KEY ISSUE

1.1 | Why Is Geography a Science?

The word *geography*, invented by the ancient Greek scholar Eratosthenes, is based on two Greek words. Geo means "Earth," and graphy means "to write." Geography is the study of where things are found on Earth's surface and the reasons for their locations. Human geographers ask two simple questions: Where are people and activities found on Earth? Why are they found there?

Geography's Basic Concepts

Learning Outcome 1.1.1 Summarize geography's basic concepts.

Thinking geographically is one of the oldest human activities. Perhaps the first geographer was a prehistoric human who crossed a river or climbed a hill, observed what was on the other side, returned home to tell about it, and scratched the route in the dirt. The second geographer may have been a friend or relative who followed the dirt drawing to reach the other side.

Geography & History

Human geography and history both rely on the collection of evidence about human activity. In his framework of all scientific knowledge, the German philosopher Immanuel Kant (1724–1804) compared geography and history:

Geographers . . .	Historians . . .
identify the location of important places.	identify the dates of important events.
explain why one human activity is found near another.	explain why one human activity follows another chronologically.
ask where and why.	ask when and why.
organize material spatially.	organize material chronologically.
recognize that an action at one point on Earth can result from actions at another point, which can consequently affect conditions elsewhere.	recognize that an action at one point in time can result from past actions and can in turn affect future ones.

History and geography differ in one especially important manner: A geographer can drive or fly to another place to study Earth's surface, whereas a historian cannot travel to another time to study other eras firsthand. This ability to reach other places lends excitement to the discipline of geography – and geographic training raises the understanding of other spaces to a level above that of casual sightseeing.

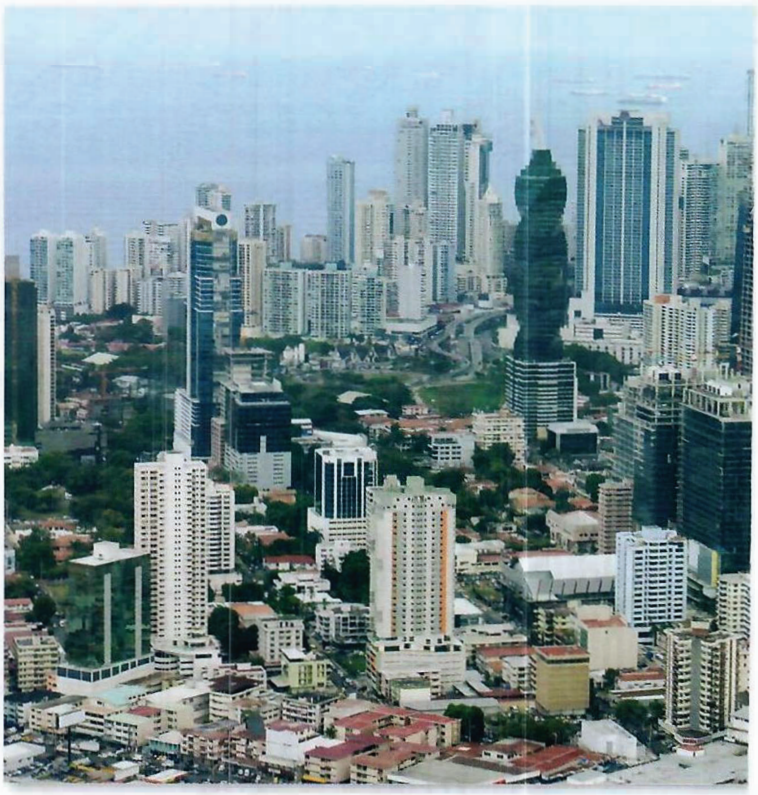
To introduce human geography, we concentrate on two main features of human behavior – culture and economy. The first half of the book explains why the most important cultural features, such as major languages, religions, and ethnicities, are arranged as they are across Earth. The second half of the book looks at the distribution of the most important economic activities, including agriculture, manufacturing, and services.

Everywhere Is Unique

This chapter introduces basic concepts that geographers employ to address their "where" and "why" questions. To explain where things are, one of geography's most important tools is a map. Ancient and medieval geographers created maps to describe what they knew about Earth. Today, accurate maps are generated from electronic data.

Geographers employ several basic concepts to explain why everywhere on Earth is in some ways unique and in other ways related to other locations. Many of these concepts are commonly used English words, but they are given particular meaning by geographers. To explain why everywhere on Earth is unique, geographers have two basic concepts:

- A **place** is a specific point on Earth, distinguished by a particular characteristic. Every place occupies a unique location, or position, on Earth's surface. Panama City, the capital of the country of Panama, is uniquely situated on Panama Bay, which opens out into the Pacific Ocean (Figure 1-1).



▲ **FIGURE 1-1 PANAMA: PLACE** Panama City, the capital of the country of Panama, has 1.5 million inhabitants in its metropolitan area.

- A **region** is an area of Earth defined by one or more distinctive characteristics. Geographers divide the world into a number of regions, such as Latin America, which includes Panama (Figure 1-2).

▲ **FIGURE 1-2 PANAMA: REGION** Panama City is part of the world region of Latin America.

All Locations Are Interrelated

To explain why different locations are interrelated, geographers have three basic concepts:

- **Scale** is the relationship between the portion of Earth being studied and Earth as a whole. Geographers study a variety of scales, from local to global. Many processes that affect humanity's occupance of Earth are global in scale, such as climate change and depletion of energy supplies. At the same time, local-scale processes are increasingly important, such as preservation of distinctive cultural and economic activities (Figure 1-3).
- **Space** refers to the physical gap or interval between two objects. Geographers observe that many objects are distributed across space in a regular manner, for discernible reasons (Figure 1-4).
- **Connection** refers to relationships among people and objects across the barrier of space. Geographers are concerned with the various means by which connections occur (Figure 1-5).

Pause & Reflect 1.1.1 What are the principal connections from your hometown to other places?

▲ **FIGURE 1-3 PANAMA: SCALE** At a local scale, a craft market in Panama City features distinctive crafts made by the Kuna Indigenous people. At a global scale, the principal customers for the crafts are tourists from other countries.

