

UNIT 7 CHAPTER 39

# Chapter 39 Biomes

LIU Yang



# LEARNING OUTLINE

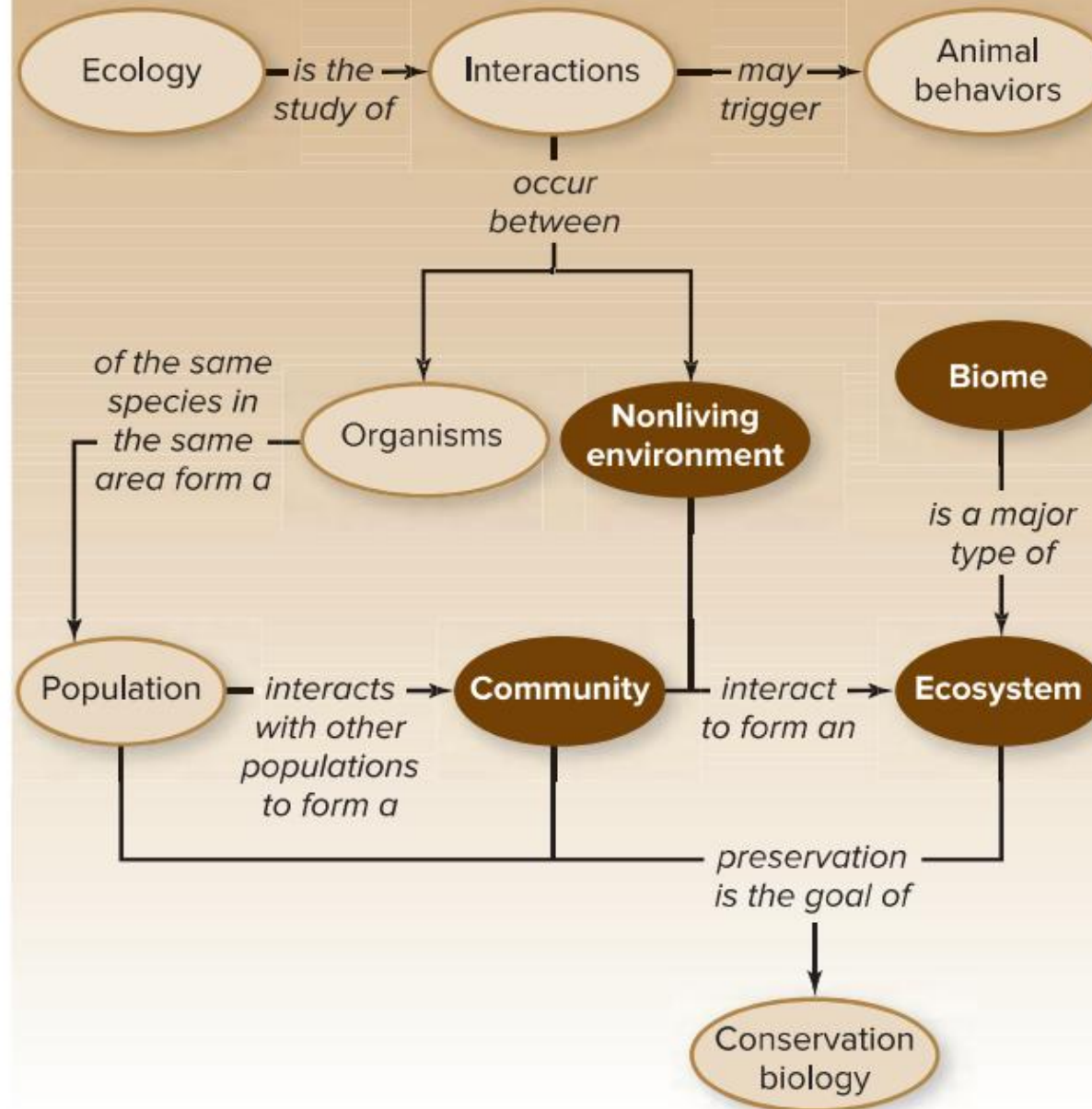
- 39.1 The Physical Environment Determines Where Life Exists
- 39.2 Earth Has Diverse Climates
- 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles
- 39.4 Freshwater Biomes Include Lakes, Ponds, and Streams
- 39.5 Oceans Make Up Earth's Largest Ecosystem





