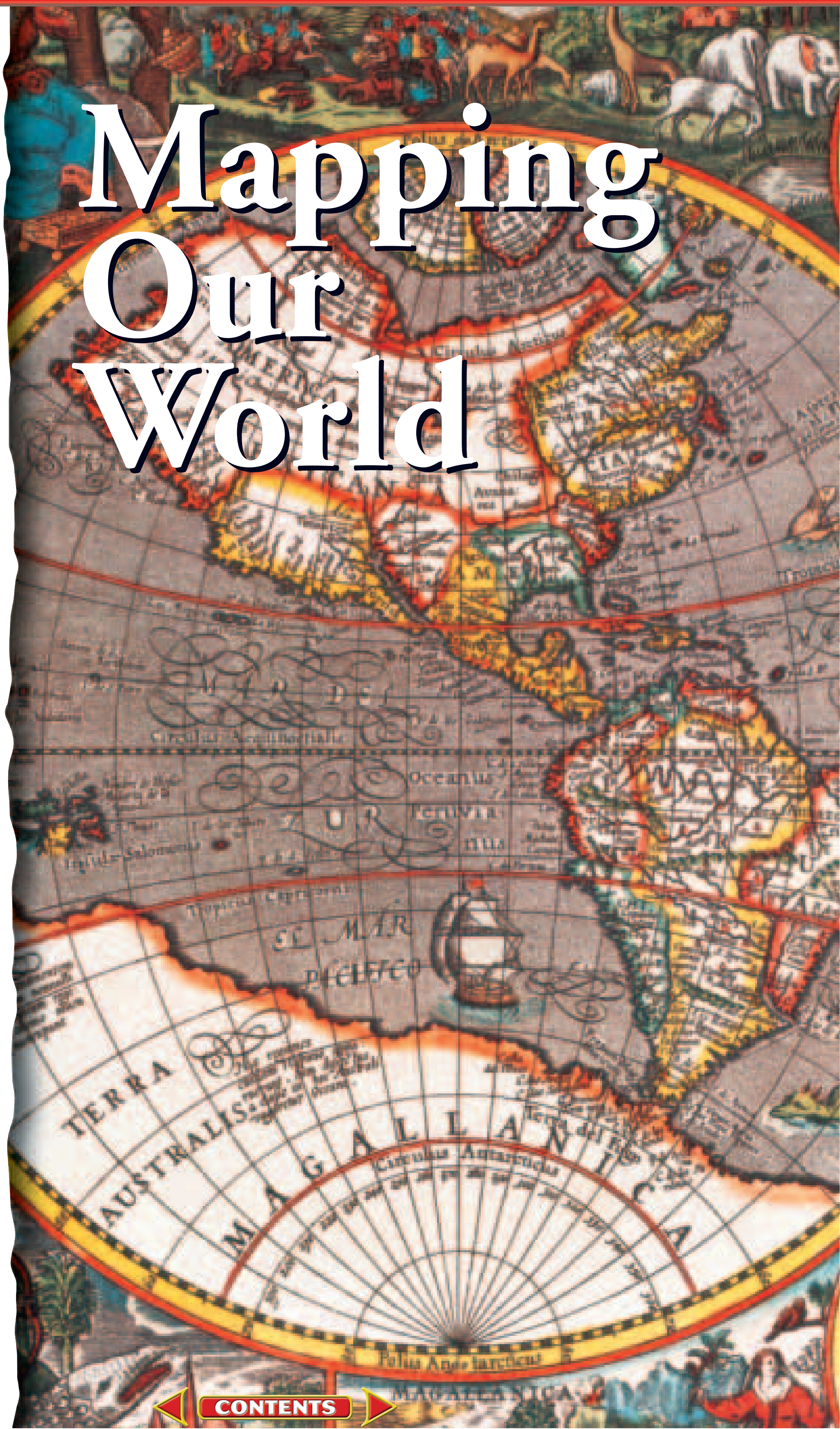
Chapter 2

Mapping Our World



What You'll Learn

- How latitude and longitude are used to locate places on Earth.
- How maps are made, and what types of maps are best suited to particular purposes.
- What technology is used to map Earth from space.

Why It's Important

Maps help us to locate exact places on Earth. All forms of transportation, including ships, planes, cars, and trucks, rely on accurate maps for guidance.

Earth Science Online

To find out more about maps, visit the Earth Science Web Site at earthgeu.com

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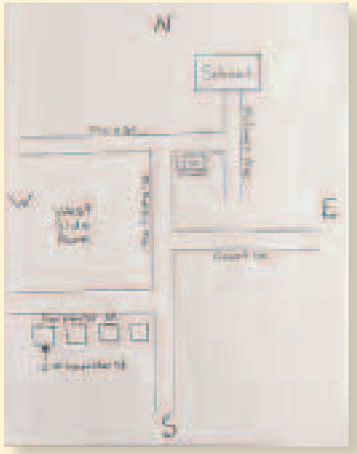
Discovery Lab

Make and Use a Map

Have you ever been asked for directions? If so, you know that it's important to include as much detail as possible so that the person asking for directions will not get lost. You also may have realized that it helps to draw a detailed map of the destination in question.

1. Give verbal directions from your school to your home to a classmate who does not know where you live. Include as much detail as possible in your description.
2. Use a sheet of graph paper and colored pencils to draw a map from your school to your home. Include landmarks and other details. Share this map with your classmate.
3. Have your classmate also give you a description of where his or her home is located in relation to your school. Your classmate should then draw a map to his or her home for you to examine.



Observe Which did you find more helpful, the verbal directions or the map? Explain your answer. What kind of information did you include in your map? With your classmate, discuss how you could improve your maps. What details would you add?

SECTION 2.1 *Latitude and Longitude*

OBJECTIVES

- **Compare** *and* **contrast** *latitude and longitude.*
- **Describe** *how time zones vary.*

VOCABULARY

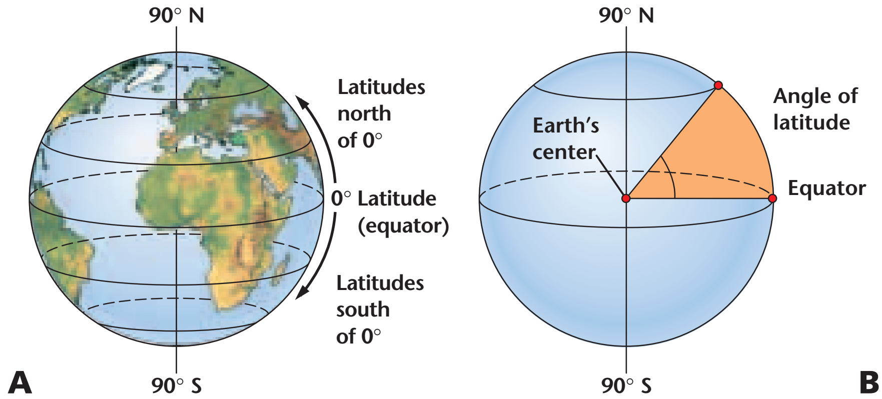
cartography
equator
latitude
longitude
prime meridian
International Date Line

For thousands of years people have used maps such as the one shown at left to define borders and to find places. We still rely on maps for a variety of purposes. The science of mapmaking is called **cartography.** Cartographers use an imaginary grid of parallel lines and vertical lines to locate points on Earth exactly. In this grid, the **equator** circles Earth halfway between the north and south poles. The equator separates Earth into two equal halves called the northern hemisphere and the southern hemisphere.

LATITUDE

Lines running parallel to the equator are called lines of latitude. **Latitude** is the distance in degrees north or south of the equator. The equator, which serves as the reference point for latitude, is numbered 0° latitude. The poles are each numbered 90° latitude. Latitude is thus measured from 0° at the equator to 90° at the poles. Locations

Figure 2-1 Lines of latitude are parallel to the equator **(A).** The value in degrees of each line of latitude is determined by measuring the imaginary angle created between the equator, the center of Earth, and the line of latitude **(B).**



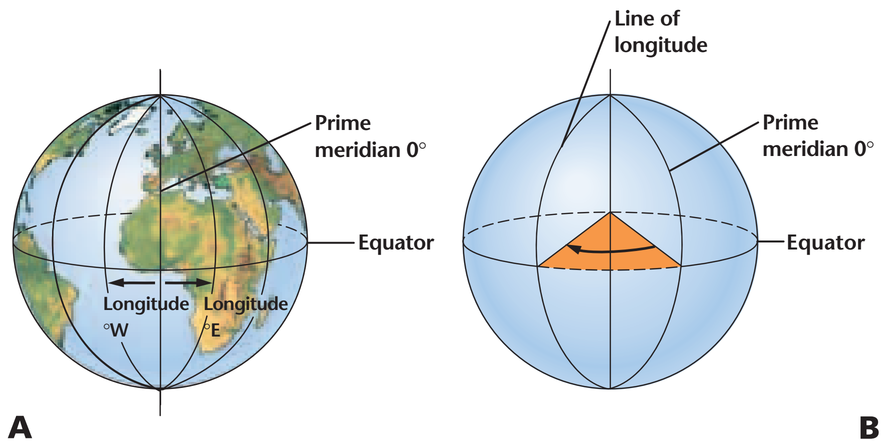
north of the equator are referred to by degrees north latitude (N). Locations south of the equator are referred to by degrees south latitude (S). For example, Syracuse, New York, is located at 43° north latitude, and Christchurch, New Zealand, is located at 43° south latitude. Lines of latitude are illustrated in ***Figure 2-1.***

Using Math

Using Numbers Your plane has flown from 30° north latitude to 42° north latitude. Approximately how many kilometers have you traveled?