▲ **FIGURE 1-4 PANAMA: SPACE** The gap between places can be minimal or substantial. The distance between the Panama City market in Figure 1-3 and the Barro Colorado Nature Monument is only 50 kilometers (30 miles), but it takes at least two hours to travel that distance via a busy toll road and a ferry.

◀ **FIGURE 1-5 PANAMA: CONNECTIONS** The Panama Canal connects the Atlantic and Pacific oceans. The Puente Centenario (Centennial Bridge) spans the Panama Canal, providing connections for people between the two sides of the canal.

Mapping

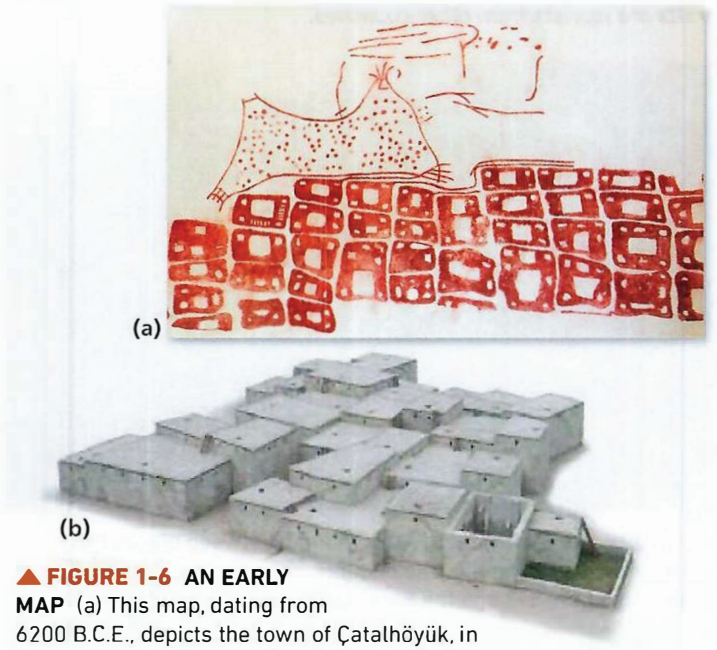
Learning Outcome 1.1.2 Explain the development of the science of cartography.

Geography's most important tool for thinking spatially about the distribution of features across Earth is a map. A **map** is a two-dimensional or flat-scale model of Earth's surface, or a portion of it. Geography is immediately distinguished from other disciplines by its reliance on maps to display and analyze information.

A map serves two purposes:

- **As a reference tool.** A map helps us to find the shortest route between two places and to avoid getting lost along the way. We consult maps to learn where in the world something is found, especially in relationship to a place we know, such as a town, body of water, or highway. The maps in an atlas or a road map are especially useful for this purpose.
- **As a communications tool.** A map is often the best means for depicting the distribution of human activities or physical features, as well as for thinking about reasons underlying a distribution.

A map is a scale model of the real world, made small enough to work with on a desk or computer. It can be a hasty here's-how-to-get-to-the-party sketch, an elaborate work of art, or a precise computer-generated product. For centuries, geographers have worked to perfect the science of mapmaking, called **cartography**. Contemporary cartographers are assisted by computers and satellite imagery.



▲ **FIGURE 1-6 AN EARLY MAP** (a) This map, dating from 6200 B.C.E., depicts the town of Çatalhöyük, in present-day Turkey, and the eruption of the Hasan Dağ| (Mount Hasan) twin-peaks volcano, which is actually located around 140 kilometers (87 miles) northeast of the town. Archaeological evidence indicates that the volcano did erupt around the time that the map was made. The map is now in the Konya Archaeology Museum. (b) Artist's impression of Çatalhöyük,created from details on the map.

Geography in the Ancient World

The science of geography has prehistoric roots. One of the earliest surviving fully authenticated maps, depicting the town of Çatalhöyük in present-day Turkey, dates from approximately 6200 B.C.E. Archaeologists found the map on the wall of a house that was excavated during the 1960s (Figure 1-6).

Major contributors to geographic thought in the ancient eastern Mediterranean included:

- Thales of Miletus (ca. 624–ca. 546 B.C.E.), who applied principles of geometry to measuring land area.
- Anaximander (610–ca. 546 B.C.E.), a student of Thales, who made a world map based on information from sailors and argued that the world was shaped like a cylinder.
- Pythagoras (ca. 570–ca. 495 B.C.E.), who may have been the first to propose a spherical world, arguing that the sphere was the most perfect form.
- Hecataeus (ca. 550–ca. 476 B.C.E.), who may have produced the first geography book, called *Periodos Ges* ("Journey Around the Earth").
- Aristotle (384–322 B.C.E.), who was the first to demonstrate that Earth was spherical on the basis of evidence.
- Eratosthenes (ca. 276–ca. 194 B.C.E.), the inventor of the word "geography," who accepted that Earth was round (as few others did in his day), calculated its circumference within 0.5 percent accuracy, accurately divided Earth into five climatic regions, and described the known world in one of the first geography books.
- Strabo (ca. 64 B.C.E.–ca. 24 C.E.), who described the known world in a 17-volume work titled *Geographica* ("Geography").
- Ptolemy (ca. 100–ca. 170 C.E.), who wrote an eight-volume *Geographia*, codified basic principles of mapmaking, and prepared numerous maps that were not improved upon for more than 1,000 years (Figure 1-7).