# SURVEY THE LANDSCAPE

## The Ecology of Life



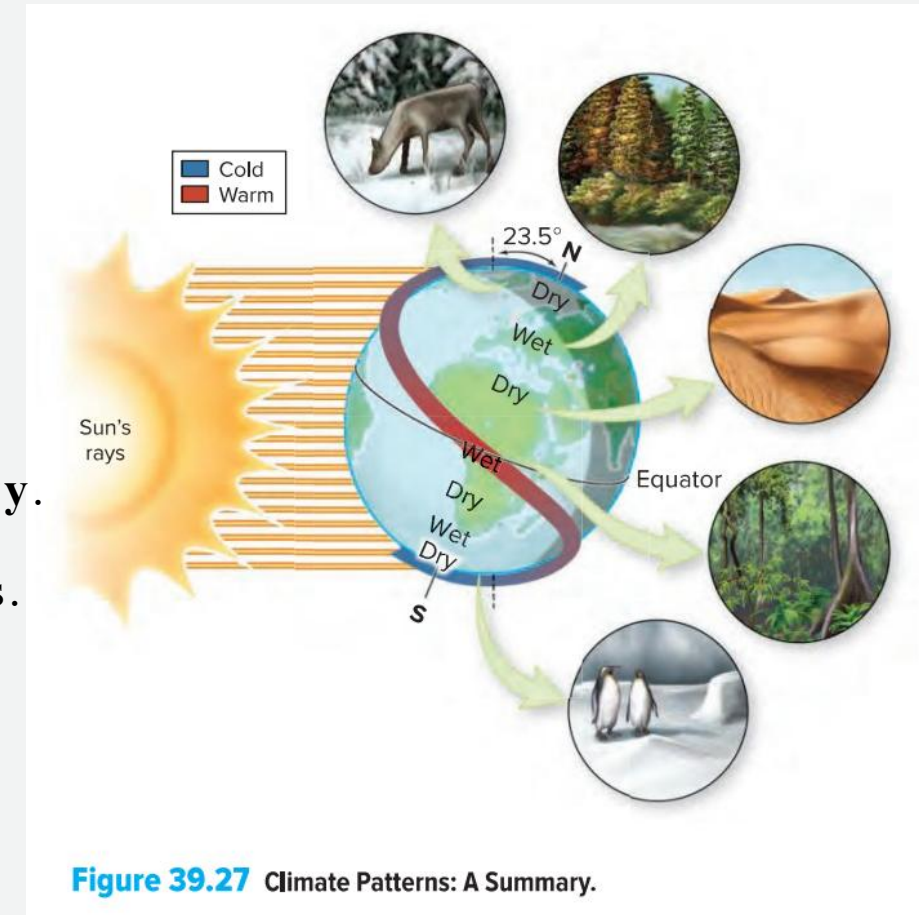
## 39.1 The Physical Environment Determines Where Life Exists

- All of these areas are part of the biosphere, the portion of Earth where life exists.
- **The biosphere is one huge ecosystem, an interconnected community of organisms and their physical environment.** Community ecologists study the biotic interactions among species, such as competition, predation, and mutualism. Ecosystem ecologists incorporate the community's interaction with its abiotic, or nonliving, environment. As we have already seen, both biotic and abiotic interactions shape the adaptations that contribute to the survival and reproductive success of each species.
- Ecologists divide the biosphere into biomes, which are major types of ecosystems characterized by a particular climate and a distinctive group of species. Forests, deserts, and grasslands are examples of terrestrial biomes. Lakes, streams, and oceans are water-based ecosystems.
- Although it is convenient to classify each ecosystem as belonging to one biome or another for convenience, keep in mind that no ecosystem exists in isolation. Water, air, sediments, and organisms travel freely from one part of the biosphere to another.



## 39.1 The Physical Environment Determines Where Life Exists

- Sunlight is the energy source for most ecosystems. On land, plants are the dominant primary producers. In water, however, most photosynthesis occurs courtesy of phytoplankton.
- Besides sunlight, the major abiotic factors that determine the numbers and types of plants on land are **temperature and moisture**. All organisms are adapted to a limited temperature range. In addition, all life requires water.
- **Nutrient availability** is another crucial abiotic factor that often determines an ecosystem's productivity.
- Another important abiotic factor in water and on land is **salinity**.
- **Fire** is an essential abiotic condition in some terrestrial biomes.



