

CHAPTER

3

Climates of the Earth

GeoJournal

As you read this chapter, note factors that affect climate. Then write a description of the climate in your community. List three factors that contribute to climate, and sketch a landscape showing one kind of common weather in this climate.



Chapter Overview Visit the **Glencoe World Geography** Web site at tx.geography.glencoe.com and click on Chapter Overviews—Chapter 3 to preview information about Earth's climates.

CLICK HERE

CONTENTS

Guide to Reading

Consider What You Know

News reports sometimes feature unusual events such as solar eclipses or solar flares, intense bursts of energy from the sun's surface. In what ways does the sun affect human activities?

Read to Find Out

- How does Earth's position in relation to the sun affect temperatures on Earth?
- How does Earth's rotation cause day and night?
- What is Earth's position in relation to the sun during each season?
- How might global warming affect Earth's air, land, and water?

Terms to Know

- weather
- climate
- axis
- temperature
- revolution
- equinox
- solstice
- greenhouse effect
- global warming

Places to Locate

- Tropic of Cancer
- Tropic of Capricorn

◀ *Flamingoes enjoy an oasis at the foot of sand dunes in Namibia.*

Earth-Sun Relationships

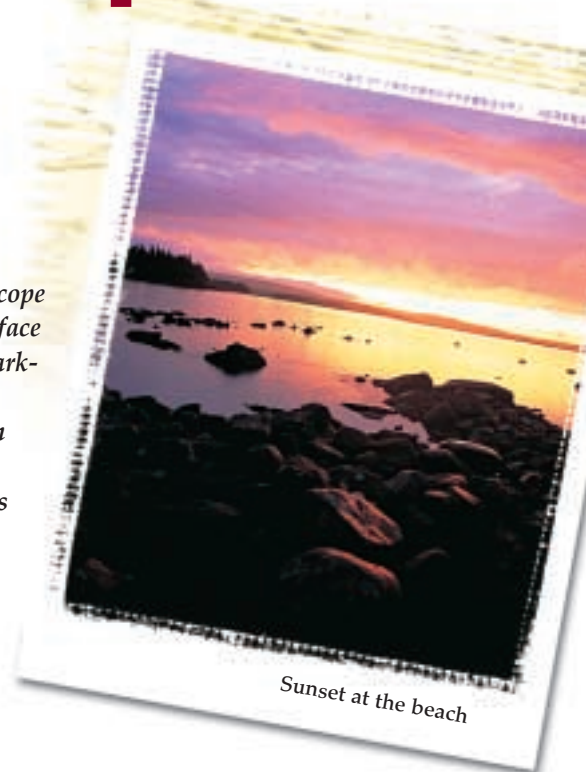
NATIONAL GEOGRAPHIC

A Geographic View

Our Home Star

Through a small occulting telescope [equipped to block the sun's surface from view] . . . I stared at the darkened face of the sun, ringed by its glowing, gauzy corona. From that blazing disk high in the Hawaiian sky comes the endless power that drives and rules all life on earth: its plant growth and the food chains of all its creatures; the winds, rains, and churning weather of the planet; the ocean currents, forests, prairies, and deserts.

—Samuel W. Matthews, "Under the Sun: Is Our World Warming?"
National Geographic, October 1990



Sunset at the beach

From atop the Mauna Loa Observatory on the island of Hawaii, scientists gather data about changes in the earth's atmosphere. Their research reveals information about the dynamic relationships between the earth and the sun, which influence all life on Earth. In this section you will explore how earth-sun relationships affect climate.

Climate and Weather

Climate is often confused with weather, which is a short-term aspect of climate. **Weather** is the condition of the atmosphere in one place during a limited period of time. When people look out the window or watch the news to see whether they need umbrellas or sunscreen, they are checking the weather. **Climate** is the term for the weather patterns that an area typically experiences over a long period of time. People who live in Seattle, Washington, for example, frequently use umbrellas



because of the rainy, wet climate. In contrast, people who live in the dry, desert climate of Arizona must protect themselves from the sun.

Whether the climate in a particular region is cool and wet or hot and dry is determined by many factors, the most important of which is the earth's position in relation to the sun.

The sun's heat and light reach the earth as warmth and sunlight, but they do not reach all parts of the earth at the same time or with the same intensity.

Earth's Tilt and Rotation

Earth's tilt is one reason for variations in sunlight. The earth's **axis**—an imaginary line running from the North Pole to the South Pole through the planet's center—is currently tilted at an angle of about $23\frac{1}{2}^\circ$. Because of the tilt of this axis, not all places on the planet receive the same amount of direct sunlight at the same time.

For this reason the angle of tilt affects the **temperature**—the measure of how hot or cold a place is. Areas that receive a large amount of direct sunlight have warmer temperatures than places that receive little direct sunlight. Temperature is usually measured in degrees on a set scale. The most common scales for measuring air temperature are Fahrenheit (°F) and Celsius (°C).

Whether or not a particular place on Earth receives light also depends on the side of the planet that is facing the sun. Earth rotates on its axis, making one complete rotation every 24 hours. Rotating from west to east, the earth turns first one hemisphere and then the other toward the sun, alternating between the light of day and the darkness of night.

Earth's Revolution

While planet Earth is rotating on its axis, it also is traveling in an orbit around the sun, our nearest star. It takes the earth a few hours more than 365 days—1 year—to complete one **revolution**, or trip around the sun.

Geography

Skills for Life

Arizona Lightning

Lightning and thunder are related weather events that result from the powerful air currents of thunderstorms during the warm-weather months.

Place What factor distinguishes weather from climate?

The earth's revolution and its tilt cause changes in the angle and amount of sunlight that reach different locations on the planet. These changes follow a regular progression known as the seasons. During the course of a year, people on most parts of the earth experience distinct differences in the length of days and the daily temperature as the seasons change.

The seasons are reversed north and south of the Equator. When it is spring in the Northern Hemisphere, it is fall in the Southern Hemisphere. When it is winter in the Southern Hemisphere, it is summer in the Northern Hemisphere. Around March 21, the sun's rays fall directly on the Equator. This day is called an **equinox** (meaning "equal night") because daylight and nighttime hours are equal. In the Northern Hemisphere, the day on which this equinox falls marks the beginning of spring.

The Tropics of Cancer and Capricorn

As the earth continues its revolution around the sun, it moves so that eventually the sun's rays directly strike the latitude $23\frac{1}{2}^\circ\text{N}$. This latitude is known as the **Tropic of Cancer**—the northernmost point on the earth to receive the direct rays of the sun. These direct rays reach the Tropic of Cancer about June 21, bringing the Northern Hemisphere

its longest day of sunlight. This date, known as the summer **solstice**, marks the beginning of summer in the Northern Hemisphere.

By about September 23, the earth has moved so that the sun's rays directly strike the Equator again. This equinox marks the beginning of fall in the Northern Hemisphere. Gradually the sun's direct rays strike farther south, reaching their southernmost latitude— $23\frac{1}{2}^{\circ}\text{S}$, or the **Tropic of Capricorn**—about December 22. The winter solstice is the day of shortest daylight in the Northern Hemisphere, beginning the season of winter. This cycle repeats itself each year as the earth revolves around the sun.

