

## Mapping Our World

**BIG (mtml)** Earth scientists use mapping technologies to investigate and describe the world.

### 2.1 Latitude and Longitude

**MAIN 1, 1m** Lines of latitude and longitude are used to locate places on Earth.

### 2.2 Types of Maps

**MAIN {G}** Maps are flat projections that come in many different forms.

### 2.3 Remote Sensing

**MAIN rG** New technologies have changed the appearance and use of maps.

## GeoFacts

- Maps predate written history. The earliest known map was created as a cave painting in ancient Turkey.
- China spans five international time zones; however, the entire country operates on only one standard time.
- Global Positioning System (GPS) satellites were originally designed for strategic defense and navigation purposes.





# Start-Up Activities

## LAUNCH Lab

### Can you make an accurate map?

If you have ever been asked to give someone directions, you know that it is important to include as many details as possible so that the person asking for directions will not get lost. Perhaps you drew a detailed map of the destination in question.

#### Procedure

1. Read and complete the lab safety form.
2. With a classmate, choose a location in your school or schoolyard.
3. Use a sheet of **graph paper** and **colored pencils** to draw a map from your classroom to the location you chose. Include landmarks such as drinking fountains and restrooms.
4. Share your map with a classmate. Compare the landmarks you chose and the path each of you chose to get to your locations. If they were different, explain why.
5. Follow your map to the location you and your partner chose. Was your map correct? Were there details you left out that might have been helpful?

#### Analysis

1. **Discuss** with your classmate how you could improve your maps.
2. **Examine** What details could you add?

## FOLDABLES™ Study Organizer

**Types of Mapping Technologies**  
Make this Foldable to help organize information about the four major types of mapping technologies.

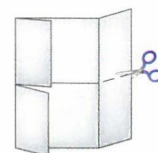
- ▶ **STEP 1** Find the middle of a horizontal sheet of paper and mark it. Fold the left and right sides of the paper to the middle and crease the folds.



- ▶ **STEP 2** Fold the piece of paper in half.



- ▶ **STEP 3** Open the last fold and cut along the fold lines to make four tabs.



- ▶ **STEP 4** Label the tabs *Landsat*, *GPS/GIS*, *TOPEXI*, and *Sea Beam*.



**Use this Foldable with Section 2.3.**

As you read this section, summarize information about the mapping technologies.



Visit [glencoe.com](http://glencoe.com) to

- ▶ study entire chapters online;
- ▶ explore **concepts** in **Motion** animations:
  - Interactive Time Lines
  - Interactive Figures
  - Interactive Tables
- ▶ access Web Links for more information, projects, and activities;  
review content with the Interactive Tutor and take Self-Check Quizzes.

## Section 2.1

### Objectives

- t **Describe** the difference between latitude and longitude.
- t **Explain** why it is important to give a city's complete coordinates when describing its location.
- t **Explain** why there are different time zones from one geographic area to the next.

### Review Vocabulary

**time zone:** a geographic region within which the same standard time is used

### New Vocabulary

cartography  
equator  
latitude  
longitude  
prime meridian  
International Date Line

## Latitude and Longitude

**Key Concept** Lines of latitude and longitude are used to locate places on Earth.

**Real-World Reading Link** Imagine you were traveling from New York City, New York, to Los Angeles, California. How would you know where to go? Many people use maps to help them plan the quickest route.

### Latitude

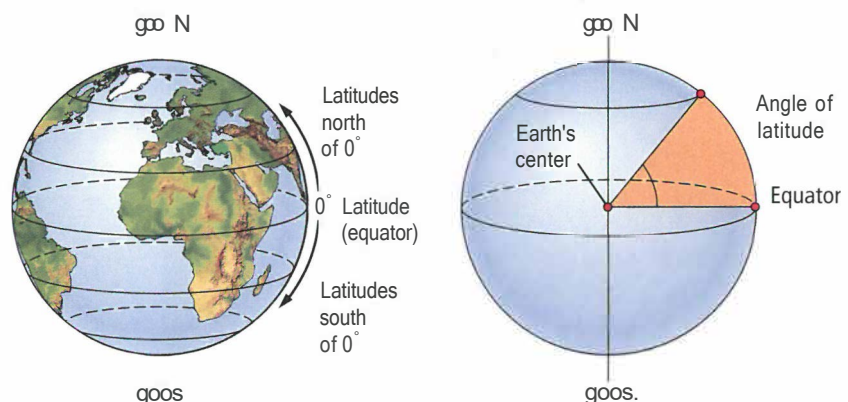
Maps are flat models of three-dimensional objects. For thousands of years people have used maps to define borders and to find places. The map at the beginning of this chapter was made in 1570. What do you notice about the size and shape of the continents? Today, more information is available to create more accurate maps. The science of mapmaking is called **cartography**.

Cartographers use an imaginary grid of parallel lines to locate exact points on Earth. In this grid, the **equator** horizontally 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.

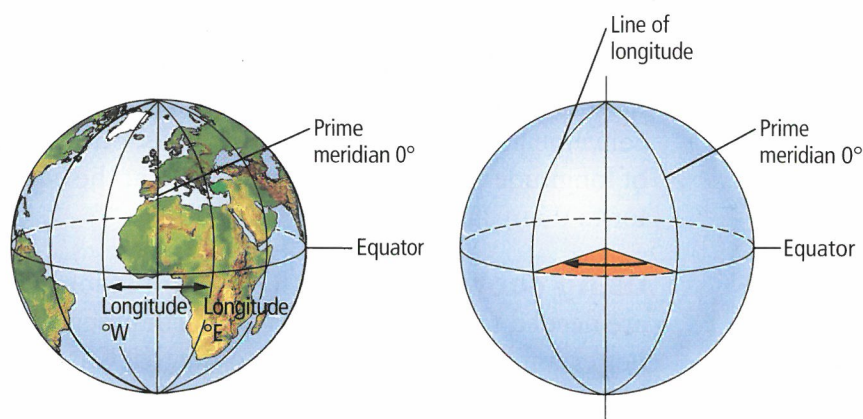
Lines on a map running parallel to the equator are called lines of **latitude**. Latitude is the distance in degrees north or south of the equator as shown in **Figure 2.1**. The equator, which serves as the reference point for latitude, is numbered  $0^\circ$  latitude. The poles are each numbered  $90^\circ$  latitude. Latitude is thus measured from  $0^\circ$  at the equator to  $90^\circ$  at the poles.

Locations 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  $43^\circ$  N, and Christchurch, New Zealand, is located at  $43^\circ$  S.

**Figure 2.1** Lines of latitude are parallel to the equator. 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 as seen in the globe on the right.







■ **Figure 2.2** The reference line for longitude is the prime meridian. 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 as seen on the globe on the right.

**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  $360^\circ$ . The circumference of Earth is about 40,000 km. To find the distance of each degree of latitude, cartographers divided 40,000 km by  $360^\circ$ .

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 is also divided into degrees, minutes, and seconds.

## 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  $0^\circ$  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  $0^\circ$  to  $180^\circ$  west longitude (W); points east of the prime meridian are numbered from  $0^\circ$  to  $180^\circ$  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  $180^\circ$  meridian. There, east lines of longitude meet west lines of longitude. This meridian is also known as the International Date Line, and will be discussed later in this section.

## VOCABULARY

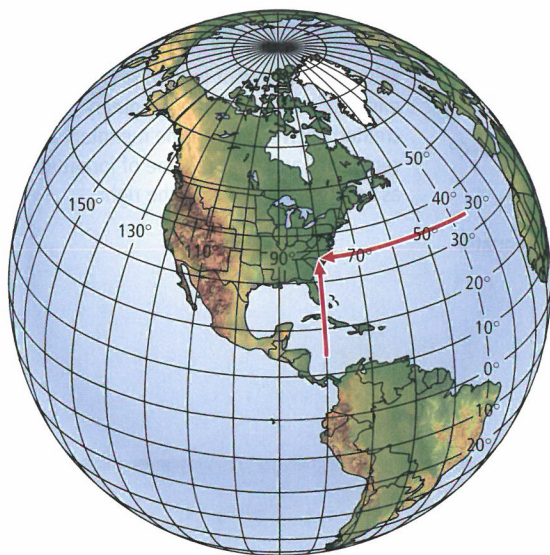
### SCIENCE USAGE V. COMMON USAGE

#### Minute

**Science usage:** a unit used to indicate a portion of a degree of latitude

**Common usage:** a unit of time comprised of 60 seconds





■ **Figure 2.3** The precise location of Charlotte is  $35^{\circ}14'N$ ,  $80^{\circ}50'W$ . Note that latitude comes first in reference to the coordinates of a particular location.

**Degrees of longitude** Degrees of latitude cover relatively consistent distances. The distances covered by degrees of longitude, however, vary with location. As shown in **Figure 2.2**, lines of longitude converge at the poles into a point. Thus, one degree of longitude varies from about 111 km at the equator to 0 km at the poles.

**Using coordinates** Both latitude and longitude are needed to locate positions on Earth precisely. For example, it is not sufficient to say that Charlotte, North Carolina, is located at  $35^{\circ}14'N$  because that measurement includes any place on Earth located along the  $35^{\circ}14'$  line of north latitude.