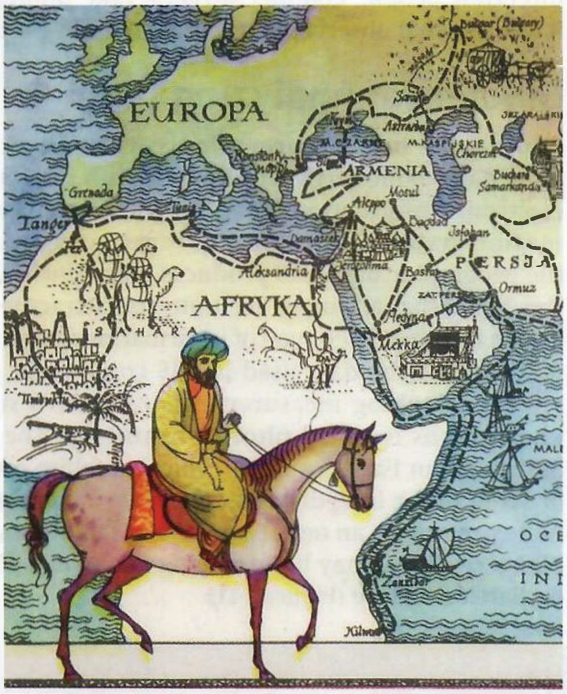
▲ **FIGURE 1-7 WORLD MAP BY PTOLEMY, CA.150 C.E.** The map shows the known world at the height of the Roman Empire, around the Mediterranean Sea and Indian Ocean.

Geography's Revival

After Ptolemy, little progress in mapmaking or geographic thought was made in Europe for more than 1,000 years. Maps became less mathematical and more fanciful, showing Earth as a flat disk surrounded by fierce animals and monsters. Geographic inquiry continued, though, elsewhere in the world. Ancient and medieval contributors outside Europe included:

- "Yu Gong" ("Tribute of Yu"), written by an unknown author in the fifth century B.C.E., described the economic resources of the country's different provinces; it was a chapter in a book called *Shujing* ("Book of Documents"), considered one of five classics of ancient Chinese literature.
- Pei Xiu (224–271 C.E.), the "father of Chinese cartography," who produced an elaborate map of the country in 267 C.E.
- Muhammad al-Idrisi (1100–1165), an Arab geographer whose extensive travels through Southwest Asia & North Africa informed his creation of a world map and geography text in 1154, building on Ptolemy's long-neglected work (Figure 1-8).
- Ibn Battuta (1304–ca. 1368), a Moroccan scholar who wrote *Rihla* ("Travels") based on three decades of journeys covering more than 120,000 kilometers (75,000 miles) through northern Africa, southern Europe, and much of Asia (Figure 1-9).

▲ **FIGURE 1-8 WORLD MAP BY AL-IDRISI, 1154** Al-Idrisi built on Ptolemy's map, which had been neglected for nearly a millennium.



▲ **FIGURE 1-9 IBN BATTUTA** Ibn Battuta on horseback in front of a map of his journeys, illustrated by twentieth-century Polish artist Hanna Balicka-Fribes.

The making of maps as reference tools was revived during the Age of Exploration and Discovery. Columbus, Magellan, and other explorers who sailed across the oceans in search of trade routes and resources in the fifteenth and sixteenth centuries required accurate maps to reach desired destinations without wrecking their ships. In turn, cartographers took information collected by the explorers to create more accurate maps. Influential European cartographers included:

- Martin Waldseemüller (ca. 1470–1520), a German cartographer who was credited with producing the first map to use the label "America"; he wrote on the map (translated from Latin) "from Amerigo the discoverer . . . as if it were the land of Americus, thus America" (Figure 1-10).
- Abraham Ortelius (1527–1598), a Flemish cartographer, who created the first modern atlas and was the first to hypothesize that the continents were once joined together before drifting apart.
- Bernhardus Varenius (1622–1650), who produced *Geographia Generalis*, which stood for more than a century as the standard treatise on systematic geography.

▲ **FIGURE 1-10 WORLD MAP BY WALDSEEMÜLLER, 1508**

Pause & Reflect 1.1.2 What is one main difference between the world maps of Ptolemy (Figure 1-7) and of Waldseemüller (Figure 1-10)?

Contemporary Geographic Tools

Learning Outcome 1.1.3 Identify geography's principal contemporary mapping tools.

Maps are not just paper documents in textbooks. They have become essential for delivery of contemporary online services through smartphones, tablets, and computers. Location data used in applications and devices are collected through electronic tools. While these digital systems allow geographers to explore more of Earth, they still rely on field work to collect data and ground-truth conclusions. They interview people, conduct surveys, take photographs, and have informal observations of the landscape around them.

GIScience: Analyzing Data

Geographic information science (GIScience) is the analysis of data about Earth acquired through satellite and other electronic information technologies. A **geographic information system (GIS)** captures, stores, queries, and displays the geographic data. GIS produces maps (including those in this book) that are more accurate and attractive than those drawn by hand. Each type of information is stored in a layer.

Some of the data used in GIS come from photos. The science of taking measurements of Earth's surface from photographs is called **photogrammetry**. The acquisition of data about Earth's surface from a satellite orbiting Earth or from other long-distance methods is **remote sensing**. At any moment, an aerial sensor attached to a satellite, airplane, or drone may be recording the image of a tiny area on Earth's surface (Figure 1-11).

▲ **FIGURE 1-11 PHOTOGRAMMETRY** A drone records images of Earth's surface.

Note: *This is a digitally altered image.*

▲ **FIGURE 1-12 3D VIRTUAL REPRESENTATION MAP** A 3D Google Earth image of Venice, Italy, is projected on a large screen at the Whitney Museum of American Art, New York.

1. *Give an example of how you, as the owner of a business, might use a 3D aerial image of a place.* 2. *Give an example of how a government might use such images.*

Corporations and government agencies use photogrammetry and remote sensing to create high-quality 3D virtual representations of portions of Earth. These maps can depict the distribution of a wide variety of urban and rural features (Figure 1-12).

GIScience helps geographers create more accurate and complex maps and measure changes over time in the characteristics of places. Layers of information acquired through remote sensing and produced through GIS can be described and analyzed. GIScience enables geographers to calculate whether relationships between objects on a map are significant or merely coincidental.

GPS: Pinpointing Locations

Our smartphones, tablets, and computers are equipped with **Global Positioning System (GPS),** which is a system that determines the precise position of something on Earth. The GPS in use in the United States includes two dozen satellites placed in predetermined orbits; a series of tracking stations to monitor and control the satellites; and receivers that compute position, velocity, and time from the satellite signals.