The Poles

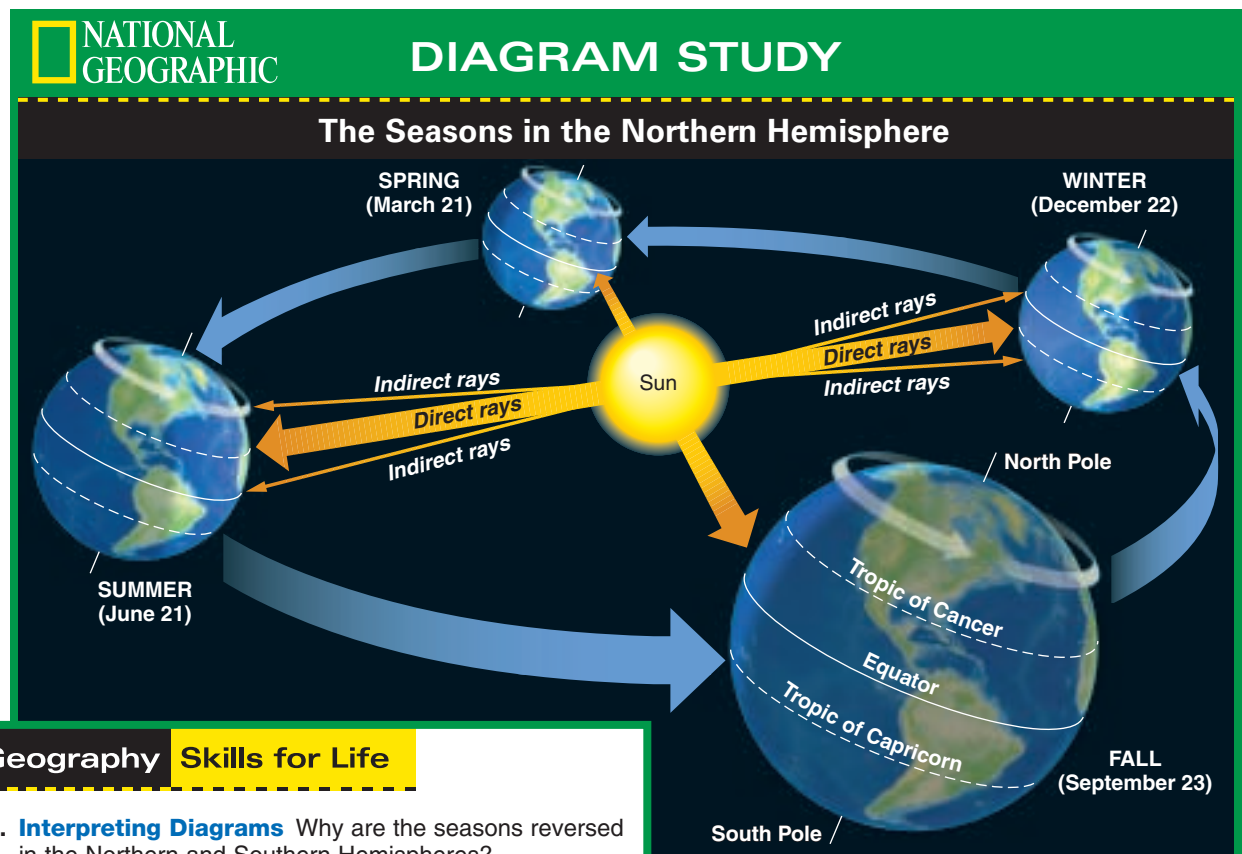
The amount of sunlight at the Poles varies most dramatically as the earth's revolution and tilt cause the changing seasons. For six months of the year, one Pole is tilted toward the sun and receives con-

tinuous sunlight, while the other Pole is tilted away from the sun and receives little to no sunlight. An Arctic explorer describes the surreal quality of the winter day:

“The winter sun had completely disappeared below the horizon, and the ‘days’ were now only a few hours long. . . . I saw the Arctic in a whole new way, with its twilight days and auroral nights.”

Keith Nyitray, “Alone Across the Arctic Crown,” *National Geographic*, April 1993

At the North Pole, the sun never sets from about March 20 to September 23. At the South Pole, continuous daylight lasts from about September 23 to March 20. The tilt of the earth's axis as it revolves around the sun causes this natural phenomenon, known as the midnight sun. The occurrence of the



Geography Skills for Life

- Interpreting Diagrams** Why are the seasons reversed in the Northern and Southern Hemispheres?
- Applying Geography Skills** Explain the difference between the equinoxes and the solstices.

midnight sun goes almost unnoticed in sparsely populated Antarctica. Parts of northern North America (including Alaska) and northern Europe in the Arctic, however, have become popular tourist destinations as “lands of the midnight sun.”

The Greenhouse Effect

Even on the sunniest days in the warmest climates, only part of the sun’s radiation passes through the earth’s atmosphere. The atmosphere reflects some radiation back into space. Enough radiation, however, reaches the earth to warm the air, land, and water.

Because the atmosphere traps some heat and keeps it from escaping back into space too quickly, Earth’s atmosphere is like the glass in a greenhouse—it traps the sun’s warmth for growing plants even in cold weather. Without this **greenhouse effect**, the earth would be too cold for most living things. The diagram on page 70 shows the greenhouse effect.

In order to support plant growth, conditions in a greenhouse must be regulated. If too much heat escapes, the plants will freeze. If too much heat is trapped, the plants will wilt or dry out.

The greenhouse effect of Earth’s atmosphere follows some of the same general rules. Normally, the atmosphere provides just the right amount of insulation to promote life on the planet. The 50 percent of the sun’s radiation that reaches the earth is converted into infrared radiation, or heat. Clouds and greenhouse gases—atmospheric components such

as water vapor and carbon dioxide (CO₂)—absorb the heat reflected by the earth and radiate it back again so that a balance is created.

Many scientists, however, claim that in recent decades a rise in atmospheric CO₂ levels has coincided with a general rise in global temperatures. This trend—known as **global warming**—is believed to be caused in part by human activities, such as the burning of coal, oil, and natural gas. As more fossil fuels are burned, greenhouse gases enter the atmosphere and trap more heat.

Using computer models, some scientists predict that global warming will make weather patterns more extreme. Water, for example, will evaporate more rapidly from oceans, increasing humidity and rainfall generally. Rapid water evaporation from soil, however, will cause land to dry out more quickly between rains. Some areas may even become drier than before.

Scientists do not all agree on global warming and its effects. Some claim that a natural cycle, not human activity, is causing rising temperatures. Others claim that evidence for global warming is inconclusive and that it is too early to forecast future effects.



Student Web Activity Visit the **Glencoe World Geography** Web site at tx.geography.glencoe.com and click on Student Web Activities—Chapter 3 for an activity about global warming.

TX TAKS Practice

SECTION 1 ASSESSMENT

CLICK HERE

Checking for Understanding

- 1. Define** weather, climate, axis, temperature, revolution, equinox, solstice, greenhouse effect, global warming.
- 2. Main Ideas** On a chart, list characteristics of the earth-sun relationship and describe their effects on climate.

Earth-Sun Relationships	Effects on Climate

Critical Thinking

- 3. Comparing and Contrasting** What differences in the weather would you expect in Alaska and in Florida? Explain.
- 4. Drawing Conclusions** What effects does the earth’s tilt on its axis have on your daily life?
- 5. Analyzing Information** What would you pack if you were visiting Argentina in December?

Analyzing Diagrams

- 6. Location** Study the diagram of the seasons on page 57. In what months do the sun’s rays strike the Equator directly? The Tropics of Cancer and Capricorn?

Applying Geography

- 7. Effects of Global Warming** Review the text in Section 1 about global warming. In what ways might agriculture be affected? Explain.

Guide to Reading

Consider What You Know

You are familiar with the climate of the area where you live, such as the usual weather and temperature range for each season. What geographic factors do you think affect your climate?

Read to Find Out

- How do latitude and elevation affect climate?
- What role do wind patterns and ocean currents play in Earth's climates?
- How do landforms and climate patterns influence each other?

Terms to Know

- prevailing wind
- Coriolis effect
- doldrums
- current
- El Niño
- windward
- leeward
- rain shadow

Places to Locate

- low latitudes
- high latitudes
- Arctic Circle
- Antarctic Circle
- mid-latitudes

Factors Affecting Climate



A Geographic View

The Stormy Sea

As I survey the wreckage [from my yacht]—broken steering wheel, patched sails, ruined winches, life rails ripped away by bounding seas . . . I can see it's been a harrowing 4,600 miles since the start [of this leg of the Whitbread race] in Cape Town, South Africa. For eight of the twelve men aboard, including Paul Cayard, the skipper, the run east has been their first encounter with the ocean latitudes known as the roaring forties and furious fifties, where gales blow year-round and seas build to towering peaks, "the liquid Himalayas," as one Kiwi [New Zealand] broadcaster calls them.