Degrees of Latitude Each degree of latitude is equivalent to about 111 km on Earth's surface. How did cartographers determine this distance? Earth is a sphere, and can be divided into 360 degrees. The circumference of Earth is about 40 000 km. To find the distance of each degree of latitude, cartographers divide 40 000 km by 360°. To locate positions on Earth more precisely, cartographers break down degrees of latitude into 60 smaller units, called minutes. The symbol for a minute is ′. The actual distance on Earth's surface of each minute of latitude is 1.85 km, which is obtained by dividing 111 km by 60′. A minute of latitude can be further divided into seconds, which are represented by the symbol ″. Longitude, which is discussed next, is also divided into degrees, minutes, and seconds.

Figure 2-2 The reference line for longitude is the prime meridian **(A).** The degree value of each line of longitude is determined by measuring the imaginary angle created between the prime meridian, the center of Earth, and the line of longitude **(B).**



LONGITUDE

To locate positions in east and west directions, cartographers use lines of longitude, also known as meridians. As shown in ***Figure 2-2,*** **longitude** is the distance in degrees east or west of the prime meridian, which is the reference point for longitude. The **prime meridian** represents 0° longitude. In 1884, astronomers decided that the prime meridian should go through Greenwich, England, home of the Royal Naval Observatory. Points west of the prime meridian are numbered from 0° to 180° west longitude (W); points east of the prime meridian are numbered from 0° to 180° east longitude (E).

Semicircles Unlike lines of latitude, lines of longitude are not parallel. Instead, they are large semicircles that extend vertically from pole to pole. For instance, the prime meridian runs from the north pole through Greenwich, England, to the south pole. The line of longitude on the opposite side of Earth from the prime meridian is the 180° meridian. There, east lines of longitude meet west lines of longitude. This meridian is also known as the International Date Line, as you'll learn later in this section.

Degrees of Longitude Degrees of latitude cover relatively consistent distances. The distances covered by degrees of longitude, however, vary with location. Refer back to ***Figure 2-2.*** As you can see, lines of longitude converge at the poles into a point. Thus, one degree of longitude varies from about 111 km at the equator to essentially the distance covered by a point at the poles.

Locating Places with Coordinates Both latitude and longitude are needed to precisely locate positions on Earth, as you'll see in the *MiniLab* on this page. For example, it is not sufficient to say that New Orleans,

MiniLab

How can you locate places on Earth?

Determine latitude and longitude for specific places.

Procedure

1. Use a world map or globe to locate the prime meridian and the equator.
2. Take a few moments to become familiar with the grid system. Examine lines of latitude and longitude on the map or globe.

Analyze and Conclude

1. Use a map to find the latitude and longitude of the following places.
   Mount St. Helens, Washington
   Niagara Falls, New York
   Mt. Everest, Nepal
   Great Barrier Reef, Australia
2. Use the map to find the name of the places with the following coordinates.
   0°03′S, 90°30′W
   27°07′S, 109°22′W
   41°10′N, 112°30′W
   35°02′N, 111°02′W
   3°04′S, 37°22′E
3. Find the latitude and longitude of your hometown, the nearest national or state park, and your state capital.

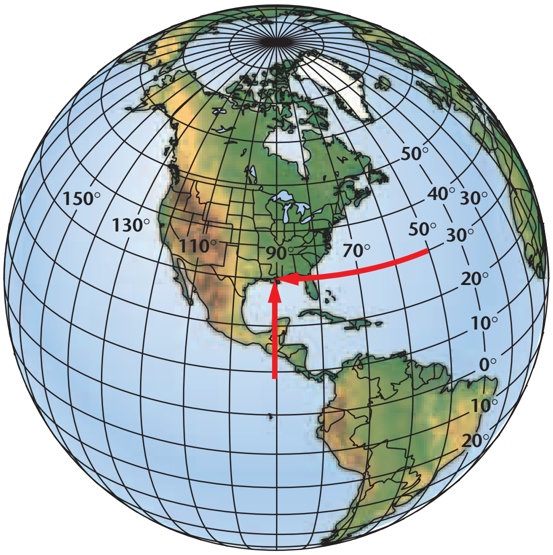


Figure 2-3 The precise location of New Orleans is 29°57′N, 90°04′W.

Louisiana, is located at 29°57′ north latitude because that measurement includes any place on Earth located along the 29°57′ line of north latitude. The same is true of the longitude of New Orleans—90°04′ west longitude could be any point along that longitude from pole to pole. To precisely locate New Orleans, we use its complete coordinates, latitude and longitude, as shown in ***Figure 2-3.*** Note that latitude comes first in reference to the coordinates of a particular location.

Time Zones

As ***Figure 2-4*** shows, Earth is divided into 24 time zones. Why 24? Earth takes about 24 hours to rotate once on its axis. Thus, there are 24 times zones, each representing a different hour. Because Earth is constantly spinning, time is always changing. Each time zone is 15° wide, corresponding roughly to lines of longitude. For convenience's sake, however, time zone boundaries have been adjusted in local areas. For example, if a city were split by a time zone, confusion would result. In such a situation, the time zone boundary is moved outside of the city. Large countries, however, often have several times zones. There are six different time zones in the United States, as shown in ***Figure 2-5.*** When it's 10 A.M. in Atlanta, Georgia, it's 7 A.M. in Los Angeles, California. What time is it in Chicago, Illinois?

Figure 2-4 Earth is divided into 24 time zones. Each zone represents a different hour.

Source: Time Almanac 2001

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Figure 2-5 Large countries such as the United States are often split into multiple time zones. The United States has six time zones, including Alaska and Hawaii.

Calendar Dates Each day ends and the next day begins at the stroke of midnight. Every time zone experiences this transition from one day to the next, with the calendar advancing to the next day at midnight. Each time you travel through a time zone, you gain or lose time until, at some point, you gain or lose an entire day. The **International Date Line,** or 180° meridian, serves as the transition line for calendar days. If you were traveling west across the International Date Line, you would advance your calendar one day. If you were traveling east, you would move your calendar back one day.

Section Assessment

1. What is cartography?
2. Compare and contrast latitude and longitude. What is the reference point for lines of latitude? What is the reference point for lines of longitude?
3. What is the International Date Line? If it is 3 P.M. on Thursday, July 4, in Salt Lake City, Utah, what time and day is it in Tokyo, Japan? Use ***Figure 2-4*** for help.
4. Estimate the time difference between your home and places that are 60° east and west longitude of your home.
5. **Critical Thinking** If you were flying directly south from the north pole and reached 70° north latitude, how many more degrees of latitude would be left to pass over before you reached the south pole?

Skill Review

6. **Comparing and Contrasting** Describe how the distance of a degree of longitude varies from the equator to the poles. For more help, refer to the *Skill Handbook.*

SECTION 2.2 Types of Maps

OBJECTIVES

- **Compare** *and* **contrast** *different map projections.*
- **Analyze** *topographic maps.*
- **Describe** *map characteristics, such as map scales and map legends.*

VOCABULARY

Mercator projection
conic projection
gnomonic projection
topographic map
contour line
contour interval
map legend
map scale

Maps are flat models of a three-dimensional object, Earth. Because Earth is curved, it's difficult to represent on a piece of paper. Thus, all flat maps distort to some degree either the shapes or the areas of landmasses. Cartographers use projections to make maps. A map projection is made by transferring points and lines on a globe's surface onto a sheet of paper. You'll use a projection of a world map in the *Science & Math* feature at the end of this chapter.