The same is true of the longitude of Charlotte;  $80^{\circ}50'W$  could be any point along that longitude from pole to pole. To locate Charlotte, use its complete coordinates—latitude and longitude—as shown in **Figure 2.3**.

**Time zones** Earth is divided into 24 time zones. Why 24? Earth takes about 24 hours to rotate once on its axis. Thus, there are 24 time zones, each representing a different hour. Because Earth is constantly spinning, time is always changing. Each time zone is  $15^{\circ}$  wide, corresponding roughly to lines of longitude. To avoid confusion, however, time zone boundaries have been adjusted in local areas so that cities and towns are not split into different time zones.

## MiniLab

### Locate places on Earth

How can you locate specific places on Earth with latitude and longitude?

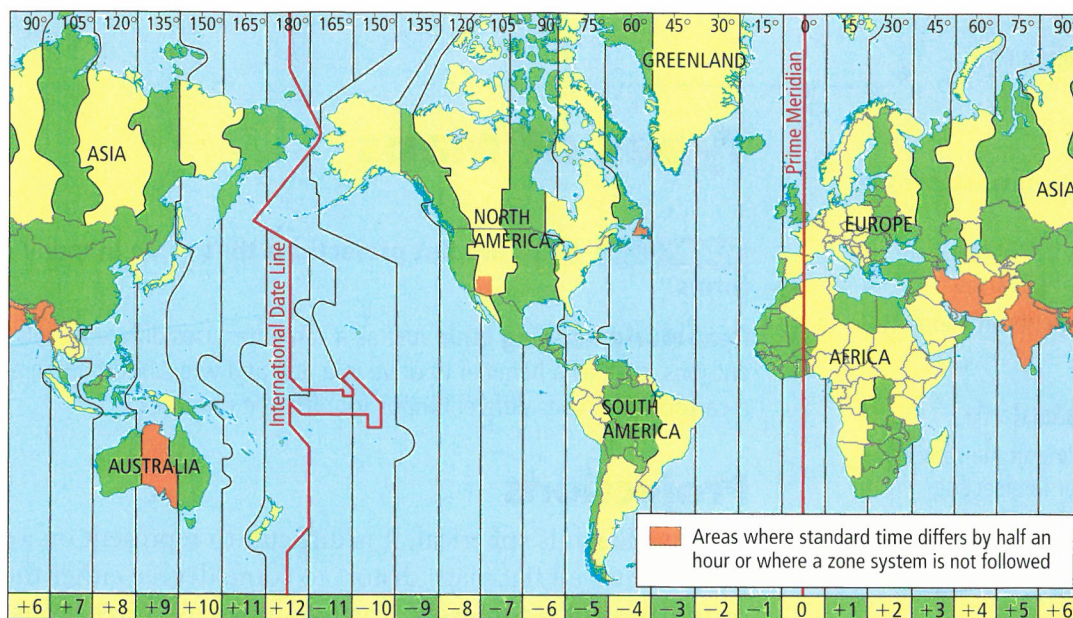
#### Procedure

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

#### Analysis

1. **Locate** the following places:
  - Mount St. Helens, Washington; Niagara Falls, New York; Mount Everest, Nepal; Great Barrier Reef, Australia
2. **Locate** the following coordinates, and record the names of the places there:
  - $0^{\circ}03'S$ ,  $90^{\circ}30'W$ ;  $27^{\circ}07'S$ ,  $109^{\circ}22'W$ ;  $41^{\circ}10'N$ ,  $112^{\circ}30'W$ ;  $35^{\circ}02'N$ ,  $111^{\circ}02'W$ ;  $3^{\circ}04'S$ ,  $37^{\circ}22'E$
3. **Analyze** How might early cartographers have located cities, mountains, or rivers without latitude and longitude lines?





For example all of Morton County, North Dakota, operates within the central time zone, even though the western part of the county is within the mountain-time-zone boundary. As shown in **Figure 2.4**, there are six time zones in the United States.

**International Date Line** 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**, which is 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.

■ **Figure 2.4** In most cases, each time zone represents a different hour. However, there are some exceptions.

**Identify** two areas where the time zone is not standard.

**Concepts in Motion**

**Interactive Figure** To see an animation of time zones, visit [glencoe.com](http://glencoe.com).

## Section 2.1 Assessment

### Section Summary

- ▶ Latitude lines run parallel to the equator.
- ▶ Longitude lines run east and west of the prime meridian.
- ▶ Both latitude and longitude lines are necessary to locate exact places on Earth.
- ▶ Earth is divided into 24 time zones, each 15° wide, that help regulate daylight hours across the world.

### Understand Main Ideas

1. **MAIN Idea** **Explain** why it is important to give both latitude and longitude when giving coordinates.
2. **Describe** how the distance of a degree of longitude varies from the equator to the poles.
3. **Estimate** the time difference between your home and places that are 60° east and west longitude of your home.

### Think Critically

4. **Evaluate** If you were flying directly south from the north pole and reached 70° N, how many degrees of latitude would be between you and the south pole?

### WRITING in Earth Science

5. Imagine what it would be like to fly from where you live to Paris, France. Describe what it would be like to adjust to the time difference.



## Section 2.2

### Objectives

- ▶ **Compare and contrast** different types of maps.
- ▶ **Explain** why different maps are used for different purposes.
- ▶ **Calculate** gradients on a topographic map.

### Review Vocabulary

**parallel:** extending in the same direction and never intersecting

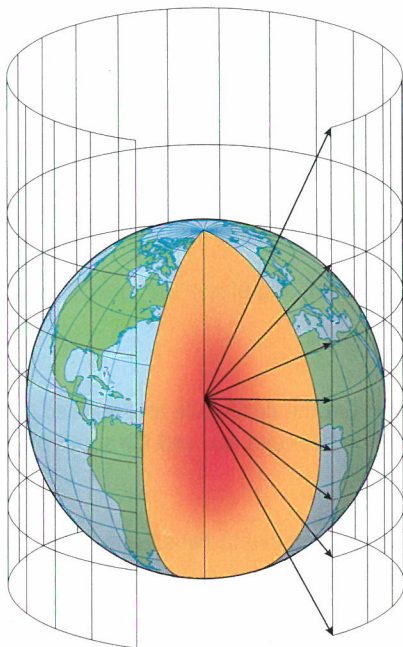
### New Vocabulary

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

### Concepts In Motion

**Interactive Figure** To see an animation of map projections, visit [glencoe.com](http://glencoe.com).

■ **Figure 2.5** In a Mercator projection, points and lines on a globe are transferred onto cylinder-shaped paper. Mercator projections show true direction but distort areas near the poles.



## Types of Maps

**MAIN Idea** Maps are flat projections that come in many different forms.

**Real-World Reading Link** Just as a carpenter uses different tools for different jobs, such as a hammer to drive in a nail and wrench to tighten a bolt, a cartographer uses different maps for different purposes.

## Projections

Because Earth is spherical, it is 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.

**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 2.5**, 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.

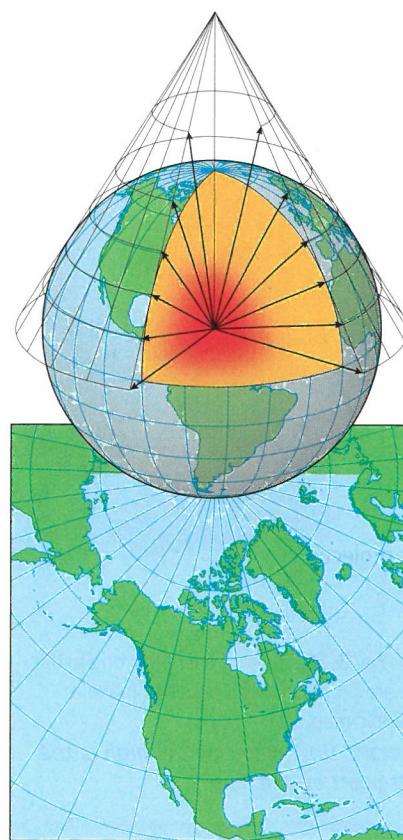




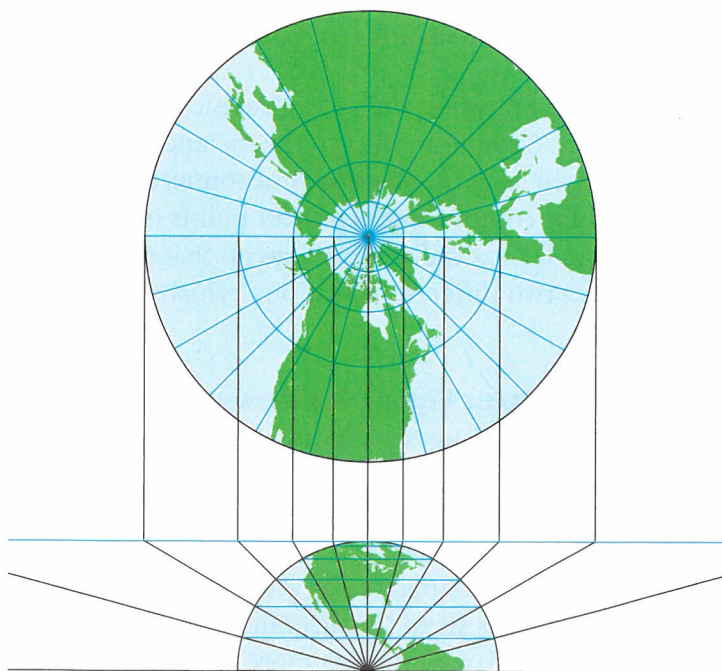
**Conic projections** A **conic projection** is made by projecting points and lines from a globe onto a cone, as shown in **Figure 2.6**. The cone touches the globe at a particular line of latitude. There is little distortion in the areas or shapes of landmasses that fall along this line of latitude. Distortion is evident, however, near the top and bottom of the projection. As shown in **Figure 2.6**, the landmass at the top of the map is distorted. 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.

