Chapter 1

1.1 What Is Earth Science?

Reading Focus

Section Objectives
1.1 Define Earth science.
1.2 Describe the formation of Earth and the solar system.

Build Vocabulary

Word Parts Ask students to use a dictionary to determine the meanings of the following word parts:
- geo- (Earth);
- astro- (outer space);
- -ology (study of);
- -ography (study of);
- -onomy (study of)

Based on this discussion and their prior knowledge, have students predict the meaning of this section’s vocabulary words. Then, have students look up the words in the Glossary to check their predictions and make any necessary corrections. Meteorology will likely present a problem, with most students predicting that it is the study of meteors, rather than the study of the atmosphere.

Reading Strategy

a. Earth, earthquakes, mountains, volcanoes, Earth’s history
b. oceanography
c. composition and movements of seawater, coastal processes, seafloor topography, marine life
d. meteorology
e. atmosphere, weather, climate
f. astronomy
g. universe, solar system

Overview of Earth Science

Earth science is the name for the group of sciences that deals with Earth and its neighbors in space. Earth science includes many subdivisions of geology such as geochemistry, geophysics, geobiology and paleontology, as well as oceanography, meteorology, and astronomy.

Units 1 through 4 focus on the science of geology, a word that means “study of Earth.” Geology is divided into two broad areas—physical geology and historical geology.

Physical geology includes the examination of the materials that make up Earth and the possible explanations for the many processes that shape our planet. Processes below the surface create earthquakes, build mountains, and produce volcanoes. Processes at the surface break rock apart and create
different landforms. Erosion by water, wind, and ice results in different landscapes. You will learn that rocks and minerals form in response to Earth’s internal and external processes. Understanding the origin of rocks and minerals is an important part of understanding Earth.

In contrast to physical geology, the aim of historical geology is to understand Earth’s long history. Historical geology tries to establish a timeline of the vast number of physical and biological changes that have occurred in the past. See Figure 1. We study physical geology before historical geology because we must first understand how Earth works before we try to unravel its past.

![ReadingCheckpoint]

What are the two main areas of geology?

Unit 5 is devoted to oceanography. Oceanography integrates the sciences of chemistry, physics, geology, and biology. Oceanographers study the composition and movements of seawater, as well as coastal processes, seafloor topography, and marine life. See Figure 2.

Unit 6 examines the composition of Earth’s atmosphere. The combined effects of Earth’s motions and energy from the sun cause the atmosphere to produce different weather conditions. This, in turn, creates the basic pattern of global climates. Meteorology is the study of the atmosphere and the processes that produce weather and climate. Like oceanography, meteorology also involves other branches of science.

Unit 7 demonstrates that understanding Earth requires an understanding of Earth’s position in the universe. The science of astronomy, the study of the universe, is useful in probing the origins of our own environment. All objects in space, including Earth, are subject to the same physical laws. Learning about the other members of our solar system and the universe beyond helps us to understand Earth.

Throughout its long existence, Earth has been changing. In fact, it is changing as you read this page and will continue to do so. Sometimes the changes are rapid and violent, such as when tornadoes, landslides, or volcanic eruptions occur. Many changes, however, take place so gradually that they go unnoticed during a lifetime.

**Formation of Earth**

Earth is one of nine planets that revolve around the sun. Our solar system has an orderly nature. Scientists understand that Earth and the other planets formed during the same time span and from the same material as the sun. The nebular hypothesis suggests that the bodies of our solar system evolved from an enormous rotating cloud called the solar nebula. It was made up mostly of hydrogen and helium, with a small percentage of heavier elements. Figure 3 on page 4 summarizes some key points of this hypothesis.

![Figure 2: Oceanographers study all aspects of the ocean—the chemistry of its waters, the geology of its seafloor, the physics of its interactions with the atmosphere, and the biology of its organisms.]