—Angus Phillips, "The Whitbread—Race Into Danger," National Geographic, May 1998



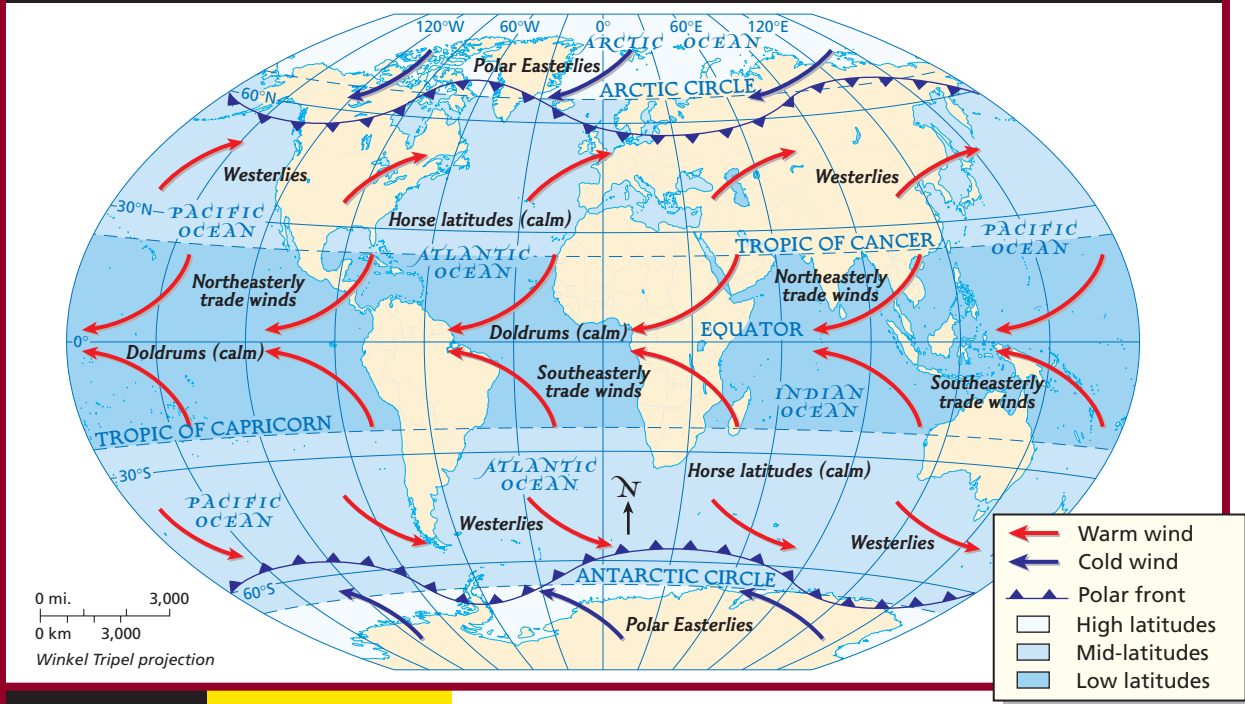
Sailing in the southern Indian Ocean

Sailing in the Whitbread race can be frightening. The part of this journey from South Africa to Australia is dangerous because of high winds and strong ocean currents at these latitudes. In this section you will learn how latitude, wind and water patterns, and landforms combine with the earth-sun relationship to influence Earth's climates.

Latitude and Climate

The influence of latitude on climate is part of the earth-sun relationship. During the earth's annual revolution around the sun, the sun's direct rays fall upon the planet in a regular pattern. This pattern can be

World Zones of Latitude and Wind Patterns



Geography Skills for Life

1. **Interpreting Maps** What air currents flow over the mid-latitudes? The low latitudes?

2. **Applying Geography Skills** If you were to sail within the low latitudes from India to Africa, in which direction would you sail to take advantage of the prevailing winds?

Find NGS online map resources @ www.nationalgeographic.com/maps

correlated with bands, or zones, of latitude to describe climate regions. Within each latitude zone, the climate follows general patterns.

Low Latitudes

Between the Tropic of Cancer and the Tropic of Capricorn is a zone known as the **low latitudes**. This zone includes the Equator. Portions of the low latitudes receive the direct rays of the sun year-round. Places located in the low latitudes have warm to hot climates. Because of the latitudes that form its boundaries, this zone is called the Tropics.

High Latitudes

The earth's polar areas are called the **high latitudes**. When either the Northern or the Southern Hemisphere is tilted toward the sun, its polar

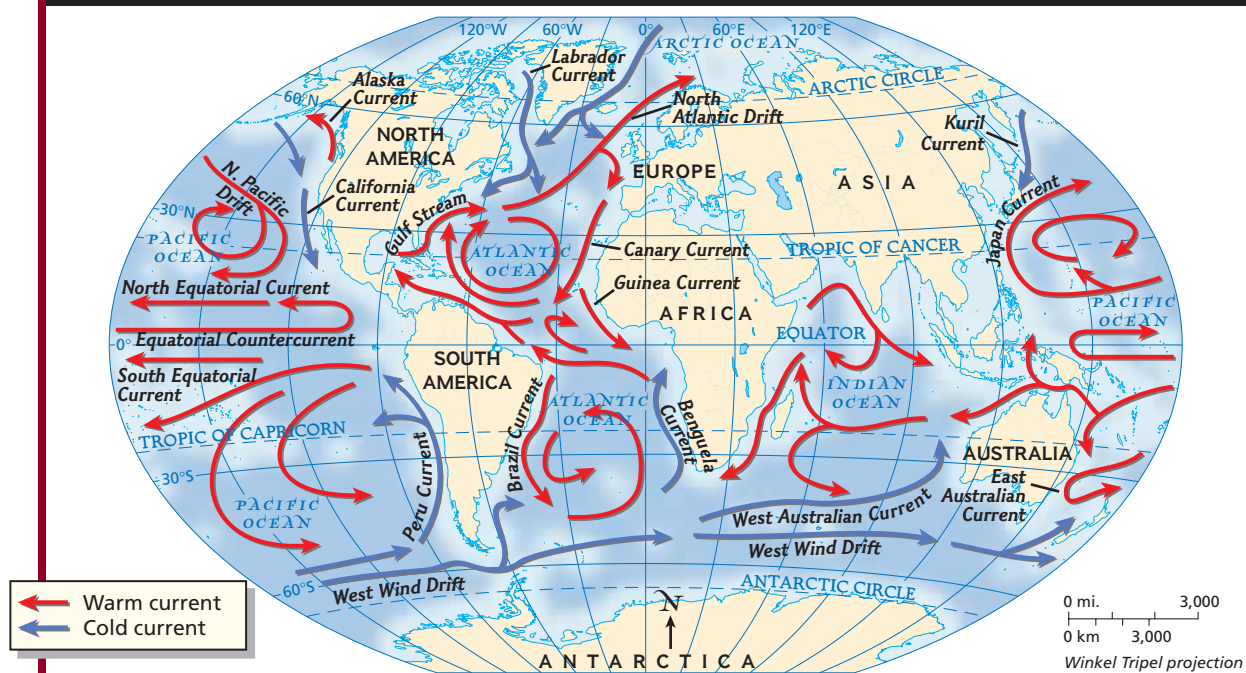
area receives continuous, but indirect, sunlight. From about March 20 to about September 23, the polar area north of the **Arctic Circle** (latitude 66°N) experiences continuous daylight or twilight. The polar area south of the **Antarctic Circle** (latitude 66°S) experiences continuous daylight or twilight for the other six months of the year.

Mid-Latitudes

The most variable weather on Earth is found in the **mid-latitudes** between the Tropic of Cancer and the Arctic Circle in the Northern Hemisphere and between the Tropic of Capricorn and the Antarctic Circle in the Southern Hemisphere. In summer the mid-latitudes receive warm masses of air from the Tropics. In winter, cold masses of air move into the mid-latitudes from the high latitudes. The



World Ocean Currents



Geography Skills for Life

1. **Interpreting Maps** Which current moves along the northwestern coast of Africa?

2. **Applying Geography Skills** How do ocean currents develop? How is this process similar to the development of wind currents?

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mid-latitudes generally have a temperate climate—one that ranges from fairly hot to fairly cold—with dramatic seasonal weather changes.

Elevation and Climate

At all latitudes elevation influences climate because of the relationship between the elevation of a place and its temperature. The earth’s atmosphere thins as altitude increases. Thinner air retains less heat. As elevation increases, temperatures decrease by about 3.5°F (1.9°C) for each 1,000 feet (305 m). This effect occurs at all latitudes. For example, in Ecuador, the city of Quito (KEE•toh) is nearly on the Equator. However, Quito lies in the Andes at an elevation of more than 9,000 feet (2,743 m), so average temperatures are about 32°F (17°C) cooler than in the nearby lowlands.

