The study of geography involves looking at every aspect of the Earth’s systems. Aspects such as human economies, societies, and cultures, and plants, animals, climate, and the physical environment affect each other in many ways. Geography analyzes these diverse interactions to learn more about how Earth’s systems are interconnected. Geographers gather information from various sources using a variety of tools to study these complex and interrelated Earth systems.

Globes and Map Projections

How are globes and map projections related?

A globe is a scale model of the Earth that depicts properties such as area, distance, and direction. Globes accurately display all these properties because they are round just like the Earth. A map is a flat representation of all or part of the planet. But, unlike globes, maps cannot show all the properties accurately.

Mapmakers, called cartographers, use mathematical formulas to transfer information from the three-dimensional globe to the two-dimensional map. However, when the curves of a globe become straight or only slightly curved lines on a map, distortion occurs in shape, distance, area, or direction.

A straight line of true direction on a map is not always the shortest distance between two points on Earth. The measured distance between any two points on a flat map will not have the same distance when measured on a round globe. To find the actual shortest distance between any two places, stretch a piece of string around a globe from one point to the other. The string will form an arc that is part of a great circle, an imaginary line that follows the Earth’s curvature. Great circle routes therefore mark the shortest distance that an object can travel between two points. They are useful because they indicate actual distances between two locations. Determining a great circle route is important for travel and transportation. Ship captains and airplane pilots use great circle routes to reduce travel time and conserve fuel.

While globes are useful for portraying the entire Earth, their ability to display detailed features of a particular region are limited. Maps, however, are useful for showing more in-depth information. Cartographers convert the three-dimensional globe image onto a flat map by creating a map projection. But because map projections can distort one or more of the properties of size, shape, distance, area, or direction, the cartographer must choose the projection to use based on the purpose of the map. It is important to know which properties are distorted, and how much they are distorted, so you can use and interpret the map accurately.

There are many kinds of map projections, some with general names and some named after the cartographer who developed them. Three major categories of map projections are planar, cylindrical, and conic.

A planar projection, also known as an azimuthal projection, shows the Earth centered in such a way that a straight line coming from the center to any other point represents the shortest distance. Because a planar projection is most accurately represented from its center, it is often used for maps of the Poles.

A cylindrical projection is based on how a map would look if the globe was projected onto a cylinder. This type of projection is most accurate at the Equator because shapes and distances are increasingly distorted when moving away from the Equator and toward the Poles. A Mercator projection is a common example of a cylindrical projection. Because it displays true direction, a Mercator projection is useful for sea navigation.

A conic projection is the Earth’s surface projected onto a map formed into a cone. Shape is relatively accurate on such projections, and straight lines drawn on them approximate great circle routes if distances are not great.

World maps used for general reference use the Winkel Tripel projection. This map projection cannot be used to determine precise distances, sizes, or shapes of specific global features. It does, however, provide a good balance between the overall size and shape of land areas shown.

A Robinson projection looks similar to a Winkel Tripel projection, although its east-west projections run in a straight line. The Robinson projection produces minor distortions, particularly in the polar areas that appear flattened on the map. The sizes and shapes near the eastern and western edges of the map are accurate, and outlines of the continents appear much as they do on the three-dimensional globe.

Goode’s Interrupted Equal-Area projection resembles a globe that has been cut apart and laid flat. The process of creating this interrupted projection can be compared to slicing an orange peel in order to lay it flat on a page. Although this projection shows the true size and shape of Earth’s landmasses, distances between land features are generally distorted.

**Explaining** Why is a trip from Tokyo to Los Angeles a longer distance than it appears to be on a map?
Determining Location

How is location determined?

Geography addresses the question of where. To answer this question, a geographer identifies a location. Both globes and maps use a grid system in order to form a pattern of lines that cross one another. These patterns are used to help find the location of places on the Earth’s surface.

Lines of latitude, or parallels, circle the Earth parallel to the Equator. Although they run in an east-to-west direction, they measure distance to the north and south of the Equator. The measurements are in degrees. Parallels north of the Equator are called north latitude. Parallels south of the Equator are called south latitude. The Equator is defined as 0° latitude, the North Pole as 90° N, and the South Pole as 90° S.

