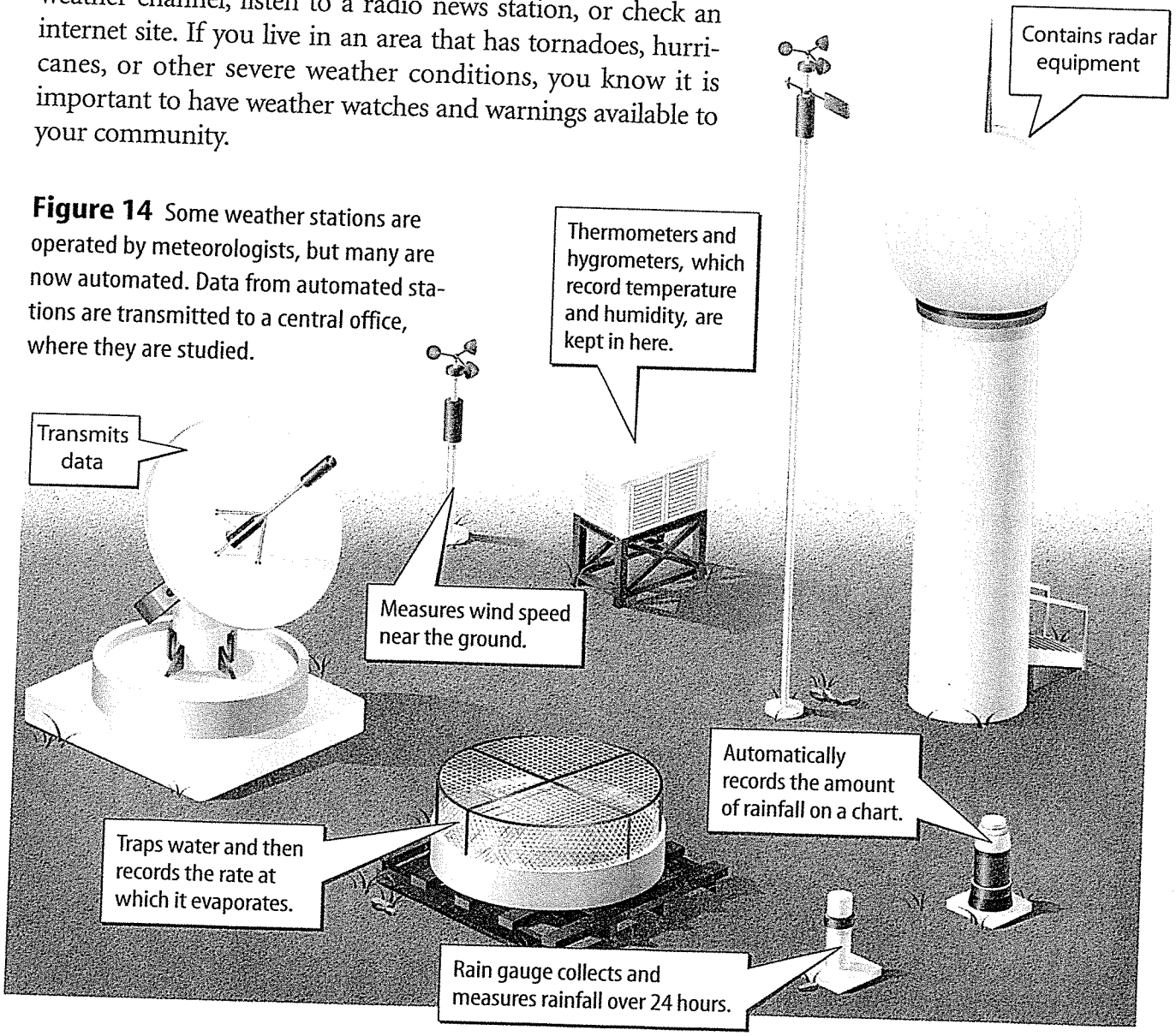


Figure 14 Some weather stations are operated by meteorologists, but many are now automated. Data from automated stations are transmitted to a central office, where they are studied.

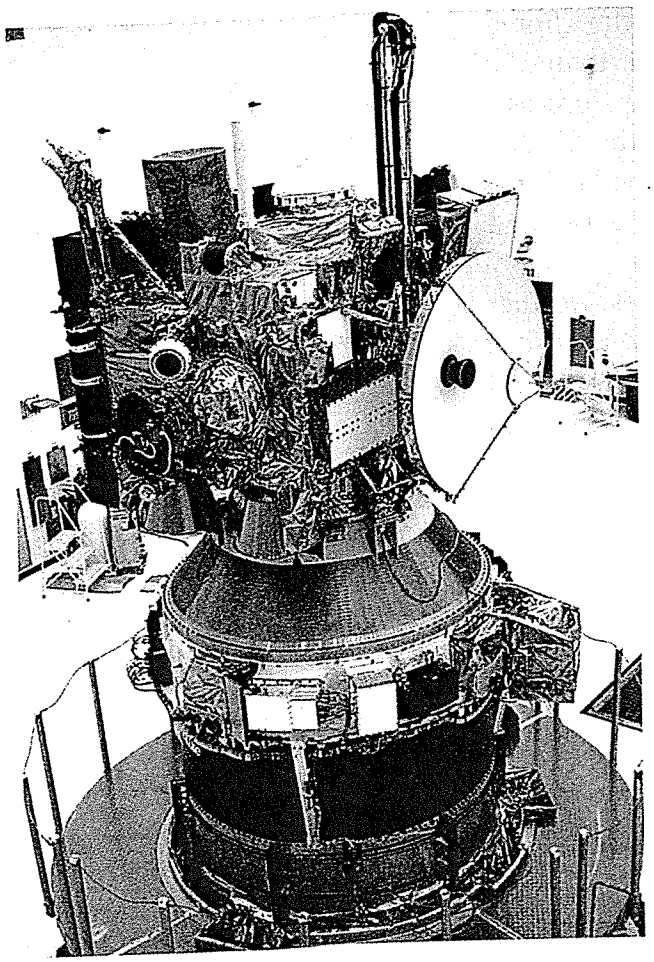


Figure 15 The Global Positioning System (GPS) can pinpoint a person's location on Earth. A radio receiver gets signals from several orbiting *Navstar* satellites like this one. By comparing how far the receiver is from each satellite, the receiver's position can be determined and displayed.

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.*