Sunlight is bright in Quito and other places with high elevation because the thinner atmosphere filters fewer rays of the sun. Even in bright sunlight, the world’s highest mountains are cold, snowy places year-round.

Wind and Ocean Currents

Wind and water combine with the effects of the sun to influence Earth’s weather and climate. Air moving across the face of the earth is called wind. Winds occur because the sun heats up the earth’s atmosphere and surface unevenly. Rising warm air creates areas of low pressure, and falling cool air causes areas of high pressure. The cool air then flows in to replace the warm rising air. These movements over the earth’s surface cause winds, which distribute the sun’s heat around the planet.

Wind Patterns

Global winds blow in fairly constant patterns called **prevailing winds**, shown on the map on page 60. The direction of prevailing winds is determined by latitude and is affected by the earth's movement. Because Earth rotates to the east, the global winds are displaced clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. This phenomenon, called the **Coriolis effect**, causes prevailing winds to blow diagonally rather than along strict north-south or east-west lines.

Winds are often named for the direction from which they blow, but they sometimes were given names from the early days of sailing. Named for their ability to move trading ships through the region, the prevailing winds of the low latitudes are called *trade winds*. They blow from the northeast toward the Equator from about latitude 30°N and from the southeast toward the Equator from about latitude 30°S. *Westerlies* are the prevailing winds in the mid-latitudes, blowing diagonally west to east between about 30°N and 60°N and between about 30°S and 60°S. In the high latitudes, the *polar easterlies* blow diagonally east to west, pushing cold air toward the mid-latitudes.

History

The Horse Latitudes

At the Equator, global winds are diverted north and south, leaving a narrow, generally windless band called the **doldrums**. Two other narrow bands of calm air encircle the globe just north of the Tropic of Cancer and just south of the Tropic of Capricorn. In the days of wind-powered sailing ships, crews feared being stranded in these windless areas. With no moving air to lift the sails, ships were stranded for weeks in the hot, still weather. Meanwhile, food supplies dwindled, and perishable cargoes spoiled as the ships sat. The English poet Samuel Taylor Coleridge described this frightening experience:

“*Day after day, day after day
We struck, nor breath nor motion;
As idle as a painted ship
Upon a painted ocean.*”

Samuel Taylor Coleridge, *The Rime
of the Ancient Mariner*, 1798

To lighten the load so the ships could take advantage of the slightest breeze, sailors would toss excess cargo and supplies overboard, including livestock being carried to colonial settlements. This practice gave rise to the name by which the calm areas at the edges of the Tropics are known—the *horse latitudes*.

Ocean Currents

Just as winds move in patterns, cold and warm streams of water, known as **currents**, move through the oceans. Ocean currents are caused by many of the same factors that cause winds, including the earth's rotation, changes in air pressure, and differences in water temperature. The Coriolis effect is observed in ocean currents, too, causing them to move in clockwise circles in the Northern Hemisphere and counterclockwise circles in the Southern Hemisphere.

As ocean currents circulate, cold water from the polar areas moves slowly toward the Equator, warming as it moves through the Tropics. This water forms the warm ocean currents. The warm water, in turn, moves away from the Equator, cooling to become a cold ocean current.

Ocean currents affect climate in the coastal lands along which they flow. Cold ocean currents cool the lands they pass. Warm ocean currents bring warmer temperatures. For example, the North Atlantic Drift, a warm-water extension of the Gulf Stream current, flows near western Europe. This current gives western Europe a relatively mild climate in spite of its northern latitude.

Weather and the Water Cycle

Wind and water work together to affect weather in another important way. Driven by temperature, condensation creates precipitation, moisture falling to the earth in the form of rain, sleet, hail, or snow. The sudden cloudburst that cools a steamy summer day is an example of how precipitation both affects and is affected by temperature. Water vapor forms in the atmosphere from evaporated surface water. As colder temperatures cool the rising moist air, the vapor condenses into liquid droplets, forming clouds. Further cooling causes rain to fall, which can help lower the temperature on warm days.

El Niño

Climate is also affected by recurring phenomena, or events, that alter weather patterns. The most famous of these recurring climatic events is the **El Niño** (ehl NEE•nyoh) phenomenon. El Niño is a periodic change in the pattern of ocean currents and water temperatures in the mid-Pacific region.

El Niño does not occur every year, but its frequency appears to have increased in the latter half of the 1900s. In an El Niño year, the normally low atmospheric pressure over the western Pacific rises, and the normally high pressure over the eastern Pacific drops. This reversal causes the trade winds to diminish or even to reverse direction. The change in wind pattern reverses the equatorial ocean currents, drawing warm water from near Indonesia east to Ecuador, where it spreads along the South American coast.

The changed air pressures resulting from El Niño influence climates around the world in a kind of domino effect. Precipitation increases along the coasts of North and South America, warming winters and increasing the risk of floods. Hawaii experiences reduced winds like those in the doldrums, and also drier weather. In Southeast Asia and Australia, drought and occasional massive forest fires occur.

Scientists are not sure what causes El Niño or why it appears to be occurring more frequently. Preliminary studies have linked this climatic event to global warming. The costs in human and economic terms of the weather catastrophes associated with El Niño make learning more about this climatic event vitally important.

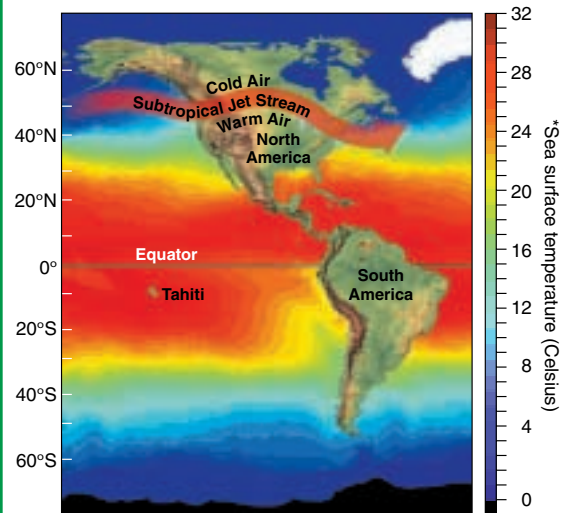
Landforms and Climate

The surface features of the earth, such as bodies of water and mountains, also can affect and be affected by climate. The climates of places located at the same latitude can be very different, depending on the presence or absence of certain landforms.

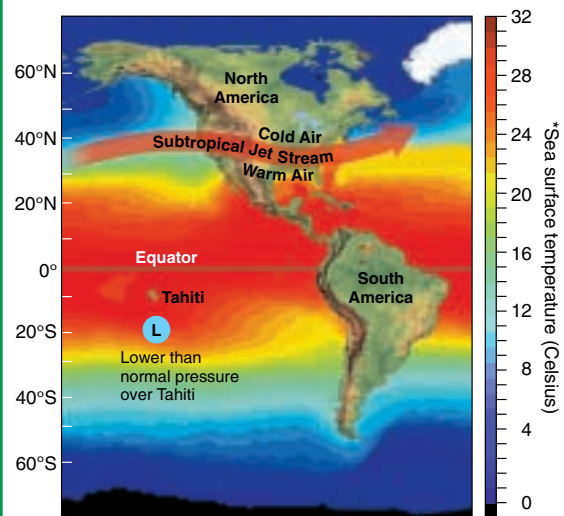
Large bodies of water, for example, are slower to heat and to cool than land. As a result, water temperatures are more uniform and constant than land temperatures. Coastal lands receive the benefit of this moderating influence and experience less changeable weather than do inland areas. Large lakes, such as the Great Lakes in the United States and Canada, also create this effect.

El Niño

NORMAL CONDITIONS



EL NIÑO CONDITIONS



*Sea surface temperature data taken at one-degree intervals.

Geography Skills for Life

1. **Interpreting Diagrams** At what latitude does the subtropical jet stream flow under normal conditions?
2. **Applying Geography Skills** Describe the impact of El Niño on the lives of people in different parts of the world.