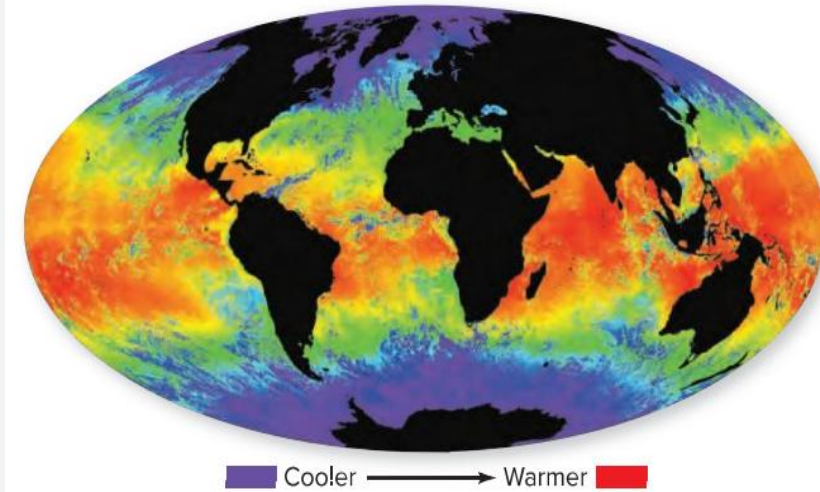
## **FIGURE IT OUT**

**1.What is a major primary producer in many aquatic biomes?**

**a.Underwater plants      b.The sun      c.Phytoplankton      d.Insect larvae**

## 39.2 Earth Has Diverse Climates

- Earth has a wide variety of climates, from the year-round warmth and moisture of the tropics to the perpetually chilly poles.
- **Equatorial regions** receive not only the most light but also the most precipitation. When sunlight heats the air over the equator, the air rises, expands, and cools. Because cool air cannot hold as much moisture as warm air, the excess water vapor condenses, forming the clouds that pour rain over the tropics. Air that rises near the equator also travels north and south. As the air cools at higher latitudes, its density increases, and it sinks back down to Earth at about **30° North and South latitude**. Here the warming air absorbs moisture from the land, creating the vast deserts of Asia, Africa, the Americas, and Australia. Some of the air continues toward the poles, rising and cooling at about **60° North and South latitude**, bringing the rains that support temperate (midlatitude) forests in these areas. The air rises, and some again continues toward the poles, where precipitation is quite low. The rest returns to the equator, where the air heats up again, and the cycle begins anew.



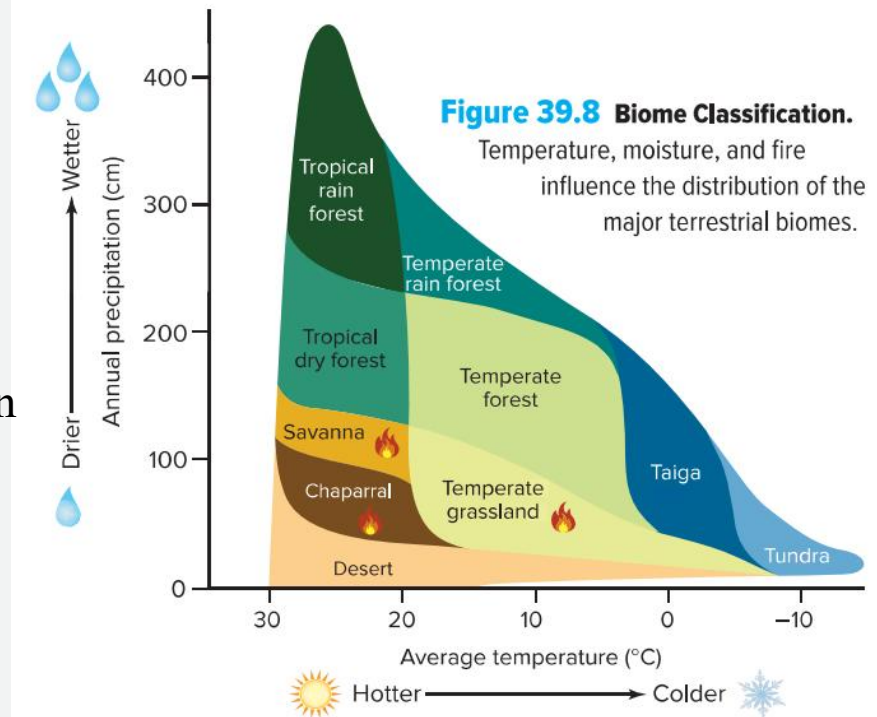
**Figure 39.3 From Warm to Cold.** The colored bands on this map show that Earth's surface is warmest at the equator and coldest at the poles.

MODIS Oceans Group, NASA Goddard Space Flight Center



## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

- Earth's climatic zones give rise to huge bands of characteristic types of vegetation, which correspond to the terrestrial biomes. Temperature and moisture are the main factors that determine the dominant plants in each location. The overall pattern of vegetation, in turn, influences which microorganisms and animals can live in a biome.
- **Soils form the framework of terrestrial biomes because they directly support plant life.** Although soil may seem like “just dirt,” it is actually a complex mixture of rock fragments, organic matter, and microbes. **Climate influences soil development in many ways.** Heavy rain may leach nutrients from surface layers and deposit them in deeper layers, or it may remove them entirely from the soil. In addition, in a warm, moist climate, rapid decomposition may leave little organic material in the soil. In cold, damp areas, on the other hand, undecomposed peat may accumulate in the soil.
- It is important to remember, however, that **humans have drastically reduced many natural biomes, replacing them with farmland, suburban housing, and cities.** In addition, human activities threaten much of the native habitat that remains.