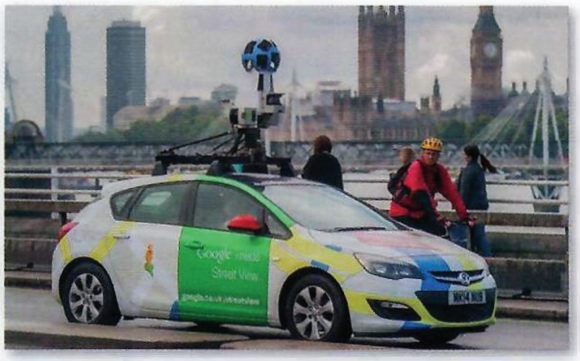
GPS is most commonly used for navigation. Pilots of aircraft and ships stay on course with GPS. On land, GPS detects a vehicle's current position, the motorist programs the desired destination into a GPS device, and the device provides instructions on how to reach the destination.

Thanks to GPS, our electronic devices provide us with a wealth of information about the specific place on Earth we currently occupy. The locations of all the information we gather and photos we take with our electronic devices are recorded through **geotagging**, which is identification and storage of a piece of information by its precise latitude and longitude coordinates. Geotagging has led to concerns about privacy (refer ahead to Debate It! feature on page 33).

VGI: Making Maps Yourself

Most of the maps fed into our electronic devices are provided by a handful of companies (Figure 1-13). However, smartphones, tablets, and computers enable individuals to make maps and share them with others. **Volunteered geographic information (VGI)** is the creation and dissemination of geographic data contributed voluntarily and for free by individuals. VGI is part of the broader trend of **citizen science**, which is scientific research by amateur scientists, and **participatory GIS (PGIS)**, which is community-based mapping. Citizen science and PGIS collect and disseminate local knowledge and information through electronic devices.

A **mashup** is a map that overlays data from one source on top of a map provided by a mapping service, such as Google Maps or Bing Maps. The term comes from the hip hop practice of mixing two or more songs.



▲ **FIGURE 1-13 GOOGLE STREET MAPPING**

Individuals can create mashups on their personal computers because mapping services provide access to the application programming interface (API), which is the language that links a database such as an address list with software such as mapping software (see Doing Geography feature).

Pause & Reflect 1.1.3 What is an example of a mashup done for your community?

DOING GEOGRAPHY — Participatory GIS & Hurricane Maria

After Hurricane Maria devastated Puerto Rico in September 2017, geographers at Miami University mapped a southeastern section of the island. Using software from the Humanitarian OpenStreetMap Team, the geographers placed on the map outlines of buildings from satellite imagery taken before the hurricane. The Red Cross requested the map to help identify where to respond first (Figure 1-14).

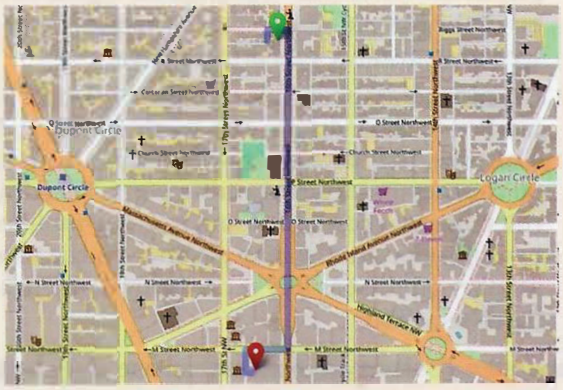
▲ **FIGURE 1-14 PARTICIPATORY GIS** Miami University geographers help the Red Cross map devastation in Puerto Rico from Hurricane Maria.

Crowdsourcing Hurricane Maria
https://goo.gl/EYFhBv

What's Your **HUMAN** Geography?

A **mental map** is a personal representation of a portion of Earth's surface. A mental map depicts what an individual knows about a place, and it contains personal impressions of what is in the place and where the place is located.

1. Draw on paper a mental map depicting your route between two familiar places, such as between home and geography class. Show the paths (roads or walkways) and landmarks along the route, such as buildings or shops.
2. Compare your mental map to those made by others in your class. How detailed is your depiction of paths and landmarks compared to those of others? At school, for example, a senior is likely to have a more detailed map than a newcomer.
3. Compare your mental map to a map of the same area from Google Maps or Bing Maps. How accurate is your map? Did you forget something important or put something in the wrong place?
4. At OpenStreetMap.org, see if your route has been mapped. Click the Directions arrow icon to the right of "Go." Enter your starting and ending addresses. Choose car, bicycle, or foot. Press "Go." Is this your preferred route? Why or why not (Figure 1-15)? Are any landmarks you consider important on the map? Why or why not?



▲ **FIGURE 1-15 OPENSTREETMAP, WASHINGTON, D.C.** The path by foot from the Association of American Geographers office (green pin) to the National Geographic office (red pin) passes several landmarks, including churches, memorials, and embassies.

Making Maps

Learning Outcome 1.1.4 Explain the role of map scale and projection in reading maps.

To make any map, a cartographer must make two decisions:

- How much of Earth's surface to depict on the map (map scale).
- How to transfer a spherical Earth to a flat map (projection).

