CHAPTER 1

Introduction to Earth Science

CONCEPTS in Action

Exploration Lab
Determining Latitude and Longitude

Earth as a System
Earth's Place in the Universe

Understanding Earth
Studying Earth From Space

Discovery Channel School

Video Field Trip

Mapping the World

Take a field trip with Discovery Channel to learn more about maps. Answer the following questions after watching the video.

1. Name and describe two types of maps.
2. What is the significance of the prime meridian, and what European city does it run through?

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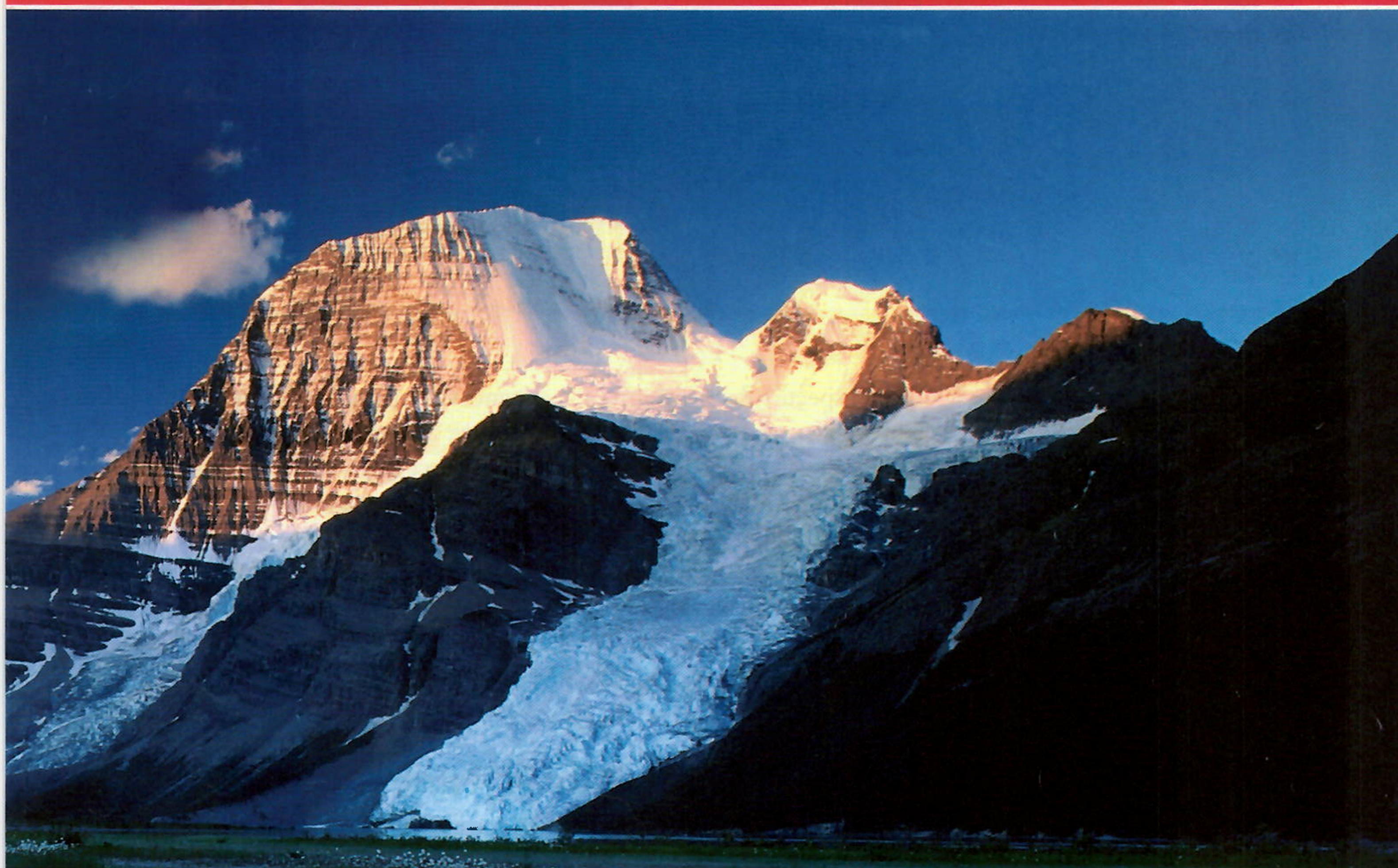
This photograph shows British Columbia's Mount Robson, the highest point in the Canadian Rockies. ▶

Chapter Preview



Inquiry Activity

Developing Your Observation Skills

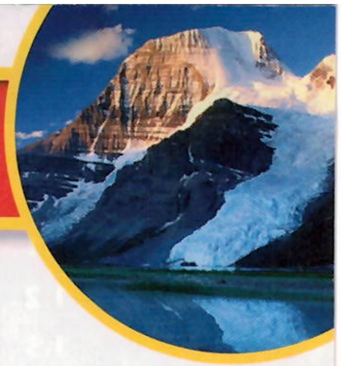
Procedure

Look at the photograph on this page. Have you ever seen anything like it?

Think About It

1. **Observing** What features can you identify in the photograph?
2. **Inferring** Where do you think this photograph came from?
3. **Designing Experiments** If you were an Earth scientist, how could you use this photograph in your work?

1.1 What Is Earth Science?



Reading Focus

Key Concepts

- What is the study of Earth science?
- How did Earth and the solar system form?

Vocabulary

- Earth science
- geology
- oceanography
- meteorology
- astronomy

Reading Strategy

Categorizing As you read about the different branches of Earth science, fill in the column with the name of each branch and list some of the things that are studied.

geology	a. ___?___
b. ___?___	c. ___?___
d. ___?___	e. ___?___
f. ___?___	g. ___?___

The spectacular eruption of a volcano, the magnificent scenery of a rocky coast, and the destruction created by a hurricane are all subjects for Earth science. The study of Earth science deals with many fascinating and practical questions about our environment. What forces produced the mountains shown on page 1? Why does our daily weather change? Is our climate changing? How old is Earth? How is Earth related to the other planets in the solar system? What causes ocean tides? What was the Ice Age like? Will there be another?

Understanding Earth is not an easy task because our planet is always changing. Earth is a dynamic planet with a long and complex history.

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

Figure 1 Scientists called paleontologists study fossils, which are signs of life in the distant past, to find out how life-forms have changed through time.
Posing Questions ***What questions do you have about this fossil?***

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.

Reading Checkpoint ***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.

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.

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 tornados, 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.

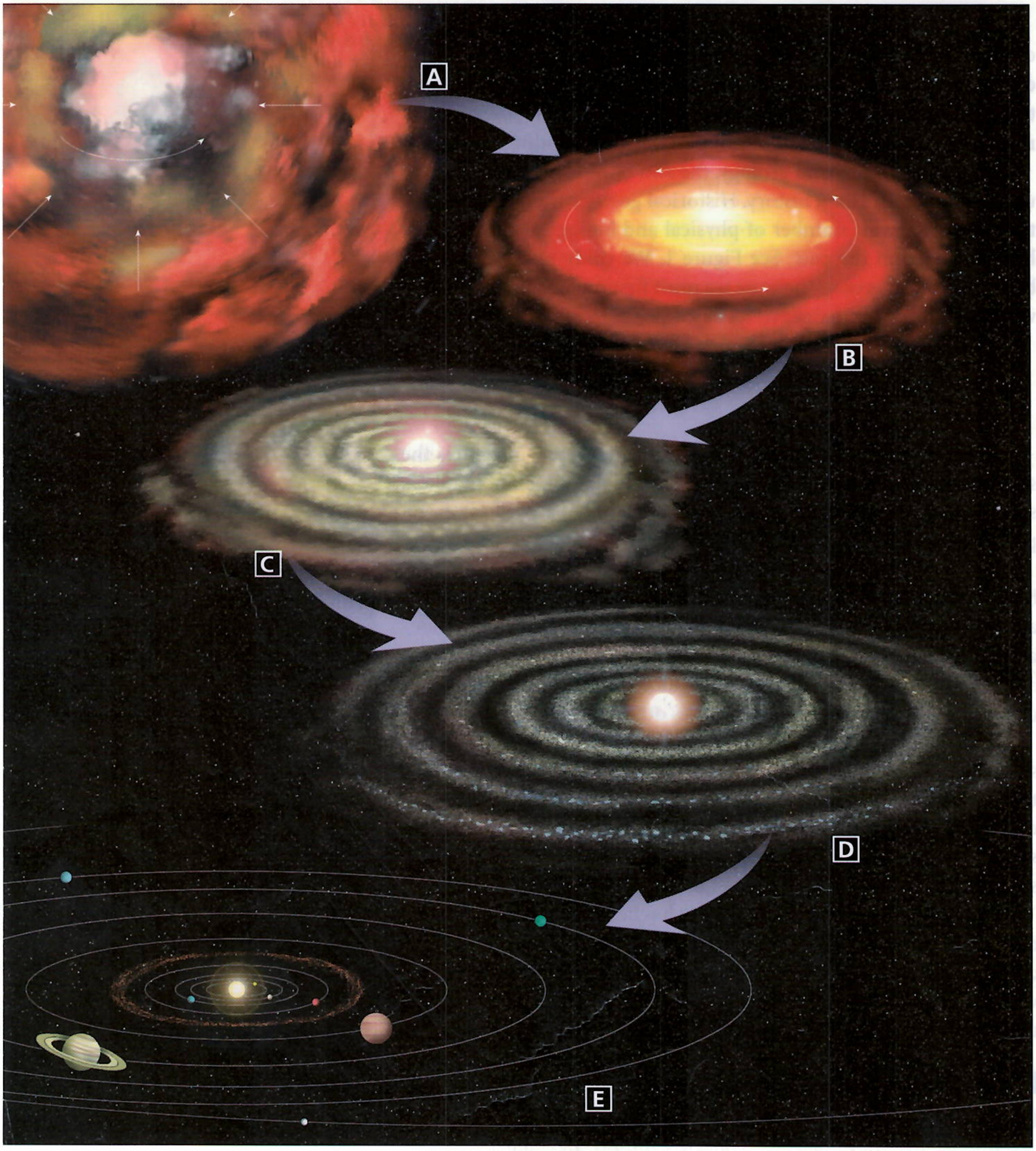


Figure 3 Formation of the Solar System According to the Nebular Hypothesis A Our solar system began as an enormous cloud of dust and gases made up mostly of hydrogen and helium with a small percentage of heavier elements. **B** This cloud, called a nebula, started to rotate and collapse toward the center of the cloud. Heat was generated at the center, which eventually formed the sun. **C** Cooling of the nebula caused rocky and metallic materials to form tiny solid particles. **D** Repeated collisions of these particles resulted in the formation of asteroid-sized bodies. **E** These asteroids eventually combined to form the four inner planets—Mercury, Venus, Earth, and Mars. The lighter materials and gases combined farther away from the center to form the four outer planets—Jupiter, Saturn, Uranus, and Neptune.