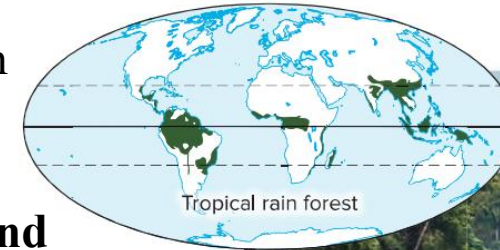




## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

### A. Towering Trees Dominate the Forests

- Forests supply many of the resources that we use every day: lumber, paper, furniture, and foods such as wild mushrooms and nuts. The trees in the forest also provide wildlife habitat and protect soil from erosion. Moreover, like all plants, trees absorb  $\text{CO}_2$  from the atmosphere and use it in photosynthesis, a process that also releases  $\text{O}_2$ . The wood of a living tree is an especially important long-term “carbon store-house” that helps offset  $\text{CO}_2$  released when humans burn fossil fuels.
- **Tropical Rain Forests**
- **The tropical rain forests encircle the equator in Africa, Southeast Asia, and Central and South America; their location ensures that the climate is almost constantly warm and moist. These forests are home to a stunning diversity of species connected by intricate networks of relationships. Plants and Animal life is similarly diverse.**
- Despite the lush plant growth, **tropical rain forest soils are usually nutrient-poor and low in organic matter.**
- **Worldwide, people are logging and burning tropical rainforests to make room for crops and domesticated animals. Tropical rain forest destruction threatens indigenous people and global water and carbon cycles.**

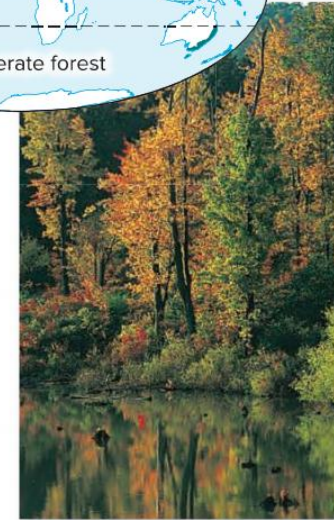
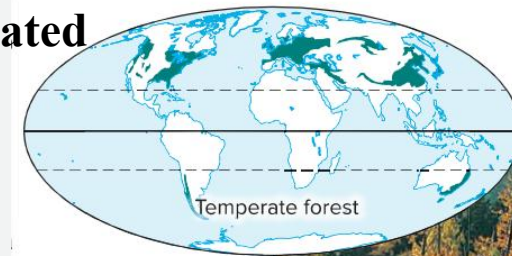


**Figure 39.9 Tropical Rain Forest.** Plants in the tropical rain forest form distinct layers, from the tallest trees emerging from the canopy to the tiniest residents of the shady forest floor. This rain forest is in southern Thailand.  
Photo: ©Muzhik/Shutterstock RF

## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

### A. Towering Trees Dominate the Forests

- **Temperate Deciduous and Coniferous Forests**
- **The world's temperate forests occupy large areas between 30° and 60° North latitude.** Temperate deciduous forests are dominated by trees that shed their foliage in autumn, whereas temperate coniferous forests contain mostly evergreen conifers that lose only a few leaves at a time. These forests once covered parts of Asia, western Europe, North America, South America, Australia, and New Zealand, but **logging, agriculture, and urbanization have decimated most of the world's native temperate forests.**
- Deciduous trees occur where summers are warm, winters are cold, and precipitation is approximately constant throughout the year.
- Mild winters, cool summers, and abundant rain and fog favor the temperate coniferous forest (sometimes called the temperate rain forest). Most trees in the temperate coniferous forest are evergreens such as spruce, pine, fir, and hemlock, all of which have waxy, needlelike leaves adapted to year-round photosynthesis.
- **Seed- or leaf-eating herbivores, omnivores (杂食动物) and carnivores.**



a.