Map Scale

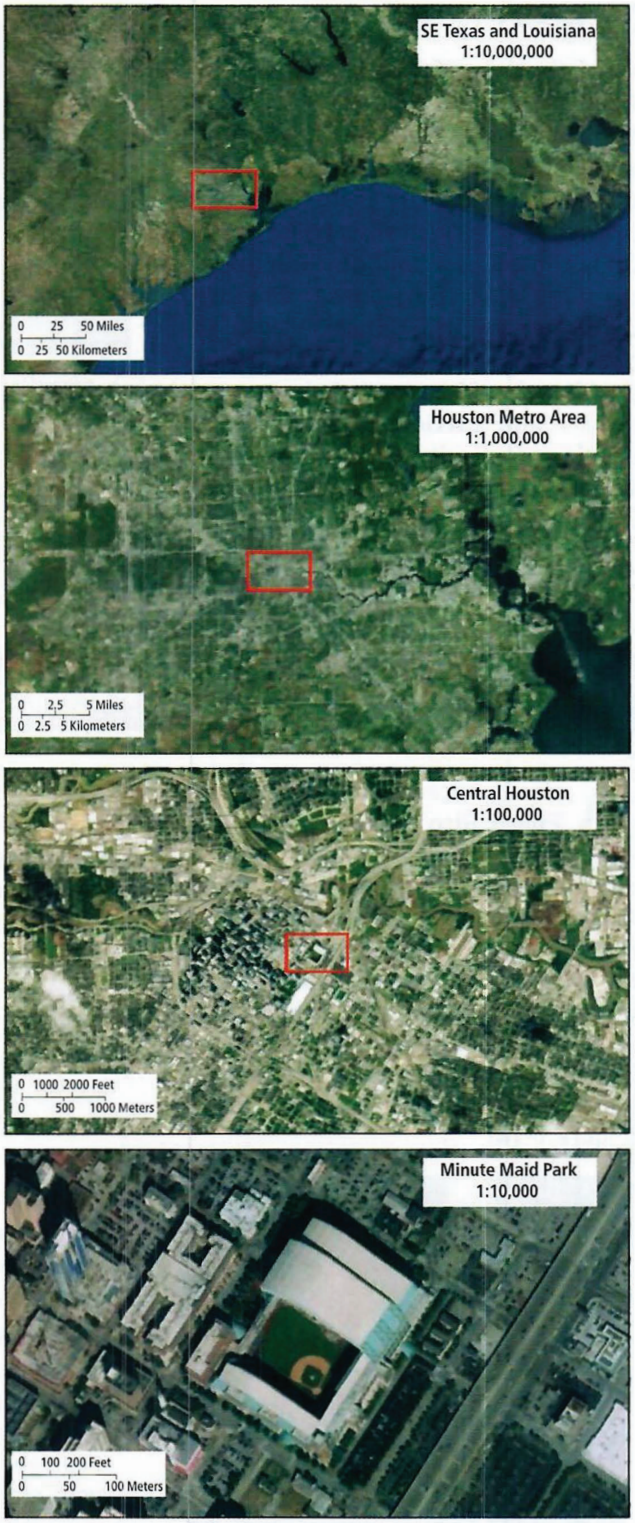
What is the purpose of the map? Is it necessary to show the entire globe on a map, or just one continent, or a country, or a city? To make a scale model of the entire world, many details must be omitted because there simply is not enough space. Conversely, if a map shows only a small portion of Earth's surface, such as a street map of a city, it can provide a wealth of detail about a particular place.

The level of detail and the amount of area covered on a map depend on its **map scale**. When specifically applied to a map, map scale refers to the relationship of a feature's size on a map to its actual size on Earth. Map scale is presented in three ways (Figure 1-16).

- **Ratio.** A ratio or fraction shows the numerical relationship between distances on the map and Earth's surface. A scale of 1:1,000,000 means that 1 unit (for example, inch, centimeter, foot, finger length) on the map represents 1 million of the same unit on the ground. The 1 on the left side of the ratio always refers to a unit of distance on the map, and the number on the right always refers to the same unit of distance on Earth's surface.
- **Written.** A written scale describes the relationship between map and Earth distances in words. For example, in the statement "1 centimeter equals 10 kilometers," the first number refers to map distance and the second to distance on Earth's surface.
- **Graphic.** A graphic scale usually consists of a bar line marked to show distance on Earth's surface. To use a bar line, first determine with a ruler the distance on the map in inches or centimeters. Then hold the ruler against the bar line and read the number on the bar line opposite the map distance on the ruler. The number on the bar line is the equivalent distance on Earth's surface.

Maps often display scale in more than one of these three ways.

The appropriate scale for a map depends on the information being portrayed. A map of a downtown area, such as Figure 1-16 (bottom), may have a scale of 1:10,000, whereas a map of southeast Texas, such as Figure 1-16 (top), may have a scale of 1:10,000,000. One inch represents about 800 feet on the Minute Maid Park map and about 158 miles on the southeast Texas map.



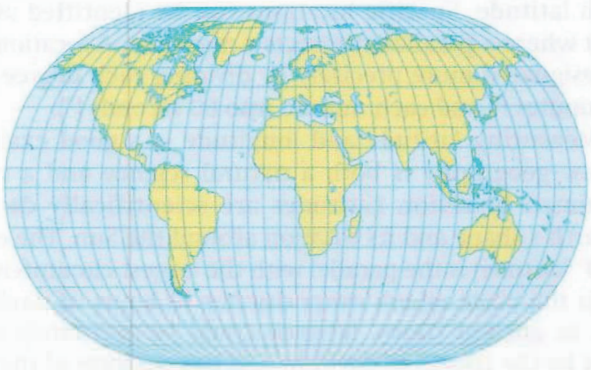
▲ **FIGURE 1-16 MAP SCALE** The four images show (from top to bottom) an area centered on Houston, Texas, at progressively larger scales: (top) southeast Texas, (second) the city of Houston, (third) central Houston, and (bottom) Minute Maid Park. Each map includes ratio and graphic scales.

At the scale of a small portion of Earth's surface, a map can provide detailed information about an area such as a city's downtown. At the scale of the entire globe, the amount of detail must be greatly reduced, but the map can still effectively communicate processes and trends that affect everyone.

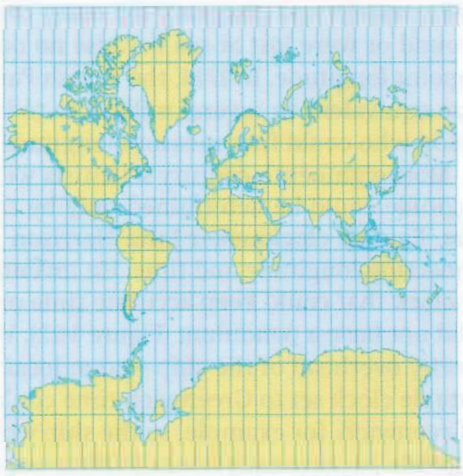
Projection

Earth is very nearly a sphere and is therefore accurately represented with a globe. However, a globe is an extremely limited tool with which to communicate information about Earth's surface. A small globe does not have enough space to display detailed information, whereas a large globe is too bulky and cumbersome to use. And a globe is difficult to write on, photocopy, display on a computer screen, or carry in the glove box of a car. Consequently, most maps – including those in this book – are flat. Three-dimensional maps can be made but are expensive and difficult to reproduce.