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 the 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.

Reading Checkpoint ***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?

earth as a SYSTEM

Earth's Place in the Universe

For centuries, people who have gazed at the night sky have wondered about the nature of the universe, Earth's place within it, and whether or not we are alone. Today many exciting discoveries in astronomy are beginning to provide answers about the origin of the universe, the formation and evolution of stars, and how Earth came into existence.

The realization that the universe is immense and orderly began in the early 1900s. Edwin Hubble and other scientists demonstrated that the Milky Way galaxy is one of hundreds of billions of galaxies, each of which contains billions of stars. Evidence supports that Earth, its materials, and all living things are the result of the Big Bang theory. The universe began between 13 and 14 billion years ago as a dense, hot, massive amount of material exploded with violent force. See Figure 4. Within about one second, the temperature of the expanding universe cooled to approximately 10 billion degrees. Basic atomic particles called protons and neutrons began to appear. After a few minutes, atoms of the simplest elements—hydrogen and helium—had formed. The initial conversion of energy to matter in the young universe was completed.

During the first billion years or so, matter (essentially hydrogen and helium) in the expanding universe clumped together to form enormous clouds that eventually collapsed to become galaxies and clusters of galaxies. Inside these collapsing clouds, smaller concentrations of matter formed into stars. One of the billions of galaxies to form was the Milky Way.

During the life of most stars, energy produced as hydrogen nuclei (protons) fuses with other hydrogen nuclei to form helium. During this process, called nuclear fusion, matter is converted to energy. Stars begin to die when their nuclear fuel is used up. Massive stars often have explosive deaths. During these events, called supernovas, nuclear fusion produces atoms such as oxygen, carbon, and iron. These atoms may become the materials that make up future generations of stars. From the debris scattered during the death of a preexisting star, our sun, and the solar system formed

Our star, the sun, is at the very least a second-generation star. Along with the planets in our solar system, the sun began forming nearly 5 billion years ago from a large interstellar cloud called a nebula. This nebula consisted of dust particles and gases enriched in heavy elements from supernova explosions. Gravitational energy caused the nebula to contract, rotate, and flatten. Inside, smaller concentrations of matter began condensing to form the planets. At the center of the nebula there was sufficient pressure and heat to initiate hydrogen nuclear fusion, and our sun was born.

It has been said that all life on Earth is related to the stars. This is true because the atoms in our bodies and the atoms that make up everything on Earth, owe their origin to a supernova event that occurred billions of years ago, trillions of kilometers away.

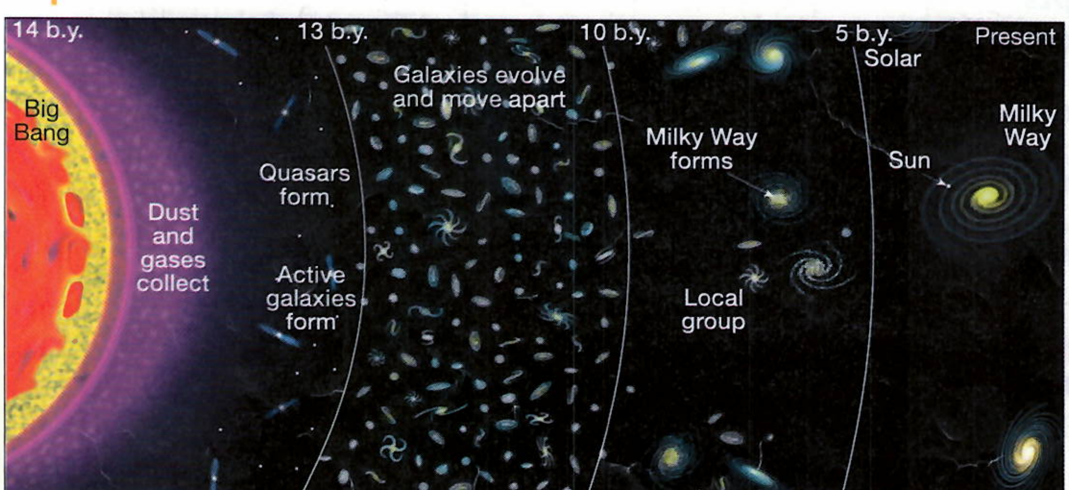


Figure 4 Big Bang Theory Between 13 and 14 billion years ago, a huge explosion sent all of the universe's matter flying outward at great speed. After a few billion years, the material cooled and condensed into the first stars and galaxies. About 5 billion years ago, our solar system began forming in a galaxy that is now called the Milky Way galaxy.

1.2 A View of Earth

Reading Focus

Key Concepts

- What are the four major spheres into which Earth is divided?
- What defines the three main parts of the solid Earth?
- Which model explains the position of continents and the occurrence of volcanoes and earthquakes?

Vocabulary

- hydrosphere
- atmosphere
- geosphere
- biosphere
- core
- mantle
- crust

Reading Strategy

Predicting Before you read, predict the meaning of the vocabulary words. After you read, revise your definition if your prediction was incorrect.

Vocabulary Term	Before You Read	After You Read
hydrosphere	a. ___?___	b. ___?___
atmosphere	c. ___?___	d. ___?___
geosphere	e. ___?___	f. ___?___
biosphere	g. ___?___	h. ___?___
core	i. ___?___	j. ___?___
mantle	k. ___?___	l. ___?___
crust	m. ___?___	n. ___?___

A view such as the one in Figure 5A provided the *Apollo 8* astronauts with a unique view of our home. Seen from space, Earth is breathtaking in its beauty. Such an image reminds us that our home is, after all, a planet—small, self-contained, and in some ways even fragile.

If you look closely at Earth from space, you may see that it is much more than rock and soil. The swirling clouds and the vast global ocean emphasize the importance of water on our planet.

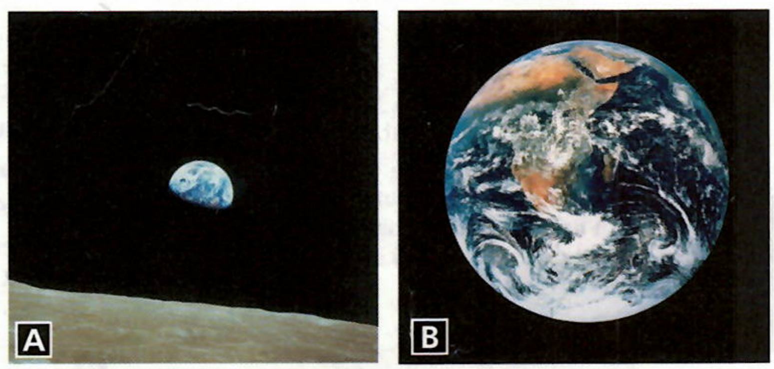


Figure 5 **A** View that greeted the *Apollo 8* astronauts as their spacecraft emerged from behind th Moon. **B** Africa and Arabia are prominent in this image of Earth taken from *Apollo 17.* The tan areas are desert regions. The bands of clouds over central Africa are associated with rainforests. Antarctica, which is covered by glacial ice, is visible at the south pole. The dark blue oceans and white swirling clouds remind us of the importance of oceans and the atmosphere.

Earth's Major Spheres

The view of Earth shown in Figure 5B should help you see why the physical environment is traditionally divided into three major spheres: the water portion of our planet, the **hydrosphere;** Earth's gaseous envelope, the **atmosphere;** and the **geosphere.**

Our environment is characterized by the continuous interactions of air and rock, rock and water, and water and air. The **biosphere,** which is made up of all the life-forms on Earth, interacts with all three of these physical spheres. **Earth can be thought of as consisting of four major spheres: the hydrosphere, atmosphere, geosphere, and biosphere.**

Hydrosphere Water is what makes Earth unique. All of the water on Earth makes up the hydrosphere. Continually on the move, water evaporates from the oceans to the atmosphere, falls back to Earth as rain, and runs back to the ocean. The oceans account for approximately 97 percent of the water on Earth. The remaining 3 percent is fresh water and is present in groundwater, streams, lakes, and glaciers.

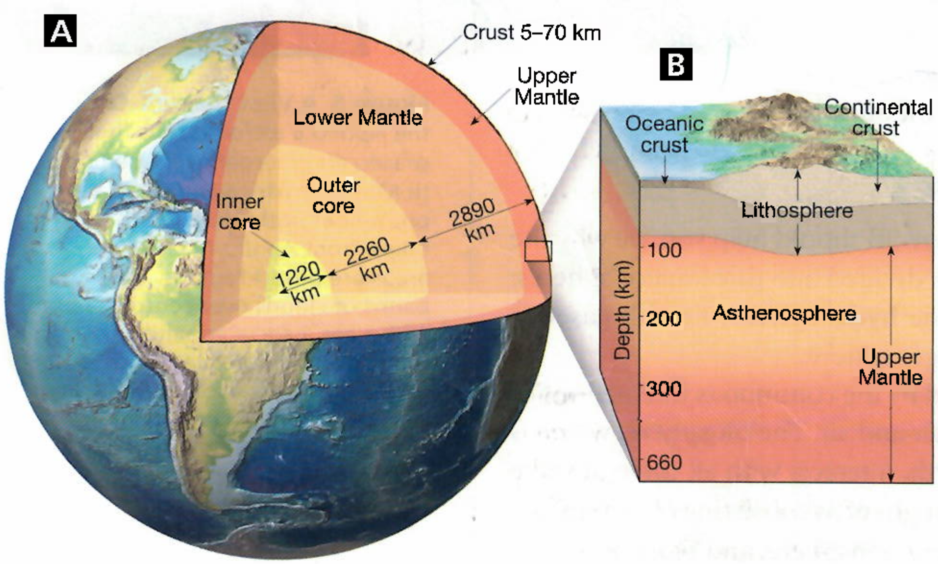
Although these freshwater sources make up a small fraction of the total amount of water on Earth, they are quite important. Streams, glaciers, and groundwater are responsible for sustaining life and creating many of Earth's varied landforms.

Atmosphere A life-sustaining, thin, gaseous envelope called the atmosphere surrounds Earth. It reaches beyond 100 kilometers above Earth, yet 90 percent occurs within just 16 kilometers of Earth's surface. This thin blanket of air is an important part of Earth. It provides the air that we breathe. It protects us from the sun's intense heat and dangerous radiation. The energy exchanges that continually occur between space, the atmosphere, and Earth's surface produce weather and climate.

