1 FOCUS

Section Objectives

1.9 **Describe** the primary goal of Earth system science and **define** the term *system*.

1.10 **Describe** Earth's two major sources of energy.

1.11 **Explain** how humans affect Earth's systems.

1.12 **Distinguish** between renewable and nonrenewable resources.

Reading Focus

Build Vocabulary L2

Word Forms Have students predict the meanings of *open system* and *closed system* based on their prior knowledge of the words *open*, *closed*, and *system*. Have students verify their predictions by reading the section.

Reading Strategy L2

Earth System Science

A. What is a System?
  1. System—any size group of interacting parts forming a whole
  2. Types of Systems—closed and open

B. Earth as a System
  1. Earth has two energy sources—the sun and Earth's interior.
  2. The parts of the Earth system are linked so a change in one part can cause changes in all the other parts.

2 INSTRUCT

What Is a System?

Build Science Skills L2

Using Analogies The text gives an analogy of a car's cooling system to a natural system. Challenge students to think of other analogies between human-made and natural systems. They should write a description of the analogy they choose, including diagrams if appropriate. The descriptions should explain how the analogies are similar to the actual process and different from it.
Verbal, Logical

1.4 Earth System Science

Reading Focus

Key Concepts

- How is Earth a system?
- What is a system?
- Where does the energy come from that powers Earth's systems?
- How do humans affect Earth's systems?
- What makes a resource renewable or nonrenewable?

Vocabulary

- system

Reading Strategy

Outlining As you read, make an outline of the most important ideas in this section. Begin with the section title, then list the green headings as the next step of the outline. Outline further as needed.

I. Earth System Science
  A. What is a System?
    1. _____?_____
    2. _____?_____
  B. _____?_____

As we study Earth, we see that it is a dynamic planet with many separate but interactive parts or spheres. Earth scientists are studying how these spheres are interconnected. **This way of looking at Earth is called Earth system science. Its aim is to understand Earth as a system made up of numerous interacting parts, or subsystems.** Instead of studying only one branch of science, such as geology, chemistry, or biology, Earth system science tries to put together what we know from our study of all of these branches. Using this type of approach, we hope to eventually understand and solve many of our global environmental problems.

Reading Checkpoint *What Is Earth system science?*

What Is a System?

Most of us hear and use the term system frequently. You might use your city's transportation system to get to school. A news report might inform us of an approaching weather system. We know that Earth is just a small part of the much larger solar system.

A system can be any size group of interacting parts that form a complex whole. Most natural systems are driven by sources of energy that move matter and/or energy from one place to another. A simple analogy is a car's cooling system. It contains a liquid (usually water and antifreeze) that is driven from the engine to the radiator and back

again. The role of this system is to transfer the heat generated by combustion in the engine to the radiator, where moving air removes the heat from the system.

This kind of system is called a closed system. Here energy moves freely in and out of the system, but no matter enters or leaves the system. In the case of the car's cooling system, the matter is the liquid. By contrast, most natural systems are open systems. Here both energy and matter flow into and out of the system. In a river system, for example, the amount of water flowing in the channel can vary a great deal. At one time or place, the river may be fuller than it is at another time or place.

Earth as a System

The Earth system is powered by energy from two sources. **One source is the sun, which drives external processes that occur in the atmosphere, hydrosphere, and at Earth's surface.** Weather and climate, ocean circulation, and erosional processes are driven by energy from the sun. **Earth's interior is the second source of energy.** There is heat that remains from the time Earth formed. There is also heat continuously generated by the decay of radioactive elements. These sources power the internal processes that produce volcanoes, earthquakes, and mountains.

The parts of the Earth system are linked so that a change in one part can produce changes in any or all of the other parts. For example, when a volcano erupts, lava may flow out at the surface and block a nearby valley. This new obstruction influences the region's drainage system by creating a lake or causing streams to change course. Volcanic ash and gases that can be discharged during an eruption might be blown high into the atmosphere and influence the amount of solar energy that can reach Earth's surface. The result could be a drop in air temperatures over the entire hemisphere.

Figure 18 When Mount St. Helens erupted in May 1980, the area shown here was buried by a volcanic mudflow. Now, plants are reestablished and new soil is forming.

Reading Checkpoint *How do we know that Earth's systems are connected?*

Over time, soil will develop on the lava or ash-covered surface and, as shown in Figure 18, plants and animals will reestablish themselves. This soil will reflect the interactions among many parts of the Earth system—the original volcanic material, the type and rate of weathering, and the impact of biological activity. Of course, there would also

Build Reading Literacy L1

Refer to **p. 216D** in **Chapter 8**, which provides guidelines for comparing and contrasting.

