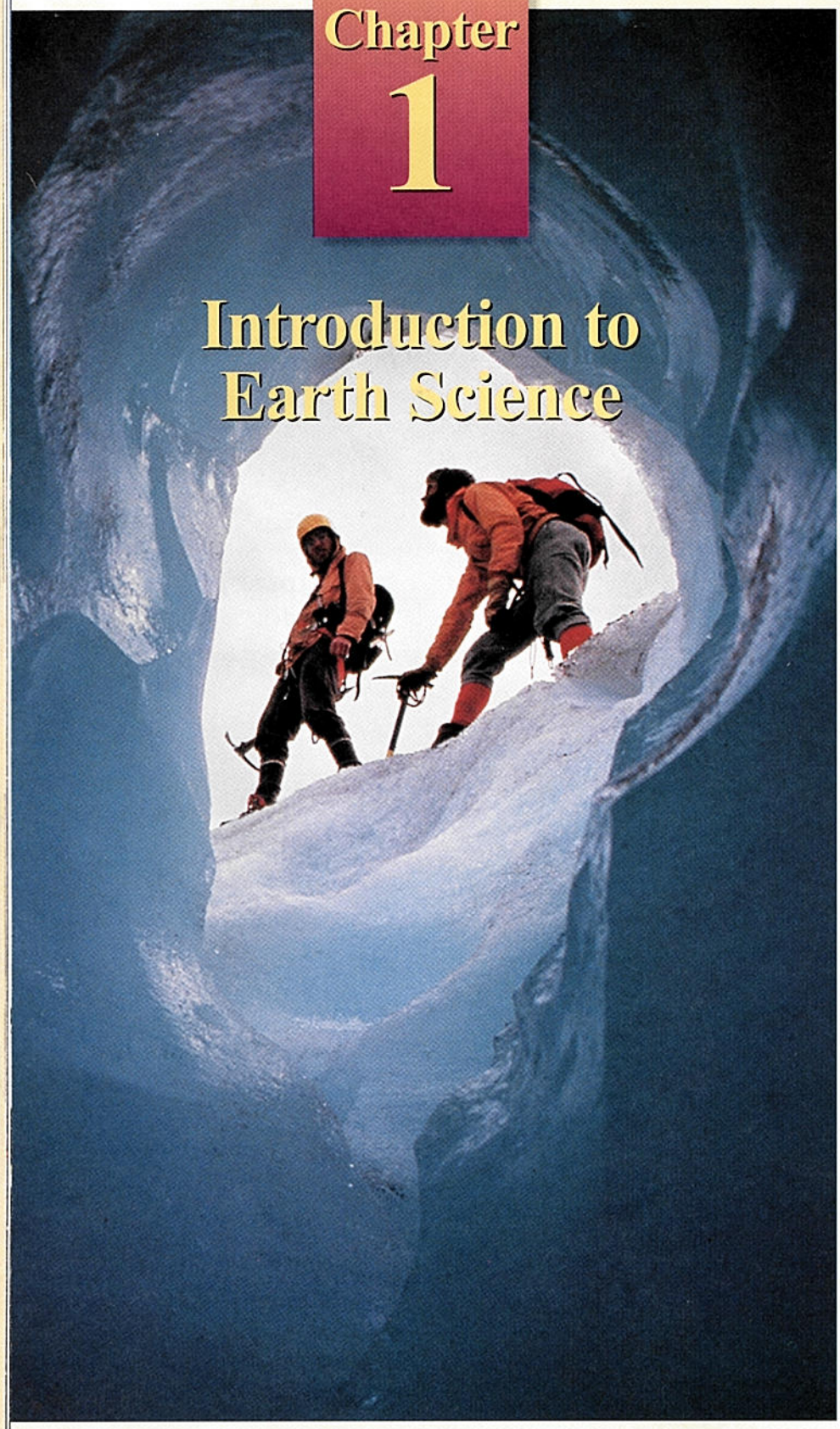
Chapter 1

Introduction to Earth Science



The natural world challenges our understanding with questions about why seasons change, rivers flood, and planets spin through space. Unlocking the secrets of the natural world takes earth scientists to the rainforests of equatorial Africa and to ice caves such as this one in Canada.

This chapter describes the origins of earth science and some of the methods earth scientists use to learn about the world around us.