If Earth had no atmosphere, life on our planet as we know it could not exist. Many of the processes and interactions that make the surface such a dynamic place would not occur. For example, without weathering and erosion, the face of our planet might more closely resemble the moon.

Geosphere Lying beneath both the atmosphere and the ocean is the geosphere. **Because the geosphere is not uniform, it is divided into three main parts based on differences in composition—the core, the mantle, and the crust.** Figure 6A shows the dense or heavy inner sphere that is the core; the less dense mantle; and the lighter, thin crust. The crust is not uniform in thickness. It is thinnest beneath the oceans and thickest beneath the continents. Figure 6B shows that the crust and uppermost mantle make up a rigid outer layer called the lithosphere. Beneath the lithosphere, the rocks become partially molten, or melted. They are able to slowly flow because of the uneven distribution of heat deep within Earth. This region is called the asthenosphere. Beneath the asthenosphere, the rock becomes more dense. This region of Earth is called the lower mantle.

Figure 6 **A** On this diagram, the inner core, outer core, and mantle are drawn to scale but the thickness of the crust is exaggerated by about 5 times. **B** There are two types of crust—oceanic and continental. The lithosphere is made up of the crust and upper mantle. Below the lithosphere are the asthenosphere and the lower mantle.



Biosphere The biosphere includes all life on Earth. It is concentrated in a zone that extends from the ocean floor upward for several kilometers into the atmosphere. Plants and animals depend on the physical environment for life. However, organisms do more than just respond to their physical environment. Through countless interactions, organisms help maintain and alter their physical environment. Without life, the makeup and nature of the solid Earth, hydrosphere, and atmosphere would be very different.

Reading Checkpoint ***What are Earth's four major spheres?***

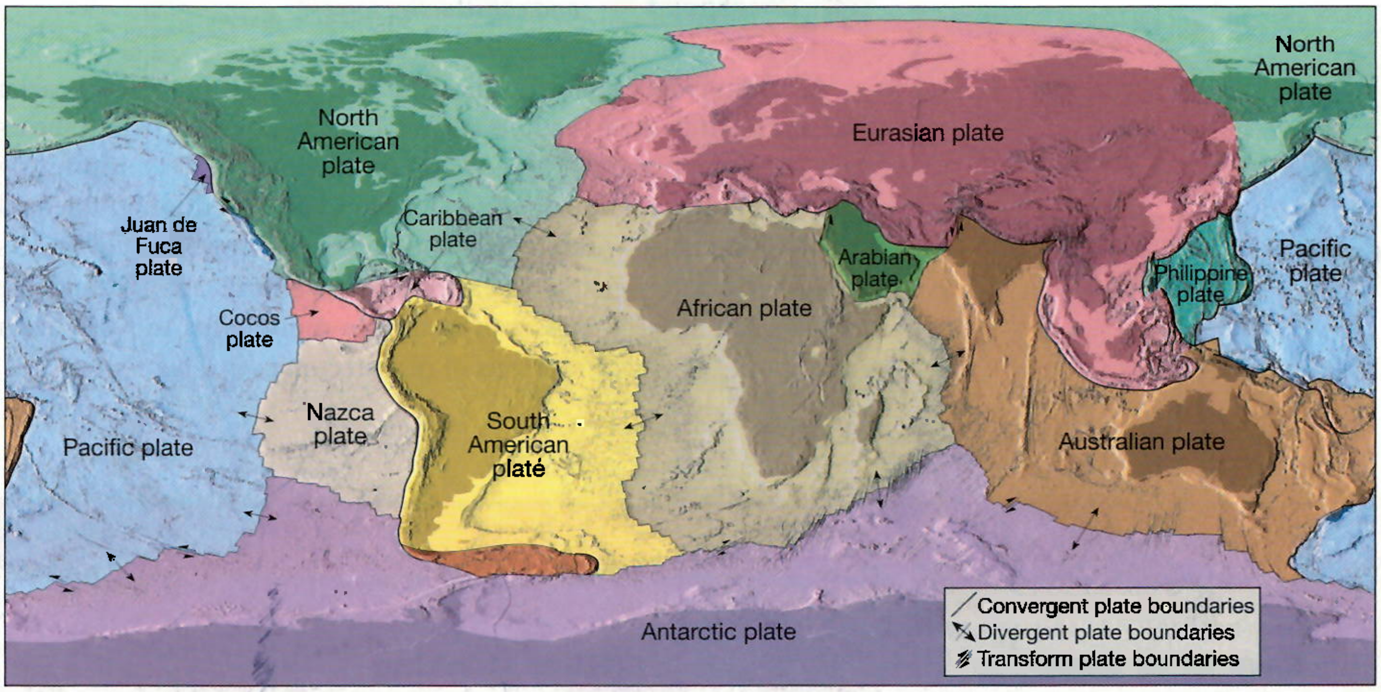


Figure 7 Plate Tectonics There are currently 7 major plates recognized and numerous smaller plates.
Relating Cause and Effect ***What is the relationship between mountain chains and plate boundaries?***

Plate Tectonics

You have read that Earth is a dynamic planet. If we could go back in time a billion years or more, we would find a planet with a surface that was dramatically different from what it is today. Such prominent features as the Grand Canyon, the Rocky Mountains, and the Appalachian Mountains did not exist. We would find that the continents had different shapes and were located in different positions from those of today.

There are two types of forces affecting Earth's surface. *Destructive forces* such as weathering and erosion work to wear away high points and flatten out the surface. *Constructive forces* such as mountain building and volcanism build up the surface by raising the land and depositing new material in the form of lava. These constructive forces depend on Earth's internal heat for their source of energy.

Within the last several decades, a great deal has been learned about the workings of Earth. In fact, this period is called a revolution in our knowledge about Earth. This revolution began in the early part of the twentieth century with the idea that the continents had moved about the face of the Earth. This idea contradicted the accepted view that the continents and ocean basins are stationary features on the face of Earth. Few scientists believed this new idea. More than 50 years passed before enough data were gathered to transform this hypothesis into a widely accepted theory. **The theory that finally emerged, called plate tectonics, provided geologists with a model to explain how earthquakes and volcanic eruptions occur and how continents move.**

Reading Checkpoint ***What is the difference between destructive forces and constructive forces?***

According to the plate tectonics model, Earth's lithosphere is broken into several individual sections called plates. Figure 7 on page 9 shows their current position. These plates move slowly and continuously across the surface. This motion is driven by the result of an unequal distribution of heat within Earth. Ultimately, this movement of Earth's lithospheric plates generates earthquakes, volcanic activity, and the deformation of large masses of rock into mountains. You will learn more about the powerful effects of plate tectonics in Chapter 9.

Section 1.2 Assessment

Reviewing Concepts

1. Which of Earth's spheres do each of these features belong: lake, meadow, canyon, cloud?
2. What are the three main parts of the geosphere?
3. Why is the solid Earth layered?
4. The plate tectonics theory explains the existence and occurrence of what features?
5. What sort of energy allows the tectonic plates to move?
6. Describe an example of how water moves through the hydrosphere.

Critical Thinking

7. **Inferring** Using the definitions of spheres as they occur on Earth, what spheres do you think are present on Venus?
8. **Applying Concepts** Describe a situation in which two or more of Earth's spheres are interacting.
9. **Classifying** Choose an Earth science branch. List how some of its studies relate to Earth's spheres.

Connecting Concepts

Earth's Spheres You learned in Section 1.1 that Earth is a dynamic planet. Explain how features in each of Earth's spheres are changing over time.

1.3 Representing Earth's Surface

Reading Focus

Key Concepts

- What lines on a globe are used to indicate location?
- What problems do mapmakers face when making maps?
- How do topographic maps differ from other maps?

Vocabulary

- latitude
- longitude
- topographic map
- contour line
- contour interval

Reading Strategy

Monitoring Your Understanding Preview the Key Concepts, topic headings, vocabulary, and figures in this section. List two things you expect to learn. After reading, state what you learned about each item you listed.

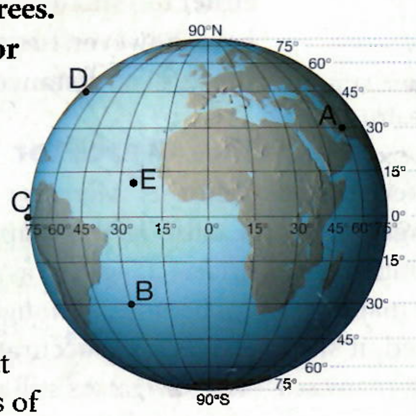
What I Expect to Learn	What I Learned
a. ?	b. ?
c. ?	d. ?

Determining Location

Today we use maps and computer programs to help us plan our routes. Long ago, people had to rely on maps that were made using data and information that were collected by travelers and explorers. Today computer technology is available to anyone who wants to use it. Mapmaking has changed a lot throughout recorded history.

After Christopher Columbus and others proved that Earth was not flat, mapmakers began to use a global grid to help determine location.

Global Grid Scientists use two special Earth measurements to describe location. The distance around Earth is measured in degrees. **Latitude is the distance north or south of the equator, measured in degrees. Longitude is the distance east or west of the prime meridian, measured in degrees.** Earth is 360 degrees in circumference. Lines of latitude are east-west circles around the globe. All points on the circle have the same latitude. The line of latitude around the middle of the globe, at 0 degrees (°), is the equator. Lines of longitude run north and south. The prime meridian is the line of longitude that marks ° of longitude as shown in Figure 8.



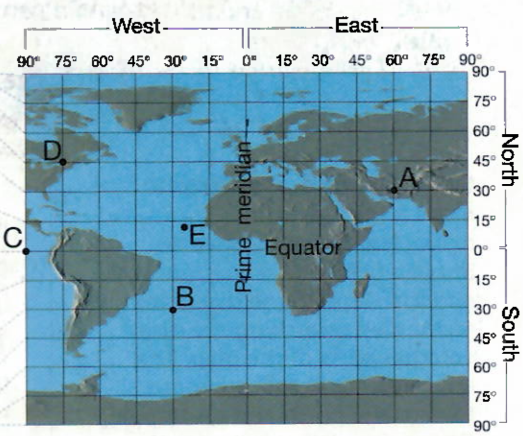


Figure 8 Global Grid

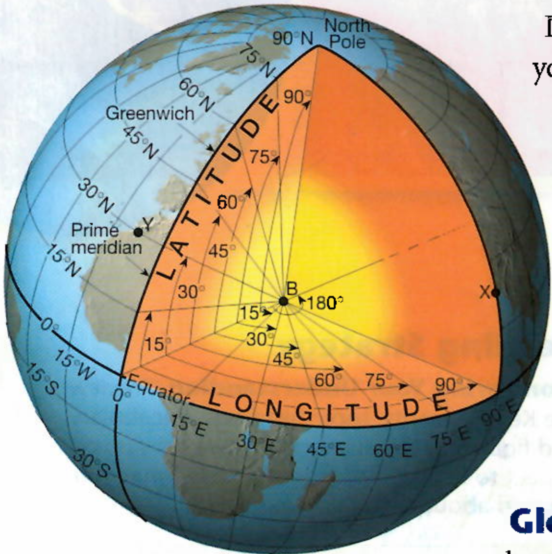


Figure 9 Measuring Latitude and Longitude

Lines of latitude and longitude form a global grid. This grid allows you to state the absolute location of any place on Earth. For example, Savannah, Georgia, is located at 32° north latitude and 81° west longitude.