Compare and Contrast Help students understand the difference between an open system and a closed system. Have students make a comparison chart, starting with the definition of each type of system. Have students classify each system listed during the brainstorming session as either an open system or a closed system. Example:

	Open System	Closed System
Definition	Energy and matter move in and out of the system.	Energy moves in and out of the system, but matter cannot enter or leave.
Examples	weather system river system	cooling system

Have students research a list of systems. Then have students put each system in the correct column on their comparison chart.
Verbal, Logical

Earth as a System
Build Science Skills L2

Relating Cause and Effect Using this section of the textbook, have students make a concept map showing how a volcanic eruption (an event of the geosphere) can causes changes in all the other spheres (hydrosphere, atmosphere, and biosphere). Have students use the concept map to make a poster to be displayed in the classroom. Challenge students to create a product that is both visually appealing and scientifically accurate. Ask students to think of another event on Earth and predict how it would affect all the other spheres. Have students make another concept map poster on this event.
Visual, Group

Customize for English Language Learners

Review with English language learners the meanings of the words *open* and *closed*. Help students relate the meanings of *open* and *closed* to *open system* and *closed system*. Before teaching the terms *renewable resources* and *nonrenewable resources*, explain what it means to renew a library book (take it out again before you return it). Help students relate this use of the word *renew* to the terms *renewable resources* and *nonrenewable resources*. Tell students that if they are not allowed to renew a library book (nonrenewable) it is often because the library does not have enough books on that topic to meet the needs of their patrons. Explain that a renewable resource can be used as often as we like because there is always more of it being made.

Answer to . . .

Reading Checkpoint *Earth system science is a way of looking at Earth as a system made up of several interacting subsystems.*

Reading Checkpoint *Events taking place in one part can produce changes in all the other parts.*

Address Misconceptions L2

Students may think that only human actions can seriously affect the environment. Use the example of the eruption of Mount St. Helens to emphasize that natural events can have widespread and negative effects on the environment. The 1980 eruptions spread ash over much of eastern Washington. About 500 square kilometers of forest were destroyed or damaged. Most large animals in the area were killed by the blast, but some small animals survived. More than 20 years later, the area is still fairly barren. It may take at least 200 years for the forest to be restored to its previous state. Large mammals such as elk have already repopulated the area, along with birds, insects, and small mammals.

People and the Environment

Use Visuals L1

Figure 19 This flood was caused by the action of humans. Ask: **What was the actual cause of this flood?** *(building the Aswan Dam)* **What are some ways humans can cause floods or make them worse?** *(by clearing forests, building cities, and constructing dams)* **Visual, Logical**

be significant changes in the biosphere. Some organisms and their habitats would be eliminated by the lava and ash, while new settings for life, such as the lake, would be created. The potential climate change could also have an effect on some life-forms.

The Earth system is characterized by processes that occur over areas that range in size from millimeters to thousands of kilometers. Time scales for Earth's processes range from milliseconds to billions of years. Despite this great range in distance and time, many processes are connected. A change in one component can influence the entire system.

Humans are also part of the Earth system. **Our actions produce changes in all of the other parts of the Earth system.** When we burn gasoline and coal, build breakwaters along a shoreline, dispose of our wastes, and clear the land, we cause other parts of the Earth system to respond, often in unforeseen ways. Throughout this book, you will learn about many of Earth's subsystems, such as the hydrologic (water) system, the tectonic (mountain-building) system, and the climate system. Remember that these components and we humans are all part of the complex interacting whole we call the Earth system.

Figure 19 The benefit that was intended by the construction of the Aswan Dam in Egypt was not achieved.
Drawing Conclusions ***How might the flooding here have been avoided?***

People and the Environment

Environment refers to everything that surrounds and influences an organism. Some of these things are biological and social. Others are nonliving such as water, air, soil and rock as well as conditions such as temperature, humidity, and sunlight. These nonliving factors make up our physical environment. Because studying the Earth sciences leads to an understanding of the physical environment, most of Earth science can be characterized as environmental science.

Reading Checkpoint ***What are examples of nonliving factors?***

Today the term *environmental science* is usually used for things that focus on the relationships between people and the natural environment. For example, we can dramatically influence natural processes. A river flooding is natural, but the size and frequency of flooding can be changed by human activities such as clearing forests, building cities, and constructing dams. Unfortunately, natural systems do not always adjust to artificial changes in ways we can anticipate. An alteration to the environment that was intended to benefit society may have the opposite effect, as shown in Figure 19.