Earth's spherical shape poses a challenge for cartographers because drawing Earth on a flat piece of paper unavoidably produces some distortion. Cartographers have invented hundreds of clever methods of producing flat maps, but none has produced perfect results. The scientific method of transferring locations on Earth's surface to a flat map is called **projection**.



▲ **FIGURE 1-17 WINKEL PROJECTION** The relative sizes of the landmasses on the map are the same as in reality. The projection minimizes distortion in the shapes of most landmasses. Areas toward the North and South poles, such as Greenland and Australia, become more distorted, but they are sparsely inhabited, so distorting their shapes usually is not important. However, by allocating space to the oceans, the land areas are much smaller than on interrupted maps of the same size.



Animation

Map Projections
https://goo.gl/48NNbb

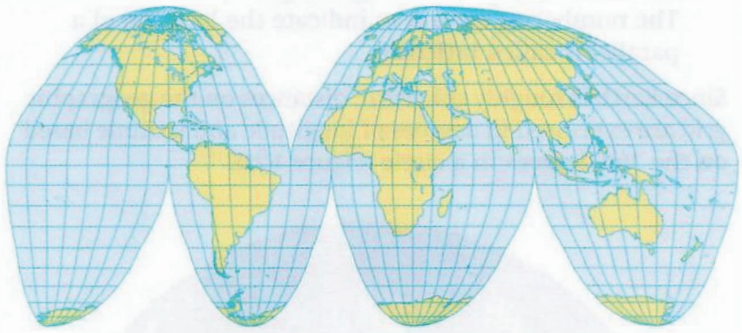
▲ **FIGURE 1-18 MERCATOR PROJECTION** Shape is distorted very little, direction is consistent, and the map is rectangular. However, relative size is grossly distorted toward the poles, making high-latitude places such as Antarctica look much larger than they actually are.

The problem of distortion is especially severe for maps depicting the entire world. Four types of distortion can result:

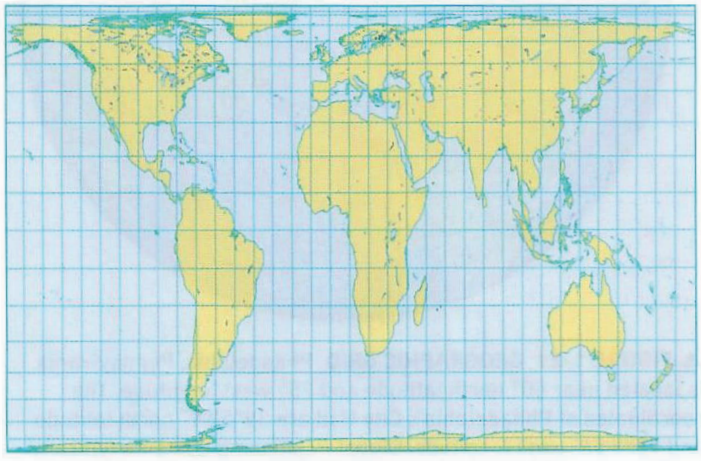
1. The ***shape*** of an area can be distorted, so that it appears more elongated or squat than in reality.
2. The ***distance*** between two points may become increased or decreased.
3. The ***relative size*** of different areas may be altered, so that one area may appear larger than another on a map but is in reality smaller.
4. The ***direction*** from one place to another can be distorted.

Most of the world maps in this book use the Winkel equal area projection (Figure 1-17). Other common world projections are Mercator (Figure 1-18), Goode Homolosine (Figure 1-19), and Gall-Peters (Figure 1-20).

Pause & Reflect 1.1.4 Compare the sizes of Greenland and South America on the four maps on this page. Which of the two landmasses is actually larger? How do you know?



▲ **FIGURE 1-19 GOODE HOMOLOSINE PROJECTION** This projection separates the Eastern and Western hemispheres into two pieces, a feature known as interruption. It gives more prominence to the landmasses. The meridians (the vertical lines), form right angles with the parallels (the horizontal lines) on a globe, but not in this projection.



▲ **FIGURE 1-20 GALL-PETERS PROJECTION** This projection does not distort relative size but does distort shape.

Interpreting Maps

Learning Outcome 1.1.5 Explain how the geographic grid locates points on Earth's surface and helps to tell time.

Geographers can create a wide variety of maps. The most suitable variety of map depends on the type of data to be displayed.

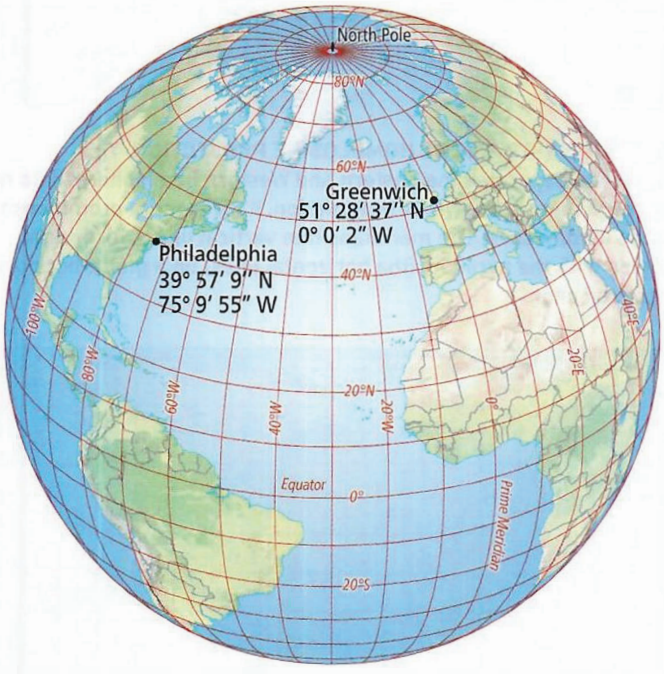
The Geographic Grid

The geographic grid is a system of imaginary arcs drawn in a grid pattern on Earth's surface. The geographic grid plays an important role in telling time.