MERCATOR PROJECTIONS

A **Mercator projection** is a map that has parallel lines of latitude and longitude. Recall that lines of longitude meet at the poles. When lines of longitude are projected as being parallel on a map, landmasses near the poles are exaggerated. Thus, in a Mercator projection, the shapes of the landmasses are correct, but their areas are distorted. As shown in ***Figure 2-6,*** Greenland appears much larger than Australia. In reality, Greenland is much smaller than Australia. Because Mercator projections show the correct shapes of landmasses and also clearly indicate direction in straight lines, they are used for the navigation of planes and ships.

CONIC PROJECTIONS

A **conic projection** is made by projecting points and lines from a globe onto a cone, as shown in ***Figure 2-7.*** The cone touches the globe at a particular line of latitude. There is very little distortion in the areas or shapes of landmasses that fall along this line of latitude. Distortion is evident, however, near the top and bottom of the projection. Because conic projections have a high degree of accuracy for limited areas, they are excellent for mapping small areas. Hence, they are used to make road maps and weather maps.

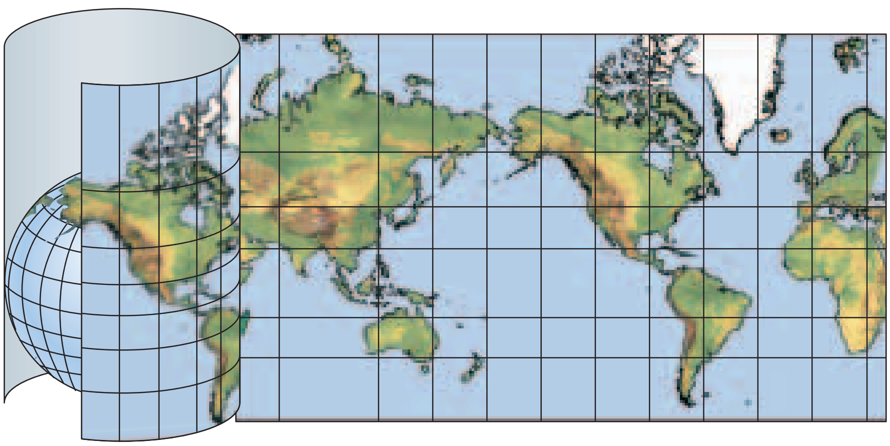


Figure 2-6 In a Mercator projection, points and lines on a globe are transferred onto a cylinder-shaped paper. Mercator projections show true direction but distort areas near the poles.

Gnomonic Projections

A **gnomonic projection** is made by projecting points and lines from a globe onto a piece of paper that touches the globe at a single point. As shown in ***Figure 2-8,*** gnomonic projections distort direction and distance between landmasses. However, they are useful in plotting long-distance trips by air and by sea. To understand why, you must understand the concept of a great circle. Great circles are imaginary lines that divide Earth into two equal halves. The equator is a great circle, as are any two lines of longitude that connect at the poles to form a complete circle. On a sphere such as Earth, the shortest distance between two points lies along a great circle. Navigators connect points on gnomonic projections to plot great-circle routes.

Topographic Maps

Detailed maps showing the hills and valleys of an area are called topographic maps. **Topographic maps** show changes in elevation of Earth's surface. They also show mountains, rivers, forests, and bridges, among other features. Topographic maps use lines, symbols, and colors to represent changes in elevation and features on Earth's surface.

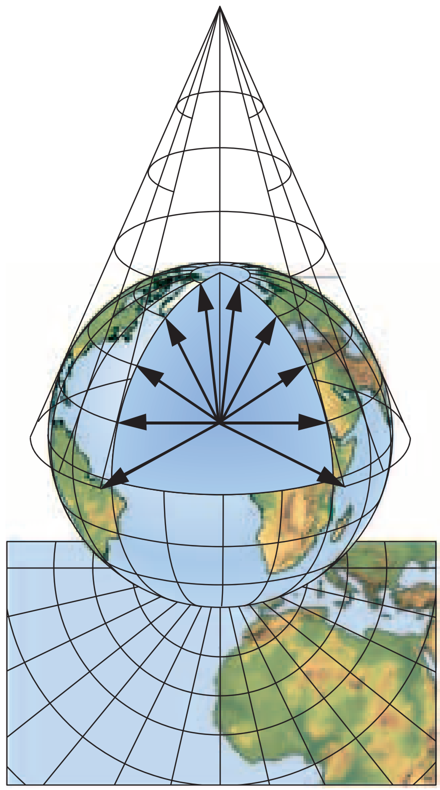


Figure 2-7 In a conic projection, points and lines on a globe are projected onto a cone-shaped paper. Along the line of latitude touched by the paper, there is little distortion.

Contour Lines Elevation on a topographic map is represented by a contour line. A **contour line** connects points of equal elevation. Elevation refers to the distance of a location above or below sea level. Because contour lines connect points of equal elevation, they never cross. If they did, it would mean that the point where they crossed had two different elevations, which would be impossible.

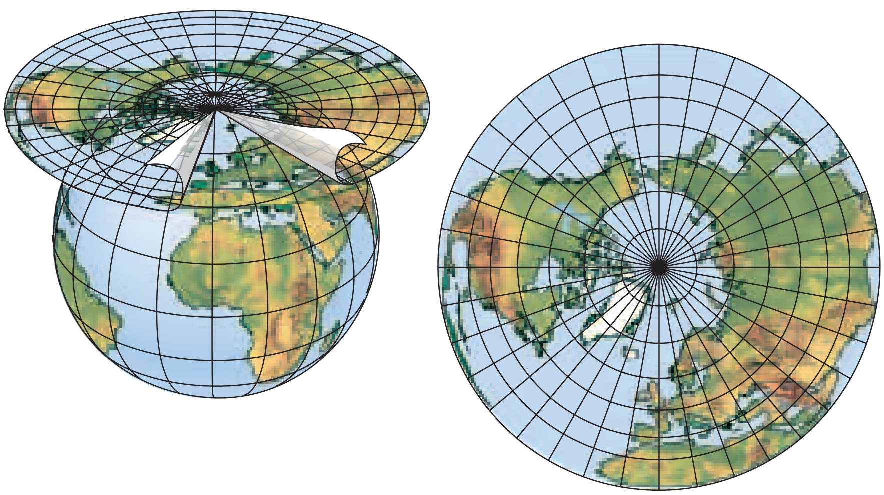


Figure 2-8 In a gnomonic projection, points and lines from a globe are projected onto paper that touches the globe at a single point.

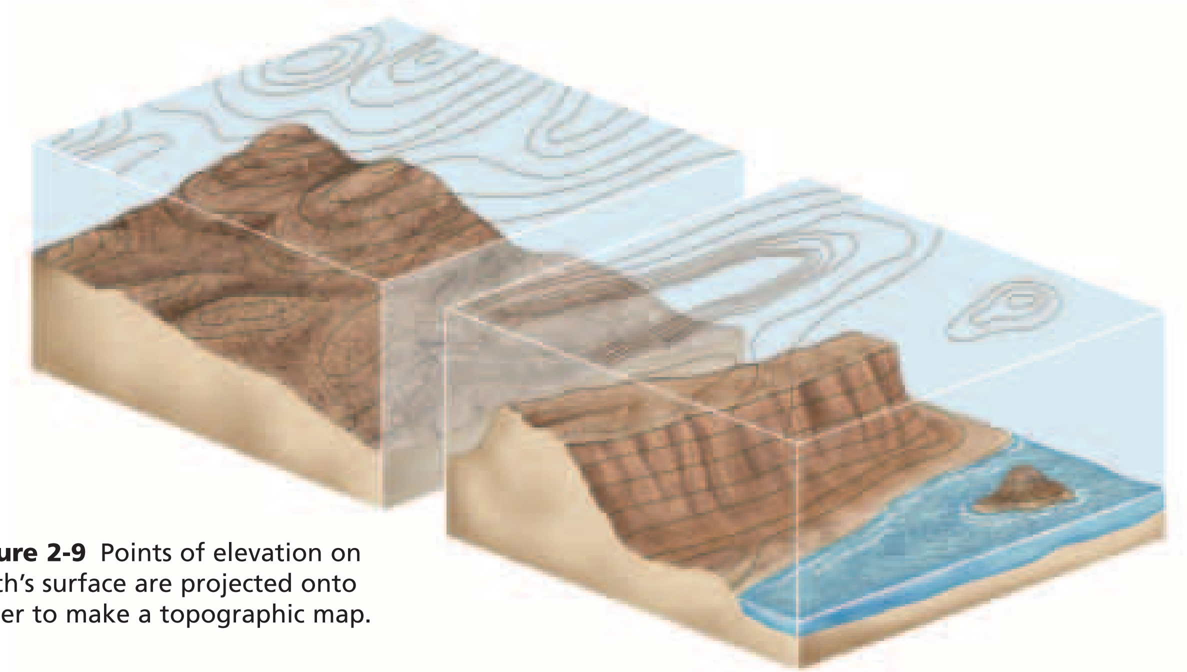


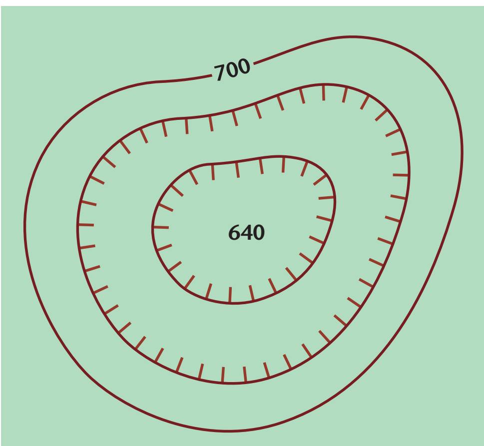
Figure 2-9 Points of elevation on Earth's surface are projected onto paper to make a topographic map.