Resources Resources are an important focus of the Earth sciences. They include water and soil, metallic and nonmetallic minerals, and energy. Together they form the foundation of modern civilization. The Earth sciences deal not only with the formation and occurrence of

Facts and Figures

One of the reasons it is often difficult to predict how natural systems will respond to unexpected changes is the prevalence of positive and negative feedback mechanisms. Processes that feed into changes, making them more severe, are considered positive feedback. As humans put more carbon dioxide into the air, Earth may hold more of the sun's heat and begin to warm. This warming may cause snow and ice near the poles to melt. This melting may make Earth absorb more of the sun's rays, thus increasing Earth's temperature further. This is an example of positive feedback. Negative feedback mechanisms work to return the system to the way it was before the change. For example, an increase in Earth's temperature may result in an increase in evaporation, and then an increase in clouds. Clouds cause Earth to reflect more of the sun's rays back into space, cooling Earth back down.

these vital resources but also with maintaining supplies and the environmental impact of their mining and use.

Resources are commonly divided into two broad categories—renewable resources and nonrenewable resources. **Renewable resources can be replenished over relatively short time spans.** Common examples are plants and animals for food, natural fibers for clothing, and forest products for lumber and paper. Energy from flowing water, wind, and the sun are also considered renewable resources.

Important metals such as iron, aluminum, and copper plus our most important fuels of oil, natural gas, and coal are classified as nonrenewable resources. **Although these and other resources continue to form, the processes that create them are so slow that it takes millions of years for significant deposits to accumulate.** Earth contains limited quantities of these materials. Although some nonrenewable resources, such as aluminum, can be used over and over again, others, such as oil, cannot. When the present supplies are exhausted, there will be no more.

Reading Checkpoint *How do renewable and nonrenewable resources differ?*

Go Online SCI LINKS NSTA

For: Links on environmental decision-making

Visit: www.SciLinks.org

Web Code: cjn-1014

Population Figure 20 shows that the population of Earth is growing rapidly. Although it took until the beginning of the nineteenth century for the population to reach 1 billion, just 130 years were needed for the population to double to 2 billion. Between 1930 and 1975, the figure doubled again to 4 billion, and by about 2010, as many as 7 billion people may inhabit Earth. Clearly, as population grows, so does the demand for resources. However, the rate of mineral and energy resource usage has increased more rapidly than the overall growth of the population.

How long will the remaining supplies of basic resources last? How long can we sustain the rising standard of living in today's industrialized countries and still provide for the growing needs of developing regions? How much environmental deterioration are we willing to accept to obtain basic resources? Can alternatives be found? If we are to cope with the increasing demand on resources and a growing world population, it is important that we have some understanding of our present and potential resources.

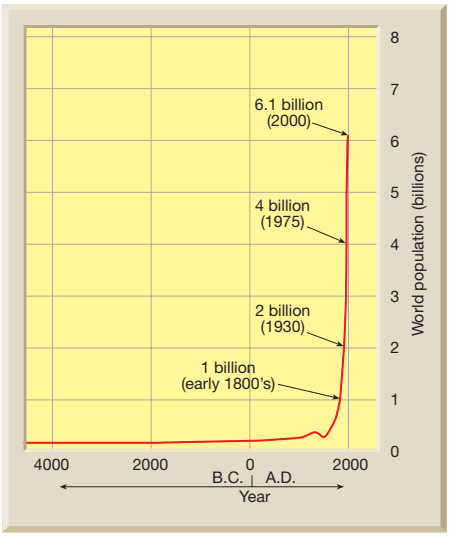

Figure 20 Growth of World Population

Environmental Problems

In addition to the search for mineral and energy resources, the Earth sciences must also deal with environmental problems. Some of these problems are local, some are regional, and still others are global. Humans can cause problems, such as the one shown in Figure 21. **Significant**

Build Science Skills L2

Problem Solving Explain that when supplies of a nonrenewable resource start running low, it is often possible to substitute some other resource. Have students work in small groups to brainstorm and research alternatives to oil that can be used when all of our oil has been used up. If students are having trouble getting started, suggest that they focus on transportation and power generation. Areas students can investigate include natural gas, coal, biodiesel, nuclear power, wind power, and solar power. Have each group present their results to the class. **Interpersonal, Logical**

Address Misconceptions L2

Students may think that the world population is expected to continue to increase indefinitely. Tell students that many demographers (scientists who study changes in human populations) expect population growth to slow down over the next 100 years. In fact, some predict that the total population may even decrease. The reason for this is that in many developed countries, people are not having enough children to replace themselves. Most current population growth is occurring in developing countries. However, as those countries develop, their birth rates are also expected to fall.