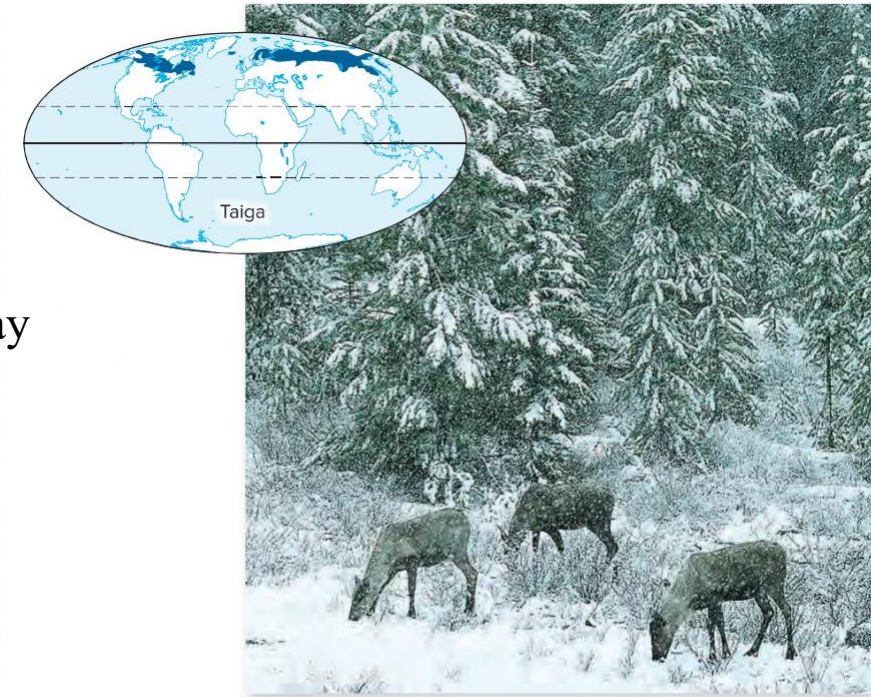
b.

**Figure 39.10 Temperate Forests.** (a) Trees that lose their leaves each autumn dominate temperate deciduous forests such as this one in Pennsylvania. (b) Temperate coniferous forests have evergreen trees such as these in Wyoming's Grand Teton National Park.

## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

### A. Towering Trees Dominate the Forests

- **Taiga (Boreal 北方的 Forests)**
- North of the temperate zone in the northern hemisphere lies the cold, snowy taiga. This biome is also called the boreal forest or the northern coniferous forest. The long, harsh winter can last more than 6 months, so the growing season is short. Moisture can be scarce in winter, when water may remain frozen for months.
- **Soils in the taiga are cold, damp, acidic, and nutrient-poor.** The low temperature and acidic pH slow decomposition, and nutrients tend to stay in the leaf litter above the soil, rather than entering the topsoil.
- Spruce, fir, pine, and tamarack (larch) are the dominant trees. **The needles of these evergreens resist water loss and can carry out photosynthesis whenever the weather is warm enough to support it.**
- **Seed- or leaf-eating herbivores** include the woodland caribou, porcupines, red squirrels, chipmunks, snowshoe hares, and moose. **Carnivores** include lynx, gray wolves, and wolverines.
- **Logging, oil exploration, hunting, and trapping, however, are rapidly depleting the boreal forests.**



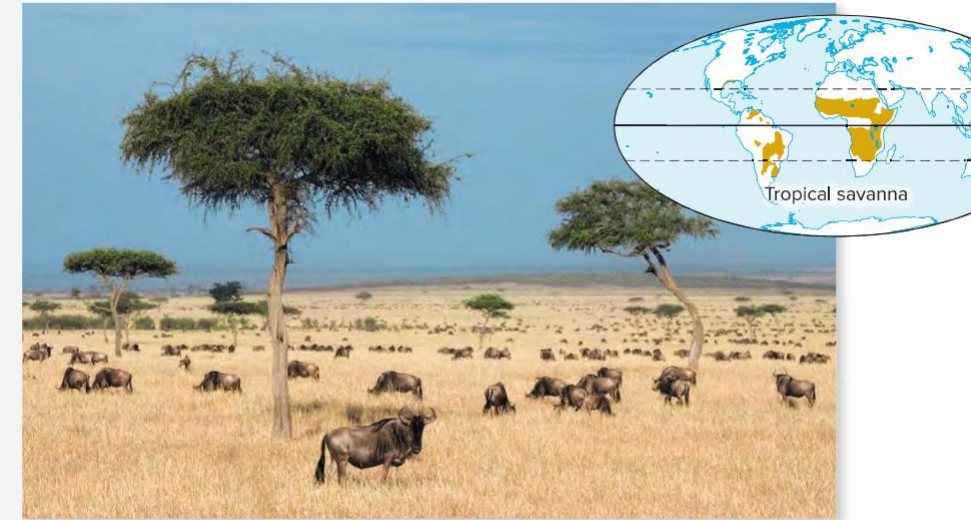
**Figure 39.11 Taiga.** Woodland caribou forage for food in the Canadian boreal forest.