The equator divides Earth in two. Each half is called a hemisphere. The equator divides Earth into northern and southern hemispheres. The prime meridian and the 180° meridian divide Earth into eastern and western hemispheres.

Reading Checkpoint ***How does the global grid divide Earth?***

Globes As people explored Earth, they collected information about the shapes and sizes of islands, continents, and bodies of water. Mapmakers wanted to present this information accurately. The best way was to put the information on a model, or globe, with the same round shape as Earth itself. By using an accurate shape for Earth, mapmakers could show the continents and oceans of Earth much as they really are. The only difference would be the scale, or relative size.

But there is a problem with globes. Try making a globe large enough to show the streets in your community. The globe might have to be larger than your school building! A globe can't be complete enough to be useful for finding directions and at the same time small enough to be convenient for everyday use.

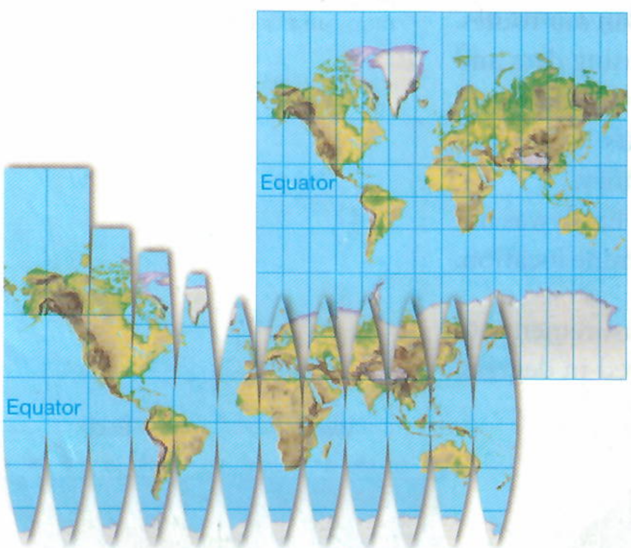


Figure 10 Mercator Map To make a Mercator map, mapmakers have to carve an image of Earth's surface into slices and then stretch the slices into rectangles. Stretching the slices enlarges parts of the map. The enlargement becomes greater toward the north and south poles. **Observing** ***What areas on the map appear larger than they should?***

Maps and Mapping

A map is a flat representation of Earth's surface. But Earth is round. Can all of Earth's features be accurately represented on a flat surface without distorting them? The answer is no. **No matter what kind of map is made, some portion of the surface will always look either too small, too big, or out of place. Mapmakers have, however, found ways to limit the distortion of shape, size, distance, and direction.**

The Mercator Projection In 1569, a mapmaker named Gerardus Mercator created a map to help sailors navigate around Earth. On this map, the lines of longitude are parallel, making this grid rectangular, as shown on the map in Figure 10. The map was useful because, although the sizes and distances were distorted, it showed directions accurately. Today, more than 400 years later, many seagoing navigators still use the Mercator projection map.

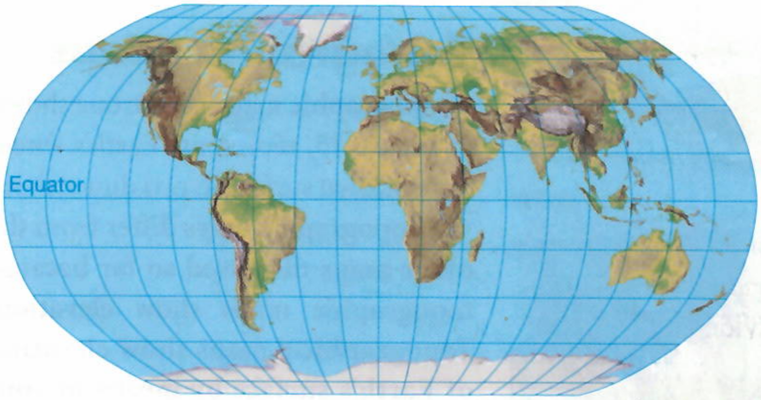


Figure 11 Robinson Projection Map Compare this map to the Mercator projection. **Comparing and Contrasting** ***How do the shapes in the continents differ between these maps? Are there any other differences?***

Different Projection Maps for Different Purposes

The best projection is always determined by its intended use. The Robinson projection map is one of the most widely used. Maps that use this projection show most distances, sizes, and shapes accurately. However, even a Robinson projection has distortions, especially in areas around the edges of the map. You can see this in Figure 11. Conic projection maps are made by wrapping a cone of paper around a globe at a particular line of latitude, as shown in Figure 12. Various points and lines are projected onto the paper. There is almost no distortion along the line of latitude that's in contact with the cone, but there can be much distortion in areas away from this latitude. Because accuracy is great over a small area, these maps are used to make road maps and weather maps. Gnonomic projections, as shown in Figure 13, are made by placing a piece of paper on a globe so that it touches a single point on the globe's surface. Various points and lines are then projected onto the paper. Although distances and directions are distorted on these maps, they are useful to sailors and navigators because they show with great accuracy the shortest distance between two points.

Figure 12 Conic Projection Map Because there is little distortion over small areas, conic projections are used to make road maps and weather maps.

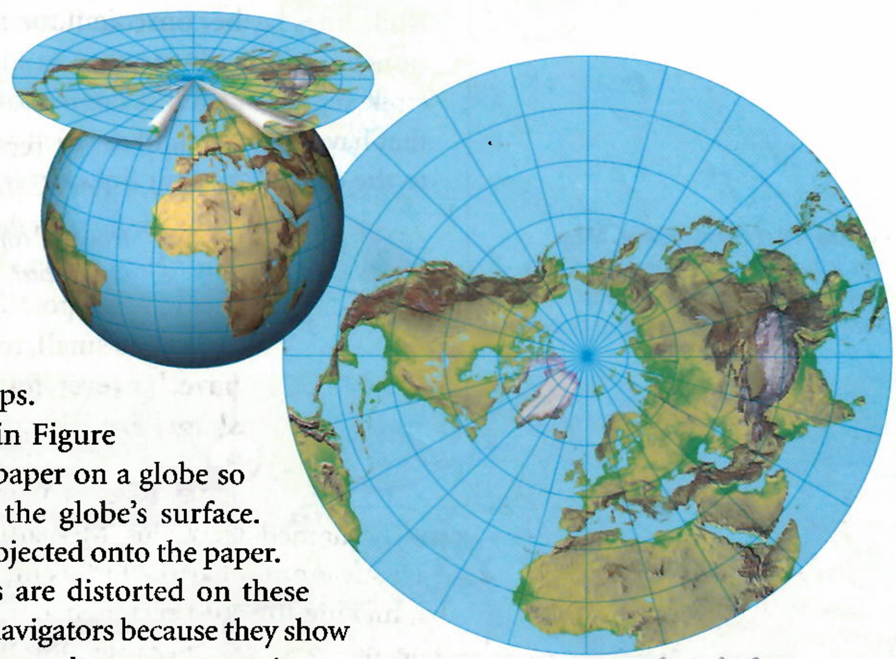


Figure 13 Gnomonic Projection Map Gnomonic projections allow sailors to accurately determine distance and direction across the oceans.

Reading Checkpoint ***What major problem must mapmakers overcome?***

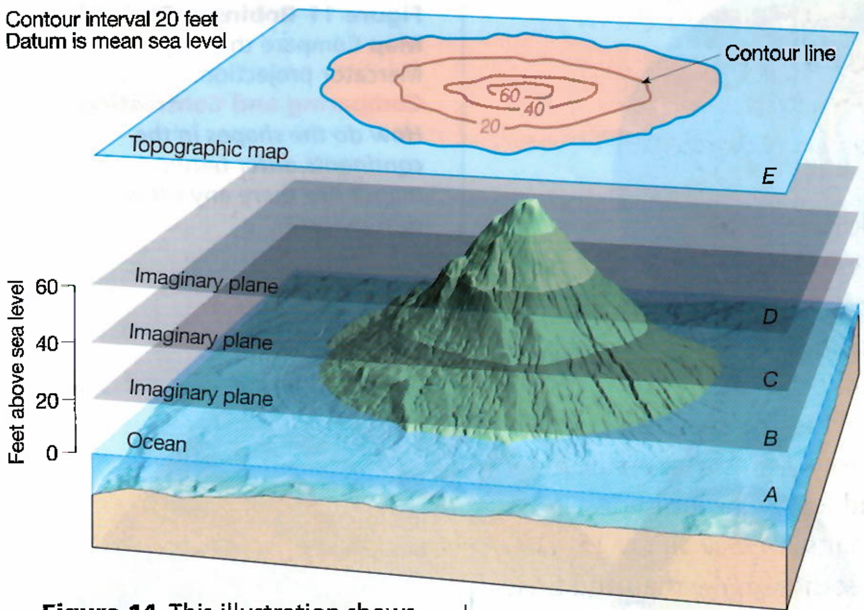


Figure 14 This illustration shows how contour lines are determined when topographic maps are constructed.

Topographic Maps

A **topographic map,** like the one shown in Figure 15, represents Earth's three-dimensional surface in two dimensions. **Topographic maps differ from the other maps discussed so far because topographic maps show elevation. Topographical maps show elevation of Earth's surface by means of contour lines.** Most also show the presence of bodies of water, roads, government and public buildings, political boundaries, and place names. These maps are important for geologists, hikers, campers and anyone else interested in the three-dimensional lay of the land.

Contour Lines The elevation of the land is indicated by using contour lines. Every position along a single contour line is the same elevation. Adjacent contour lines represent a change in elevation. Every fifth line is bold and labeled with the elevation. It is called an index contour. The **contour interval** tells you the difference in elevation between adjacent lines. The steepness of an area can be determined by examining a map. Lines that are closer together indicate a steeper slope, while lines farther apart indicate a gentler slope. You can see this relationship on the illustration in Figure 14. Contour lines that form a circle represent a hill. A depression is represented by circular contours that have hachure marks, which are small lines on the circle that point to the center. Contour lines never touch or intersect.