**Gnomonic projections** A **gnomonic** (noh MAHN ihk) **projection** is made by projecting points and lines from a globe onto a piece of paper that touches the globe at a single point. At the single point where the map is projected, there is no distortion, but outside of this single point, great amounts of distortion are visible both in direction and landmass, as shown in **Figure 2.7**.

Because Earth is a sphere, it is difficult to plan long travel routes on a flat projection with great distortion, such as a conic projection. To plan such a trip, a gnomonic projection is most useful. Although the direction and landmasses on the projection are distorted, it is useful for navigation. A straight line on a gnomonic projection is the straightest route from one point to another when traveled on Earth.

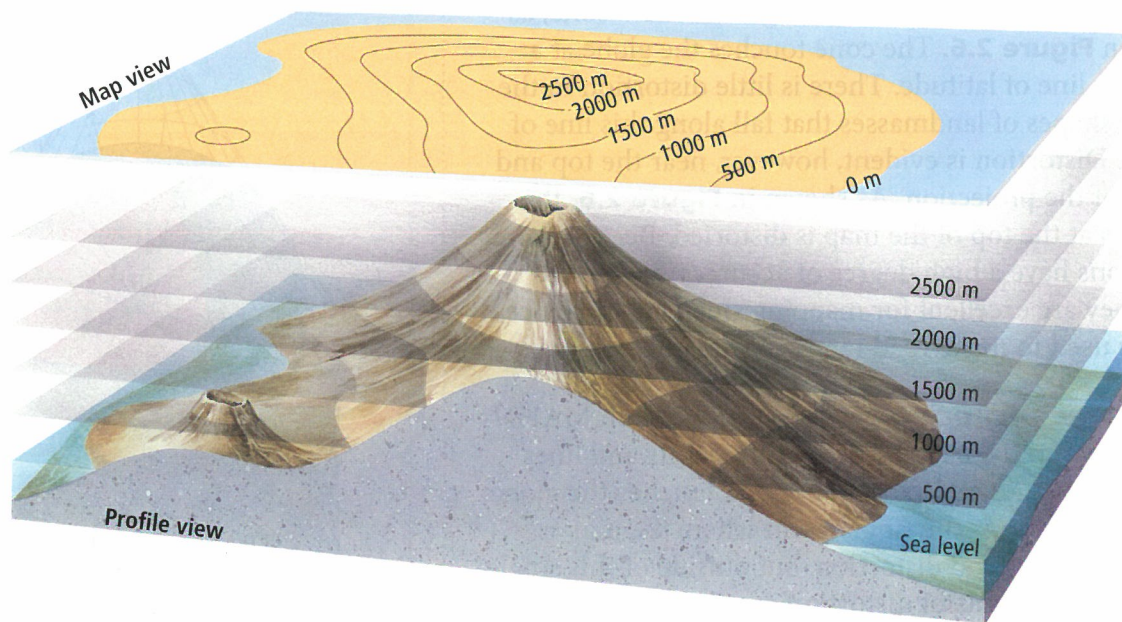


■ **Figure 2.6** In a conic projection, points and lines on a globe are projected onto cone-shaped paper. There is little distortion along the line of latitude touched by the paper.



■ **Figure 2.7** In a gnomonic projection, points and lines from a globe are projected onto paper that touches the globe at a single point.





■ **Figure 2.8** Points of elevation on Earth's surface are projected onto paper to make a topographic map.

**Interpret** How many meters high is the highest point on the map?

## 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, as shown in **Figure 2.8**. 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.

**Contour lines** Elevation on a topographic map is represented by a contour line. Elevation refers to the distance of a location above or below sea level. A **contour line** connects points of equal elevation. 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.


**Contour intervals** As **Figure 2.8** 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 steep because there is a large change in elevation between lines. You will learn more about topographic maps in the Mapping GeoLab at the end of this chapter.



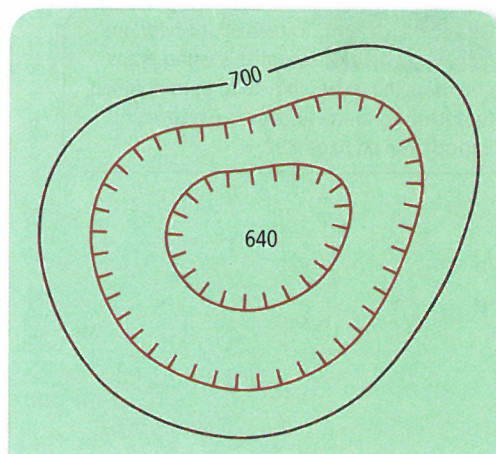
**Index contours** To aid in the interpretation of topographic maps, some contour lines are marked by numbers representing their elevations. These contour lines are called index contours, and they are used hand-in-hand with contour intervals to help determine elevation.

If you look at a map with a contour interval of 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. Learn more about contour maps and index contours in the Problem-Solving Lab on this page.

 **Reading Check Analyze** If you were looking at a topographic map with a contour interval of 50 m and the contour lines were far apart, would this indicate a rapid increase or slow increase in elevation?

**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 look like regular contour lines, but have hachures, or short lines at right angles to the contour line, to indicate depressions. As shown in **Figure 2.9**, the hachures point toward lower elevations.



■ **Figure 2.9** The depression contour lines shown here indicate that the center of the area has a lower elevation than the outer portion of the area. The short lines pointing inward are called hachures and indicate the direction of the elevation change.

## PROBLEM-SOLVING LAB

### Calculate Gradients

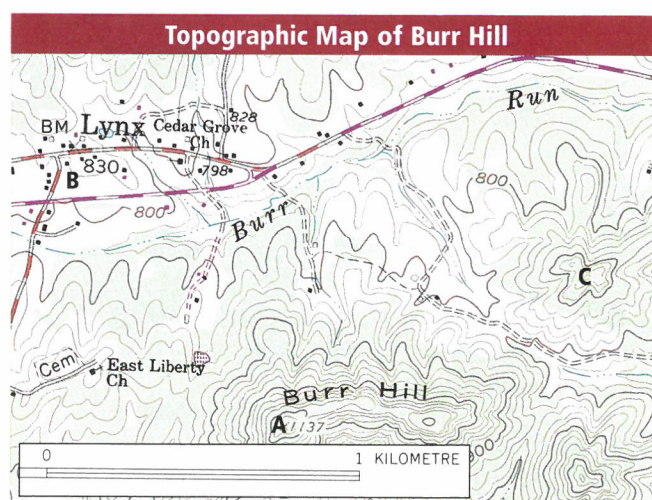
**How can you analyze changes in elevation?** Gradient refers to the steepness of a slope. To measure gradient, divide the change in elevation between two points on a map by the distance between the two points. Use the map to answer the following questions, and convert your answers to SI units.

#### Analysis

1. **Determine** the distance from Point A to Point B using the map scale.
2. **Record** the change in elevation.
3. **Calculate** If you were to hike the distance from Point A to Point B, what would be the gradient of your climb?

#### Think Critically

4. **Explain** Would it be more difficult to hike from Point A to Point B, or from Point B to Point C?



5. **Calculate** Between Point A and Point C, where is the steepest part of the hike? How do you know?



**NATIONAL GEOGRAPHIC** To read about how one scientist is using maps and mapping technology to map the human footprint, go to the **National Geographic Expedition** on page 892.

## Geologic Maps

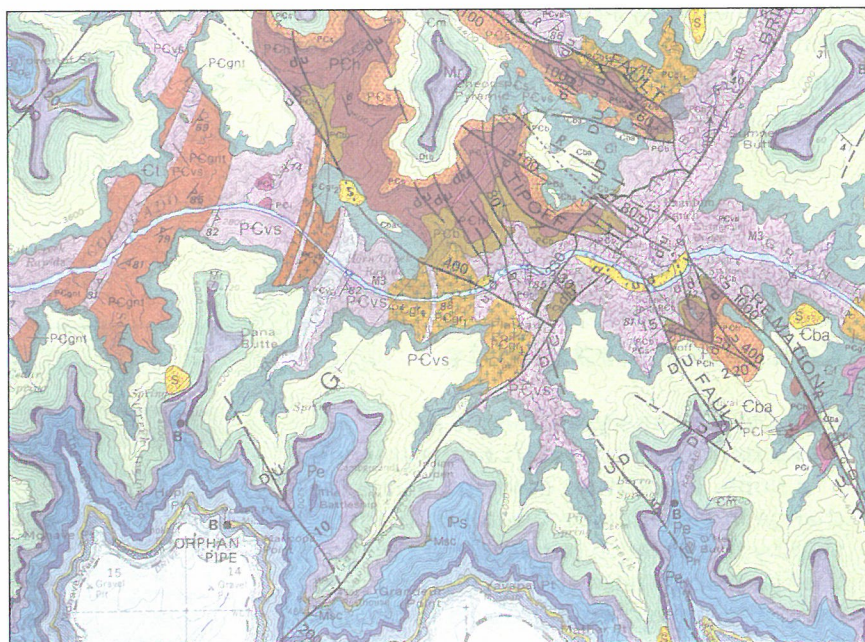
A useful tool for a geologist is a geologic map. A **geologic map** is used to show the distribution, arrangement, and type of rocks located below the soil. A geologic map can also show features such as fault lines, bedrock, and geologic formations.