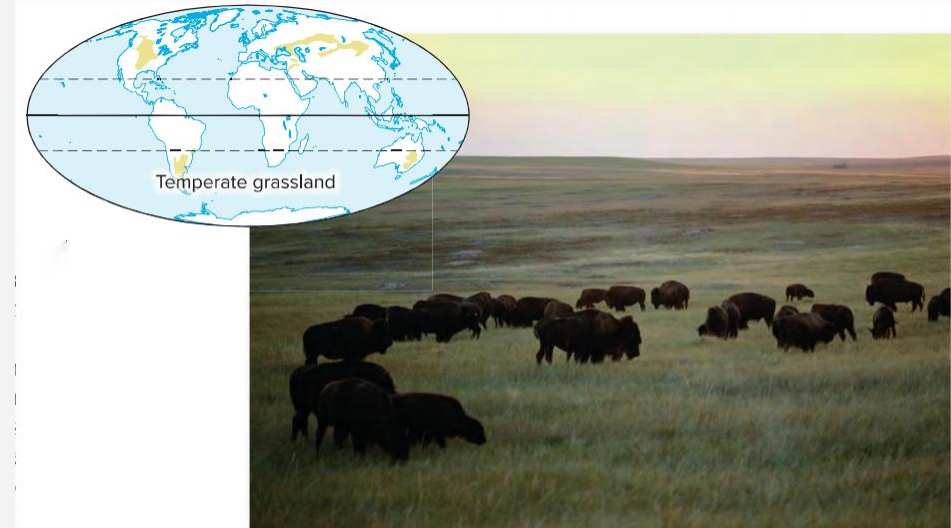
## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

### B. Grasslands Occur in Tropical and Temperate Regions

- Vast seas of grasses sustain huge herds of large, grazing animals such as bison and zebras. But the rich soils that support the grasslands also make these prime areas for agriculture. Grasslands are therefore endangered around the world.
- **Tropical Savannas**
- **Tropical savannas are grasslands with scattered trees or shrubs and bands of woody vegetation along streams. The weather is warm year-round, with distinct wet and dry seasons. Perennial grasses dominate the savanna along with patches of drought- and fire-resistant trees and shrubs such as palms, acacias, and baobabs. These plants have deep roots, thick bark, and trunks that store water.**
- **Temperate Grasslands**
- The temperate grasslands are also known as the prairies of North America, the steppes of Russia, and the pampas of Argentina. **The climate is moderately moist, with hot summers and cold winters. These ecosystems have few if any trees, partly because annual rainfall is often not sufficient to support them. Grazing and fire also suppress tree growth. The tips of a tree's branches, where growth occurs, are easily destroyed by fire or herbivores. In contrast, the perennial buds of grasses lie protected below the soil surface and resprout soon after the fire passes.**