Longitude lines, also called meridians, are lines that connect the North and South Poles. They run in a north-to-south direction, but they measure distance east and west of the Prime Meridian, which is identified as 0° longitude. Meridians run perpendicular to the lines of latitude, and they also use the measurement of degrees. Meridian lines located east of the Prime Meridian are identified as east longitude, and lines located west are known as west longitude. The longitude line located 180° from the Prime Meridian, on the opposite side of the Earth, is called the International Date Line.

The Equator divides the Earth in half, creating Northern and Southern Hemispheres. The Northern Hemisphere includes any location north of the Equator up to 90° N, while the Southern Hemisphere includes any location south of the Equator up to 90° S. Just as the Equator splits the Earth into Northern and Southern Hemispheres, the Prime Meridian and International Date Line split the globe into east and west halves. Locations east of the Prime Meridian are identified as part of the Eastern Hemisphere, and locations west of the Prime Meridian as part of the Western Hemisphere. All points on Earth are located in two of the four hemispheres: north or south and east or west.

An absolute location is an exact global address derived from the latitude and longitude lines that intersect at that place. For example, Tokyo, Japan, is located at approximately 36° N latitude and 140° E longitude. For a more precise reading of a location, a degree is divided into 60 minutes ('). Each minute is then divided into 60 seconds (") just as hours and minutes on a clock are divided to provide a more exact time. For example, the absolute location of the famous Tokyo Tower is 35°39' 30.96" N latitude and 139°44' 43.59" E longitude.

While absolute location identifies exact points using latitude and longitude, relative location uses a reference point to identify one place in relation to another. To find relative location, find a reference point—a location you already know—on a map. Then look in the appropriate direction for the new location. For example, locate the city of Paris on the map of France and use this as your reference point. The relative location of the city of Lyon can be described as southeast of Paris.

Listing List the four hemispheres of the Earth.
Skills Practice Work with a partner to compare the maps and diagrams in this lesson with the information in the paragraphs. Take turns reading the paragraphs aloud while your partner identifies the corresponding information in the visuals.

Using Maps

How do maps work?

In addition to lines of latitude and longitude, maps include other important tools to help you understand the information they provide. Learning to use map tools will help you interpret the language of maps more easily.

Parts of a Map

The purpose of a map is identified by the map’s title. For example, a map titled “Housing Developments in Washington, D.C.” would show different details than a map titled “Topography of the Washington, D.C., area.” The time period of a map is another important clue to understanding what the map shows. For example, a map titled “Europe Before World War I” would show country borders and national capitals of Europe that are quite different from Europe’s current political borders. The map title is the first thing you should look at when reading a map because it provides context for the map’s content.

An effective map will provide a legend, or key, to explain the meaning of various symbols used on the map. Geographic features represented on the map are identified by symbols, also called icons. Icons vary by map, depending on the details that are the focus of the map. Roads, highways, railroads, landmarks, parks, and buildings are all human-made features shown by icons. Dots are often used to represent cities. Sometimes the relative sizes of cities are shown using dots of different sizes. Capital cities can be identified by a star within a circle.

The compass rose indicates direction or orientation of a map. North, east, south, and west are the four cardinal directions. The intermediate directions—northeast, northwest, southeast, and southwest—may also be shown. The compass rose looks like intersecting arrows or points of a star.

Line symbols on a map emphasize various features of human activity, such as boundary lines, roads, streets, or routes of trade and transportation. On political maps, boundary lines highlight the borders between different countries and states. Line symbols can also represent physical features such as rivers, earthquake faults, and ocean shorelines.

Colors can be used to distinguish elements on a map. For example, a political map might make each country a different color. On a physical map, colors may indicate the various ranges of elevation, or the height above sea level. Colors are used for a variety of other purposes, including identifying water features such as oceans, lakes, or rivers; land features such as deserts, valleys, plains, or mountain ranges; and human-made features such as roads, parks, or streets. The meaning of a color can be identified by the map title or is provided in the legend.