Using the information contained on a geologic map, combined with data from visible rock formations, geologists can infer how rocks might look below Earth's surface. They can also gather information about geologic trends, based on the type and distribution of rock shown on the map.

Geologic maps are most often superimposed over topographic maps and color coded by type of rock formation, as shown in **Figure 2.10**. Each color corresponds to the type of bedrock present in a given area. There are also symbols that represent mineral deposits and other structural features. Refer to **Table 2.1** on the following page to compare geologic maps to the other maps you have learned about in this chapter.

■ **Figure 2.10** Geologic maps show the distribution of surface geologic features. Notice the abundance of Older Precambrian rock formations.

**Geologic Map of Grand Canyon**



### QUATERNARY

- S** Landslides and rockfalls
- r** River sediment

### PERMIAN

- Pk** Kaibab Limestone
- Pt** Toroweap Formation
- Pc** Coconino Sandstone
- Ph** Hermit Shale
- Pe** Esplanade Sandstone

### PENNSYLVANIAN

- Ps** Supai Formation

### MISSISSIPPIAN

- Mr** Redwall Limestone

### DEVONIAN

- Dtb** Temple Butte Limestone

### CAMBRIAN

- Cm** Muav Limestone
- Cba** Bright Angel Shale
- Ct** Tapeats Sandstone

### YOUNGER PRECAMBRIAN

- Pci** Diabase sills and dikes
- Pcs** Shinumo Quartzite
- Pch** Hakatai Shale
- PCb** Bass Formation

### OLDER PRECAMBRIAN

- PCgr1** Zoroaster Granite
- PCgnt** Trinity Gneiss
- PCvs** Vishnu Schist




<b>Table 2.1</b> <b>Types of Maps and Projections</b>		
Map or Projection	Common Uses	Distortions
<b>Mercator projection</b>	navigation of planes and ships	The land near the poles is distorted.
<b>Conic projection</b>	road and weather maps	The areas at the top and bottom of the map are distorted.
<b>Gnomonic projection</b>	great circle routes	The direction and distance between landmasses is distorted.
<b>Topographic map</b>	to show elevation changes on a flat projection	It depends on the type of projections used.
<b>Geologic map</b>	to show the types of rocks below the surface present in a given area	It depends on the type of projection used.

**Three-dimensional maps** Topographic and geologic maps are two-dimensional models of Earth's surface. Sometimes, scientists need to visualize Earth three-dimensionally. To do this, scientists often rely on computers to digitize features such as rivers, mountains, valleys, and hills.

## Map Legends

Most maps include both human-made and natural features 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 the *Reference Handbook*.

 **Reading Check Apply** If you made a legend for a map of your neighborhood, what symbols would you include?

## 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. Normally, map scales are measured in SI, but as you will see on the map in the GeoLab, sometimes they are measured in different units such as miles and inches. There are three types of map scales: verbal scales, graphic scales, and fractional scales.

■ **Figure 2.11** Map legends explain what the symbols on maps represent.

Interstate	
U.S. highway	
State highway	
Scenic byway	
Unpaved road	
Railroad	
River	
Tunnel	
Lake/reservoir	
Airport	
National Park, monument, or historic site	
Marina	
Hiking trail	
School, church	
Depression contour lines	



## VOCABULARY

### ACADEMIC VOCABULARY

#### Ratio

the relationship in quantity, amount, or size between two or more things

*The ratio of girls to boys in the class was one to one.*

**Verbal scales** To express distance as a statement, such as “one centimeter is equal to one kilometer,” cartographers and Earth scientists use verbal scales. The verbal scale, in this example, means that one centimeter on the map represents one kilometer on Earth’s surface.

**Graphic scales** Instead of writing the map scale out in words, graphic scales consist of a line that represents a certain distance, such as 5 km or 5 miles. The line is labeled, and then broken down into sections with hash marks, and each section represents a distance on Earth’s surface. For instance, a graphic scale of 5 km might be broken down into five sections, with each section representing 1 km. Graphic scales are the most common type of map scale.



**Reading Check Infer** why an Earth scientist might use different types of scales on different types of maps.

**Fractional scales** Fractional scales express 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. Any unit of distance can be used, but 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 km would therefore show less detail than a map with a small fractional scale such as 1:1000 km.

## Section 2.2 Assessment

### Section Summary

- Different types of projections are used for different purposes.
- Geologic maps help Earth scientists study patterns in subsurface geologic formations.
- Maps often contain a map legend that allows the user to determine what the symbols on the map signify.
- The map scale allows the user to determine the ratio between distances on a map and actual distances on the surface of Earth.

### Understand Main Ideas

1. **MAIN Idea Explain** why distortion occurs at different places on different types of projections.
2. **Describe** how a conic projection is made. Why is this type of projection best suited for mapping small areas?
3. **Determine** On a Mercator projection, where does most of the distortion occur? Why?
4. **Compare and contrast** Mercator and gnomonic projections. What are these projections commonly used for?

### Think Critically

5. **Predict** how a geologic map could help a city planner decide where to build a city park.

### MATH in Earth Science

6. Determine the gradient of a slope that starts at an elevation of 55 m and ends 20 km away at an elevation of 15 m.



## Section 2.3

### Objectives

- ▶ **Compare and contrast** different types of remote sensing.
- ▶ **Discuss** how satellites and sonar are used to map Earth's surface and its oceans.
- ▶ **Describe** the Global Positioning System and how it works.

### Review Vocabulary

**satellite:** natural or human-made object that orbits Earth, the Moon, or other celestial body

### New Vocabulary

remote sensing  
Landsat satellite  
TOPEX/Poseidon satellite  
sonar  
Global Positioning System  
Geographic Information System

## Remote Sensing

**MAIN Idea** New technologies have changed the appearance and use of maps.

**Real-World Reading Link** Many years ago, if you wanted a family portrait, it would be painted by an artist over many hours. Today, cameras can create a photo in seconds. Cartography has also changed. Cartographers use digital images to create maps with many more details that can be updated instantly.

### Landsat Satellite

Advanced technology has changed the way maps are made. The process of gathering data about Earth using instruments mounted on satellites, airplanes, or ships is called **remote sensing**.

One form of remote sensing is detected with satellites. Features on Earth's surface, such as rivers and forests, radiate warmth at slightly different frequencies. **Landsat satellites** record reflected wavelengths of energy from Earth's surface. These include wavelengths of visible light and infrared radiation. One example of a Landsat image is shown in **Figure 2.12**.

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.

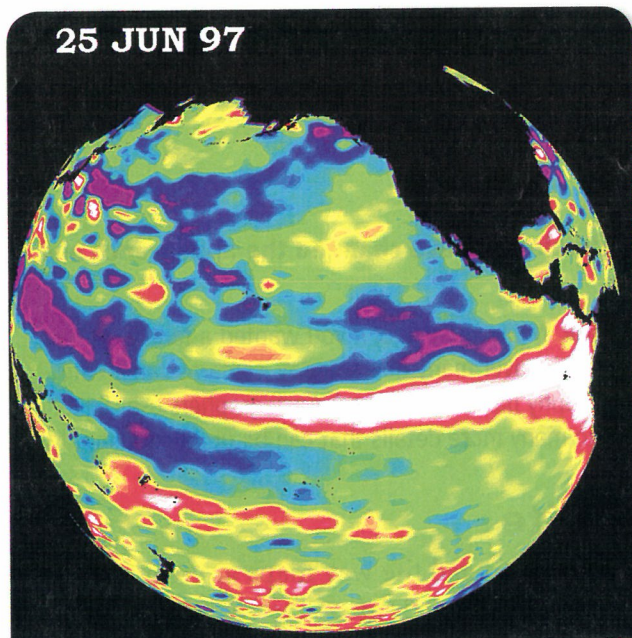
*Landsat 7*, launched in 1999, maps 185 km at a time and scans the entire surface of Earth in 16 days. Landsat data are also used to study the movements of Earth's plates, rivers, earthquakes, and pollution.

■ **Figure 2.12** Notice the differences between the two Landsat photos of New Orleans.

**Interpret** Which image was taken after Hurricane Katrina in 2005? Explain.







■ **Figure 2.13** This image, which focuses on the Pacific Ocean, was created with data from *TOPEX/Poseidon*. The white color in the image shows the change in ocean depth during a hurricane event relative to normal.