Reading Checkpoint ***How do topographic maps indicate changes in elevation?***

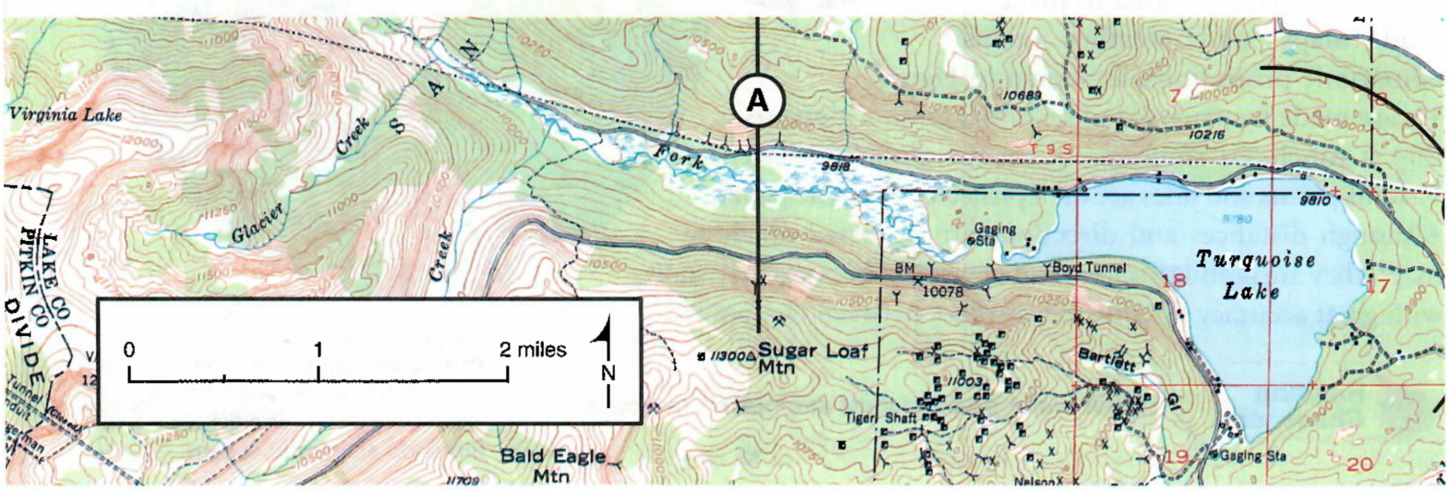


Figure 15 Topographic Map This is a portion of the Holy Cross, Colorado, topographic map. Contour lines are shown in brown.

Scale A map represents a certain amount of area on Earth's surface. So it is necessary to be able to determine distances on the map and relate them to the real world. Suppose you want to build a scale model of a boat that is 20 feet long. If your model is a 1/5-scale model, then it is 4 feet long.

In a similar way, a map is drawn to scale where a certain distance on the map is equal to a certain distance at the surface. Because maps model Earth's surface, the scale must be larger than that of the model boat. Look at the scale on the map in Figure 16. The ratio reads 1:24,000. This means that 1 unit on the map is equal to 24,000 units on the ground. Because the ratio has no units, it may stand for anything. We usually use inches or centimeters for our units. If the 1 stands for 1 centimeter on the map, how many kilometers does the 24,000 stand for on the ground?

Another scale provided on a map is a bar scale. See Figure 15. This allows you to use a ruler to measure the distance on the map and then line the ruler up to the bar to determine the distance represented.

Geologic Maps It is often desirable to know the type and age of the rocks that are exposed, or crop out, at the surface. This kind of map is shown in Figure 16. **A map that shows this information is called a geologic map.** Once individual rock formations are identified, and mapped out, their distribution and extent are drawn onto the map. Each rock formation is assigned a color and sometimes a pattern. A key provides the information needed to learn what formations are present on the map. Contour lines are often included to provide a more detailed and useful map.

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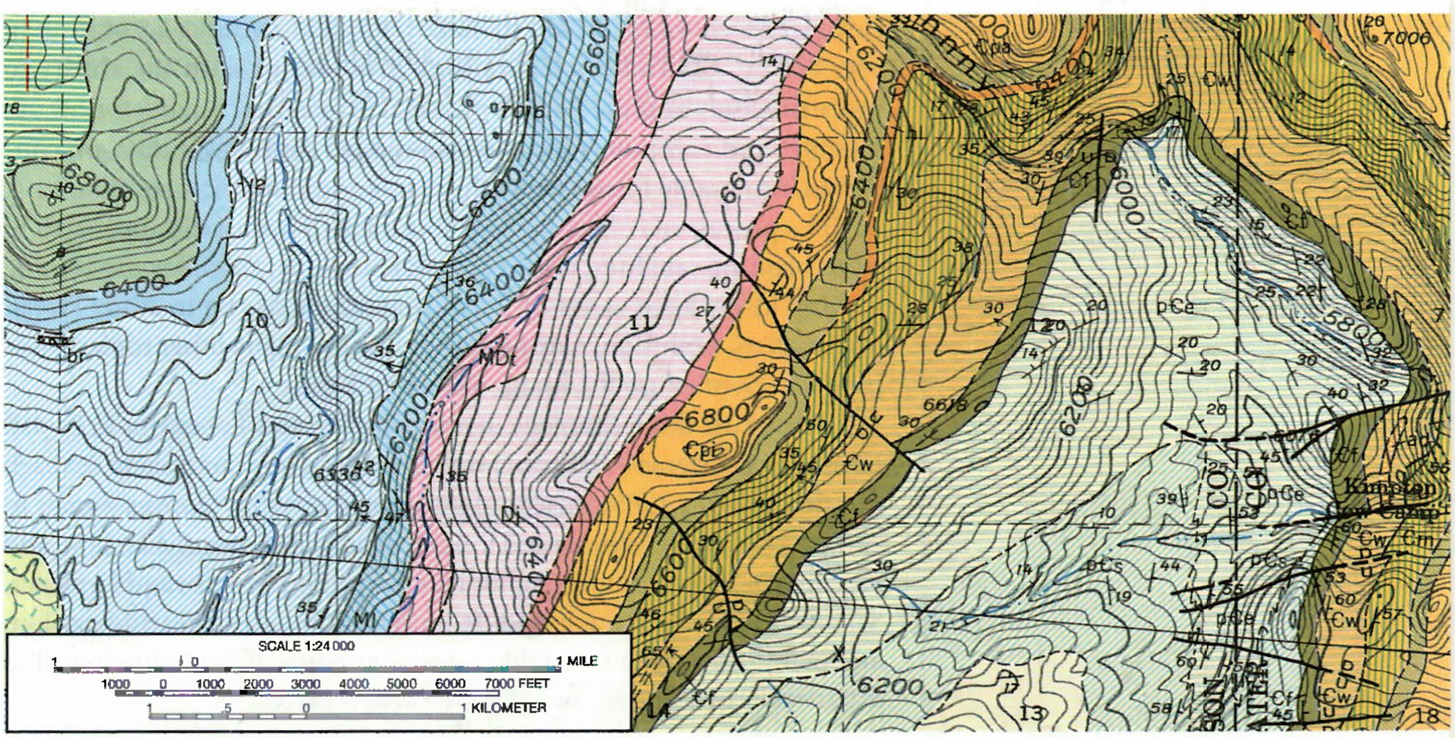
Figure 16 Geologic Map The color coding on the map represents some rock formations in Montana. Each color and pattern represents a different type of rock.



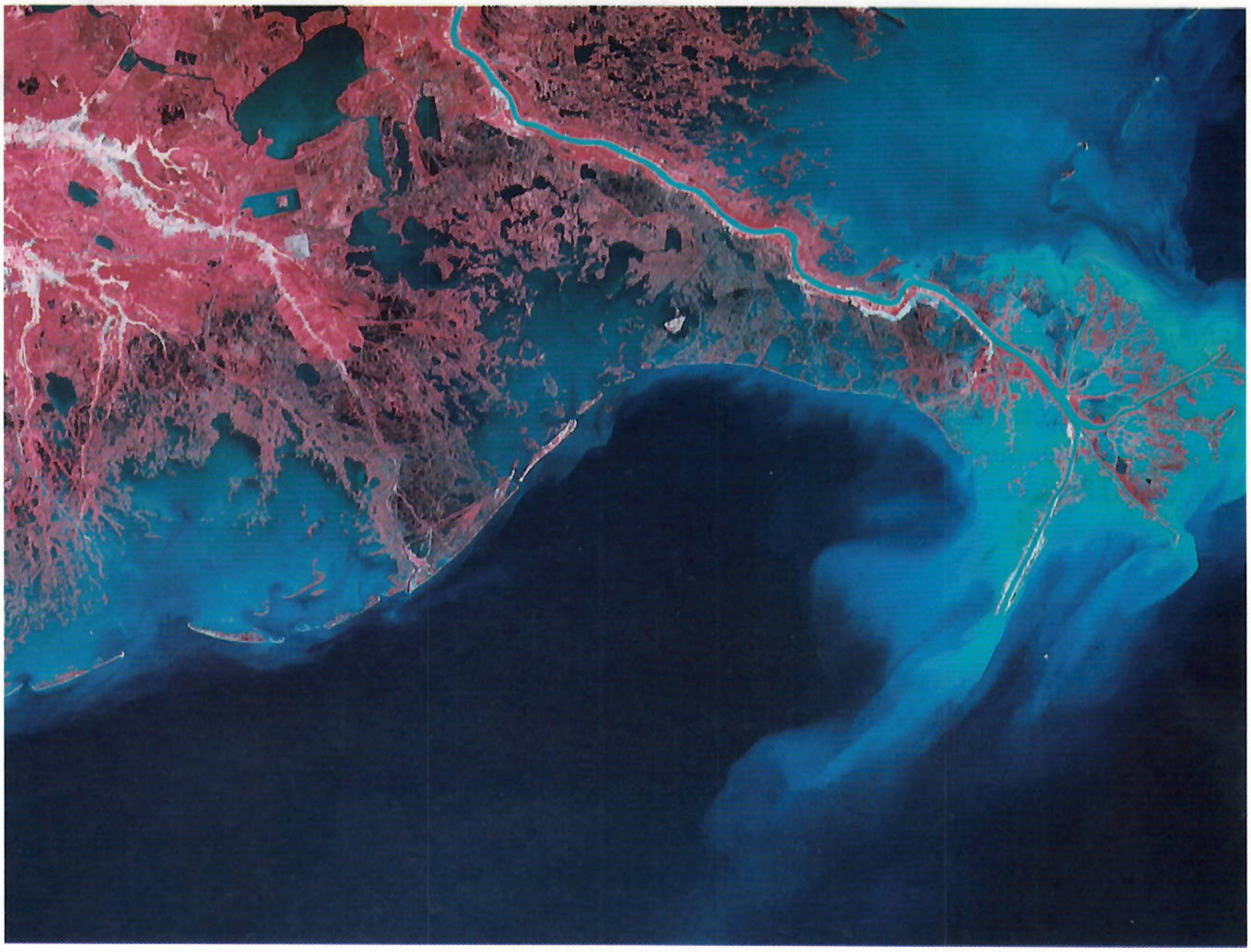


Figure 17 Satellite Image of the Mississippi River Delta Moving sediment (light blue) indicates current patterns. Red shows vegetation.