All maps are drawn to a certain scale. Scale represents the consistent, proportional relationship between the measurements shown on a map and the actual measurements of the Earth’s surface. Maps use scale to shrink what would be large distances and features of a region to a manageable size. When a map is scaled to fit on paper, every
feature of the map is scaled by the same amount so that each feature will have the same proportion to every other feature on the map. However, not all parts of a map will be perfectly to scale because flat maps are subject to some distortion. A map's scale is identified by a scale bar, which compares distances shown by a map to actual distances on the Earth. For example, a scale bar might indicate that one inch (2.5 cm) on the map represents 100 miles (160.9 km).

The amount of scale portrayed on a map depends on its depiction as a small-scale or large-scale map. A small-scale map shows a larger area with fewer details. For instance, a small-scale map can focus on a specific country and its neighboring countries to show boundary lines, major cities and capitals, important land or water features, or regional topography. For example, the scale bar on a map of France and its bordering countries could show a relationship of one inch (2.5 cm) as equal to 200 miles (321.9 km) in actual distance. On the other hand, a large-scale map can show a small area with a great amount of detail. It narrows in on an identified region to show more specific details. The map measurements of a large-scale map use much smaller distances than on a map of France. For example, a large-scale map of the city of Paris shows the layout of streets, major roads, bridges, parks, and important landmarks such as museums, hotels, and churches. The scale bar of a map of Paris could show a relationship of one inch (2.5 cm) as equal to one mile (1.6 km) in actual distance. This measurement is much more specific than for a small-scale map of France.

**Types of Maps**

A cartographer can choose from several types of maps in order to convey geographic information. Physical maps, political maps, and thematic maps each serve a unique purpose and are suited to showing different types of information. A physical map shows location and topography, or shape, of the Earth’s land features. A study of a country’s land and other physical features can help to explain the historical development of the country. For example, mountains may be barriers to transportation, and rivers and streams can provide access to a country’s interior. Physical maps show water features such as rivers, streams, and lakes. They also show landforms such as mountains, plains, plateaus, and valleys.

Physical maps highlight general relief through shading and texture. Relief shows the differences in elevation between the various landforms of an area. An elevation key can use colors to indicate specific, measured differences in elevation above sea level.

A political map provides the boundaries and locations of political units such as countries, states, counties, cities, and towns. It can show the networks and links that exist within and between political units. While some boundaries are distinguished by natural features such as bodies of water or landforms, the majority of features on a political map are human-made. Such human-made features can include boundary lines, cities and capitals, railroads, roads, highways, streets, buildings, and other landmarks.

A thematic map emphasizes a particular theme or subject. Thematic maps can show various natural and human-made features. While a general map can cover various topics, thematic maps focus on a single topic such as climate, natural vegetation, population density, or economic activities.

A type of thematic map called a flow-line map displays the movement of people, animals, goods, and ideas. It also illustrates physical processes such as hurricanes and glaciers. Arrows illustrate the flow and direction of movement for the map subject. Arrows can be distinguished by different colors to represent the varied directions of movement, and the thickness of the arrows can show the amount that is moving.

**Mental Maps**
While the diverse parts of a map are crucial elements for identifying a map’s purpose, a map reader must also learn how to mentally organize the spatial information emphasized by a map. Mental maps provide an effective method for answering and remembering important geographical questions about locations, characteristics, patterns, and relationships of places and regions. Mental maps describe an individual’s internal map—his or her perception of features of the Earth’s surface. Mental maps can be applied to local or global scales, from the orientation of an individual within a classroom or home, to the visualization one could see from an airplane on a transcontinental flight.

A person’s mental map helps geographers understand how individuals view their relationship to the space around them. Mental maps mix precise, objective data with an individual’s subjective perception or existing knowledge of places. For example, a student may be asked to memorize locations and names of the original 13 colonies to contextualize his or her experience and understanding of those places today. A biologist's mental map of major climate regions could include his or her knowledge of the distribution of various types of animals and plants within each region. Using mental maps of the world’s regions over time allows a geographer to analyze patterns of human settlement in the world and how settlements relate to land features and availability of resources. This information can be used to determine why particular routes of settlement, trade, and transportation developed.