#### FOLDABLES

Incorporate information from this section into your Foldable.

## TOPEX/Poseidon Satellite

One satellite that uses radar to map features on the ocean floor is the **TOPEX/Poseidon satellite**. **TOPEX** stands for **topography experiment** and **Poseidon** (puh SY duhn) is the Greek god of the sea. 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 and result in images such as the one shown in **Figure 2.13**, that shows ocean depths during a hurricane. Using *TOPEX/Poseidon* data, scientists were able to estimate global sea levels with an accuracy of just a few millimeters and could repeat these calculations as often as every ten days. Scientists can also use this data and combine it with other existing data to create maps of ocean-floor features.

The *TOPEX/Poseidon* satellite also has been used to study tidal changes and global ocean currents. **Figure 2.14** below shows additional technological advances in cartography.

## ■ Figure 2.14 Mapping Technology

Advances in mapping have relied on technological developments.

150 B.C. The ancient Greek scientist Ptolemy creates the first map using a coordinate grid. It depicted Earth as a sphere and included Africa, Asia, and Europe.

A.D. 1154 Arab scholar Al-Idrisi creates a world map used by European explorers for several centuries. Earlier medieval maps showed Jerusalem as the center of a flat world.



1300 B.C. An ancient Egyptian scribe draws the oldest surviving topographical map.



1569 Flemish geographer Gerhardus Mercator devises a way to project the globe onto a flat map using lines of longitude and latitude.



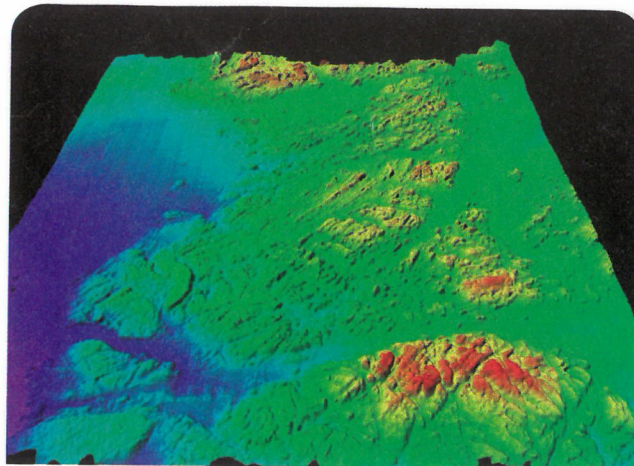
## Sea Beam

Sea Beam technology is similar to the *TOPEX/Poseidon* satellite in that it is also used to map the ocean floor. However, Sea Beam is located on a ship rather than on a satellite. **Figure 2.15** shows an example of a map created with information gathered with Sea Beam technology. To map ocean-floor features, Sea Beam relies on **sonar**, which is the use of sound waves to detect and measure objects underwater.

You might have heard of sonar before. It is often used to detect other objects like ships or submarines under water. This same technology allows scientists to detect changes in elevation or calculate distances between objects.

First, to gather the information needed to map the seafloor, a sound wave is sent from a ship toward the ocean floor. A receiving device then picks up the returning echo when it bounces off the seafloor.

Computers on the ship calculate the distance from the ship to the ocean floor using the speed of sound in water and the time it takes for the sound to be reflected. Sea Beam technology is used by fishing fleets, deep-sea drilling operations, and scientists such as oceanographers, volcanologists, and archaeologists.



■ **Figure 2.15** This image of Plymouth offshore was created with data from Sea Beam. The change in color indicates a change in elevation. The red-orange colors are the peaks, and the blue colors are the lowest elevations.

✓ **Reading Check Compare and contrast** Sea Beam images with *TOPEX/Poseidon* images and how each might be used.

**1752** A French cartographer first uses contour lines to represent elevation and marine depth for sailors exploring the New World.



**2000** Space shuttle *Endeavour* collects the most complete topographical data of Earth, mapping almost 80 percent of Earth's land surface.

1700

1800

1900

2000

**1875** Ella Eliza Fitz invents a method to mount a globe that shows the position of the Sun and the length of nights and days.

**1966** Harvard University researchers develop the first computerized grid-based mapping system, the forerunner of GIS.

**Concepts in Motion**

**Interactive Time Line** To learn more about these discoveries and others, visit [glencoe.com](http://glencoe.com). **Earth Science** online



### CAREERS IN EARTH SCIENCE

**Cartographer** An Earth scientist who works primarily with maps is called a cartographer. A cartographer might make maps, interpret maps, or research mapping techniques and procedures. To learn more about Earth science careers, visit [glencoe.com](http://glencoe.com).

### VOCABULARY

#### ACADEMIC VOCABULARY

##### Comprehensive

covering completely or broadly  
*The teacher gave the students a comprehensive study guide for the final exam.*

## The Global Positioning System

The **Global Positioning System (GPS)** is a satellite navigation system that allows users to locate their approximate position on Earth. There are 27 satellites orbiting Earth, as shown in **Figure 2.16**, for use with GPS units. The satellites are positioned around Earth, and are constantly orbiting so that signals from at least three or four satellites can be picked up at any given moment by a GPS receiver.

To use GPS to find your location on Earth, you need a GPS receiver. The receiver calculates your approximate latitude and longitude—usually within 10 m—by processing the signals emitted by the satellites. If enough information is present, these satellites can also relay information about elevation, direction of movement, and speed. With signals from three satellites, a GPS receiver can calculate location on Earth without elevation, while four satellite signals will allow a GPS receiver to calculate elevation also. For more information on how the satellites are used to determine location, see **Figure 2.16**.

**Uses for GPS technology** GPS technology is used extensively for navigation by airplanes and ships. However, as you will read later, it is also used to help detect earthquakes, create maps, and track wildlife.

GPS technology also has many applications for everyday life. Some people now have GPS receivers in their cars to help navigate to preprogrammed destinations such as restaurants, hotels, and their homes. Hikers, bikers, and other travelers often have portable, handheld GPS systems with them at all times. This allows them to find their destinations more quickly and can help them determine their location so they do not get lost. Some cell phones also contain GPS systems that can help you find your location.



**Reading Check** Compare GPS satellites with *TOPEX/Poseidon*.

## The Geographic Information System

The **Geographic Information System (GIS)** combines many of the traditional types and styles of mapping described in this chapter. GIS mapping uses a database of information gathered by scientists, professionals, and students like you from around the world to create layers, or “themes,” of information that can be placed one on top of the other to create a comprehensive map. These “themes” are often maps that were created with information gathered by remote sensing.

Scientists from many disciplines use GIS technologies. A geologist might use GIS mapping when studying a volcano to help track historical eruptions. An ecologist might use GIS mapping to track pollution or to follow animal or plant population trends of a given area.

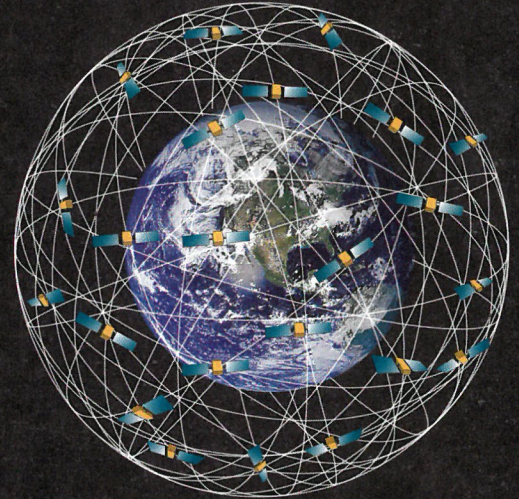
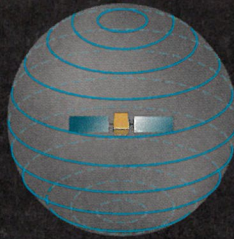


# Visualizing GPS Satellites

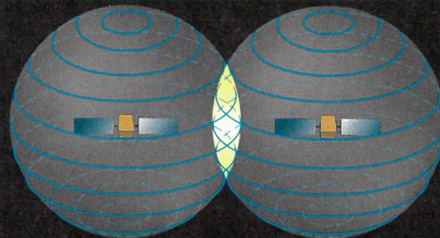


**Figure 2.16** GPS receivers detect signals from the 27 GPS satellites orbiting Earth. Using signals from at least three satellites, the receiver can calculate location within 10 m.

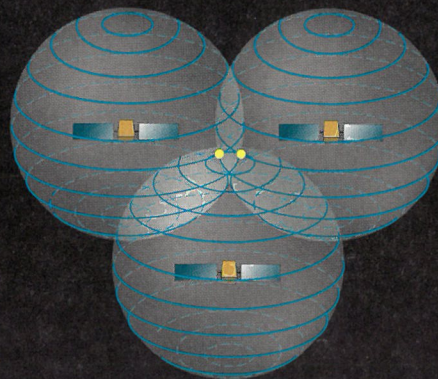
First, a GPS receiver, located in New York City, receives a signal from one satellite. The distance from the satellite to the receiver is calculated. Suppose the distance is 20,000 km. This limits the possible location of the receiver to anywhere on a sphere 20,000 km from the satellite.