Contour Intervals As ***Figure 2-9*** shows, topographic maps use contour lines to show changes in elevation. The difference in elevation between two side-by-side contour lines is called the **contour interval.** The contour interval is dependent on the terrain. For mountains, the contour lines might be very close together, and the contour interval might be as great as 100 m. This would indicate that the land is quite steep because there is a large change in elevation between lines. You'll learn more about topographic maps in the *Problem-Solving Lab* on the next page and in the *Mapping GeoLab* at the end of this chapter.

Index Contours To aid in the interpretation of topographic maps, some contour lines are marked by numbers representing their elevations. These are index contours, and they are used hand-in-hand with contour intervals. If a contour interval on a map is 5 m, you can determine the elevations represented by other lines around the index contour by adding or subtracting 5 m from the elevation indicated on the index contour.

Depression Contour Lines The elevations of some features such as volcanic craters and mines are lower than that of the surrounding landscape. Depression contour lines are used to represent such features. On a map, depression contour lines have *hachures,* or short lines at right angles to the contour line, to indicate depressions. The hachures point toward lower elevations, as shown in ***Figure 2-10.***

Figure 2-10 The depression contour lines shown here indicate that the center of the area has a lower elevation than the outer portion of the area.



Map Legends

Topographic maps and most other maps include both human-made and natural features that are located on Earth's surface. These features are represented by symbols, such as black dotted lines for trails, solid red lines for highways, and small black squares and rectangles for buildings. A **map legend,** such as the one shown in ***Figure 2-11,*** explains what the symbols represent. For more information about the symbols in map legends, see *Appendix D.*

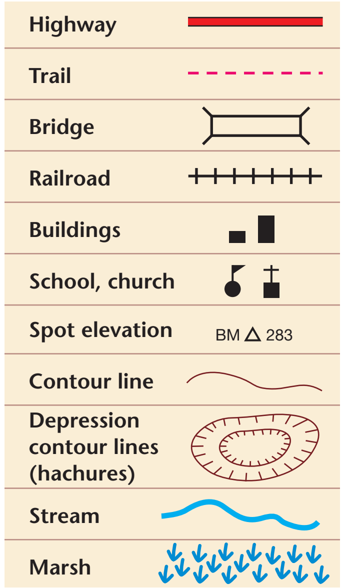


Figure 2-11 Map legends explain what the symbols on maps represent.

Map Scales

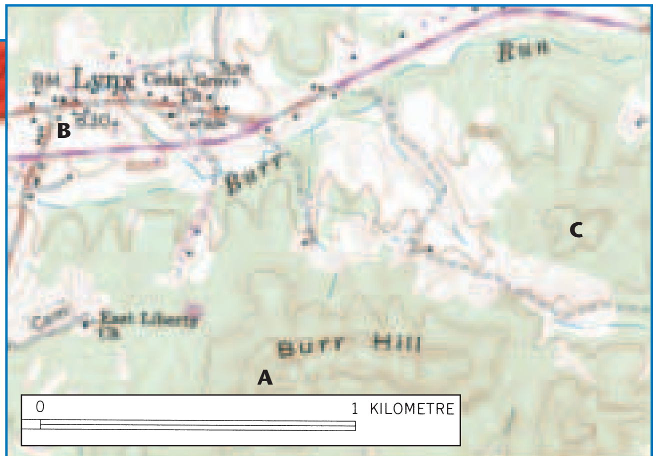
When using a map, you need to know how to measure distances. This is accomplished by using a map scale. A **map scale** is the ratio between distances on a map and actual distances on the surface of Earth. There are three types of map scales: verbal scales, graphic scales, and fractional scales. A verbal scale expresses distance as a statement, such as "One centimeter is equal to one kilometer." This means that one centimeter on the map represents one kilometer on Earth's surface. A graphic scale consists of a line that represents a certain distance, such as 5 km or 5 miles. The line is broken down into sections, with each section representing a distance on Earth's surface. For instance, a graphic scale of 5 km may be broken down into five sections, with each section representing 1 km.

Problem-Solving Lab

Calculating Gradients

Analyze changes in elevation

Gradient refers to the steepness of a slope. To measure gradient, divide the change in elevation between two points on a map by the distance between the points. Use the map to answer the questions; convert your answers to SI.



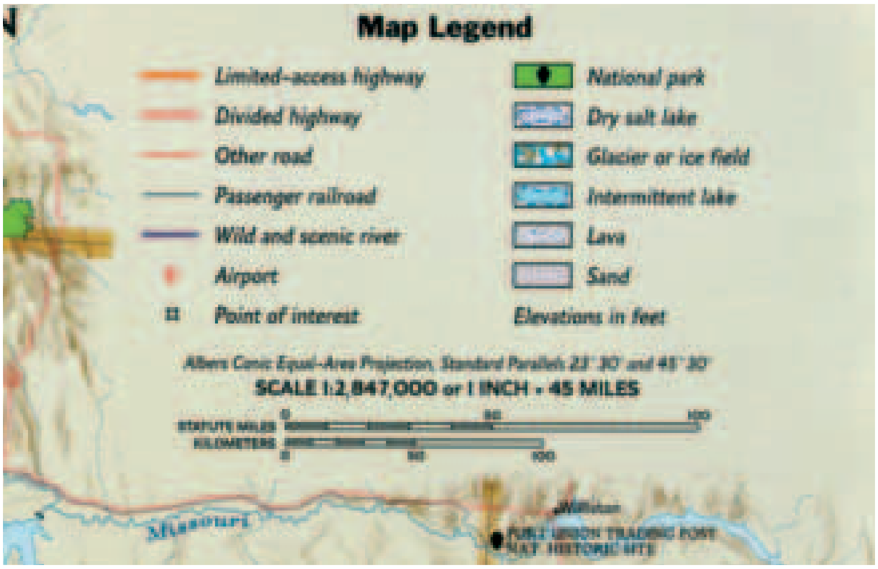
Analysis

1. Use the map scale and a ruler to determine the distance from point A to point B. Record the change in elevation between the two points.
2. If you were to hike this distance, what would be the gradient of your climb?

Thinking Critically

3. Calculate the gradient from point B to point C. Would it be more difficult to hike from point A to point B, or from point B to point C? Explain.
4. Between point A and point C, where is the steepest part of the hike? How do you know?

Figure 2-12 The map scale and legend shown here are from a map of the Rocky Mountain area in Montana.



A fractional scale expresses distance as a ratio, such as 1:63 500. This means that one unit on the map represents 63 500 units on Earth's surface. One centimeter on a map, for instance, would be equivalent to 63 500 cm on Earth's surface. The unit of distance may be feet or meters or any other measure of distance. However, the units on each side of the ratio must always be the same. A large ratio indicates that the map represents a large area, while a small ratio indicates that the map represents a small area. A map with a large fractional scale such as 1:100 000 would therefore show less detail than a map with a small fractional scale such as 1:1000. ***Figure 2-12*** shows the map scale and legend found on a typical map.

SECTION ASSESSMENT

1. Compare and contrast Mercator and gnomonic projections. What are these projections most commonly used for?
2. How is a conic projection made? Why is this type of projection best suited for mapping small areas?
3. What is a contour line? How are areas of depression represented on a topographic map?
4. A topographic map has a fractional scale of 1:80 000. The units are in centimeters. If two cities are 3 km apart, how far apart would they be on the map?
5. **Thinking Critically** The equator is the only line of latitude that is a great circle. Why?