The location of any place on Earth's surface can be described precisely by meridians and parallels, two sets of imaginary arcs drawn in a grid pattern on Earth's surface:

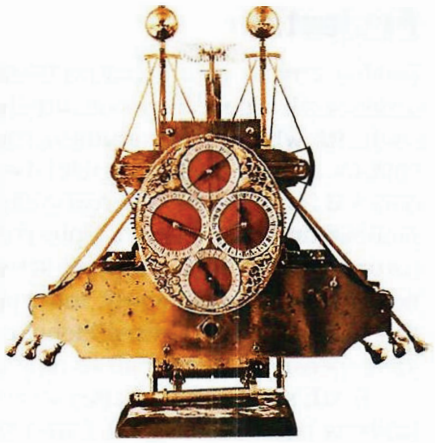
- A **meridian** is an arc connecting the North and South poles. The location of each meridian is identified on Earth's surface according to a numbering system known as **longitude**. Longitude is the basis for telling time (see page 42).
- A **parallel** is a circle drawn around the globe parallel to the equator and at right angles to the meridians. The numbering system to indicate the location of a parallel is called **latitude**.

Since Earth is roughly spherical, distances on the geographic grid are expressed in degrees of longitude and latitude based on the 360 degrees in a circle (Figure 1-21).



▲ **FIGURE 1-21 GEOGRAPHIC GRID** Philadelphia, Pennsylvania, is located near 40° north latitude and 75° west longitude. The coordinates of Philadelphia's City Hall are 39°57'9" north latitude and 75°9'54" west longitude. Global Positioning Systems typically divide degrees into decimal fractions rather than minutes and seconds. Philadelphia's City Hall is located at 39.952583° north latitude and 75.165222° west longitude.

The meridian that passes through the Royal Observatory at Greenwich, England, is 0° longitude, also called the **prime meridian**. The meridian on the opposite side of the globe from the prime meridian is 180° longitude. All other meridians have numbers between 0° and 180° east or west, depending on whether they are east or west of the prime meridian. The equator is 0° latitude, the North Pole 90° north latitude, and the South Pole 90° south latitude. Specific locations can be identified as the point where a parallel intersects a meridian. A location can be designated more precisely by dividing each degree into 60 minutes (') and each minute into 60 seconds (").



▲ **FIGURE 1-22 JOHN HARRISON'S CLOCK** This clock helped people in the eighteenth century calculate longitude.

Measuring latitude and longitude is a good example of how geography is both a natural science and a study of human behavior. Latitudes are scientifically derived by Earth's shape and its rotation around the Sun. The equator (0° latitude) is the parallel with the largest circumference and is the place where every day has 12 hours of daylight. Even in ancient times, latitude could be accurately measured by the length of daylight and the position of the Sun and stars.

On the other hand, 0° longitude is a human creation. Any meridian could have been selected as 0° longitude because all meridians have the same length and all run between the poles. The 0° longitude runs through Greenwich because England was the world's most powerful country when longitude was first accurately measured.

Inability to measure longitude was the greatest obstacle to exploration and discovery for many centuries. Ships ran aground or were lost at sea because no one on board could pinpoint longitude. In 1714, the British Parliament offered a prize equivalent to several million in today's dollars to the person who could first measure longitude accurately.

Most eighteenth-century scientists were convinced that longitude could be determined only by the position of the stars. English clockmaker John Harrison won the prize by connecting longitude and time. He invented the first portable clock that could keep accurate time on a ship – because it did not have a pendulum (Figure 1-22). When the Sun was directly overhead of the ship – noon local time – Harrison's portable clock set to Greenwich time could say it was 2 P.M. in Greenwich, for example, so the ship would be at 30° west longitude because each hour of difference was equivalent to traveling 15° longitude.

Pause & Reflect 1.1.5 Use a search tool to find the longitude and latitude of your community.

Types of Maps

Maps can represent the distribution of data for one or more variables in a variety of ways:

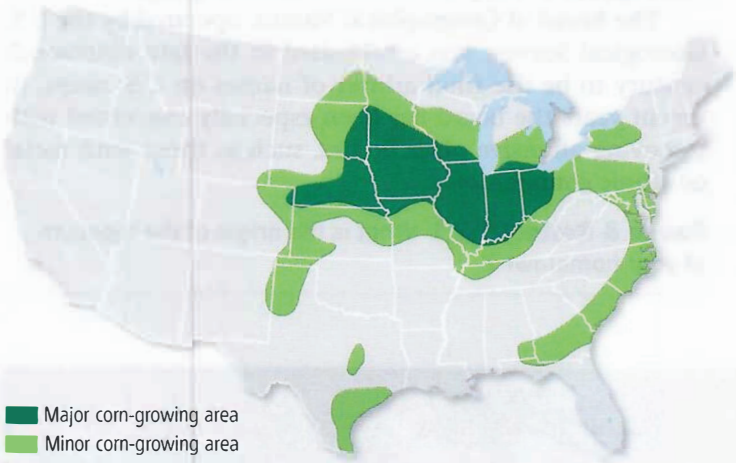
An **isoline map** connects with lines all the places that have particular values (Figure 1-23).

A **dot distribution map** depicts data as points and shows how those points are clustered together or spread out over an area. Each dot represents a predetermined number of observations, which could be one or many (Figure 1-24).