Next, the receiver measures the distance to a second satellite. Suppose this distance is calculated to be 21,000 km away. The location of the receiver has to be somewhere on the area where the two spheres intersect, shown here in yellow.



Finally, the distance to a third satellite is calculated. Using this information, the location of the receiver can be narrowed even further. By adding a third sphere, the location can be calculated to be one of two points as shown. Often one of these points can be rejected as an improbable or impossible location.

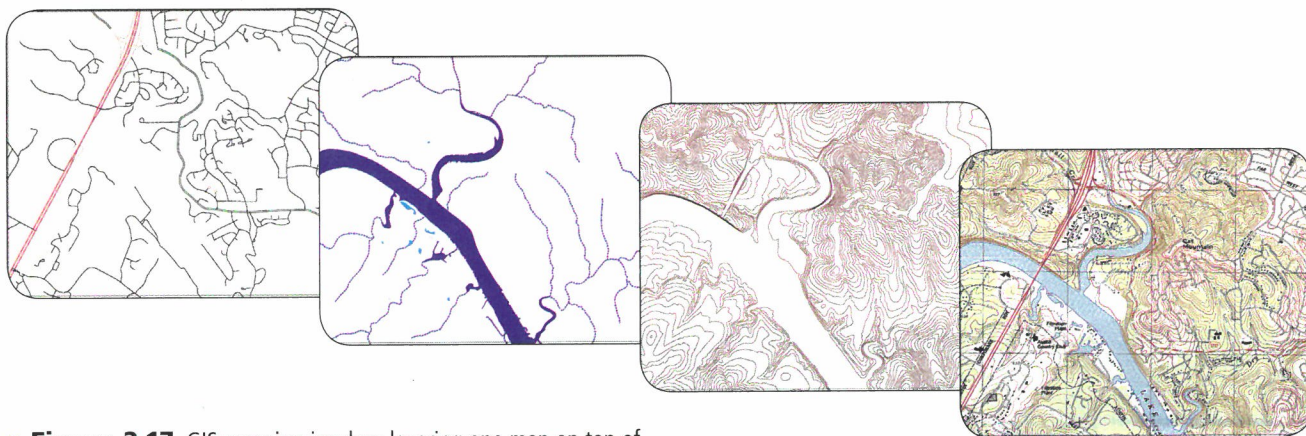


**Concepts in Motion**  
To explore more about GPS satellites, visit [glencoe.com](http://glencoe.com).

To explore more about GPS satellites, visit [glencoe.com](http://glencoe.com).







■ **Figure 2.17** GIS mapping involves layering one map on top of another. In this image, you can see how one layer builds on the next.

GIS maps might contain many layers of information compiled from several different types of maps, such as a geologic map and a topographic map. As shown in **Figure 2.17**, layers such as rivers, topography, roads, and landforms from the same geographic area can be placed on top of each other to create a comprehensive map.

One major difference between GIS mapping and traditional mapping is that a GIS map can be updated as new information is loaded into the database. Once a map is created, the layers are still linked to the original information. If this information changes, the GIS layers also change. The result is a map that is always up-to-date—a valuable resource for people who rely on current information.

## Section 2.3 Assessment

### Section Summary

- Remote sensing is an important part of modern cartography.
- Satellites are used to gather data about features of Earth's surface.
- Sonar is also used to gather data about features of Earth's surface.
- GPS is a navigational tool that is now used in many everyday items.

### Understand Main Ideas

1. **MAIN Idea** Describe how remote sensing works and why it is important in cartography.
2. **Apply** Why is GPS navigation important to Earth scientists?
3. **Explain** the different types of information that can be gathered with satellites.
4. **Predict** why it might be important to be able to add and subtract map layers as with GIS mapping.

### Think Critically

5. **Infer** How could GIS mapping be helpful in determining where to build a housing development?
6. **Explain** why it is important to have maps of the ocean floor, such as those gathered with Sea Beam technology.

### WRITING in Earth Science

7. Write an article describing how GPS satellites help you locate your position on Earth.



# EARTH SCIENCE AND TECHNOLOGY

## MAPPING DISASTER ZONES

On August 29, 2005, Hurricane Katrina hit the New Orleans area, causing \$81.2 billion in damage and resulting in the deaths of nearly 2000 people. With such widespread devastation, how did relief workers reach the damaged areas? Mapping technologies helped workers to identify priority areas and create a plan to aid those affected.

**GPS and disaster relief** Global Positioning System (GPS) satellites send signals back to Earth telling the receiver the exact location of the user. The satellites travel at approximately 14,000 km/h, and are powered by solar energy. During Katrina, GPS signals provided up-to-the-minute information regarding destruction detail and locations of survivors and aid workers.

**Using GIS** Another important mapping tool used during disasters is the Geographic Information System Technology (GIS). This technology captures, stores, records, and analyzes data dependent on geography and location. As a result, many important decisions about environmental issues or relief efforts can be made using GIS data. After Katrina, GIS data provided relief workers with images of area hospitals within a small geographic area. This enabled emergency workers to get injured individuals to medical facilities quickly.

**Other imaging systems** Other mapping software packages provide actual pictorial images of Earth. These images show the damaged areas as well as buildings that can be appropriate for setting up relief sites.

Synthetic Aperture Radar (SAR) polarimetry is an imaging technology that is able to rapidly detect disaster zones.



This aerial image shows some of the flooding and destruction caused by Hurricane Katrina. Images like this help workers navigate through the altered landscape.

With other satellite images, views of the affected landscape can be blocked by clouds, darkness, smoke, or dust. By using radar, SAR mapping is not affected by these things, thus making the images readily available to relief workers.

Mapping areas affected by natural disasters with satellite and aerial images makes these areas accessible by relief workers. They are better able to prepare for the changes in local geography, destruction of buildings, and other physical challenges in the disaster zone. Continued improvements in mapping technologies and increased accessibility are important for continued improvement of disaster relief programs.

### **WRITING in** Earth Science

**Mapping Applications** Research a recent natural disaster by visiting [glencoe.com](http://glencoe.com). Write a news article that describes the disaster based on the images of the disaster you find. Include several images in your news article.



# GEO LAB

## MAPPING: USE A TOPOGRAPHIC MAP

**Background:** Topographic maps show two-dimensional representations of Earth's surface. With these maps, you can determine the slope of a hill, what direction streams flow, and where mines and other features are located. In this lab, you will use the topographic map on the following page to determine elevation for several routes and to create a profile showing elevation.

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

### Materials

ruler  
string  
piece of paper

### Procedure

1. Read and complete the lab safety form.
2. Take a piece of paper and lay it on the map so that it intersects Point A and Point B.
3. On this piece of paper, draw a small line at each place where a contour line intersects the line from Point A to Point B. Also note the elevation at each hash mark and any rivers crossed.
4. Copy the table shown on this page into your science journal.
5. Now take your paper where you marked your lines and place it along the base of the table.
6. Mark a corresponding dot on the table for each elevation.
7. Connect the dots to create a topographic profile.
8. Use the map to answer the following questions. Be sure to check the map's scale.
9. Use the string to measure distances between two points that are not in a straight line. Lay the string along curves, and then measure the distance by laying the string along the ruler. Remember that elevations on United States Geological Survey (USGS) maps are given in feet.