Chapter Outline

These climbers are poised at the mouth of an ice cave in Canada.

1.1 What Is Earth Science?

Section Objectives

- **Name the four main branches of earth science.**
- **Discuss the relationship between earth science and ecology.**

Since the beginning of human history, people have observed the world around them and wondered about the forces that shaped that world. As early humans watched a volcano erupt, felt the earth tremble beneath them, or saw the moon darken during an eclipse, they asked why. To explain these natural phenomena, ancient people forged myths and legends, attributing such events to powerful supernatural forces. Angry goddesses hurled fire from volcanoes; giants wrestled underground, causing the earth to shake.

Not until people began to make careful observations and to search for natural causes to natural phenomena did the scientific study of the earth begin. The ancient Chinese, for example, began keeping written records of earthquakes as early as 780 B.C. The ancient Greeks compiled a catalogue of rocks and minerals in the third century B.C. Other ancient people, such as the Mayas in Central America, kept track of the movements of the sun, the moon, and the planets. They used these observations to create accurate calendars.

At first, scientific discoveries were limited to observations made with the unaided eye. Then, in the seventeenth century, the invention of instruments such as the microscope and the telescope extended human observation to previously hidden worlds.

Eventually, people accumulated an organized body of knowledge about the earth, and the field of **earth science** was born. Earth science is the study of the earth and of the universe around it. Earth science, like other modern sciences, is based on the assumption that the causes of natural phenomena can be discovered through careful observation and experimentation.

Branches of Earth Science

As the technology for studying the earth improved, the range of human observation increased dramatically. With the help of special equipment, scientists began to explore the dark ocean depths, the

Figure 1-1. El Caracol, an observatory built by the ancient Mayas of Mexico, is the oldest known observatory in the Americas.

EARTH BEAT

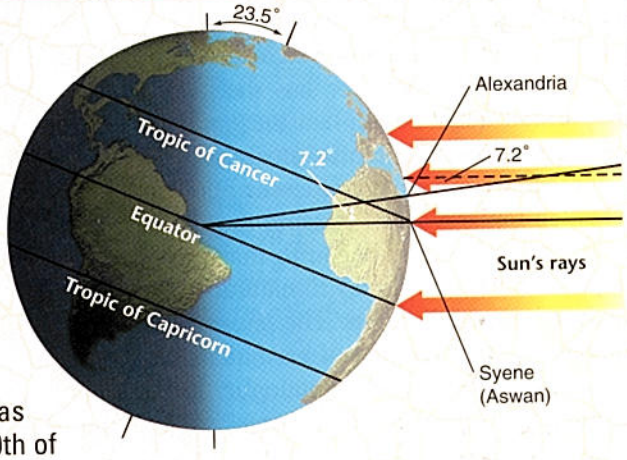
The Earth's Circumference

More than 22 centuries ago, a Greek mathematician named Eratosthenes used careful observations and simple geometry to determine the circumference of, or distance around, the earth.

Eratosthenes read of a well in Syene, Egypt—modern-day Aswan, Egypt—where the sun's rays reached the bottom once each year, at noon on June 21. Furthermore, the sun cast no shadows in Syene at that time. Eratosthenes thought these facts meant that the sun was directly overhead at Syene on June 21. Eratosthenes knew that the sun *did* cast shadows in Alexandria, a city to the north of Syene, on June 21, indicating that the sun's rays were striking that city at an angle.

Eratosthenes determined that the angle of the sun's rays in Alexandria at noon on June 21 was 7.2°. He thought that meant that the distance between the two cities was also 7.2°, or 1/50th of the 360° circumference of the earth. Eratosthenes knew that the distance between Syene and Alexandria was about 5,000 stadia (925 km). By multiplying the known distance between Alexandria and Syene by 50, Eratosthenes calculated the polar circumference of the earth to be 250,000 stadia (46,250 km).

With the aid of modern technology and sophisticated instruments, scientists now calculate the earth's circumference to be about 40,000 km.



This value, which is considered accurate, differs from Eratosthenes' calculation of 46,250 km by only 6,250 km.

Suppose that city A is 3,335 km north of city B and that on June 21 the angle of the sun's rays in city A is 0° while the angle of the rays in city B is 30°. Use Eratosthenes' method to find the earth's circumference.

earth's unknown interior, and the vastness of space. Their discoveries have created an immense body of knowledge about the earth.