Advanced Technology

Advanced technology is used to make maps that are more accurate than ever before. **Today's technology provides us with the ability to more precisely analyze Earth's physical properties.** Scientists now use satellites and computers to send and receive data. These data are converted into usable forms such as pictures and numerical summaries.

The process of collecting data about Earth from a distance, such as from orbiting satellites, is called remote sensing. Satellites use remote sensing to produce views of Earth that scientists use to study rivers, oceans, fires, pollution, natural resources, and many other topics. How might a scientist use the image shown in Figure 17?

We can use this technology in our daily lives too. For example, Global Positioning Systems (GPS) can provide maps in our cars to help us reach our destinations. GPS consists of an instrument that receives signals to compute the user's latitude and longitude as well as speed, direction, and elevation. GPS is an important tool for navigation by ships and airplanes. Scientists use GPS to track wildlife, study earthquakes, measure erosion, and many other purposes. Table 1 describes some of the technology that is particularly useful in the study of Earth science.

Table 1 Technology and Earth Science	
Type of Equipment	**Capabilities**
Weather Satellites	• These monitor atmospheric temperature and humidity, ground and surface seawater temperature, cloud cover, and water-ice boundaries. • They can help locate sources of distress signals. • They are able to scan Earth's surface in one 24-hour period.
Navigation Satellites	• These assist ships and submarines to determine their exact location at any time.
Landsat Satellites	• The first Landsat satellite was launched in 1972. Landsat 7 was launched in 1999. • They provide data on Earth's landmasses, coastal boundaries, and coral reefs. • Pictures taken are transmitted to ground stations around the world. • They orbit Earth every 99 minutes and complete 14 orbits per day. • Total coverage of Earth is achieved in 16 days.
Global Positioning System (GPS)	• This system combines satellite information with computer technology to provide location information in three dimensions: latitude, longitude, and altitude. • Three satellite signals are detected by a receiver. The distance from the satellites to the receiver is calculated, and the location is determined using the triangulation method. A fourth signal is then used to mathematically determine exact position.
Very Long Baseline Interferometry (VLBI)	• VLBI utilizes a large network of antennas around the world to receive radio waves from space objects such as quasars. • In Earth science, VLBI is used in geodesy, or the measurement of the geosphere. • Using the arrival times of radio waves from quasars, the position of radio telescopes on Earth are determined to within millimeters of their position. • Small changes in the telescope positions allow scientists to study tectonic plate motions and other movements of Earth's crust with great precision and accuracy.

Section 1.3 Assessment

Reviewing Concepts

1. Describe the two sets of lines that are used on globes and some maps.
2. What happens to the images on the globe when they are transferred to a flat surface?
3. What is the purpose of contour lines on topographic maps?
4. What two lines mark zero degrees on the globe? In which directions do these lines run?
5. Why is the Mercator projection map still in use today?
6. What types of advanced technology are used in mapmaking today?

Critical Thinking

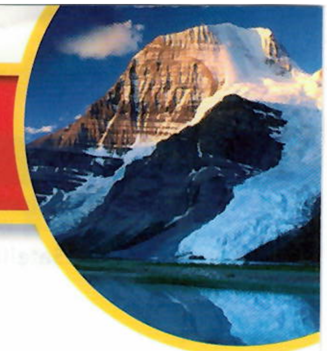
7. **Applying Concepts** Why are there so many different types of maps?
8. **Drawing Conclusions** How can data from VLBI be used in mapmaking today?
9. **Conceptualizing** An area on a topographic map has the following contour line configuration: First, the lines are fairly widely spaced. Then they are closely spaced. Finally, they are circular. Describe the topography represented by these lines.

Math Practice

Use the bar scale on Figure 15 to answer the following question.

10. Determine the distance along the shoreline of Turquoise Lake from the gaging station on the west shore to the gaging station on the south shore. Record your answer in kilometers.

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.

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.

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.

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 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.

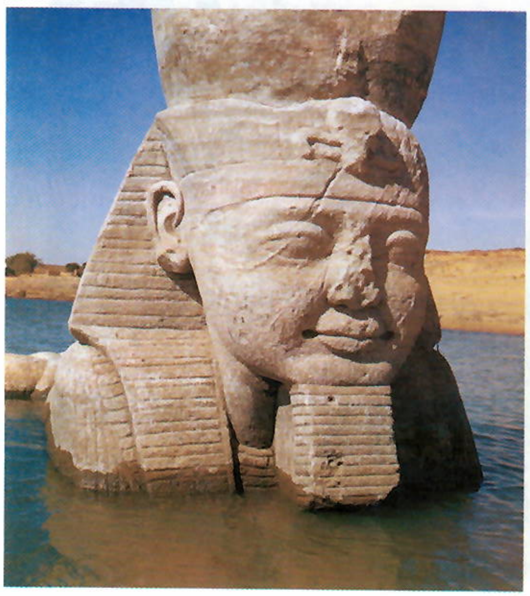


Figure 19 The benefit that was intended by the construction of the Aswan Dam in Egypt was not achieved.
Drawing Conclusions ***How might the flooding here have been avoided?***

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 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?***

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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.

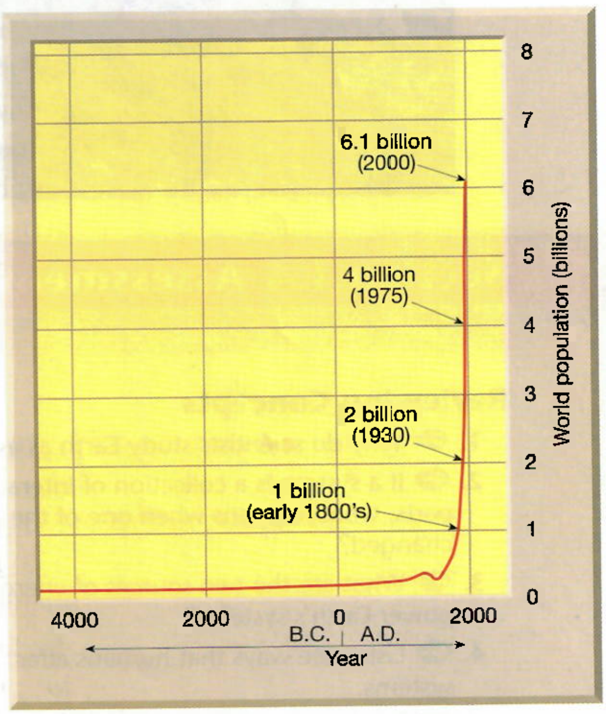


Figure 20 Growth of World Population

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**

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?

1.5 What Is Scientific Inquiry?

Reading Focus

Key Concepts

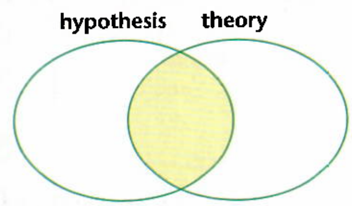
- What is a hypothesis?
- What is a theory?

Vocabulary

- hypothesis
- theory

Reading Strategy

Comparing and Contrasting Complete the Venn diagram by listing the ways hypothesis and theory are alike and how they differ.



All science is based on two assumptions. First, the natural world behaves in a consistent and predictable manner. Second, through careful, systematic study, we can understand and explain the natural world's behavior. We can use this knowledge to make predictions about what should or should not be expected. For example, by knowing how oil deposits form, geologists are able to predict the most likely sites for exploration.

The development of new scientific knowledge involves some basic steps. First, scientists collect data through observation and measurement. These data are essential to science and serve as the starting point for the development of scientific theories.

Hypothesis

Once data have been gathered, scientists try to explain how or why things happen in the manner observed. Scientists do this by stating a possible explanation called a scientific hypothesis. Sometimes more than one hypothesis is developed to explain a given set of observations. Just because a hypothesis is stated doesn't mean that it is correct or that the scientific community will automatically accept it.

Before a hypothesis can become an accepted part of scientific knowledge, it must be tested and analyzed. If a hypothesis can't be tested, it is not scientifically useful, no matter how interesting it might seem. Hypotheses that fail rigorous testing are discarded. The history of science is filled with discarded hypotheses. One of the best known is the Earth-centered model of the universe. This hypothesis was based on the apparent movement of the sun, moon, and stars around Earth.

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As the mathematician Jacob Bronowski stated, "Science is a great many things, but in the end they all return to this: Science is the acceptance of what works and the rejection of what does not."

Theory

When a hypothesis has survived extensive testing and when competing hypotheses have been eliminated, a hypothesis may become a scientific **theory.** **A scientific theory is well tested and widely accepted by the scientific community and best explains certain observable facts.** For example, the theory of plate tectonics provides the framework for understanding the origin of continents and ocean basins, plus the occurrence of mountains, earthquakes, and volcanoes.

Scientific Methods

The process of gathering facts through observations and formulating scientific hypotheses and theories is called the scientific method. There is no set path that scientists must follow in order to gain scientific knowledge. However, many scientific investigations involve the following steps: (1) the collection of scientific facts through observation and measurement, (2) the development of one or more working hypotheses or models to explain these facts, (3) development of observations and experiments to test the hypotheses, and (4) the acceptance, modification, or rejection of the hypothesis based on extensive testing.

Section 1.5 Assessment

Reviewing Concepts

1. You have just come up with an explanation to a question that has bothered you for some time. What must you do to have your explanation become a hypothesis?
2. Explain how a hypothesis can become a theory.
3. According to the scientific community, how does the natural world behave?
4. What happens if more than one hypothesis is put forward to explain the same observations?
5. When is a model useful in scientific investigations?