### Analyze and Conclude

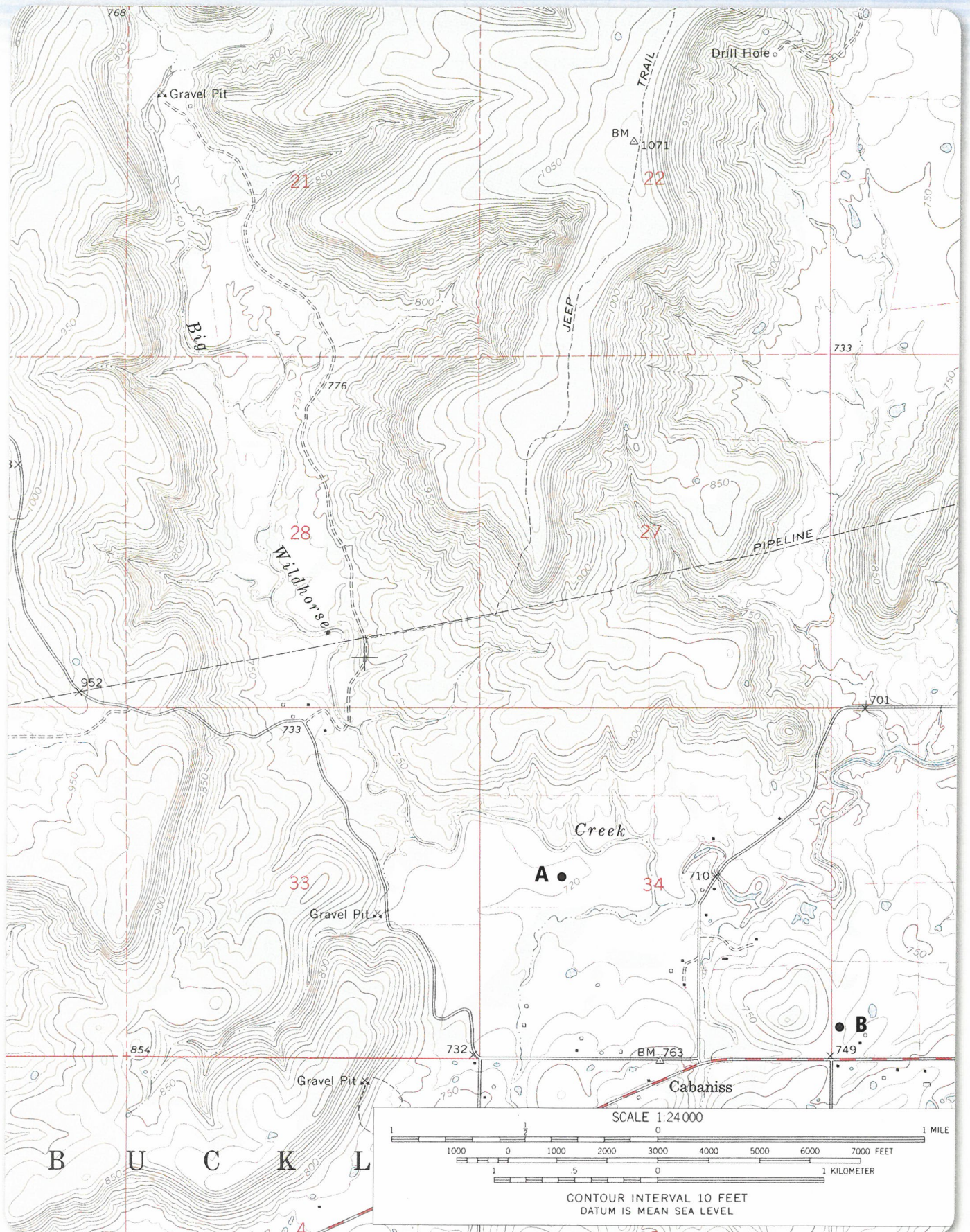
1. **Determine** What is the contour interval?
2. **Identify** what type of map scale the map utilizes.
3. **Calculate** the stream gradient of Big Wildhorse Creek from the Gravel Pit in Section 21 to where the creek crosses the road in Section 34.
4. **Calculate** What is the highest elevation of the 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?
5. **Apply** 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 hike?
6. **Analyze** What is the straight line distance between the two points in Question 4? What is the change in elevation?
7. **Predict** Does Big Wildhorse Creek flow throughout the year? Explain your answer.
8. **Calculate** What is the shortest distance along roads from the Gravel Pit in Section 21 to the secondary highway?

	820
	810
	800
	790
	780
	770
	760
	750
	740
	730
	720
	710
	700

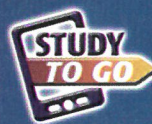
### INQUIRY EXTENSION

**Make a Map** Using what you have learned in this lab, create a topographic map of your hometown. For more information on topographic maps, visit [glencoe.com](http://glencoe.com).









**BIG Idea** Earth scientists use mapping technologies to investigate and describe the world.

## Vocabulary

## Key Concepts

### Section 2.1 Latitude and Longitude

- cartography (p. 30)
- equator (p. 30)
- International Date Line (p. 33)
- latitude (p. 30)
- longitude (p. 31)
- prime meridian (p. 31)

- MAIN Idea** Lines of latitude and longitude are used to locate places on Earth.
- Latitude lines run parallel to the equator.
  - Longitude lines run east and west of the prime meridian.
  - Both latitude and longitude lines are necessary to locate exact places on Earth.
  - Earth is divided into 24 time zones, each 15° wide, that help regulate daylight hours across the world.

### Section 2.2 Types of Maps

- conic projection (p. 35)
- contour interval (p. 36)
- contour line (p. 36)
- geologic map (p. 38)
- gnomonic projection (p. 35)
- map legend (p. 39)
- map scale (p. 39)
- Mercator projection (p. 34)
- topographic map (p. 36)

- MAIN Idea** Maps are flat projections that come in many different forms.
- Different types of projections are used for different purposes.
  - Geologic maps help Earth scientists study patterns in subsurface geologic formations.
  - Maps often contain a map legend that allows the user to determine what the symbols on the map signify.
  - The map scale allows the user to determine the ratio between distances on a map and actual distances on the surface of Earth.

### Section 2.3 Remote Sensing

- Geographic Information System (p. 44)
- Global Positioning System (p. 44)
- Landsat satellite (p. 41)
- remote sensing (p. 41)
- sonar (p. 43)
- TOPEX/Poseidon satellite (p. 42)

- MAIN Idea** New technologies have changed the appearance and use of maps.
- Remote sensing is an important part of modern cartography.
  - Satellites are used to gather data about features of Earth's surface.
  - Sonar is also used to gather data about features of Earth's surface.
  - GPS is a navigational tool that is now used in many everyday items.



## Vocabulary Review

Each of the following sentences is false. Make each sentence true by replacing the italicized word with a vocabulary term from the Study Guide.

1. The study of mapmaking is called *topology*.
2. A *gnomonic projection* is a map that has parallel lines of latitude and longitude.
3. The process of collecting data about Earth from far above Earth's surface is called *planetology*.
4. *Landsat satellite* uses sonar waves emitted from a ship to map the ocean floor.
5. A *map scale* explains what the symbols on the map represent.

Replace the underlined words with the correct vocabulary term from the Study Guide.

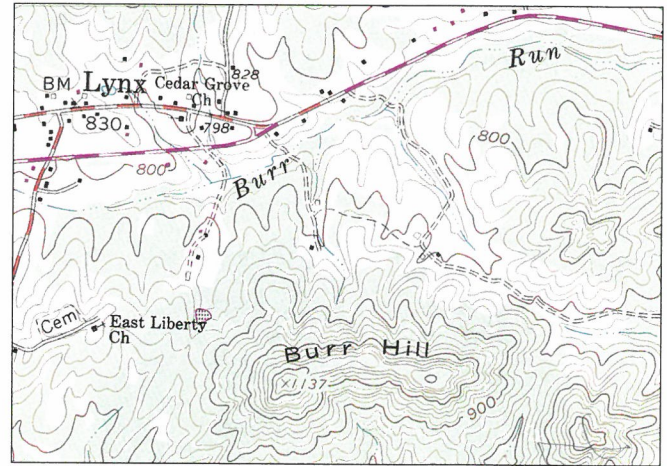
6. Latitude lines run north to south and are measured from the prime meridan.
7. A map legend shows the ratio between distances on a map.
8. GPS mapping combines many traditional types of maps into one.
9. GIS technology helps determine a user's exact location.

Choose the correct vocabulary term from the Study Guide to complete the following sentences.

10. Zero longitude is known as the \_\_\_\_\_.
11. The difference in elevation between two side-by-side contour lines on a topographic map is called the \_\_\_\_\_.
12. \_\_\_\_\_ is the use of sound waves to detect and measure objects underwater.
13. The \_\_\_\_\_ serves as the transition line for calendar days.
14. A(n) \_\_\_\_\_ is used on a topographic map to indicate elevation.

## Understand Key Concepts

Use the figure below to answer Questions 15 and 16.



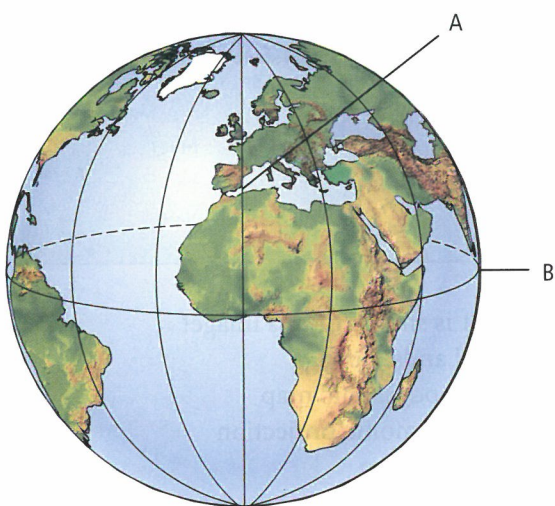
15. What is shown in this image?
  - A. a Landsat image
  - B. a topographic map
  - C. a gnomonic projection
  - D. a GIS map
16. What are the lines in the figure called?
  - A. hachures
  - B. contour lines
  - C. latitude lines
  - D. longitude lines
17. Refer to **Figure 2.4**. How many time zones are there in Australia?
  - A. 5
  - B. 1
  - C. 3
  - D. 10
18. Which is a use of Sea Beam?
  - A. to map continents
  - B. to map the ocean floor
  - C. to map Antarctica
  - D. to map mountains and valleys
19. On a topographic map, which do hachures point toward?
  - A. higher elevations
  - B. lakes
  - C. no change in elevation
  - D. lower elevations
20. Which is not usually included in map legends?
  - A. interstates
  - B. people
  - C. rivers
  - D. railroads



## Constructed Response

21. **Locate** What time is it in New Orleans, LA, if it is 3 P.M. in Syracuse, NY? Refer to **Figure 2.4** for help.
22. **Explain** If you wanted to study detailed features of a volcano, would you use a map with a scale of 1:150 m or 1:150,000 m? Why?

Use the figure below to answer Questions 23 and 24.