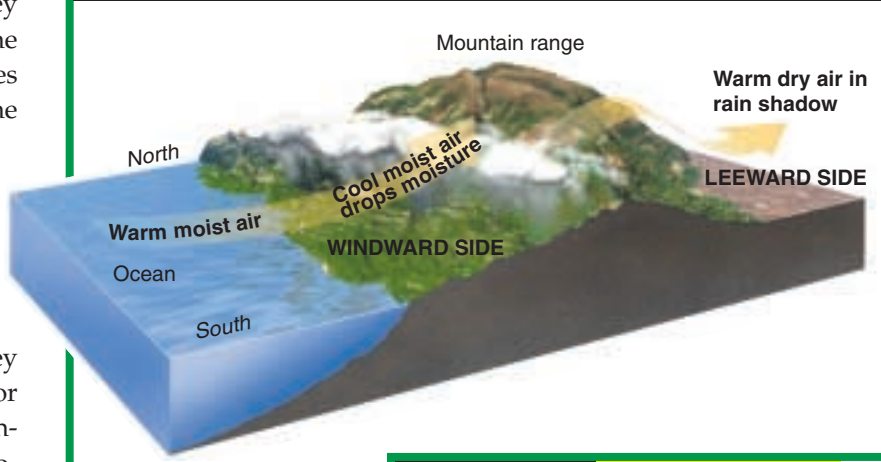
Mountain ranges also influence precipitation and affect climate. Winds that blow over an ocean are pushed upward when they meet a mountain range. The rising air cools and releases most of its moisture in the form of precipitation on the **windward** side—the side of the mountain range facing the wind. After the precipitation is released, winds become warmer and drier as they descend on the opposite, or **leeward**, side of the mountains. The hot, dry air produces little precipitation in an effect known as a **rain shadow**. The rain shadow effect often causes dry areas—and even deserts—to develop on the leeward sides of mountain ranges.

From the interaction of landforms, wind and water currents, latitude, and elevation arise a remarkable variety of climates. In the next section, you will learn about the earth’s climate regions and the kinds of natural vegetation that grows in each climate region. You will also learn about the ways that climates have changed over millions of years and

explore the many natural causes of climate change. As you explore the ways that human activities may cause climate change, you will also learn about ways that humans can protect their environment.

NATIONAL GEOGRAPHIC **DIAGRAM STUDY**

The Rain Shadow Effect



Geography Skills for Life

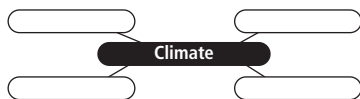
- 1. Interpreting Diagrams** On which side of a mountain does precipitation fall?
- 2. Applying Geography Skills** How do landforms cause the formation of a rain shadow?

TAKS Practice

SECTION 2 ASSESSMENT

Checking for Understanding

- 1. Define** prevailing wind, Coriolis effect, doldrums, current, El Niño, windward, leeward, rain shadow.
- 2. Main Ideas** On a web diagram, fill in information about each of the factors affecting climate. Indicate whether these factors affect the climate where you live.



Critical Thinking

- 3. Comparing and Contrasting** Describe the general differences in climate between the low latitudes and the mid-latitudes.
- 4. Predicting Consequences** Without the Coriolis effect, how might the earth’s climates be different?
- 5. Identifying Cause-and-Effect Relationships** How does the presence of mountain ranges influence climate?

Analyzing Maps

- 6. Location** Study the map of wind patterns on page 60. Where are the high latitudes located?

Applying Geography

- 7. Movement of Ocean Currents** Study the map on page 61. If your ship were drifting from west to east in the Equatorial Countercurrent, what might happen as you drifted past longitude 120°W?

Guide to Reading

Consider What You Know

Think about the types of vegetation that grow in the region where you live. What does the vegetation reveal about the regional climate there?

Read to Find Out

- How do geographers classify the climate regions of the world?
- Which kinds of vegetation are characteristic of each climate region?
- How do recurring phenomena influence climate patterns?

Terms to Know

- natural vegetation
- oasis
- coniferous
- deciduous
- mixed forest
- chaparral
- prairie
- permafrost
- hypothesis
- smog

Places to Locate

- Tropics
- Sahara
- Mediterranean Sea

World Climate Patterns



A Geographic View

Damage from El Niño

From South America, cradle of El Niño, came reports of appalling flood damage. I headed south, past drought-stricken Mexico, and alighted on the soggy soil of Guayaquil, Ecuador. Three months before Christmas a colossal slab of warm water 450 feet thick had arrived off Ecuador and Peru, smothering the cool ocean surface. Coastal fishing ceased, and the simmering sea brought rains that threatened to wash Ecuador into the sea. "Areas that normally measure precipitation in inches have had ten feet," said Jimmy Aycart, . . . director of emergency relief for the Guayaquil area.

—Thomas Y. Canby, "El Niño's Ill Wind," National Geographic, February 1984



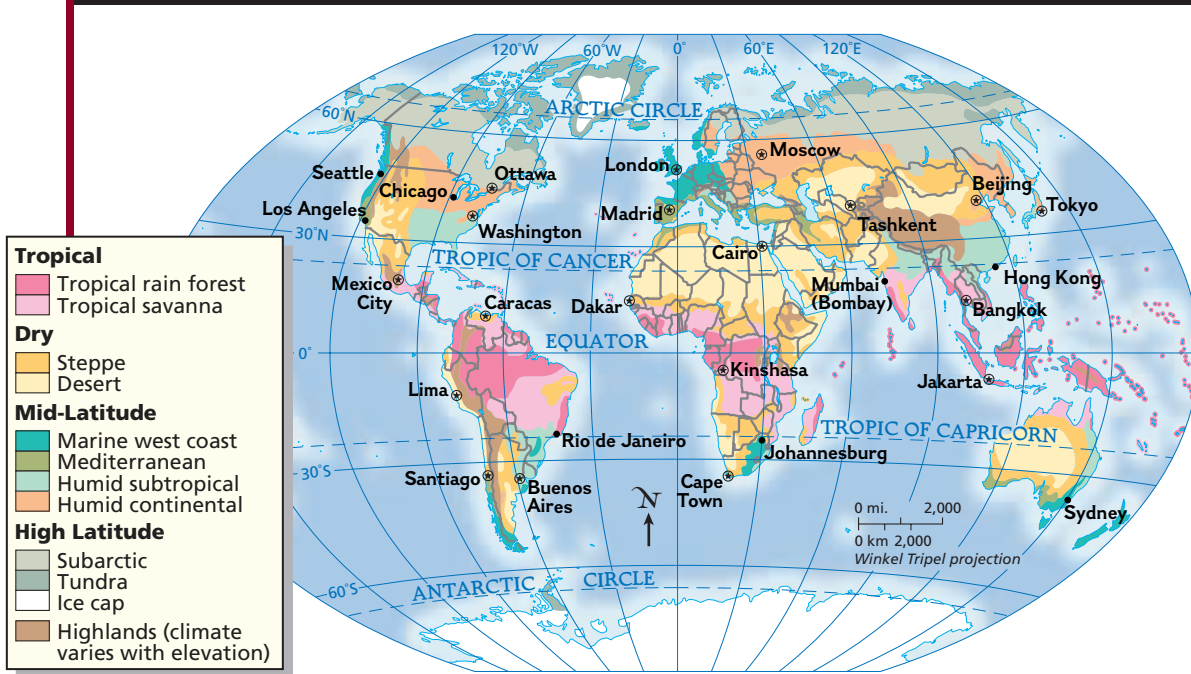
Flooding in Ecuador caused by El Niño

The effects of El Niño are felt around the world. It has triggered floods in southern California and droughts in Africa. However, even ordinary climate patterns vary from region to region, depending on the climate factors present. In this section you will learn how geographers classify the world's climates and how climate change occurs.

Climate Regions

Geographers often divide the earth into climate regions—tropical, dry, mid-latitude, high latitude, and highlands. Because climates vary within these broad regions, geographers further divide the major regions into smaller ones. Each of these divisions has its own

World Climate Regions



Geography Skills for Life

1. **Interpreting Maps** Where are tropical climates found?

2. **Applying Geography Skills** How do large bodies of water affect the climate in coastal areas?

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characteristic soils and **natural vegetation**—the plant life that grows in an area where the natural environment is unchanged by human activity.

Tropical Climates

Tropical climates are found in or near the low latitudes—the **Tropics**. The two most widespread kinds of tropical climate regions are tropical rain forest and tropical savanna.