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**Customize for English Language Learners**

Students should use the words and word parts they just learned, along with their prior knowledge, to define the following words: oceanographer, meteorologist, geography, geologist, geological, astronaut, astronomer. Students should then use a dictionary to check their definitions. Review the correct meanings of these words with students when they are finished.

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**Use Community Resources**

The USGS (United States Geological Survey) has a network of regional offices where geologists study geological phenomena at local, regional, and global levels. Their activities include monitoring earthquake activity, mapping subsurface rock formations, and providing public with information about geologic events such as floods and landslides. Ask a USGS geologist from a local office to talk to the class about what geologists do at their jobs. Ask students to prepare questions in advance.

**Interpersonal**

**Formation of Earth Build Reading Literacy**

Refer to p. 186D in Chapter 7, which provides guidelines for relating text and visuals.

**Relate Text and Visuals** Have students turn ahead in the text to Figure 3 on p. 4 for a visual representation of the nebular hypothesis. Have them read the figure caption, then use the figure to describe the major steps in the nebular hypothesis. (Solar system begins as cloud of dust and gases. Cloud starts to rotate and collapse. Heated center forms the sun. Cooling creates solid particles. Collisions create asteroid-sized bodies. Asteroids form the inner planets. Lighter materials and gases form the outer planets.)

**Visual**
**Use Visuals**

*Figure 3* Have students study the diagram illustrating the nebular hypothesis. Ask: What do all stages of this hypothesis have in common? (In all stages, the system is spinning.) What was the first stage in the development of our solar system? (Our solar system began as an enormous cloud of gas and dust.) Challenge students to make a timeline or flowchart of the key events in the formation of our solar system. (Students should make a timeline or flowchart based on steps A through E given in the figure caption.)

Visual, Logical

### Separation and Density

**Purpose** Students see how substances separate based on density.

**Materials** 2 large glass jars with lids, 100 mL sand, 100 mL rock salt, 100 mL sugar, 100 mL water, 100 mL vegetable oil, 100 mL corn syrup

**Procedure** At the start of the class, place all of the solids in one jar and all the liquids in another jar. Put the lids on both jars and shake them carefully. Let the jars settle during the class. Then, have the students look at them. Ask: Why did the liquids separate? (Differences in density made the liquids rise or fall and separate.) Why didn’t the solids separate? (The solid particles were unable to move past each other.) What state was Earth most likely in when it separated into layers? (The materials that made up Earth must have been molten or nearly molten.)

**Expected Outcome** The liquids will separate into different layers. The solids will remain mixed.

Visual, Logical

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**Facts and Figures**

As Earth was forming, density differences caused denser materials to sink to Earth’s core, while less dense materials escaped to the atmosphere. Density differences continue to shape Earth today. Today’s volcanic eruptions are generally caused by less dense magma and gases rising up through the mantle until they penetrate the crust, resulting in a volcanic eruption. This is an example of the principle of uniformitarianism, which is essential to the study of geology. This principle states that the processes that exist on Earth today are identical to the processes that existed on Earth in the distant past. This principle allows geologists to make useful inferences based on contemporary observations.
High temperatures and weak fields of gravity characterized the inner planets. As a result, the inner planets were not able to hold onto the lighter gases of the nebular cloud. The lightest gases, hydrogen and helium, were whisked away toward the heavier planets by the solar wind. Earth, Mars, and Venus were able to retain some heavier gases including water vapor and carbon dioxide. The materials that formed by outer planets contained high percentages of water, carbon dioxide, ammonia, and methane. The size and frigid temperatures of the outer planets provided the surface gravity to hold these heavier gases.

**Layers Form on Earth**  Shortly after Earth formed, the decay of radioactive elements, combined with heat released by colliding particles, produced some melting of the interior. This allowed the denser elements, mostly iron and nickel, to sink to Earth’s center. The lighter, rocky components floated outward, toward the surface. This sinking and floating is believed to still be occurring, but on a much smaller scale. As a result of this process, Earth’s interior is not made of uniform materials. It consists of layers of materials that have different properties.  