23. **Identify** What is the line labeled A?
24. **Identify** What is the line labeled B?
25. **Explain** What is the maximum potential height of a mountain if the last contour line is 2000 m and the map has a contour interval of 100 m?
26. **Describe** how radar used in the TOPEX/Poseidon satellite differs from the sonar used in the collection of data by Sea Beam.
27. **Infer** Based on what you have learned in this chapter, how might an astronomer map objects seen in the night sky?
28. **Practice** Think back to the Launch Lab at the beginning of the chapter. What type of map projection would be best for the map you drew? Why?
29. **Explain** how degrees of longitude are calculated.
30. **Explain** how degrees of latitude are calculated.

Use the figure below to answer Question 31.



31. **Interpret** what type of projection is shown in the figure. What would this type of projection be used for?

## Think Critically

32. **Apply** Would a person flying from Virginia to California have to set his or her watch backward or forward? Explain.
33. **Consider** why a large country like China might choose to follow only one time zone.
34. **CAREERS IN EARTH SCIENCE** Analyze how an architect trying to determine where to build a house and a paleontologist trying to determine where to dig for fossils might use a geologic map.

Use the figure below to answer Question 35.



35. **Apply** What is the projection shown above? What would be two uses for this type of projection? Explain.
36. **Plan** Make a map from your school to the nearest supermarket. How will you determine the scale? What will you need to include in your legend?



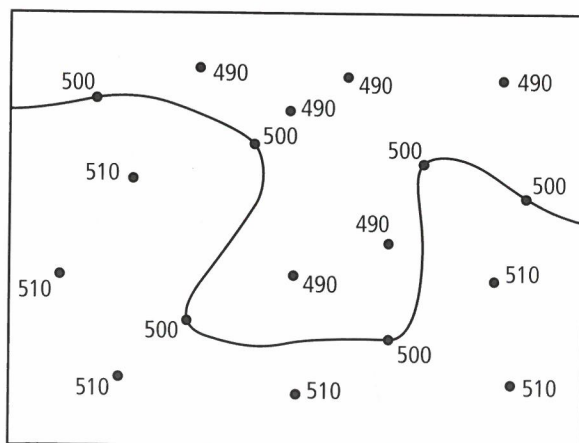
37. **Analyze** Why isn't a conic projection used to navigate a ship or an aircraft?
38. **Design** an experiment to test the accuracy of several types of GPS receivers. Make sure you include your control, dependent, and independent variables.
39. **Evaluate** Briefly describe GIS and how it can be used by your community to develop an emergency plan for a severe storm, earthquake, blizzard, drought, or another potential local disaster.
40. **Explain** why it is necessary to have three satellite signals to determine elevation when using a GPS receiver.

## Concept Mapping

41. Use the following to complete a concept map about remote sensing: *remote sensing, TOPEX/Poseidon satellite, Landsat satellite, GPS, uses radar to map ocean floor, uses visible light and infrared radiation to map Earth's surface, and uses microwaves to determine location of user.* For more help, refer to the Skillbuilder Handbook.

## Challenge Problem

Use the figure below to answer Question 42.



42. **Assess** Trace the following image to create a topographic map. Connect the elevation measurements to create contour intervals.

## Additional Assessment

43. **WRITING in Earth Science** Write a journal entry for an explorer traveling across America before an accurate map was made.

## DBQ Document-Based Questions

Data obtained from: NASA, CALIPSO satellite image.



This is a satellite image from NASA's CALIPSO satellite. CALIPSO is similar to the other remote sensing technologies you learned about in this chapter, but instead of radar or sonar, it uses something called lidar that sends pulses of light and measures the time it takes for the light to reflect back to the satellite. Based on the amount of time it takes for the light to reflect, CALIPSO and scientists can determine what is located below the satellite. The image above was collected on June 7, 2006, across the Indian Ocean. The navy blue areas indicate that no data was detected.

44. At approximately how many kilometers is the volcanic plume located?
45. At approximately how many kilometers is the thick cirrus cloud located?
46. Why do you think the volcanic plume is higher than the thick cirrus clouds?
47. Why do you think there was no data detected below the thick cirrus clouds?

## Cumulative Review

48. Why are graphs, charts, and maps useful? (**Chapter 1**)
49. Why is good communication important in the field of science? (**Chapter 1**)



# Standardized Test Practice

## Multiple Choice

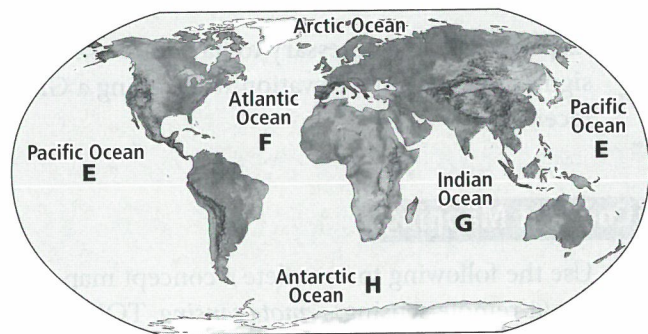
Use the map to answer Questions 1 and 2.



1. What is the latitude and longitude of the location pointed out by the arrows?
  - A. 30° N, 100° W
  - B. 45° N, 105° W
  - C. 30° N, 90° W
  - D. 10° N, 90° W
2. Roughly how many degrees of latitude does the United States cover?
  - A. 10°
  - B. 15°
  - C. 20°
  - D. 25°
3. 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
4. What is the reference point for lines of longitude?
  - A. the equator
  - B. the prime meridian
  - C. the International Date Line
  - D. the 360<sup>th</sup> meridian

5. Why do cartographers break down degrees of longitude and latitude into minutes and seconds
  - A. to get a better time frame of how long it takes to get from one place to the next
  - B. to help travelers with planning trips
  - C. to locate positions on Earth more precisely
  - D. to make cartography easier to understand

Use the map below to answer Questions 6 and 7.

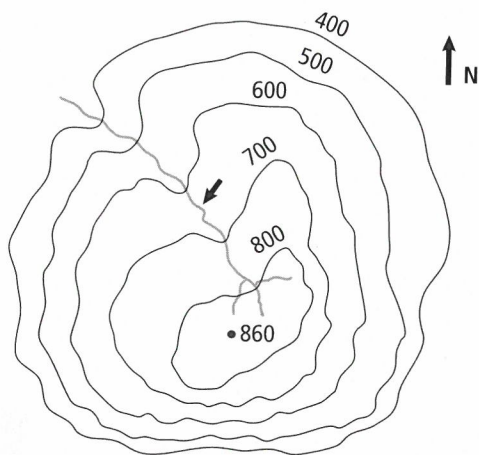


6. What problem do cartographers encounter when creating maps such as the one shown above?
  - A. placing all of the continents in the correct position
  - B. transferring a three-dimensional Earth onto a flat piece of paper
  - C. naming all of the important locations on the map
  - D. placing lines of latitude and longitude at the correct locations
7. What improvements could be made to make this map more helpful to sailors?
  - A. Distort the size of the continents.
  - B. Show only the water locations and not the locations of the land.
  - C. Label the various continents.
  - D. Add lines of latitude and longitude for navigation.
8. For what purpose are conic projection maps typically used?
  - A. road and weather maps
  - B. showing changes in elevation
  - C. plotting long distance trips
  - D. showing one specific point on Earth



## Short Answer

Use the map below to answer Questions 9–11.



9. What is the map above showing?
10. What do the numbers on the map represent?
11. How might a hiker use this map in creating a route to get to the top?
12. Why would a ship find Sea Beam technology beneficial?
13. The distance from Earth to the Sun is 149,500,000 km. Rewrite this number using scientific notation.
14. Why is it important to include legends on a map?
15. Jenna measured the temperature of solutions before, during, and after an exothermic reaction. Which type of display would show the changes in temperature throughout the reaction most clearly and why?

## Reading for Comprehension

### Map Likely Fake, Experts Say

Recently, a Chinese map, including North America, Antarctica, and Australia, was unveiled. This map purported to show that a Chinese explorer discovered America in 1418, but has been met with skepticism from cartographers and historians alike. Antiquities collector Liu Gang, who unveiled the map in Beijing, says it proves that Chinese seafarer Zheng discovered America more than 70 years before Christopher Columbus set foot in the New World. But experts have dismissed the map as a fake. They say the map resembles a French seventeenth-century world map with its depiction of California as an island. That China is not shown in the center also suggests the Chinese did not make the map, one expert says.

Article obtained from: Lovgren, S. "Chinese Columbus" map likely fake, experts say. *National Geographic News*. January 23, 2006.

16. Why might a seventeenth-century map show California as an island?
  - A. California really was an island back then.
  - B. America had not been explored well enough to know that California was actually connected.
  - C. California was so different from the rest of America that they assumed it was an island.
  - D. A river was mistakenly drawn to look like part of the ocean.
17. What can be inferred from this passage?
  - A. China should be put in the center of every map drawn.
  - B. The map is an exact copy of the seventeenth-century world map.
  - C. Liu Gang wants people to believe that the Chinese first discovered America.
  - D. Liu Gang drew the map himself.

### NEED EXTRA HELP?

#### If You Missed Question . . .

#### Review Section . . .

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	2.1	2.1	2.1	2.3	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.3	1.2	2.2	1.3