Thinking Critically

6. **Applying Concepts** Why do most scientists follow a set order of steps when carrying out a scientific investigation?
7. **Designing Experiments** While carrying out an investigation, a scientist observes some unexpected results. What are the scientist's next steps?
8. **Understanding Concepts** Why is it necessary to use careful and systematic methods when carrying out scientific investigations?

Writing in Science

Explanatory Paragraph It took a long time for the scientific community to accept the theory of plate tectonics. Write a paragraph suggesting how the use of proper scientific methods helped the theory gain acceptance.

understanding **EARTH**

Studying Earth From Space

Scientific facts are gathered in many ways, such as laboratory studies, field observations, and field measurements. Satellite images like the one in Figure 23 are another useful source of data. Such images provide perspectives that are difficult to get from more traditional sources. The high-tech instruments aboard many satellites enable scientists to gather information from remote regions where data are otherwise scarce.

The image in Figure 23 makes use of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). Because different materials reflect and give off energy in different ways, ASTER can provide detailed information about the composition of Earth's surface. Figure 23 is a three-dimensional view looking north over Death Valley, California. The data have been computer enhanced to exaggerate the color variations that highlight differences in types of surface materials.

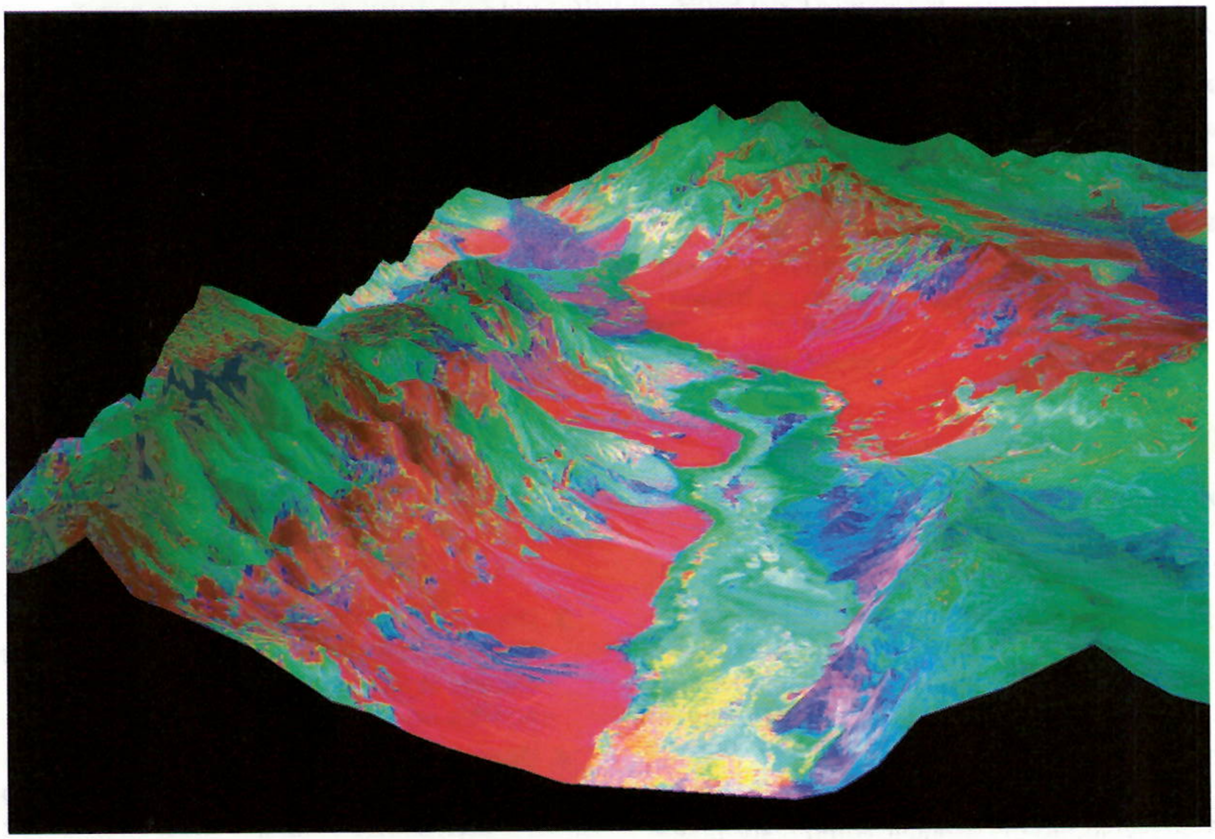

Figure 23 This satellite shows detailed information about the composition of surface materials in Death Valley, California. It was produced by superimposing nighttime thermal infrared data, acquired on April 7, 2000, over topographic data from the U.S. Geological survey. (Image courtesy of NASA)

Salt deposits on the floor of Death Valley appear in shades of yellow, green, purple, and pink. These indicate the presence of carbonate, sulfate, and chloride minerals. The Panamint Mountains to the west and the Black Mountains to the east are made up of sedimentary limestones, sandstones, shales, and metamorphic rocks. The bright red areas are dominated by the mineral quartz, found in sandstone; the green areas are limestone. In the lower center of the image is Badwater, the lowest point in North America.

Exploration Lab

Determining Latitude and Longitude

Using maps and globes to find places and features on Earth's surface is an essential skill required of all Earth scientists. The grid that is formed by lines of latitude and longitude form the basis for locating points on Earth. Latitude lines indicate north-south distance and longitude lines indicate east-west distance. Degrees are used to mark latitude and longitude distances on Earth's surface. Degrees can be divided into sixty equal parts called minutes (') and a minute of angle can be divided into sixty parts, called seconds ("). Thus, 31°10'20" means 31 degrees, 10 minutes, and 20 seconds. This exercise will introduce you to the systems used for determining location on Earth.

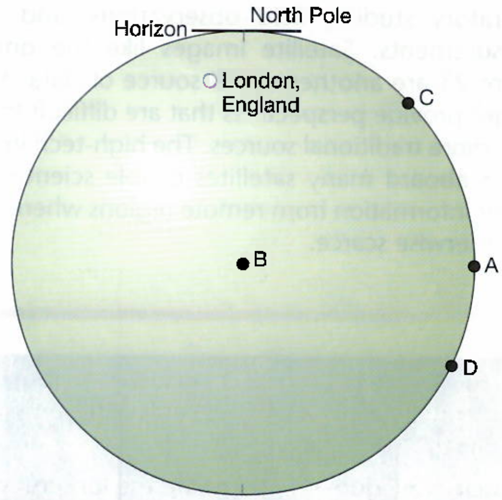

Figure A

Problem

How are latitude and longitude calculated and how do they indicate a particular location's position on the globe?

Materials

- globe
- protractor
- ruler
- compass or round object for tracing
- pencil
- world map

Skills

Interpreting, Measuring, Inferring

Procedure

Part A: Determining Latitude

1. Figure A represents Earth, with point B its center. Draw this figure on a separate piece of paper. Locate the equator on the globe. Sketch and label the equator on your diagram. Label the Northern Hemisphere and Southern Hemisphere on your diagram.
2. On your diagram, make an angle by drawing a line from point A on the equator to point B (the center of Earth). Then extend the line from point B to point C in the Northern Hemisphere. The angle you have drawn (∠ABC) is 45°. By definition of latitude, point C is located at 45° N latitude.
3. Draw a line on your figure through point C that is also parallel to the equator. What is the latitude at all points on this line? Record this number on the line.
4. Using a protractor, measure ∠ABD on your paper. Then draw a line parallel to the equator that also goes through point D. Label the line with its proper latitude.
5. How many degrees of latitude separate the latitude lines (or parallels) on the globe that you are using? Record this on your paper.
6. Refer to Figure B. Determine the latitude for each point A–F. Be sure to indicate whether it is north or south of the equator and include the word "latitude." Record these numbers on your paper.

7. Use a globe or map to locate the cities listed below. On your paper, record their latitude to the nearest degree.
   A. Moscow, Russia
   B. Durban, South Africa
   C. Your home city
8. Use the globe or map to give the name of a city or feature that is equally as far south of the equator as your home city is north.

Part B: Determining Longitude

9. Locate the prime meridian on Figure C. Sketch and label it on your diagram. Label the Eastern and Western Hemispheres.
10. How many degrees of longitude separate each meridian on your globe? Record this on your paper.
11. Refer to Figure C. Determine the longitude for each point A–F. Be sure to indicate whether it is east or west of the Prime Meridian. Record these numbers on your paper.
12. Use the globe or map to give the name of a city or feature that is equally as far east of the prime meridian as your home city is west.

Analyze and Conclude

1. **Applying Concepts** What is the maximum number of 1 degree longitude or latitude lines that can be drawn on a globe?
2. **Comparing and Contrasting** How are longitude and latitude lines the same and how are they different?
3. **Thinking Critically** Amelia Earhart, her flight engineer, and her plane are believed to have been lost somewhere over the Pacific Ocean. It is now thought that the coordinates that she was given for her fuel stop at Howley Island in the Pacific Ocean were wrong. Knowing what you do about how latitude and longitude coordinates are written, why would a wrong number have been so catastrophic for her?

Go Further Use reference books or the Internet to research the number of time zones on Earth. Find out how many there are and draw their boundaries on the figure you created for this lab. What time zone do you live in? What time zone is the location that you chose in question 12? What is the time difference between these two locations?

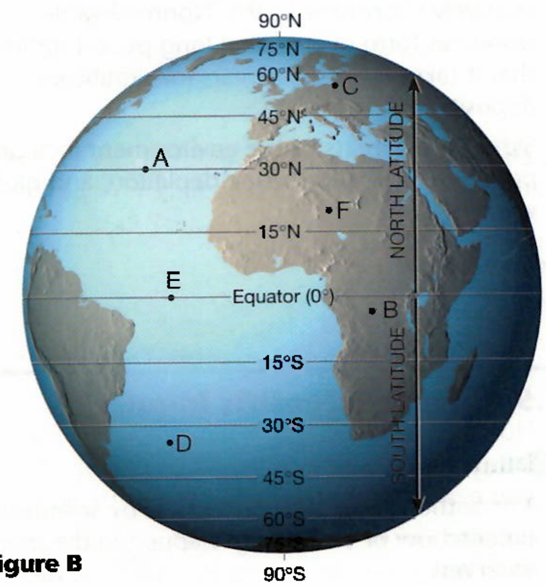

Figure B

Figure C

CHAPTER 1

Study Guide

1.1 What Is Earth Science?

Key Concepts

- Earth science is the name for the group of sciences that deals with Earth and its neighbors in space.
- The nebular hypothesis suggests that the bodies of our solar system eveolved 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.