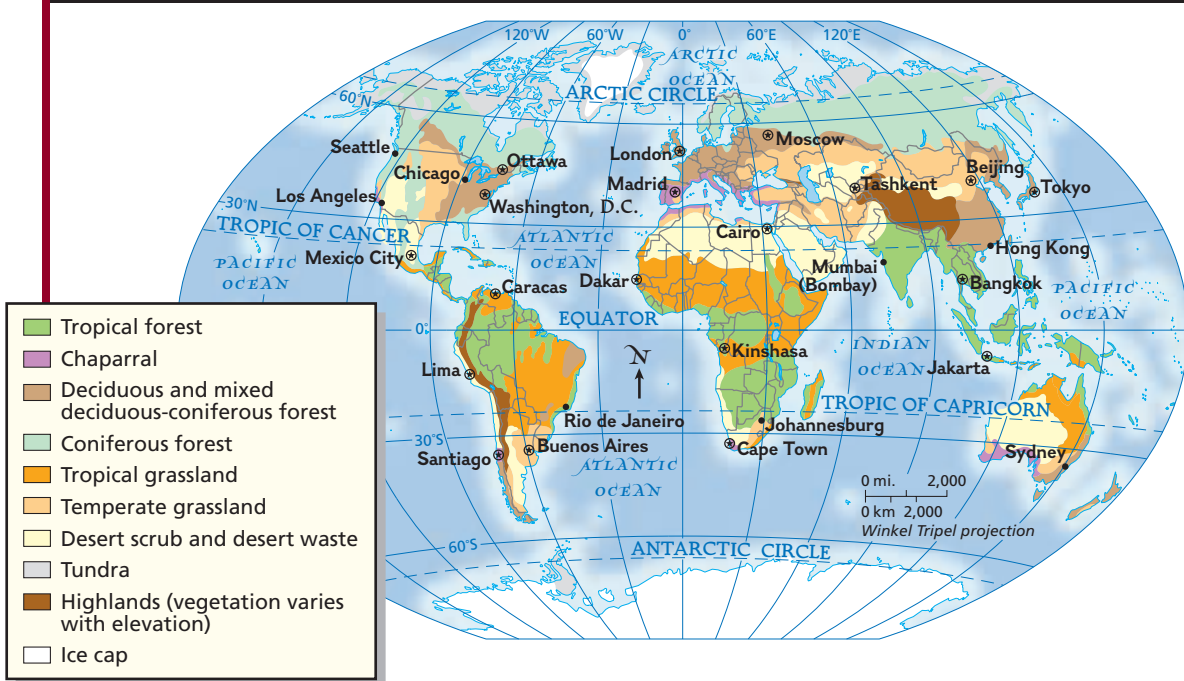
Hot and wet throughout the year, *tropical rain forest* climates have an average temperature of 80°F (27°C). The warm, humid air is saturated with moisture, producing rain almost daily. Yearly rainfall averages about 80 inches (203 cm). Lush vegetation is common in tropical climates, although the continual rain tends to leach, or draw out, nutrients from the soil in these climates. Wildlife is also abundant.

“Like an undiscovered continent encircling the globe, tropical rain forests shelter an astonishing abundance of organisms—probably more than half the Earth’s plant and animal species.”

Edward O. Wilson, “Rain Forest Canopy: The High Frontier,” *National Geographic*, December 1991

Tropical rain forest vegetation grows thickly in layers. Tall teak or mahogany trees form a canopy over shorter trees and bushes. Vines and shade-loving plants grow on the forest floor. The world’s largest tropical rain forest is in South America’s Amazon River basin. Similar climate and vegetation exist in other parts of South America, in the Caribbean area, and Asia and Africa.

World Natural Vegetation Regions



Geography Skills for Life

1. **Interpreting Maps** What continents have large tropical forests?

2. **Applying Geography Skills** Explain why the amount of vegetation decreases as you move toward higher latitudes.

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Tropical savanna climates have dry winters and wet summers, accompanied by high year-round temperatures. In the dry season, the ground is covered with clumps of coarse grass. Fewer trees exist in savanna regions than in the rain forests. Tropical savannas are found in Africa, Central and South America, Asia, and Australia.

Dry Climates

Geographers have identified two types of dry climates, based on the vegetation in each. Both *desert* and *steppe* climates occur in many parts of the world.

Dry areas with sparse plant life are called deserts. Yearly rainfall in deserts seldom exceeds 10 inches (about 25 cm), and temperatures vary widely from the heat of day to the cool of night and from season to season. Desert climates occur in just under

one-third of the earth's total land area. The **Sahara** alone extends over almost the entire northern one-third of the African continent.

The natural vegetation of deserts consists of scattered scrub and cactus, plants that tolerate low humidity and wide temperature ranges. In some desert areas, underground springs may support an **oasis**, an area of lush vegetation. Some deserts have dunes or rocky surfaces, and others have fertile soil that can yield crops through irrigation.

Often bordering deserts are dry, largely treeless grasslands called steppes. Yearly rainfall in steppe areas averages 10 to 20 inches (25 to 51 cm). The world's largest steppe stretches across eastern Europe and western and central Asia. Steppes are also found in North America, South America, Africa, and Australia.

Mid-Latitude Climates

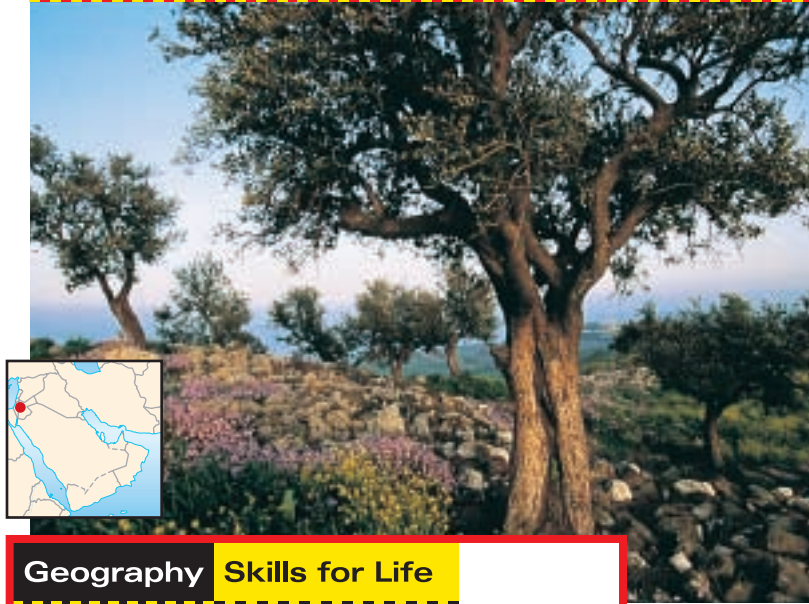
The world's mid-latitudes include four temperate climate regions. Mid-latitude climates experience variable weather patterns and seasonal changes that give rise to a variety of natural vegetation.

Along western coastlines, between the latitudes of 30° and 60° north and south, are regions with a *marine west coast* climate. The Pacific coast of North America, much of Europe, and parts of South America, Africa, Australia, and New Zealand have marine west coast climates. In these areas ocean winds bring cool summers and damp winters. Abundant rainfall supports the growth of both coniferous and deciduous trees. **Coniferous** trees such as evergreens have cones, needle-shaped leaves, and keep their foliage throughout the winter. **Deciduous** trees, such as oak, elm, and maple, have broad leaves that change color and drop in autumn. Typical of marine west coast climates are **mixed forests** with both kinds of trees.

Lands surrounding the **Mediterranean Sea** have mild, rainy winters and hot, sunny summers. The natural vegetation includes **chaparral** (SHA•puh•RAL), thickets of woody bushes and short trees. Geographers classify as *Mediterranean* any coastal mid-latitude areas with similar climate and vegetation. Such areas also include Southern California and parts of southern Australia.

In the southeastern United States and in southeastern parts of South America and Asia, a *humid subtropical* climate brings short, mild winters and nearly year-round rain. The wind patterns and high pressure related to nearby oceans keep humidity levels high in these areas. Vegetation consists of **prairies**, or inland grasslands, and forests of evergreen and deciduous trees.