SKILL REVIEW

6. **Interpreting Scientific Illustrations** Use *Appendix D* to draw symbols in their appropriate colors for the following features: barn, school, church, orchard, woods, perennial stream, marsh, and primary highway. For more help, refer to the *Skill Handbook.*

earthgeu.com/self_check_quiz

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Section 2.3 Remote Sensing

Until recently, mapmakers had to go on-site to collect the data needed to make maps. Today, advanced technology has changed the way maps are made. The process of collecting data about Earth from far above Earth's surface is called **remote sensing.** Let's examine how satellites, which use remote sensing, gather information about Earth's surface.

OBJECTIVES

- **Compare** *and* **contrast** *the different forms of radiation in the electromagnetic spectrum.*
- **Discuss** *how satellites and sonar are used to map Earth's surface and its oceans.*
- **Describe** *the Global Positioning System.*

VOCABULARY

remote sensing
electromagnetic spectrum
frequency
Landsat satellite
Topex/Poseidon *satellite*
Global Positioning System
sonar

The Electromagnetic Spectrum

Satellites, such as the one being launched in ***Figure 2-13,*** detect different wavelengths of energy reflected or emitted from Earth's surface. This energy has both electric and magnetic properties. Thus, it is referred to as electromagnetic radiation. Visible light is a form of electromagnetic radiation. Other types include gamma rays, X rays, ultraviolet waves, infrared waves, radio waves, and microwaves.

Wave Characteristics All electromagnetic waves travel at the speed of 300 000 km/s in a vacuum, a value commonly referred to as the speed of light. In addition, electromagnetic waves have distinct

Figure 2-13 *Landsat 7,* launched in 1999, is equipped to measure differences in thermal energy emitted by features on Earth's surface.

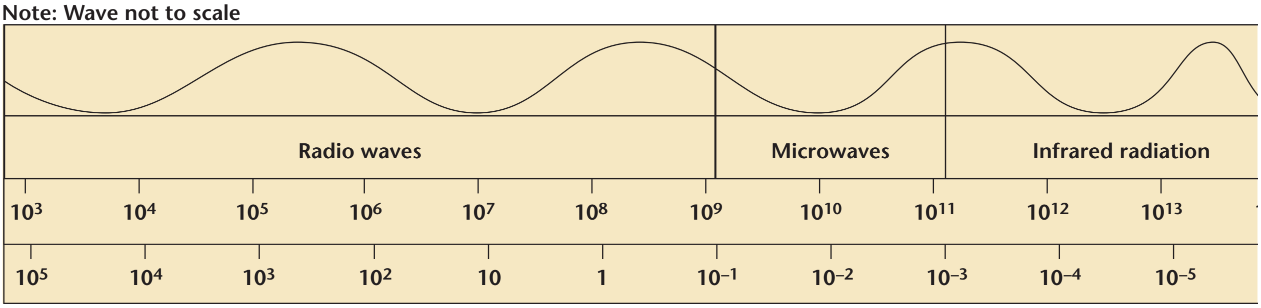
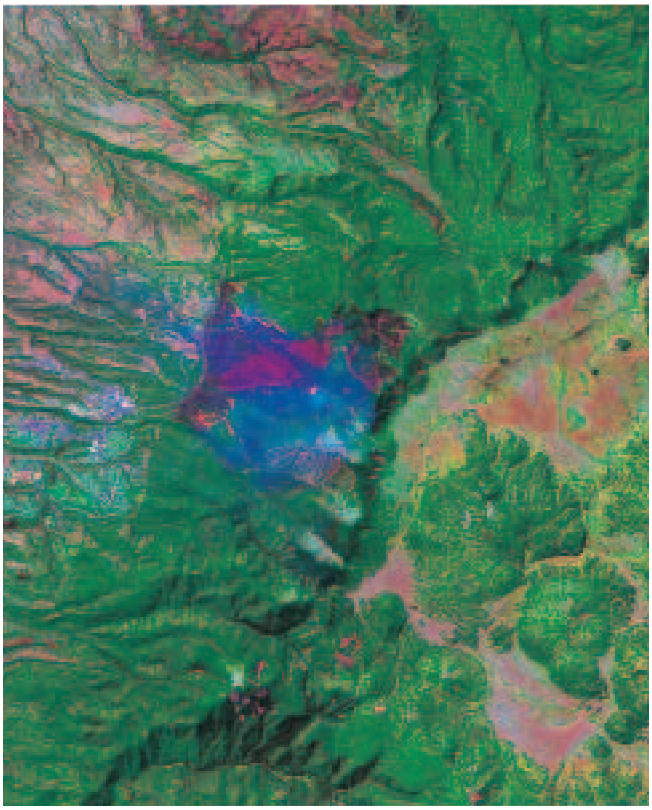


Figure 2-14 In the electromagnetic spectrum, the waves with the longest wavelengths have the lowest frequencies.

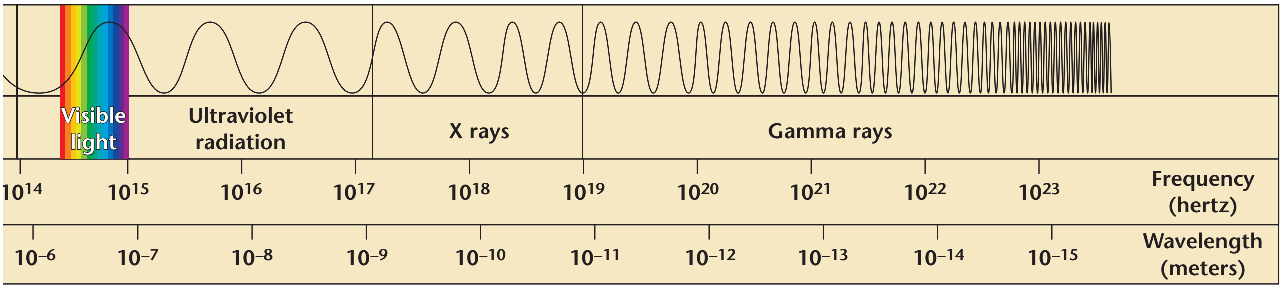
wavelengths. The arrangement of electromagnetic radiation according to wavelengths is called the **electromagnetic spectrum,** as shown in ***Figure 2-14.*** Gamma rays have wavelengths of less than 0.000 000 000 01 m, while radio waves have wavelengths of 100 000 m. An electromagnetic wave also can be described according to its **frequency,** which refers to the number of waves that pass a particular point each second. Gamma rays have the highest frequencies and radio waves have the lowest. The wavelengths, speeds, and frequencies of electromagnetic waves help determine how the energy is used by different satellites to map Earth.

Figure 2-15 The blue area in this *Landsat 7* image shows the range of a fire that occurred in Los Alamos, New Mexico, in May 2000.



Landsat Satellites

A **Landsat satellite** receives reflected wavelengths of energy emitted by Earth's surface, including some wavelengths of visible light and infrared radiation. Features on Earth's surface, such as rivers and forests, radiate warmth at slightly different frequencies. Thus, these features show up as different colors in images such as the one in ***Figure 2-15.*** To obtain such images, each Landsat satellite is equipped with a moving mirror that scans Earth's surface. This mirror has rows of detectors that measure the intensity of energy received from Earth. This information is then converted by computers into digital images that show landforms in great detail. *Landsat 7,* launched in 1999, maps 185 km at a time and scans the entire surface of the planet in 16 days. Landsat data also are used to study the movements of Earth's plates, rivers, earthquakes, and pollution.



Topex/Poseidon Satellite

Other satellites, such as the ***Topex/Poseidon* satellite,** shown in ***Figure 2-16,*** use radar to map features on the ocean floor. *Topex* stands for “topography experiment.” Radar uses high-frequency signals that are transmitted from the satellite to the surface of the ocean. A receiving device then picks up the returning echo as it is reflected off the water. The distance to the water’s surface is calculated using the known speed of light and the time it takes for the signal to be reflected. Variations in time indicate the presence of certain features on the ocean floor. For instance, ocean water bulges over seafloor mountains and forms depressions over seafloor valleys. These changes are reflected in satellite-to-sea measurements. Based on these data, computers create maps of ocean-floor features. The *Topex/Poseidon* satellite also has been used to study tidal changes and global ocean currents.

Figure 2-16 In the *Topex/Poseidon* satellite, an emitter sends an outgoing signal to the surface of the ocean. A receiver times the returning signal. The distance to the ocean’s surface is calculated using the known speed of light and the return time.

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Figure 2-17 This hiker is using a hand-held, GPS receiver.

NATIONAL GEOGRAPHIC

To learn more about mapping, go to the **National Geographic Expedition** on page 864.