Mental maps can change according to an individual’s experience and perception of people, places, regions, and environments. Because mental mapping is based on the individual, one individual’s memory of a place differs from another individual’s memory. A new experience in an unfamiliar location would alter the accuracy and number of details recalled by a person’s mental map of that place. For example, traveling through a country would help a person more easily recall city names and locations of that country than by memorizing such places by only looking at a map. The pictures of two students asked to sketch from memory their view of the Grand Canyon would vary depending on what features the individuals noticed at the time, as well as how much their memory of the place has changed since they saw the canyon.

Recalling a place related to emotion, such as a city that a student likes or dislikes, would also alter the details depicted in a mental map. An individual’s personal connection to a place or event through personal experiences or exposure to written and visual accounts can influence what is part of a mental map. As a result, mental mapping is beneficial for geographers to understand the significance of information related to a specific place and how it is perceived by individuals.

Explaining What do relief maps show?

Geospatial Technologies

How are geospatial technologies used to learn about the world?

Geospatial technologies assist geographers and other professionals in answering geographic questions. Global positioning systems (GPS), geographic information systems (GIS), and remote sensing from satellites and aircraft incorporate multiple information sources to construct detailed geographic representations of specific aspects of the Earth’s surface.

Global Positioning System
A global positioning system (GPS) is used to determine the exact, or absolute, location of something on Earth. Made up of a network of satellites and receiving instruments, GPS provides an accurate location with respect to latitude, longitude, and even altitude. GPS technology in the United States relies on a system of 24 satellites that make 6 full orbits around the Earth every 12 hours. The European Union, as well as some individual countries such as Russia and China, have their own satellites that support GPS systems.

The satellites in all these systems send out radio signals that are picked up by GPS receivers on Earth. In a process called triangulation, a GPS receiver measures the precise time taken for radio signals from four or more satellites to travel to the receiver. The receiver then multiplies the time by the speed of a radio wave to calculate the distance between it and the satellite. When signals from the four or more satellites are processed in the same manner, the receiver's built-in computer determines the point at which at least four satellite signals intersect on the Earth. This intersection then identifies the receiver's latitude, longitude, and altitude. The more satellites that are used, the more accurate the location that is pinpointed.

GPS technology serves a commercial purpose for military machinery, space shuttles, aircraft, ships, submarines, trucks, trains, and ambulance fleets. Yet it can also aid in multiple forms of personal navigation. The GPS receiver in a car, for example, tracks the car's changing location on an electronic map to provide constantly updated directions based on where the car is located and where it is headed. Many current GPS receivers are battery-powered and are no larger than the palm of your hand, while GPS computer chips are smaller than your fingernail.

Many fields of science employ GPS technology. For example, seismologists, the scientists who study earthquakes, can use GPS to determine the size of earthquakes. Scientists first plant GPS receivers in the ground in regions vulnerable to tectonic, or earthquake-prone, activity. Once an earthquake hits, seismologists can quickly measure the strength of an earthquake by calculating how far the planted GPS receivers move. This measurement allows scientists to predict how likely the earthquake is to produce large ocean waves called tsunamis. Because tsunamis can cause devastating destruction to coastal communities, early warning would diminish loss of human life by advising people to flee as soon as possible.

Another function of GPS technology in the field of science is to track the migration of animals to determine any changing patterns within the animals' ecosystems. Biologists tag animals with GPS receivers so they can track their movement due to seasonal changes, changes of food or shelter, or threats to their habitat by human activity or by other animals.

Geographic Information Systems

Advances in technology have changed the way maps are made. An important tool in mapmaking today involves computers with software programs called geographic information systems (GIS). But more than simply making maps, GIS can be used to perform advanced geographical analysis.

Many types of data can be entered into a GIS. These data come from a wide variety of sources such as maps, satellite images, printed text, and statistical databases. The primary and most important function of a GIS, however, is to link the location of a place with the characteristics, or attributes, found at that location. That function helps us not only identify and list the characteristics of places, but also analyze how places compare to one another and interact with one another. These patterns of interactions are known as spatial organization, and the study of them is called spatial analysis.

The locational data of places is stored in a GIS as latitude and longitude coordinates. These coordinates can be obtained from existing maps, GPS receivers, and satellite images. The attribute data come from a wide range of
sources. The GIS stores all these data in a digital database. Cartographers then select an appropriate map projection and program the GIS to produce thematic maps of the data. Each of the various types of attribute data in the database can be displayed on the map as a theme. The different themes can be saved as separate electronic layers that can be turned on or off. The GIS can show just one layer of information or multiple layers at the same time.