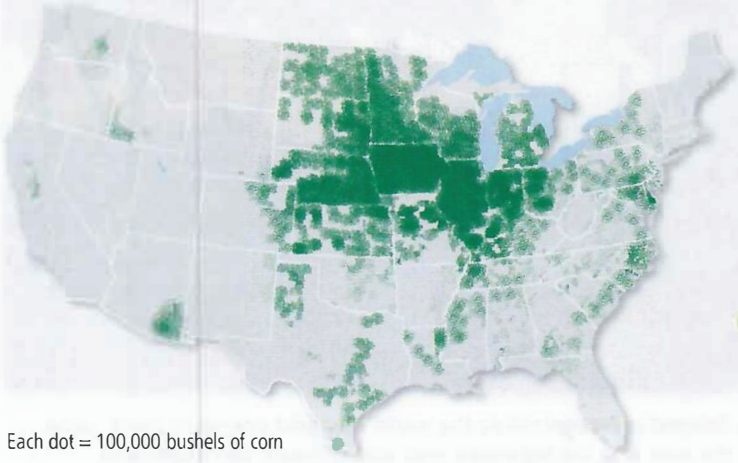
A **choropleth map** is a map where recognizable areas are shaded or patterned in proportion to the measurement of the variable. For example, areas with darker colors may represent the highest range of the data (Figure 1-25).

A **graduated symbol map** displays symbols that change in size according to the value of the variable. A higher value is typically represented by a larger symbol (Figure 1-26).

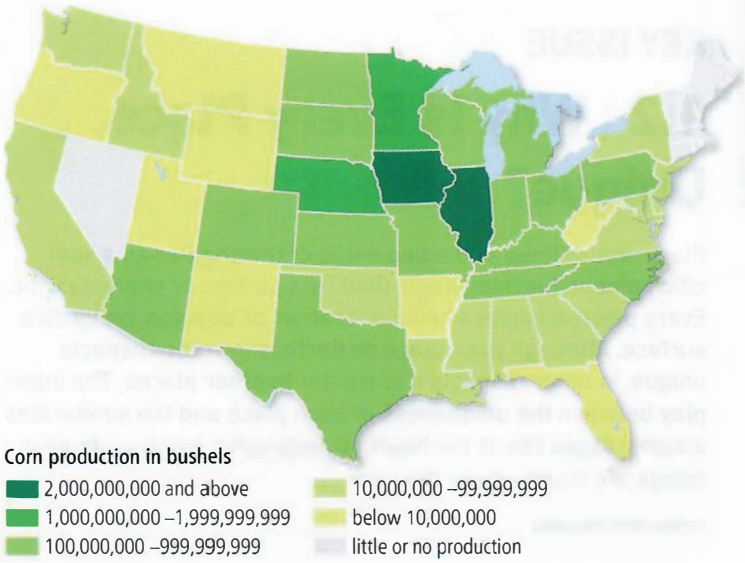
A **cartogram** is a map in which the size of a country or U.S. state is proportional to the value of a particular variable, such as the amount of corn produced, rather than to the actual land area. The cartogram in Figure 1-27 preserves the rough shapes and positions of the states, but distorts their scale: Iowa is much larger than Texas because Iowa produces a lot more corn.



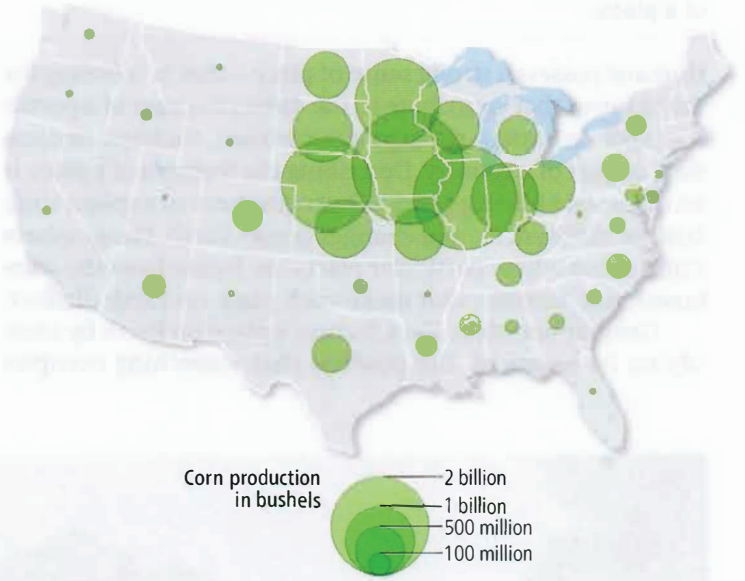
▲ **FIGURE 1-23 ISOLINE MAP** The darker the color, the more important the region for corn production.



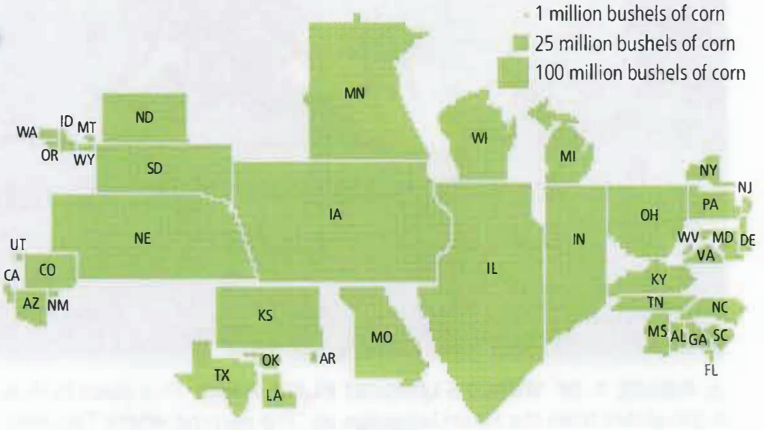
▲ **FIGURE 1-24 DOT DISTRIBUTION MAP** More dots mean more corn production.



▲ **FIGURE 1-25 CHOROPLETH MAP** The darker the state, the more corn production.



▲ **FIGURE 1-26 GRADUATED SYMBOL MAP** The larger the circle, the more corn production.



▲ **FIGURE 1-27 CARTOGRAM** The more corn production, the larger the area of the state.