The Global Positioning System

The **Global Positioning System** (GPS) is a radio-navigation system of at least 24 satellites that allows its users to determine their exact position on Earth. Each satellite orbits Earth and transmits high-frequency microwaves that contain information about the satellite's position and the time of transmission. The orbits of the satellites are arranged so that signals from several satellites can be picked up at any given moment by a GPS user equipped with a hand-held receiver, as shown in ***Figure 2-17.*** The receiver calculates the user's precise latitude and longitude by processing the signals emitted by multiple satellites. The satellites also can relay information about elevation, direction, and speed. GPS technology is used extensively for navigation by airplanes and ships. However, it is also used to detect earthquakes, create maps, and track wildlife. Lately, it has become increasingly popular among hikers, backpackers, and other travelers.

Sea Beam

Sea Beam technology is similar to the *Topex/Poseidon* satellite in that it is used to map the ocean floor. However, Sea Beam is located on a ship rather than on a satellite. To map ocean-floor features, Sea Beam relies on **sonar,** which is the use of sound waves to detect and measure objects underwater. First, a sound wave is sent from a ship toward the ocean floor, as shown in ***Figure 2-18.*** A receiving device then picks up the returning echo when it bounces off the seafloor. Computers on the ship calculate the distance to the ocean bottom

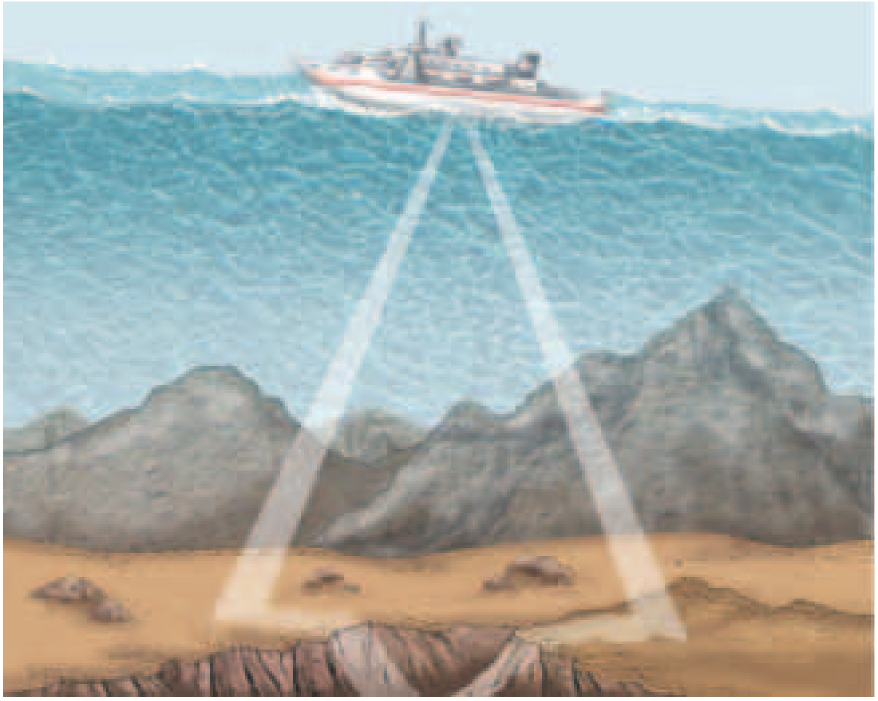


Figure 2-18 In a ship equipped with Sea Beam, a sound wave is sent to the ocean floor. The wave bounces off the seafloor and its returning echo is recorded by a receiver on the ship. The distance to the ocean floor is then calculated using the known speed of sound in water and the return time of the sound wave.

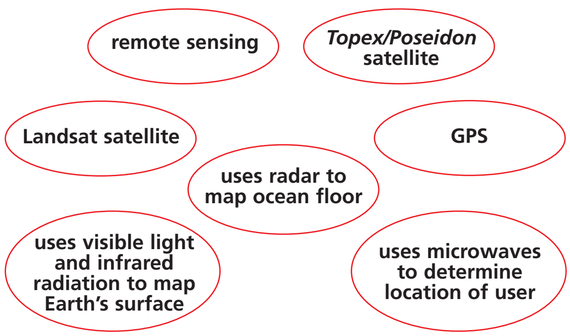
using the speed of sound in water and the time it takes for the sound to be reflected. A ship equipped with Sea Beam has more than a dozen sonar devices aimed at different parts of the sea. Sea Beam technology is used by fishing fleets, deep-sea drilling operations, and scientists such as oceanographers, volcanologists, and archaeologists.

SECTION ASSESSMENT

1. What is the electromagnetic spectrum? Sequence the forms of electromagnetic radiation from longest wavelength to shortest wavelength.
2. How do Landsat satellites collect and analyze data to map Earth's surface?
3. What features are mapped by the *Topex/Poseidon* satellite? Describe the mapping process.
4. Describe the Global Positioning System.
5. **Thinking Critically** Explain why electromagnetic waves with short wavelengths have higher frequencies than electromagnetic waves with long wavelengths.

SKILL REVIEW

6. **Concept Mapping** Use the following words and phrases to complete a concept map about remote sensing. For more help, refer to the *Skill Handbook.*



Mapping GeoLab

Using a Topographic Map

Topographic maps show two-dimensional representations of Earth's surface. With these maps, you can determine how steep a hill is, what direction streams flow, and where mines, wetlands, and other features are located.

Preparation

Problem

How can you use a topographic map to interpret information about an area?

Materials

ruler
pencil
string

Procedure

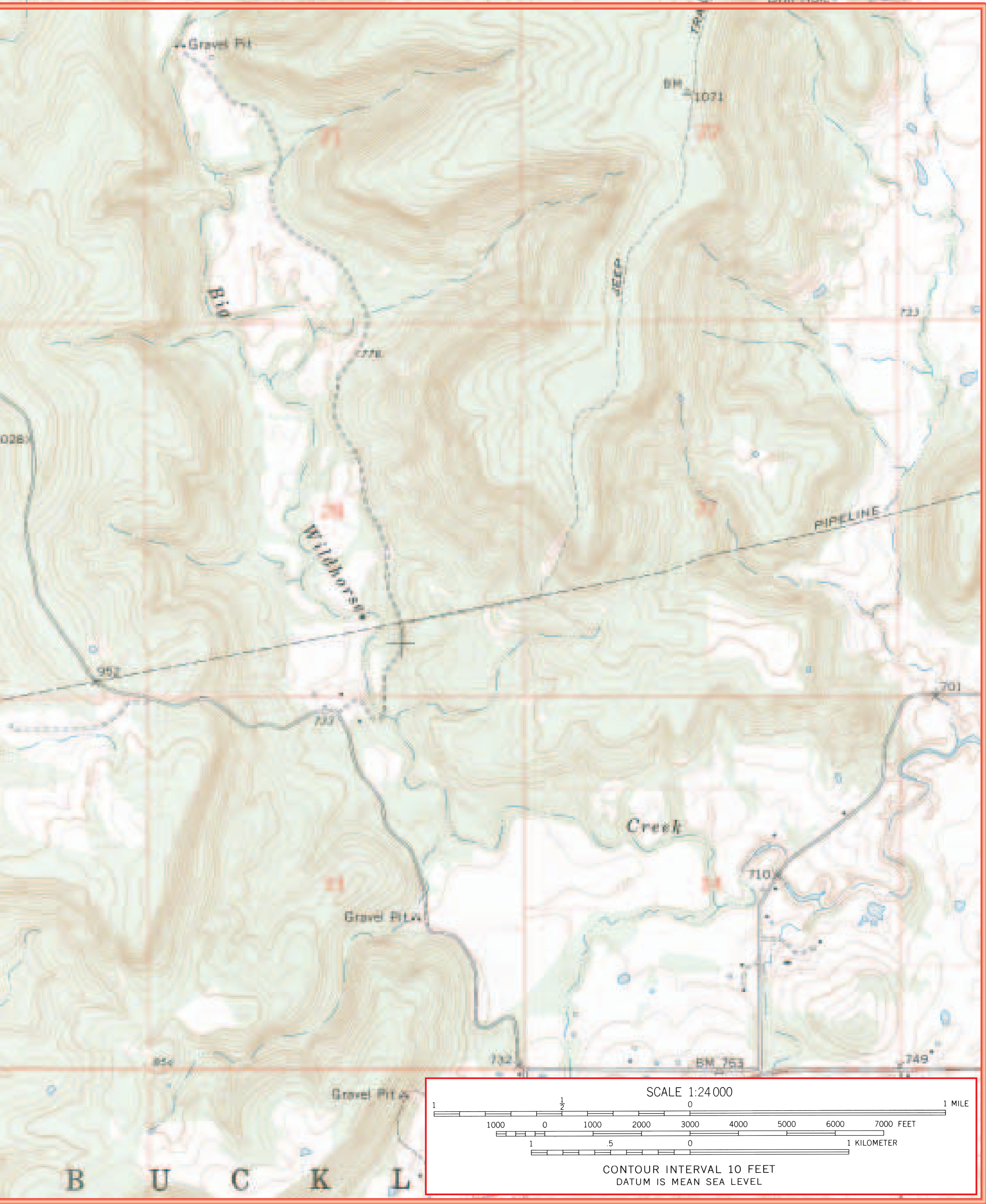
1. Use the map to answer the following questions. Be sure to check the map's scale.
2. Use the string to measure distances between two points that are not in a straight line. Lay the string along the curves, and then measure the distance by laying the string along the ruler.
3. Remember that elevations on United States Geological Survey maps are given in feet.