In some mid-latitude regions of the Northern Hemisphere, such as southern Canada, western Russia, and northeastern China, landforms influence climate more than winds, precipitation, or ocean temperatures do. These *humid continental* climate regions do not experience the moderating effect of ocean winds because of their northerly continental, or inland, locations. The farther north one travels in these humid continental areas, the longer and more severe are the snowy winters and the shorter and cooler are the summers. Vegetation in humid continental regions is similar to that found in marine west coast areas, with evergreens outnumbering deciduous trees in the northernmost areas of the region.



Geography Skills for Life

Mid-latitude Vegetation Chaparral, which includes shrubs and olive trees, grows in Mediterranean climate zones.

Region What kind of vegetation grows in humid subtropical climate zones? Humid continental?

High Latitude Climates

In high latitude climates, freezing temperatures are common throughout much of the year because of the lack of direct sunlight. As a result, the amount and variety of vegetation is limited.

Just south of the Arctic Circle lie the *subarctic* climate regions. Winters here are bitterly cold, and summers are short and cool. Subarctic regions have the world's widest temperature ranges, varying from winter to summer by as much as 120°F (49°C). In parts of the subarctic, only a thin layer of surface soil thaws each summer. Below it is permanently frozen subsoil, or **permafrost**. Brief summer growing seasons may support needled evergreens.

Closer to the polar regions, *tundra* climate regions are very cold. Here the winter darkness and bitter cold last for half the year, and the sun's indirect rays bring constant summer light but little heat. In tundra regions, most of which lie in the far north of the Northern Hemisphere, the layer of thawed soil is even thinner than in the subarctic.

Trees cannot establish roots on these frigid plains, so tundra vegetation is limited to low bushes, very short grasses, mosses, and lichens (LY•kuhns).

Snow and ice, often more than 2 miles (3 km) thick, constantly cover the surfaces of *ice cap* regions. Lichens are the only form of vegetation that can survive in these areas, where monthly temperatures average below freezing. Earth’s largest polar ice cap covers almost all of Antarctica. Greenland’s interior also has an ice cap climate.

Highlands Climates

Elevation can determine a climate region, regardless of latitude. High mountain areas, even along the Equator, share some of the same characteristics of high latitude climates because of the thinning of the atmosphere at high altitudes. The higher the elevation, the cooler the temperatures. The natural vegetation of highlands climates also varies with elevation. Mixed forests generally lie at the bases of mountain ranges. Higher up, meadows with small trees, shrubs, and wildflowers line the mountainsides.

Climatic Changes

Climates change gradually over time, although the causes of these changes are unclear. Scientists search for answers by studying the interrelationships

among ocean temperatures, greenhouse gases, wind patterns, and cloud cover.

During the last 1 to 2 million years, for example, the earth passed through four ice ages, eras when glaciers covered large areas of the planet’s surface. One **hypothesis**, or scientific explanation, for these ice ages is that the earth absorbed less solar energy because of variations in the sun’s output of energy or because of variations in the earth’s orbit. Another hypothesis suggests that dust clouds from volcanic activity reflected sunlight back into space, cooling the atmosphere and lowering surface temperatures.

Human interaction with the environment also affects climate. Burning fossil fuels releases gases that mix with water in the air, forming acids that fall in rain and snow. Acid rain can destroy forests. Fewer forests may result in climatic change. The exhaust released from burning fossil fuels in automobile engines and factories is heated in the atmosphere by the sun’s ultraviolet rays, forming **smog**, a visible chemical haze in the atmosphere that endangers people’s health. Other human-driven changes result from dams and river diversions. These projects, intended to supply water to dry areas, may cause new areas to flood or to dry out and may affect climate over time.

TAKS Practice

SECTION 3 ASSESSMENT

Checking for Understanding

- 1. Define** natural vegetation, oasis, coniferous, deciduous, mixed forest, chaparral, prairie, permafrost, hypothesis, smog.
- 2. Main Ideas** Create a table like the one below, adding information and a brief description about each of the world’s climate regions.

Earth’s Climates	
Climate Region	Features

Critical Thinking

- 3. Analyzing Information** What patterns of vegetation are typical of tropical climates? Explain.
- 4. Comparing and Contrasting** What factors account for the similarities and differences between the subdivisions in tropical climate zones?
- 5. Categorizing Information** How are the five major climate regions related to the three zones of latitude?
- 6. Drawing Conclusions** What are the two main categories of factors causing climate change?

Analyzing Maps

- 7. Region** Study the map of world natural vegetation regions on page 67. What vegetation type dominates Europe? Canada and the United States?

Applying Geography

- 8. Climate and Settlement Patterns** On the map of world climate regions on page 66, locate the climate regions for Tashkent, Cape Town, Lima, Chicago, London, and Jakarta. What can you conclude about the relationship between climate and settlement?

Learning the Skill

A diagram is a graphic design that shows a process or event. Diagrams are extremely useful in communicating information clearly and quickly. A diagram can show placement, relationships, cycles, and movement, using symbols and drawn objects. Diagrams can be very useful for showing changes over time or for comparing two or more actions or relationships. Presenting information visually can make complex events or ideas more understandable.

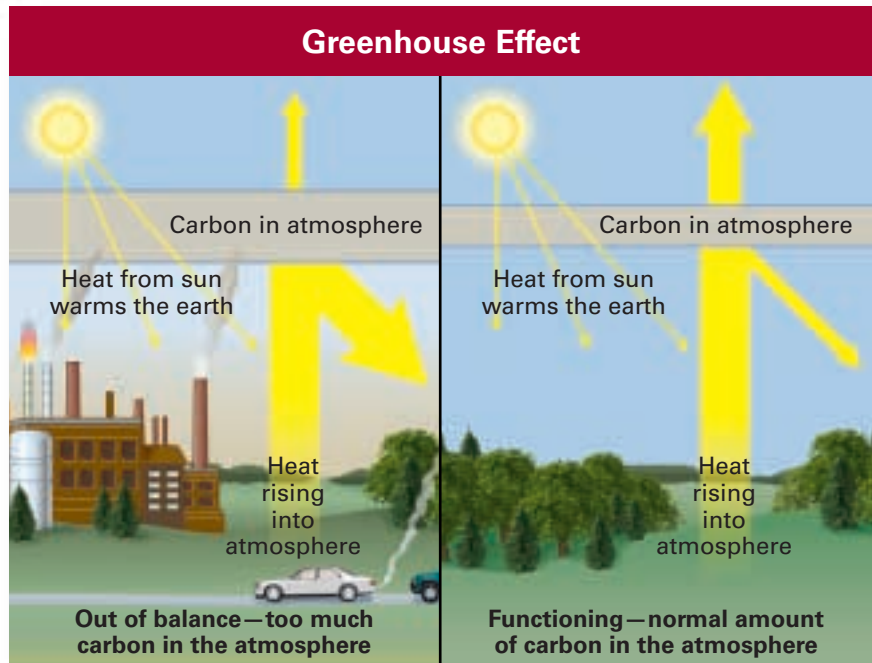
Newspapers, magazines, and the Internet use diagrams to supplement written information. Geographers use diagrams to explain complex processes such as climate and weather phenomena. A diagram can be a very effective way of communicating an idea.

Follow these steps to understand a diagram:

- **Note its title, caption, and labels.** These features provide information that is important for understanding the diagram.
- **Study carefully the objects and symbols used.** Sometimes a diagram includes a key to the symbols.
- **Look at the relationships or actions shown.** If the diagram compares two or more things, look for details that show how the relationship

Reading a Diagram

Have you ever assembled a model airplane or car? Kits and how-to books give detailed instructions that often include diagrams. Because they present information visually, diagrams can help explain ideas and processes easily.



or action changes under different circumstances.

Practicing the Skill

The diagrams above explain and compare two aspects of the greenhouse effect. Use the diagrams to answer the following questions.

1. Describe the two aspects of the greenhouse effect shown above.
2. How is plant life different in the two diagrams?
3. What objects are shown contributing more carbon to the atmosphere?

4. How is the amount of heat retained in the Earth's atmosphere related to the amount of carbon in the atmosphere?

Applying the Skill

Design and draw a diagram that explains a natural process. Look through newspapers or magazines for ideas relating to geography. In the diagram, include drawn objects, symbols, a title, and labels.