In this way, maps can be made—and changed—quickly and easily to display various complex types of information with a single map source. GIS is used by a diverse range of professional fields with work that relies on maps, including environmental and urban planners, marketing researchers, retail developers, environmentalists, and other professionals.

**Satellites**

A satellite is a natural or human-made object that orbits a planet or other large astronomical body. The first human-made satellite was launched in 1957 by the Soviet Union, and today hundreds of human-made satellites orbit the Earth. These satellites are useful for many purposes, such as navigation, collecting atmospheric data to make weather predictions, and communications for cellular phones and the Internet. Some satellites collect visual information of the Earth’s surface as they orbit the Earth. Others carry instruments to observe the presence of and interaction between the land, ocean, air, and living things. Because scientists can gather very specific information regarding atmospheric phenomena, they can compare satellite images with ground research and knowledge of Earth’s natural history to analyze how the environment has changed over time.

Different types of satellites are used to collect different types of information about the Earth. Once the data are collected, computers on a satellite store and then transmit those data by radio signals to receiving stations on Earth. Scientists on Earth receive the transmitted data and use their specialized knowledge to interpret the meaning of these data. The received data sometimes serve as inputs to computer models using mathematical formulas. Just as cartographers produce maps from data processed by GIS, so do scientists who use the converted data from satellite imagery to study Earth’s natural and human-made processes.

Remote sensing is any technique used to measure, observe, or monitor a subject or process without physically touching the object under observation. For example, scientists use remote sensing when they analyze images from satellites, telescopes, and cameras in airplanes and spacecraft. Often, remote sensing collects images of things that could not be seen with the unaided human eye. It is also a useful process for obtaining information from locations that would otherwise be dangerous or difficult to reach, such as estimating precipitation rates in a desert region. The immediate and frequent flow of images from remote sensing allows cartographers to create detailed and relevant maps to estimate constant and changing environmental conditions, such as sediment buildup, air pollution, ocean surface roughness, surface temperatures, biomass volumes, mineral resources, and changes created by storms and floods.

**Quality and Limitations of Geospatial Technologies**

Geospatial technologies are excellent sources of information because they provide actual images and data related to a location and can provide a great amount of detail. While scientists can use observational and historical data to gather information about a place, geospatial technology acts as a primary source for compiling raw data. Because they are a relatively new innovation in comparison to traditional forms of mapmaking, the current uses of geospatial technologies can be limited. These informational technologies are constantly changing, and they will improve with the advancement of computer, aerospace, and Internet based technology. Accelerated development in geospatial technology offers a number of possibilities for its use with government, private industry, scientists, and the general
Because the economic, cultural, and political activities of the world's regions have become increasingly interconnected, information related to the world's physical and human systems needs to be readily available, consistent, and up-to-date. The combination of mental mapping with GPS, GIS, and aerial imagery can create a very detailed picture of places and regions.

Geospatial technologies allow access to a wealth of information about what sorts of features and objects are in the world and where those features and objects are located. This "geospatial information" can be very helpful for identifying and navigating, but by itself, does not help much in answering the "why" or the "why care" questions that lie at the heart of understanding and making decisions about the world in which we live. It is important to go beyond geospatial information to geographical understanding of peoples, places, and environments—and the connections among them—that are interesting as well as useful.

Identifying What type of data do geospatial technologies provide?

Reviewing Vocabulary

1. Identifying What is the difference between absolute location and relative location?

Using Your Notes

2. Describing Using your graphic organizer, list and describe the four common map projections.

Answering the Guiding Questions

3. Comparing How are globes and map projections related?

4. Explaining How is location determined?
5. **Summarizing** How do maps work?

**TEKS:** 21A

6. **Analyzing** How are geospatial technologies used to learn about the world?

**Writing Activity**

**TEKS:** 20A, 21A, 23B

7. **Informative/Explanatory** If you were planning to open a sporting goods store, in what ways could GIS technologies help you choose a good location? Discuss the types of layers that might be helpful to your decision.