Because one person cannot keep up with the developments in all areas of earth science, most earth scientists today specialize. Currently, earth scientists specialize in one of the following four major areas of study: the solid earth, the oceans, the atmosphere, and the universe beyond the earth. *Career Focus,* a special feature that appears in each unit of this book, offers detailed information about careers in earth science.

Geology

The study of the origin, history, and structure of the solid earth and the processes that shape it is called **geology.** Geology is a broad field that includes many areas of specialization. Some geologists explore the earth's crust in search of new deposits of coal, oil, gas, and

other valuable resources; some geologists study the forces within the earth in order to better understand and forecast earthquakes and volcanic eruptions; and some geologists study fossils to learn more about the earth's past. Units 1, 2, 3, 4, and 5 of this book deal with topics of primary concern to geologists.

Oceanography

Vast oceans cover nearly three-fourths of the earth's surface. The study of the earth's oceans is called **oceanography.** Some oceanographers work on research ships equipped with special instruments for studying the sea. Other oceanographers study waves, tides, and ocean currents. Some oceanographers explore the ocean floor for clues to the earth's history and to locate mineral deposits. Other oceanographers study marine plant and animal life. A discussion of the earth's oceans is presented in Unit 6.

Meteorology

The study of the earth's atmosphere is called **meteorology.** Using satellites, radar, and other modern technology, meteorologists study the variations in atmospheric conditions that produce weather. Many meteorologists work as weather observers, measuring such factors

Figure 1–2. A geologist uses special equipment to study erupting volcanoes (left). Oceanographers prepare to enter a submersible to study the ocean floor (above).

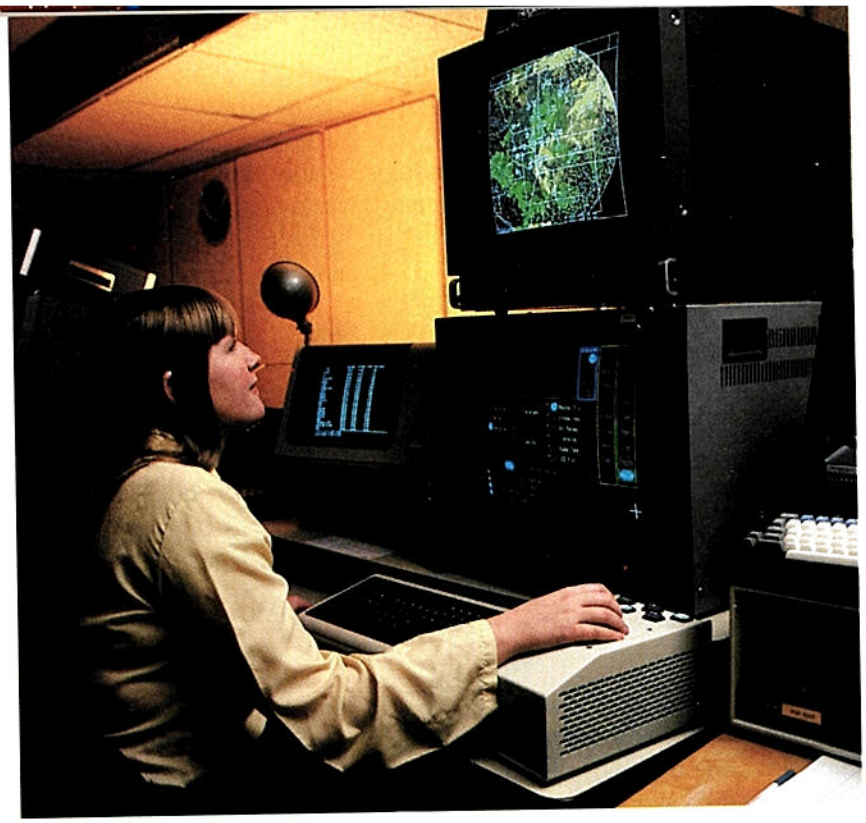


Figure 1–3. Two astronomers use a telescope to observe distant stars (left). A meteorologist uses a computerized system to track storms (right).

as wind speed, temperature, and rainfall. This weather information is then used to prepare detailed weather maps. Other meteorologists use weather maps, satellite images, and computer data to make weather forecasts. You will learn more about meteorology in Unit 7 of this book.