**Figure 39.12 Tropical Savanna.** A herd of wildebeest roams the savanna in Kenya's Masai Mara National Reserve.

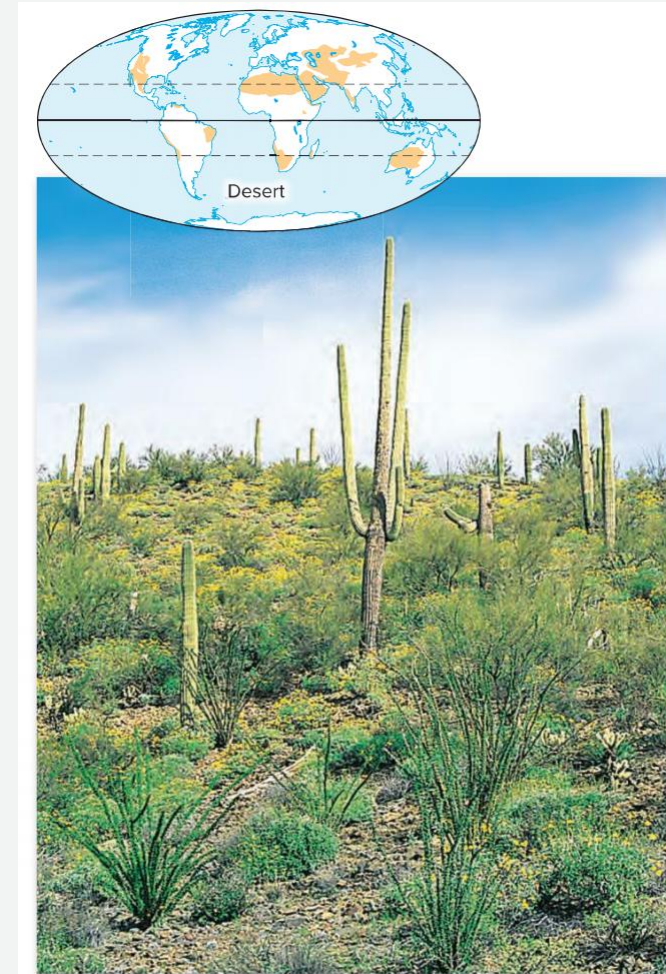


**Figure 39.13 Temperate Grassland.** Bison once dominated the North American prairie, a temperate grassland.

## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

### C. Whether Hot or Cold, All Deserts Are Dry

- **All deserts are dry, receiving less than 20 centimeters of rainfall per year.** They ring the globe at 30° North and South latitude, and additional deserts occur in the rain shadows of tall mountains. **Sparse desert life means soils are low in organic matter.**
- Although deserts have a reputation for being hot, the temperature can vary dramatically. In a hot desert such as the Sonoran, which spans parts of Arizona and Mexico, few clouds filter the sun's strongest rays, and the days can be scorchingly hot. In China's cold Gobi Desert, in contrast, the average annual temperature is below freezing.
- **Some desert habitats, however, are species-rich.** Desert plants often have long taproots, quick life cycles that exploit the brief rainy periods, fleshy stems or leaves that store water, and spines or toxins that guard against thirsty herbivores. **Many use CAM photosynthesis, a water-saving variation on the photosynthetic pathway.**
- **Urban development, however, changes the desert ecosystem drastically by diverting huge amounts of water from faraway rivers.** Even so, deserts are among the few biomes that are expanding worldwide, as unsustainable agriculture eats away at forests and savannas.



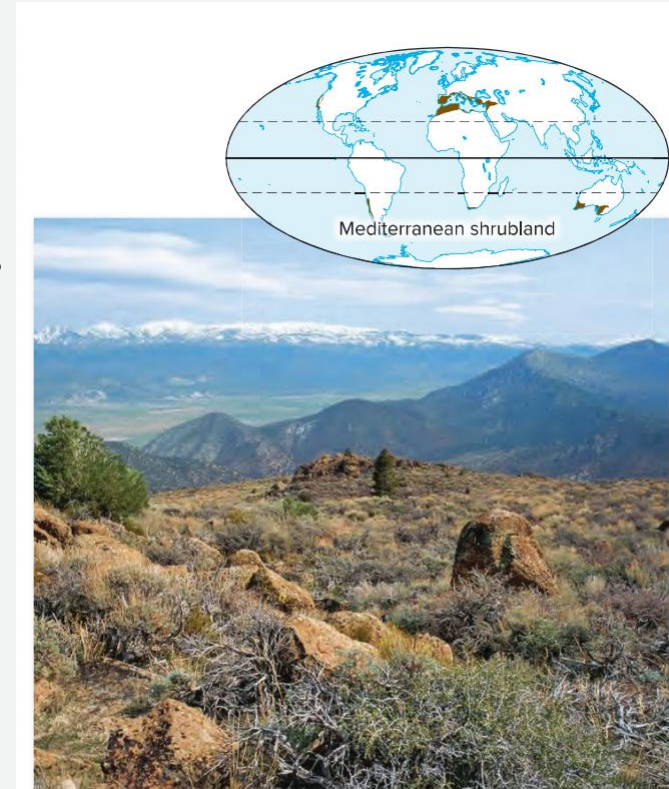
**Figure 39.14 Desert.** Saguaro cacti and many other desert plants have water-conserving adaptations. This is the Sonoran Desert in the southwestern United States. Photo: ©Ed Reschke



## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

### D. Fire-and Drought-Adapted Plants Dominate Mediterranean Shrublands(Chaparral)

- Despite the name, Mediterranean shrublands occur not only around the Mediterranean Sea but also in other small areas along the west coasts of North and South America, Australia, and South Africa. **Summers are hot and dry; winters are mild and moist.** As the name suggests, **the dominant vegetation is shrubby plants**, including poison oak, manzanita, and scrub oak. The plants have thick bark and small, leathery, evergreen leaves with thick cuticles and hairs that slow moisture loss during the dry summers. **Herbivores** include jackrabbits, mule deer, and birds and rodents that forage for seeds under the shrub canopy; some of their **predators** include coyotes, foxes, snakes, and hawks.
- **Mediterranean shrublands are especially susceptible to fires because the vegetation dries out during the summer. The sandy soils retain little water.** The fire-adapted plants resprout from underground parts or produce seeds that germinate only after the heat of a fire. Burning the plant cover makes the soil susceptible to erosion, raising the risk of mud slides and further property damage.