Analyze

1. What is the contour interval?
2. Calculate the stream gradient of Big Wildhorse Creek from the Gravel Pit in section 21 to where the creek crosses the road in section 34.
3. What is the highest elevation of the jeep trail? If you followed the jeep trail from the highest point to where it intersects an unimproved road, what would be your change in elevation?
4. If you started at the bench mark (BM) on the jeep trail and hiked along the trail and the road to the Gravel Pit in section 21, how far would you have hiked?
5. What is the straight line distance between the two points in question 4? What is the change in elevation?

Conclude & Apply

1. Does Big Wildhorse Creek flow all year round? Explain your answer.
2. What is the shortest distance along roads from the Gravel Pit in section 21 to the secondary highway?
3. Draw a profile of the land surface from the bench mark in section 22 to the Gravel Pit in section 33.


Drill Hole
Gravel Pit
BM 1071
JEEP
Wildhorse
PIPELINE
952
701
Creek
710
Gravel Pit
Gravel Pit
732
BM 763
749
B U C K L
SCALE 1:24 000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

Science & Math


Polar bear

Thriving in the Arctic

How do you envision conditions in the arctic circle, which surrounds the north pole? Barren of life? Not quite! More than 20 000 polar bears live in this region, along with many other species. These hardy animals have unique adaptations that allow them to survive the harsh climate.

The Ring of Life

The borders of five countries—Russia, Norway, Greenland, Canada, and the United States—meet in a rough U-shape around the Arctic Ocean. The vast majority of this region is covered with ice some 2 m thick. In a climate where average winter temperatures hover around –35°C, survival is tenuous. The southern boundaries of this region, however, teem with life. Polar bears, walruses, beluga whales, fish, birds, and seals make the arctic circle their home.

Animal Adaptations

Polar bears in particular thrive where the ocean meets the shoreline, an area of constant freezing and thawing. Supremely adapted to this environment, they have long necks that help them keep their heads above water and huge forepaws that act as paddles. Light-colored fur provides camouflage to help them hunt, and an outer coat of hollow hairs makes the half-ton bears fairly buoyant in the water.

Traveling Bears

Polar bears can swim for an average of approximately 96.5 km without stopping for a rest. They have been tracked on land traveling 30 km a day for several days in a row. A polar bear's home range—the area in which it hunts, mates, and cares for its young—may be around 259 000 km^2. The home ranges of polar bears vary in size from 50 000 km^2 to as much as 350 000 km^2. Polar bear ranges are much greater than those of other mammals because the sea ice on which they live changes from season to season and year to year.

Procedure

1. Calculate the range of a polar bear that travels for six hours a day for seven days at a speed of 5.5 km/h.
2. Calculate how far a polar bear could swim in six hours at a speed of 10 km/h.
3. Convert your answers for questions 1 and 2 into U.S. units.

Challenge

1. Assume that polar bears do equal amounts of swimming and walking, and that they travel an average of four hours a day. Use your calculations and a world map or globe to determine whether a polar bear could travel around the circumference of Greenland in a year.

Earth Science Online

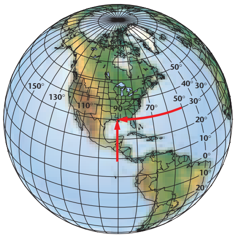
To find out more about polar bears, visit the Earth Science Web Site at earthgeu.com

CHAPTER 2 Study Guide

Summary

SECTION 2.1

Latitude and Longitude



Main Ideas

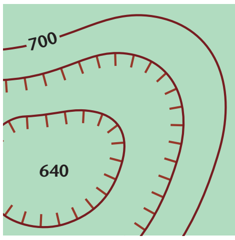
- Cartographers use a grid system to locate exact positions on Earth. Lines of latitude refer to distances north and south of the equator. Lines of longitude refer to distances east and west of the prime meridian.
- Earth is divided into 24 time zones. Each zone represents a different hour. The International Date Line, or 180° meridian, is the transition line for calendar days. The calendar advances to the next day in each time zone at midnight.

Vocabulary

cartography (p. 27)
equator (p. 27)
International Date Line (p. 31)
latitude (p. 27)
longitude (p. 29)
prime meridian (p. 29)

SECTION 2.2

Types of Maps



Main Ideas

- Maps are flat models of Earth's surface. All maps contain some sort of distortion in the shapes or areas of landmasses.
- Maps are made by transferring points and lines on a globe onto paper. Mercator projections and gnomonic projections are commonly used for navigation by ships and planes. Conic projections are best suited for mapping small areas.
- Topographic maps show changes in elevation of Earth's surface. Contour lines connect points of equal elevation. A map legend explains the symbols on a map. A map scale shows the relationship between distances on a map and actual distances on Earth.

Vocabulary

conic projection (p. 32)
contour interval (p. 34)
contour line (p. 33)
gnomonic projection (p. 33)
map legend (p. 35)
map scale (p. 35)
Mercator projection (p. 32)
topographic map (p. 33)

SECTION 2.3

Remote Sensing

Main Ideas

- The process of gathering data about Earth from far above the planet is called remote sensing. The electromagnetic spectrum shows the arrangement of electromagnetic radiation, which is often used by remote-sensing devices to map Earth.
- Landsat satellites use visible light and infrared radiation to map Earth's surface. The *Topex/Poseidon* satellite uses radar to map features on the ocean floor.
- The Global Positioning System is a satellite-based navigation system that allows a user to pinpoint his or her exact location on Earth.

Vocabulary

electromagnetic spectrum (p. 38)
frequency (p. 38)
Global Positioning System (p. 40)
Landsat satellite (p. 38)
remote sensing (p. 37)
sonar (p. 40)
Topex/Poseidon satellite (p. 39)

earthgeu.com/vocabulary_puzzlemaker

CHAPTER 2

Assessment

Understanding Main Ideas

1. What feature on a map shows the ratio of map distance to actual distance on Earth?
   a. map legend
   b. map scale
   c. map symbol
   d. contour line

2. What type of map shows changes in elevation on Earth's surface?
   a. Mercator projection
   b. gnomonic projection
   c. topographic map
   d. GPS

3. Which of the following is NOT true of lines of longitude?
   a. They are semicircles.
   b. They measure distances east and west of the prime meridian.
   c. They run from pole to pole.
   d. They are parallel lines.

4. What technology is used to map seafloor features?
   a. conic projections
   b. *Topex/Poseidon* satellite
   c. the Global Positioning System
   d. Landsat satellite

5. What is the main disadvantage of a Mercator projection?
   a. It distorts areas near the equator.
   b. It distorts the shapes of landmasses.
   c. It distorts areas near the poles.
   d. It does not show true direction.

6. What is the reference point for lines of latitude?
   a. the equator
   b. the prime meridian
   c. the International Date Line
   d. the 180° meridian

7. What is the distance of one degree of latitude?
   a. 11 km
   b. 111 km
   c. 40 000 km
   d. 1.85 km

8. Some areas have lower elevations than the surrounding land. Which of the following represents these areas on a topographic map?
   a. index contours
   b. contour intervals
   c. depression contour lines
   d. map legends

9. What is the Global Positioning System? Describe how it might be used by a hiker lost in the woods.

10. Compare and contrast a verbal scale, a graphic scale, and a fractional scale.

11. Would a topographic map of the Great Plains have a large or small contour interval? Explain.

12. Why can't two contour lines overlap?

13. How could you leave home on Monday to go sailing, sail for an hour on Sunday, and return home on Monday?

14. What is a map legend? Give examples of features found in a map legend.

Applying Main Ideas

15. What type of map would best show true direction?

16. Do closely spaced contour lines indicate a steep slope or a gradual slope? Explain.

Test-Taking Tip

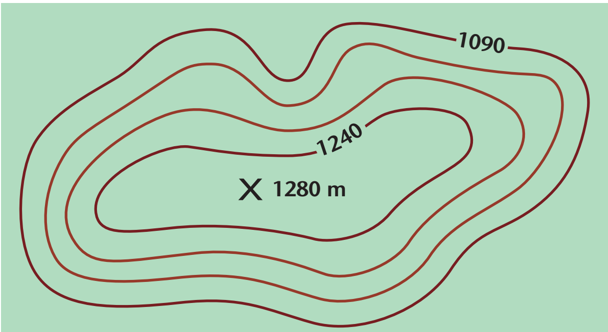
WHERE HAVE I HEARD THAT BEFORE? If you don't know the definition of a word, you can usually work through the question by thinking about how you've heard the word used before. Think about the context in which the word was used. This will narrow its meaning.