Why does Earth have layers?  

An important result of this process is that gaseous materials were allowed to escape from Earth’s interior, just as gases escape today during volcanic eruptions. In this way, an atmosphere gradually formed along with the ocean. It was composed mainly of gases that were released from within the planet.

**Section 1.1 Assessment**

**Reviewing Concepts**
1. What are the sciences that are included in Earth science?
2. What topics are included in the study of physical geology?
3. Explain how physical geology differs from historical geology.
4. Describe the nebular hypothesis.

**Critical Thinking**
5. Forming Conclusions  Explain why Earth is called a dynamic planet.

6. Inferring  Would meteorology be a useful science to apply to the study of planets such as Mercury and Mars? Explain.

7. Hypothesizing  Suppose that as Earth formed, all lighter elements were released to surrounding space. How might this affect the structure of Earth today?

**Connecting Concepts**

Summarizing  Earth science is composed of many different areas of study. Why is it important to include all of these areas in the study of Earth and the solar system?

**Answer to . . .**

Earth has layers because denser elements sank to Earth’s center and less dense elements floated to the surface.

**Build Science Skills**

Inferring  Based on the information in this section, ask students to infer which of Earth’s layers will be the densest. Have students turn ahead in the text to Figure 6 on p. 8 to see a diagram of Earth’s layers.

Logical

3  **ASSESS**

Evaluate Understanding  To assess students’ knowledge of section content, ask them to answer the Key Concepts questions at the beginning of this section.

Reteach  Have students use Figure 3 to explain in their own words the formation of our solar system.

Because Earth is an ever-changing planet, all the spheres on Earth are interactive and affect one another. To understand Earth’s existence and history, it is important to study all aspects of Earth together.

**Section 1.1 Assessment**

1. Earth science includes many subdivisions of geology such as geochemistry, geophysics, geobiology, and paleontology, as well as meteorology, oceanography, and astronomy.
2. Physical geology includes processes that operate on and below Earth’s surface such as volcanoes, mountain building, erosion, and earthquakes.
3. Historical geology’s aim is to understand Earth’s history. Physical geology’s aim is to understand the processes that shape Earth.
4. This hypothesis suggests that the solar system began as an enormous cloud of dust and gas. The cloud began to rotate, heat was produced, and the cloud began to collapse toward the center. The sun formed at the center from this heat. Cooling of the cloud caused rocky and metallic materials to form the inner planets. The outer planets formed from lighter materials and gases.
5. The surface of Earth is continually changing due to its layered structure.
6. It would not be very useful because these two planets have only very thin atmospheres. Very few meteorological processes are occurring on them.
7. If all the lighter elements were no longer a part of Earth’s structure, Earth probably would not have layers defined by their density.
Earth’s Place in the Universe

Background
The Milky Way is a collection of several hundred billion stars, the oldest of which is about 10 billion years. It is one of a cluster of approximately 28 galaxies, called the Local Group, that exists in our region of the universe. Initially, the oldest stars in the Milky Way formed from nearly pure hydrogen. Later, succeeding generations of younger stars, including our Sun, would have heavier, more complex atoms available for their formation.

Teaching Tips
• As students read the feature and look at Figure 4, have them make a timeline of the events shown from the big bang to the present.
• While reading Earth’s Place in the Universe feature, have students create a flowchart showing the chain of events starting with the big bang and ending with the formation of our sun and the planets of our solar system.

Address Misconceptions
Students may think that the Milky Way is at the center of the universe. They may have inferred this from learning that almost all galaxies are moving away from the Milky Way in all directions. To dispel this misconception, have students mark with a black marker a number of dots on a partially inflated balloon. Blow up the balloon and observe what happens to the dots. They all move away from each other, as do almost all galaxies. All points in the universe can be thought of as being the center of the universe, as everything else is moving away from everything else.

Visual