Vocabulary

Earth science, *p. 2;* geology, *p. 2;* oceanography, *p. 3;* meteorology, *p. 3;* astronomy, *p. 3*

1.2 A View of Earth

Key Concepts

- Earth can be thought of as consisting of four major spheres: the hydrosphere, atmosphere, geosphere, and biosphere.
- Because the geosphere is not uniform, it is divided into three main parts based on differences in composition—the core, the mantle, and the crust.
- The model that explains the position of continents and the occurrence of volcanoes and earthquakes is called plate tectonics.

Vocabulary

hydrosphere, *p. 7* atmosphere, *p. 7;* geosphere, *p. 7;* biosphere, *p. 7;* core, *p. 8;* mantle, *p. 8;* crust, *p. 8*

1.3 Representing Earth's Surface

Key Concepts

- Latitude is the distance north or south of the equator, measured in degrees. Longitude is the distance east or west of the prime meridian, measured in degrees.
- No matter what kind of map is made, some portion of the surface will always look either too small, too big, or out of place. Mapmakers have, however, found ways to limit the distortaion of shape, size, distance, and direction.
- Topographic maps differ from other maps because topographic maps show elevation.
- The elevation of the land is indicated by using contour lines.
- A map that shows the type and age of exposed rock is called a geologic map.
- Today's technology provides us with the ability to more precisely analyze Earth's physical properties.

Vocabulary

latitude, *p. 11;* longitude, *p. 11;* topographic map, *p. 14;* contour line, *p. 14;* contour interval, *p. 14*

1.4 Earth System Science

Key Concepts

- Earth system science aims to study Earth as a system made up of numerous interacting parts, or subsystems.
- A system can be any size group of interacting parts that form a complex whole.
- The sun drives external processes that occur in the atmosphere, hydrosphere, and at Earth's surface. Earth's interior is also a source of energy.
- Our actions produce changes in all other parts of the Earth system.
- Renewable resources can be replenished over relatively short time spans. Nonrenewable resources form over such a long period of time that it takes millions of years for significant deposits to accumulate.
- Significant threats to the environment include air pollution, acid rain, ozone depletion, and global warming.

Vocabulary

system, *p. 18*

1.5 What Is Scientific Inquiry?

Key Concepts

- A hypothesis is a statement made by scientists to explain how or why things happen in the manner observed.
- A scientific theory is well tested and widely accepted by the scientific community and best explains certain observable facts.

Vocabulary

hypothesis, *p. 23;* theory, *p. 24*

CHAPTER 1

Assessment

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Reviewing Content

Choose the letter that best answers the question or completes the statement.

1. The science that deals with the study of the atmosphere is
   - **a.** oceanography.
   - **b.** meteorology.
   - **c.** geology.
   - **d.** astronomy.

2. What caused Earth to develop layers as it cooled?
   - **a.** differences in composition
   - **b.** the magnetic field
   - **c.** the speed of rotation
   - **d.** escaping gases

3. What drives the process of plate tectonics, the currently accepted explanation for the movement of drifting continents?
   - **a.** gravity
   - **b.** ocean currents
   - **c.** unequal heat distribution
   - **d.** earthquakes

4. Lines of latitude describe position
   - **a.** north or south of the equator.
   - **b.** east or west of the equator.
   - **c.** north or south of the prime meridian.
   - **d.** east or west of the prime meridian.

5. The Robinson map projection is considered very useful because
   - **a.** all of the continents are the same size.
   - **b.** most distances, sizes, and shapes are accurate.
   - **c.** it shows landmasses in three dimensions.
   - **d.** features along latitude lines are accurate.

6. Which of the following maps shows the three dimensions of Earth's surface?
   - **a.** Mercator projection
   - **b.** topographic
   - **c.** gnomonic
   - **d.** conic

7. Which type of technology can scientists use to monitor coral reef development?
   - **a.** Landsat satellites
   - **b.** VLBI
   - **c.** computer imaging
   - **d.** weather satellites

8. What makes a hypothesis scientifically useful?
   - **a.** Many people think it is a good idea.
   - **b.** It can be tested.
   - **c.** It contains numerical data.
   - **d.** It applies directly to Earth science.

9. The theory that Earth's lithosphere is broken into large sections that move is called
   - **a.** biosphere.
   - **b.** global positioning.
   - **c.** nebular.
   - **d.** plate tectonics.

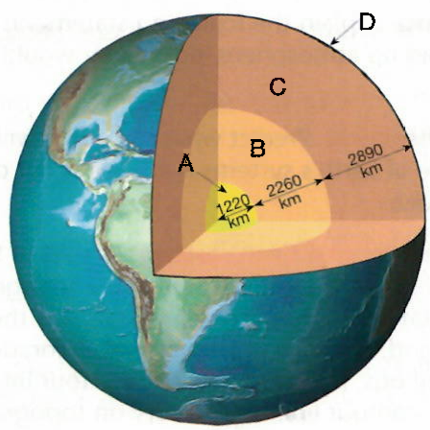
10. On a topographic map, contour lines that are closer together indicate
    - **a.** forest.
    - **b.** a steeper slope.
    - **c.** a mountain top.
    - **d.** roads.

Understanding Concepts

11. Briefly list the events that led to the formation of the solar system.

12. Which of Earth's spheres do mountains, lakes, trees, clouds, ice, and snow represent?

13. List the three parts of the geosphere indicated at the letters in the figure below.



14. The Mercator projection map shows Earth's features on a grid. Why is this map useful to sailors?

15. Why is the contour interval included on a topographic map?

16. What type of satellite is used to monitor cloud cover and air temperature?

17. What happens to matter and energy in a closed system?

18. What types of factors make up our nonliving environment?

CHAPTER 1

Assessment *continued*

19. What are the two sources of energy for the Earth system?

20. What requirements must be satisfied in order for a resource to be considered renewable?

21. List at least four processes that could be regarded as natural hazards.

22. Briefly describe the four steps that most scientific investigations follow.

Critical Thinking

23. **Comparing and Contrasting** How is a scientific hypothesis different from a scientific theory?

24. **Applying Concepts** If oceans cover nearly 71 percent of Earth's surface, why is it important to conserve water?

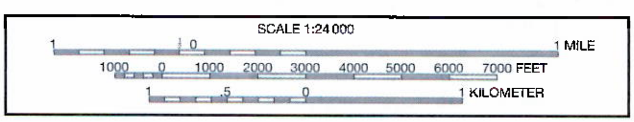
25. **Inferring** Explain the following statement: If Earth had no atmosphere, our planet would be lifeless.

26. **Hypothesizing** Predict what the effect will be on some of Earth's systems if a forest is cut down for lumber.

27. **Comparing and Contrasting** As part of the Great Plains of the United States, the topography of the state of Kansas is relatively flat. On the other hand, portions of the state of Colorado are mountainous. Describe how the contour interval and the contour lines might vary on topographic maps of these two states.

Math Skills

Use the bar graph to answer Questions 28 and 29.



28. **Using Graphs** Approximately how many miles is 1 kilometer equal to?

29. **Calculating** If 1 kilometer is equal to 1 centimeter on the map, what is the distance in km between two cities that are 7.5 cm apart?

30. **Calculating** Recall that Earth is divided into 360 degrees. If you travel to a location that is 90 degrees starting from the prime meridian, how far around the globe have you gone? What about a location that is 120 degrees from the prime meridian?

Map Skills

Use the topographic map in Figure 15 on page 14 to answer Questions 31–33.

31. **Reading Maps** About how wide is Turquoise Lake at its widest point from east to west?

32. **Reading Maps** What is the elevation of Sugar Loaf Mountain?

33. **Reading Maps** How does the land on the east side of Turquoise Lake differ from the land on the southwest side of the lake? How do you know?

Concepts in Action

34. **Applying Concepts** List at least three examples of how you can influence one or more of Earth's major spheres.

35. **Applying Concepts** A local company wants to open a new limestone quarry. Explain what type of map they should use to determine if limestone is present in your area.

36. **Classifying** The planet Mars has been in the news recently. Based on the information that has been reported, list and explain the spheres that are present or might have been present on Mars.

37. **Writing in Science** You are given the opportunity to address the city council about the proposed construction of a dam on the river in your community. Prepare a list of questions about the project that you would like to ask the city council and the dam engineers before deciding whether or not you would support the project.

Standardized Test Prep

Test-Taking Tip

Narrowing the Choices
If, after reading all the answer choices, you are not sure which one is correct, eliminate those answers that you know are wrong. In the question below, read the descriptions provided in I, II, and III. Eliminate any of these that you know to be wrong. Then carefully read the answer choices and choose the one that matches up with your decision above.

Which of these statements is(are) true of geologic maps?

I. They show the location and extent of different rock formations.
II. They indicate the age of each rock formation.
III. They never indicate the topography of the land.
(A) I only
(B) I and II
(C) I, II and III
(D) II only

(Answer: B)

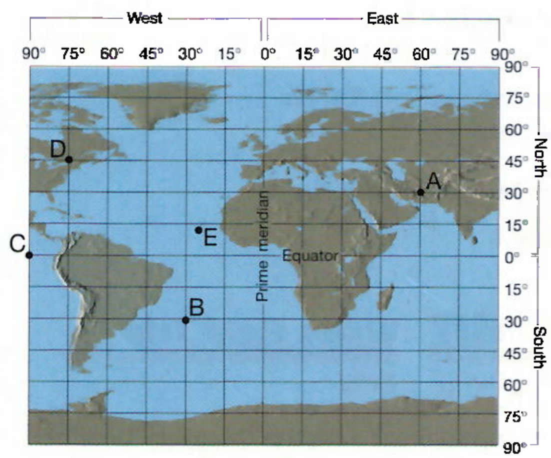
Choose the letter that best answers the question or completes the statement.

1. The _____ strongly influences the other three "spheres" because without life their makeup and nature would be much different.
(A) atmosphere
(B) hydrosphere
(C) geosphere
(D) biosphere

2. The science that includes the study of the composition and movements of water, as well as coastal processes, the seafloor, and marine life is _________.
(A) geology
(B) oceanography
(C) meteorology
(D) astronomy

3. Which of these situations is(are) an example of an open system?
I. a car's cooling system
II. a boiling teakettle
III. a loaf of bread in a sealed plastic bag.
IV. your digestive system
(A) I only
(B) II & IV
(C) I & III
(D) I, II, III & IV

Use the figure below to answer Questions 4, 5, and 6.



4. What is the latitude and longitude for point A on the map?

5. Locate the state of Florida on the map. What is the approximate location of its southernmost point?

6. Why does the continent of Antarctica appear to be stretched out?

7. The three principal layers of Earth are differentiated by their density. List these three layers by increasing density.