CHAPTER 2
Assessment

17. Approximately how many kilometers separate Orlando, Florida, at 29° north latitude and Cleveland, Ohio, at 41° north latitude?

18. If it is 10 A.M. in Syracuse, New York, at 76° west longitude, what time is it in Athens, Greece, at 24° east longitude?

Use the map to answer questions 19–21.



19. Copy the map shown here. What is its contour interval?

20. Based on the contour interval, label the elevations of all the contour lines.

21. Does the map represent a flat or hilly terrain? Explain.

Thinking Critically

22. Would a person flying from Virginia to California have to set his or her watch backward or forward? Explain.

23. If you wanted to study detailed features of a volcano on the island of Hawaii, would you use a map with a scale of 1:150 or 1:150 000? Why?

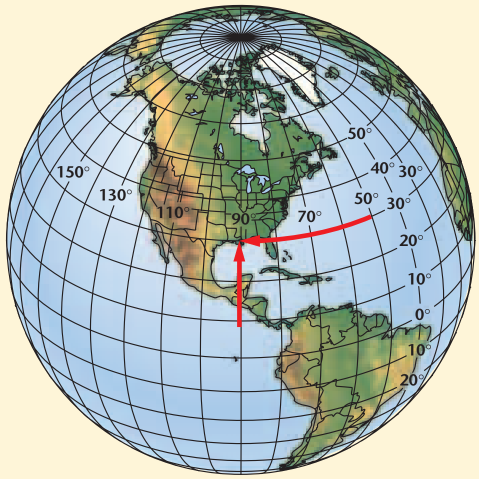
24. Based on what you have learned in this chapter, infer how astronomers map objects in the night sky.

25. Which direction would you travel along Earth's surface so that your longitude would not change? Explain your answer.

Standardized Test Practice

1. What is the reference point for lines of longitude?
- **a.** the equator
- **b.** the prime meridian
- **c.** the International Date Line
- **d.** the 360th meridian

2. Which would be most useful if you were lost in the Sahara desert?
- **a.** Landsat satellite
- **b.** *Topex/Poseidon* satellite
- **c.** Global Positioning System
- **d.** topographic map of Africa



USING MAPS Use the map to answer questions 3 and 4.

3. Roughly how many degrees of longitude does the United States cover?
a. 10° **b.** 20° **c.** 30° **d.** 40°

4. Roughly how many degrees of latitude does the United States cover?
a. 10° **b.** 15° **c.** 20° **d.** 25°

UNIT 1

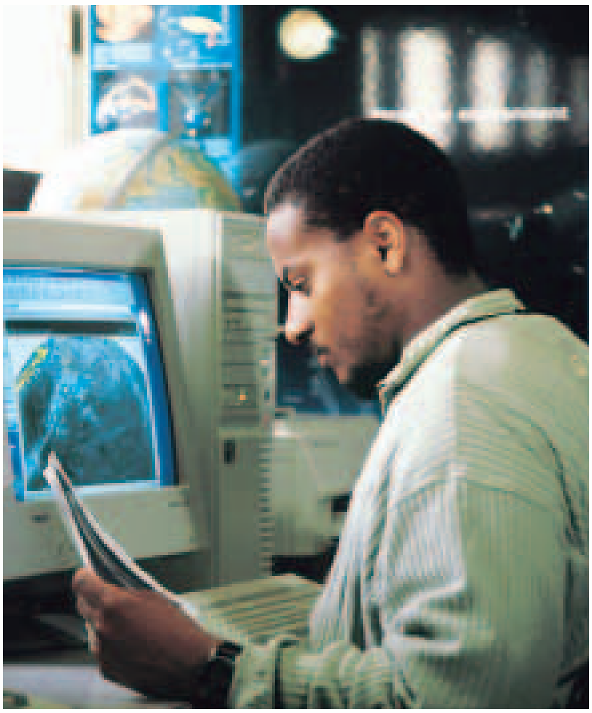
GeoDigest

For a **preview** of Earth science, study this GeoDigest before you read the chapters. After you have studied the unit, you can use the GeoDigest to **review.**

Earth Science

The Nature of Science

Earth Science Earth science is divided into four areas of specialization. Astronomy studies objects beyond Earth's atmosphere. Meteorology studies the atmosphere. Geology studies the materials of Earth and the processes that form them. Oceanography studies the oceans. The application of scientific discoveries is technology. Earth is made up of interacting systems. The lithosphere includes the rocks that make up the crust and upper mantle. The atmosphere is the gas layer that surrounds Earth. The hydrosphere is Earth's water. The biosphere is all of the life and habitats on Earth.



Methods and Communication Most scientific methods include defining the problem, stating a hypothesis, testing the hypothesis, analyzing the results of the test, and drawing conclusions. In the testing step, variables are factors in an experiment that change. A dependent variable changes in response to the independent variable. A control is a standard for comparison. Scientists use standard units of SI—liter, meter, second, kilogram, Newton, and degree Celsius. Scientists also use scientific notation, in which a number is expressed as a multiplier and a power of ten. Scientists communicate in reports and papers, and use tables, graphs, and models. A scientific theory is an explanation based on observations from repeated experiments. It is valid only if it is consistent with observations, leads to testable predictions, and is the simplest explanation. Scientific theories are changed if they are found to be incorrect. A scientific law is a basic fact that describes the behavior of a natural phenomenon.

FOCUS ON CAREERS

Science Teacher

Science teachers often provide a student's first exposure to science and may spark a life-long interest in a particular topic. High school science teachers must have at least a bachelor's degree, often from a five-year program, with an emphasis in their area of interest, such as Earth science.

GeoDigest

Mapping Our World

Latitude, Longitude, and Maps

Cartographers use a grid system of latitude and longitude to locate exact positions on Earth. Latitude refers to distances north and south of the equator. Longitude refers to distances east and west of the prime meridian. Earth is divided into 24 time zones, with each zone representing a different hour. The International Date Line, or the 180° meridian, is the transition line for calendar days. Maps are flat models of Earth's round surface, thus all maps contain some sort of distortion. Maps are made by transferring points and lines on a globe onto paper. A map legend explains map symbols. A map scale shows how distances on a map and actual distances on Earth are related. Mercator and gnomonic projections are used for aircraft and ship navigation. Conic projections are suited to mapping small areas. Topographic maps show changes in elevation of Earth's surface. Gathering data about Earth from far above is called remote sensing. Examples of remote-sensing devices include *Landsat* satellites, the *Topex-Poseidon* satellite, and the Global Positioning System. These different types of technology can be used to map Earth's surface and oceans, and to locate places on Earth.

Vital Statistics

Earth's Land Area

Continent	Area in km^2
Asia, Middle East	44 579 000
Africa	30 065 000
North America	24 256 000
South America, Central America, and Caribbean	17 819 000
Antarctica	13 209 000
Europe	9 938 000
Australia and Oceania	7 687 000
Earth Total	**148 429 000**

ASSESSMENT

Understanding Main Ideas

1. Which of the following is an area of specialization in Earth science?
   - **a.** hydrosphere
   - **b.** Mercator projection
   - **c.** meteorology
   - **d.** remote sensing
2. What happens if a scientific theory is found to be incorrect?
   - **a.** It is published.
   - **b.** It is changed.
   - **c.** It becomes a scientific law.
   - **d.** It becomes a control.
3. Which type of map shows changes in elevation of Earth's surface?
   - **a.** conic projection
   - **b.** gnomonic projection
   - **c.** topographic map
   - **d.** latitude map
4. What does a map legend contain?
   - **a.** contour lines
   - **b.** longitude lines
   - **c.** latitude lines
   - **d.** the symbols used in a map
5. What is the application of science called?
   - **a.** technology
   - **b.** latitude
   - **c.** scientific law
   - **d.** theory

Thinking Critically

1. Describe the steps commonly used in scientific methods.
2. Why isn't a conic projection used to navigate a ship or aircraft?