Astronomy

The study of the universe beyond the earth is called **astronomy.** It is one of the oldest branches of earth science. In fact, the ancient Babylonians charted the positions of planets and stars nearly 4,000 years ago. Modern astronomers use earth-based and space-based telescopes and other instruments to study the universe. Space probes, such as *Pioneer, Voyager, Galileo,* and *Ulysses* have also provided much useful data. Unit 8 of this book presents information about the moon, the planets, the sun, the stars, and the universe.

The Importance of Earth Science

Powerful forces are at work on the earth. Volcanoes erupt and earthquakes shake the ground. These events not only shape the earth, but also affect life on the earth. A volcanic eruption may bury a town in ash. An earthquake may produce huge waves that destroy shorelines. By understanding how natural forces shape our environment, earth scientists can better forecast potential disasters and help save lives and property.

Observations made by earth scientists have contributed greatly to our knowledge of the world around us. For example, information gathered by astronomers studying distant galaxies has led to theories about the origins of this solar system. Geologists studying rock layers have found clues to the earth's past environments and to the evolution of life on this planet.

The earth also provides many valuable resources that enrich the quality of people's lives. For example, the fuel that powers a jet, the metal used to make surgical instruments, and the paper and ink in this book all come from the earth. The study of earth science can help people gain access to the earth's resources and teaches them to use those resources wisely.

Ecology

Earth scientists primarily study the **geosphere,** the solid earth; the **hydrosphere,** its water; and the **atmosphere,** the gases surrounding the earth. Other scientists, called biologists, study the living world. An area of science in which biology and earth science are closely linked is called **ecology.** Ecology is the study of the complex relationships between living things and their environment. Most ecologists have backgrounds in either earth science or biology.

Organisms on the earth inhabit many different environments. A community of organisms and the environment they inhabit is called an **ecosystem.** The terms *ecology* and *ecosystem* come from the Greek word *oikos*, meaning "house." Each ecosystem is a physically distinct, self-supporting system. An ecosystem may be as large as an ocean or desert or as small as a tide pool or rotting log.

The largest ecosystem is called the **biosphere.** The biosphere encompasses all life on earth and the physical environment that supports it. The biosphere extends from the ocean depths to the atmosphere a few kilometers above the earth's surface.

A tropical rain forest is one example of a large ecosystem within the biosphere. Plants in the rain forest use sunlight to produce food through a process known as *photosynthesis*. The plants are then eaten by animals, which are in turn eaten by other animals. When

Figure 1–4. This small tidal pool on the coast of Maine, in Acadia National Park, and the vast ocean are both ecosystems.