The **Glencoe Skillbuilder Interactive Workbook, Level 2** provides instruction and practice in key social studies skills.



SECTION 1

Earth-Sun Relationships (pp. 55–58)

Terms to Know

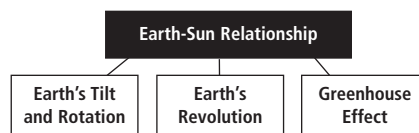
- weather
- climate
- axis
- temperature
- revolution
- equinox
- solstice
- greenhouse effect
- global warming

Key Points

- The earth's position in relation to the sun affects temperatures on Earth.
- The rotation of the earth causes day and night.
- The earth's revolution and its tilt in relation to the sun produce the seasons.
- Global temperatures may be increasing as a result of human activity.

Organizing Your Notes

Use a graphic organizer like the one below to help you organize your notes for this section.



SECTION 2

Factors Affecting Climate (pp. 59–64)

Terms to Know

- prevailing wind
- Coriolis effect
- doldrums
- current
- El Niño
- windward
- leeward
- rain shadow

Key Points

- Latitude and elevation affect climate.
- Wind patterns and ocean currents play a key role in the earth's climates.
- Climate is affected by recurring phenomena such as El Niño.
- Landforms shape and are shaped by climate patterns.

Organizing Your Notes

Use a table like the one below to help you organize information about climate.

Climate Factors	
Location	
Currents	
Surface Features	

SECTION 3

World Climate Patterns (pp. 65–69)

Terms to Know

- natural vegetation
- oasis
- coniferous
- deciduous
- mixed forest
- chaparral
- prairie
- permafrost
- hypothesis
- smog

Key Points

- Geographers divide the world into major climate regions.
- Each climate region has its own characteristic natural vegetation.
- Climate patterns change over time as a result of both natural processes and human activity.

Organizing Your Notes

Use an outline like the one below to help you organize your notes for this section.

Climate Patterns	
I. Tropical climates	
A. Tropical rain forest	
1. High temperatures	
2. Rain all year	
B.	

Reviewing Key Terms

On a sheet of paper, classify these key terms under the correct heading: earth-sun relationship, climate factors, or climate patterns.

greenhouse effect	temperature	El Niño
mixed forest	prevailing wind	oasis
equinox	chaparral	prairie
revolution	doldrums	current
deciduous	permafrost	solstice
Coriolis effect	rain shadow	axis

Reviewing Facts

SECTION 1

1. What are the effects of the earth's tilt, rotation, and revolution?
2. What are the differences in sunlight at the Tropic of Cancer, the Tropic of Capricorn, and the Poles?
3. How is CO₂ related to the greenhouse effect?

SECTION 2

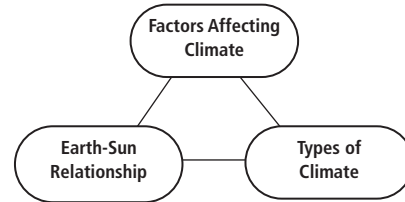
4. List three key factors that affect climate.
5. Describe the changes in air pressure that occur during an El Niño year. How do these changes affect wind patterns?
6. How do large bodies of water and mountains affect climate?

SECTION 3

7. What are the major climate regions into which geographers divide the earth?
8. What main types of vegetation grow in the earth's major climate regions?
9. In what ways might the burning of fossil fuels affect a region's vegetation?

Critical Thinking

1. **Predicting Consequences** How might increased global warming affect the earth's climates? Give examples to support your answer.
2. **Making Generalizations** Why do the mid-latitudes have a temperate climate?
3. **Categorizing Information** Create a web diagram like the one below. Connect the items with a line to show that they are related. Describe the geographical events and phenomena associated with each category.

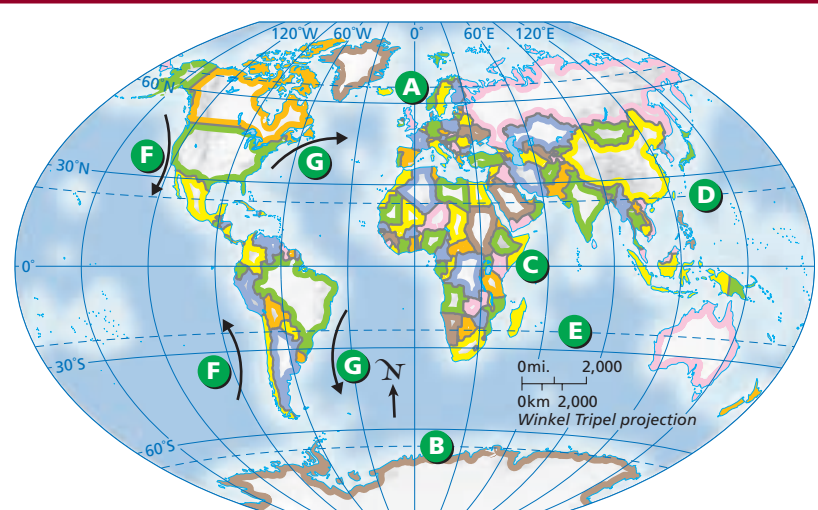


Locating Places

The World: Physical Geography

Match the letters on the map with the appropriate places and physical features. Write your answers on a separate sheet of paper.

- | | | |
|------------------------|---------------------------|--------------------------|
| 1. Equator | 4. Warm current, Atlantic | 6. Antarctic Circle |
| 2. Arctic Circle | 5. Tropic of Cancer | 7. Cold current, Pacific |
| 3. Tropic of Capricorn | | |





Self-Check Quiz Visit the **Glencoe World Geography** Web site at tx.geography.glencoe.com and click on Self-Check Quizzes—Chapter 3 to prepare for the Chapter Test.

Thinking Like a Geographer

Imagine that you have been asked to speak about global warming to a group in your community. Your goal is to persuade the audience to take steps to reduce global warming. Write an outline of the remarks you will make to the group, and use visuals to support your arguments.

Problem-Solving Activity

Problem-Solution Proposal Research and analyze the effects of a physical geographic pattern, such as El Niño, on world economies. What actions did countries take in response? Determine what preparations might lessen the impact of this pattern in the future. Write a proposal in which you outline the problem, present several possible solutions, and recommend a course of action. Include diagrams, charts, maps, and other visual elements.

GeoJournal

Cause and Effect Review your journal entries about factors affecting climate. Write a story that takes place in the future. The climate in your community has changed. Include details about how this change occurred and how it has affected vegetation, economic activities, and human and animal populations. Use specific examples as well as illustrations and concrete language to make your story interesting and engaging.



Technology Activity

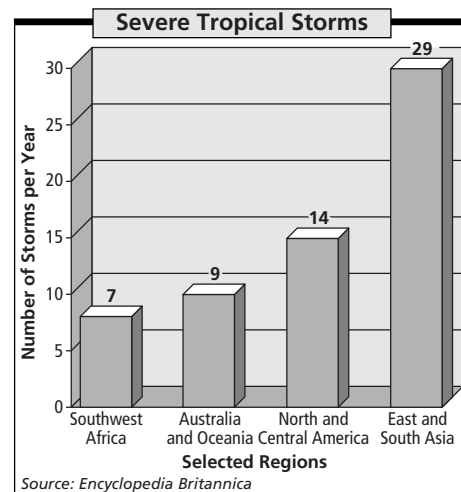
Using the Internet for Research

Work with a team to search the Internet for information about the climate in your community. Include information such as climate region, local factors that influence climate, seasonal changes, and any unusual climatic events. Then choose one aspect of your area's climate and write a paragraph explaining its effect on people in your community. For example, if your community has experienced a weather-related disaster, such as a hurricane or tornado, what effects did the event have on your community?



TAKS Test Practice

Use the graph below and your knowledge of geography to answer the question. If you have trouble answering the question, use the process of elimination to narrow your choices.



1. Which of the following statements can be inferred from the graph?

- F Severe tropical storms are rare in Oceania.
- G East and South Asia have about four times as many severe tropical storms as Southwest Africa.
- H North and Central America never go through a month without a storm.
- J South America does not have tropical storms.



Read the title and labels on the graph carefully to determine what is being presented. For example, the label on the bottom of the graph tells you that only selected regions are shown. The label on the left indicates the number of storms per year, but not the month in which they occur.