Go Online NSTA SCI LINKS

Download a worksheet on environmental decision-making for students to complete, and find additional teacher support from NSTA SciLinks.

Answer to . . .

Figure 19 *The flooding could have been avoided by not building the dam.*

Reading Checkpoint *Nonliving factors include water, air, soil, rock, temperature, humidity, and sunlight.*

Reading Checkpoint *Renewable resources can be replenished over a relatively short time span. Nonrenewable resources take millions of years to accumulate.*

Section 1.4 (continued)

Environmental Problems

Build Science Skills L2

ACTIVITY

Inferring Discuss with students that events such as earthquakes, landslides, floods, hurricanes, beach erosion from coastal storms, and drought are natural processes. Help students understand that these natural processes become hazards "only when people try to live where these processes occur." Provide small groups of students with one or more pictures of damage from natural disasters. Some examples to use would be flooded homes, a coastal home about to be carried out to sea, buildings damaged by an earthquake, or urban flooding due to too much paved land. Ask: **What happened here? How could this disaster have been prevented?** *(Sample answer: This home is being carried out to sea because it was built too close to the ocean. These homes were flooded because they were built on a flood plain. This building was destroyed because it was built too close to a fault line.)* Have students infer the answers to these two questions, and then share their ideas with the class. Use this as an opportunity to introduce students to various Earth events and processes that will be studied later in the year.
Visual

3 ASSESS

Evaluate Understanding L2

Ask students to write a five-question quiz on this section along with an answer key. Then have students ask one another the questions.

Reteach L1

Use the outlines students created for this chapter's reading strategy to review the main ideas from this section.

Connecting Concepts

Images can show scars of landslides, suggesting that the area may not be stable.

Answer to . . .

Figure 21 *Sample answer: home heating, motor vehicles, industry, power plants*

Figure 21 Air pollution in the Chinese city of Guangzhou. Air quality problems affect many cities.
Interpreting Photographs ***What may have contributed to this air pollution problem?***

threats to the environment include air pollution, acid rain, ozone depletion, and global warming. The loss of fertile soils to erosion, the disposal of toxic wastes, and the contamination and depletion of water resources are also of considerable concern. The list continues to grow.

People must cope with the many natural hazards that exist such as the one shown in Figure 22. Earthquakes, landslides, floods, hurricanes, and drought are some of the many risks. Of course, environmental hazards are simply natural processes. They become hazards only when people try to live where these processes occur.

It is clear that as world population continues to grow, pressures on the environment will increase as well. Therefore, an understanding of Earth is essential for the location and recovery of basic resources. It is also essential for dealing with the human impact on the environment and minimizing the effects of natural hazards. Knowledge about Earth and how it works is necessary to our survival and well being. Earth is the only suitable habitat we have, and its resources are limited.

Figure 22 The damage here was caused by a landslide that was triggered by an earthquake.

Section 1.4 Assessment

Reviewing Concepts

1. Why do scientists study Earth as a system?
2. If a system is a collection of interacting parts, what happens when one of the parts is changed?
3. What are the two sources of energy that power Earth's systems?
4. List three ways that humans affect Earth's systems.
5. Large numbers of tiny ocean organisms die every day, fall to the ocean floor, are buried, and are eventually converted to oil and natural gas. Why are these two fuels considered nonrenewable?

Critical Thinking

6. **Applying Concepts** Describe the parts of a tree in terms of it being a system.
7. **Evaluating** Is it possible for humans to have no effect on any of Earth's systems? Explain.
8. **Applying Concepts** How can scientists help to prevent a natural process from becoming an environmental hazard?

Connecting Concepts

City Planning In Section 1.3, you learned about Landsat satellite imaging. How can data from Landsat help city planners determine where and where not to build?

Section 1.4 Assessment

1. Earth is a system made up of numerous interacting parts, or subsystems.
2. Other parts may also change.
3. The sources are the sun and reactions in Earth's interior.
4. Sample answer: contaminating water, polluting air, disposing of toxic waste
5. It takes too long (millions of years) for the organisms to be converted into oil.
6. Roots transport food and water up through the trunk, which holds the tree upright. The trunk transports food and serves as support for branches and leaves. Leaves help keep the tree moist and shaded and release excess water through pores.
7. No, every day you affect at least one of Earth's systems, even on the smallest scale. Simply breathing changes the atmosphere around you or stepping on the grass may affect the biosphere beneath your foot.
8. Sample answer: They can analyze an area to see if it is safe to live there. If the land is unstable or subject to flooding, they may make recommendations that people not choose to live there.