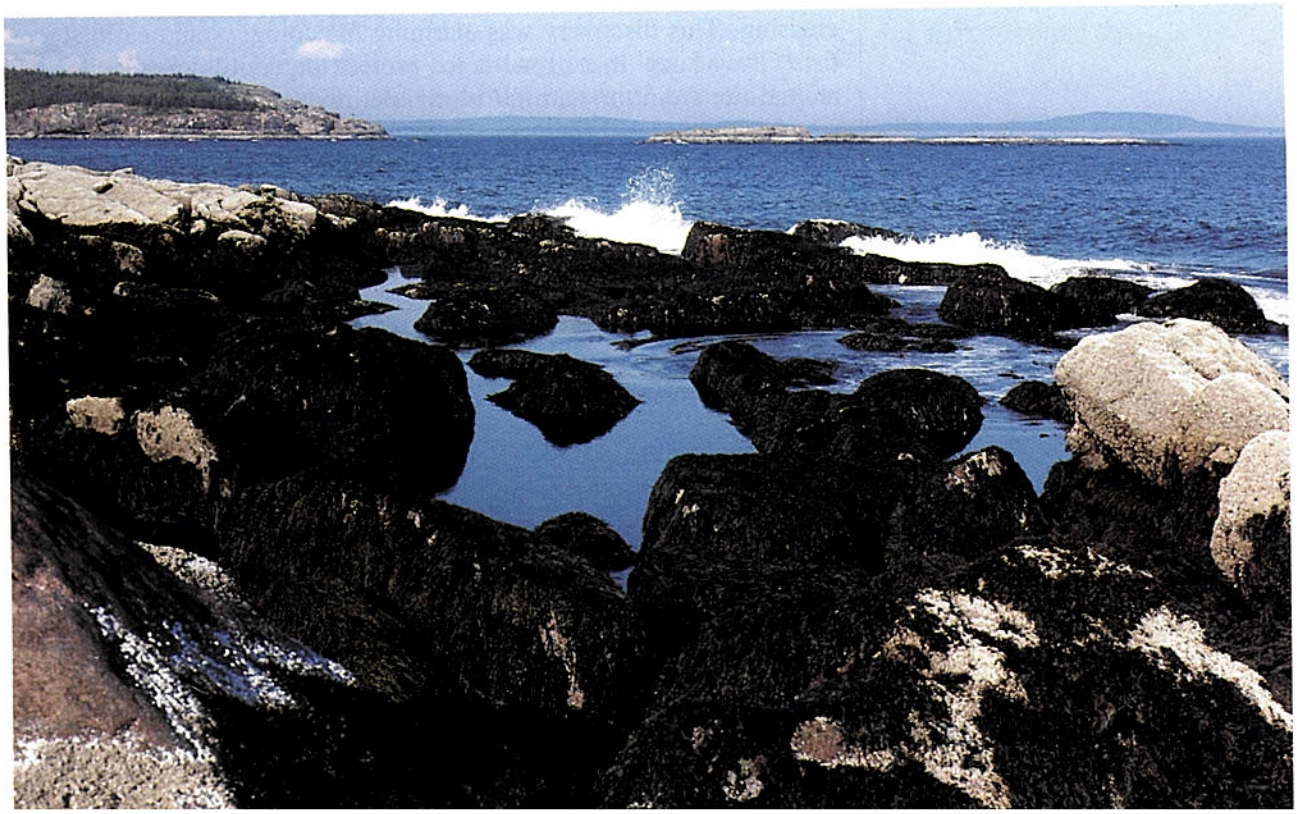


Figure 1–5. People try to help the environment by cleaning up the shore after an oil spill (top). Pollution also harms wildlife. Volunteers remove oil from a bird's feathers (bottom).

rain-forest plants and animals die, their bodies are decomposed by microorganisms. The resulting chemicals enter the soil to nourish other plants and animals. Thus, the system is practically self-supporting. What other examples of ecosystems can you name?

Environmental Pollution

Each ecosystem is delicately balanced. When that fragile ecological balance is upset, the survival of the ecosystem, and in some cases the entire biosphere, is threatened. One serious threat to ecosystems today is **pollution,** the contamination of the environment with waste products or impurities.

Some waste products are **biodegradable.** As such, they can be broken down by microorganisms into harmless substances that can then be used by other organisms. Biodegradable waste products pose little threat to the environment, and in many cases they contribute to the well-being of the environment. For example, the chemicals found in such biodegradable wastes as banana peels and eggshells make excellent plant fertilizer.

Many modern waste products, such as most plastics, are not biodegradable. Some ecosystems are threatened by the large quantities of nonbiodegradable wastes. For example, plastic wastes dumped in oceans or lakes can harm the animals there. When particles of plastic are ingested, they clog the digestive tracts of fish, birds, and turtles. Ducks and other birds can starve to death when they become tangled in plastic litter.

Protecting the Environment

Pollution poses serious problems for all living organisms. To help protect the environment from pollution, ecologists often work together with earth scientists in other fields such as meteorology.

For example, in the early 1970's, meteorologists found that the level of ozone, a form of oxygen, in the upper atmosphere was decreasing. This discovery was alarming to ecologists and earth scientists. They knew that ozone helps protect the earth's plant and animal life from the harmful ultraviolet rays of the sun. Further research revealed that the ozone layer was being destroyed by chlorofluorocarbons (CFCs), chemical compounds commonly used as propellants in aerosol sprays. To reduce this threat to the environment, the United States and other countries have agreed to abide by international treaties limiting the production and use of such ozone-depleting chemicals.

Section 1.1 Review

1. What are the four major branches of earth science?
2. Describe the work of meteorologists.
3. What is ecology?
4. Give an example of an ecosystem and explain how it is self-supporting.
5. How might the study of earth science contribute to the survival of the biosphere?