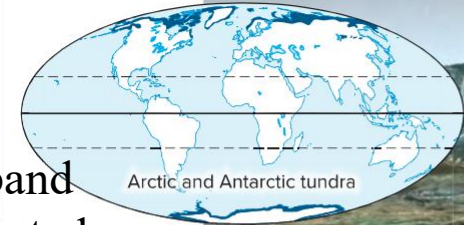
**Figure 39.15 Mediterranean Shrubland.** Dry summers, wet winters, and fire shape this chaparral ecosystem in California.



## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

### E. Tundras (苔原) Occupy High Latitudes and High Elevations

- **The tundra is a low-temperature biome.** The largest region of tundra occurs in a band across the northern parts of Asia, Europe, and North America. The **Antarctic continent** also has a small amount of tundra. **In addition, at middle latitudes, alpine tundra occupies high mountaintops between the tree line and areas of permanent snow and ice cover.**
- A Snow covers the Arctic and Antarctic tundra during the bitterly cold and dark winter. **Temperatures venture above freezing for a few months each year, and summer sunlight is intense.** Because cold temperatures slow decomposition, **tundra soils are rich in organic matter. Below the top layer of soil is a zone called permafrost, where the ground remains frozen year-round.** Permafrost limits rooting depth, which prevents the establishment of large plants. The shallow tundra soil supports reindeer lichens, mosses, dwarf shrubs, and low-growing perennial plants such as sedges, grasses, and broadleaf herbs. Penguins, seals, and other vertebrates visit the Antarctic tundra, but the Arctic tundra has much more diverse animal life. Inhabitants include caribou, musk oxen, reindeer, lemmings, hares, foxes, and wolverines, all of which have thick, warm fur. Polar bears sometimes visit coastal areas of the Arctic tundra to den. In the summer, migratory birds raise their young and feed on the insects that flourish in the tundra and its ponds.
- **The shallow soil, short growing season, and slow decomposition make the tundra a very fragile environment that recovers slowly from disturbance. In recent decades, oil drilling in the Arctic tundra has significantly increased the human presence.**

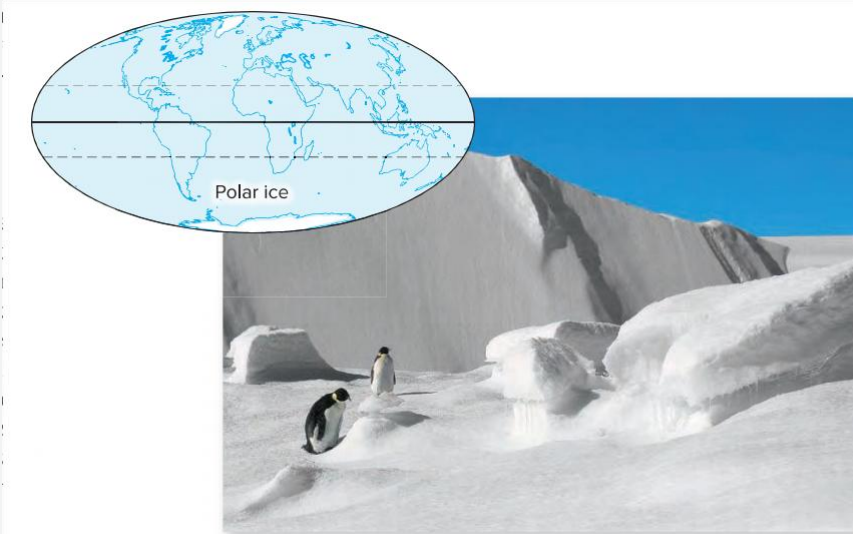


**Figure 39.16 Arctic Tundra.** In the Alaskan tundra, lichens and small plants dominate. Permafrost prevents the growth of large plants.

## 39.3 Terrestrial Biomes Range from the Lush Tropics to the Frozen Poles

### F. Polar Ice Caps Are Cold and Dry

- **Of all of the world's terrestrial biomes, polar ice at the North and South Poles is the least explored.** Although the two poles seem superficially similar, they differ from each other. The northern ice cap is a relatively thin ice layer that covers the Arctic Ocean. Antarctica, the southern most continent, is a landmass covered with a thick layer of ice. **Both ice caps interact extensively with water and therefore share characteristics of both terrestrial and aquatic biomes.**
- **Life is difficult at both poles.** Both Antarctica and the Arctic ice cap are extremely cold, dry, and windy year-round. The primary producers in ice and the surrounding ocean are phytoplankton. The light passing through the ice is dim, even in the summer. Yet these phytoplankton support a unique food web consisting of bacteria, archaea, worms, crustaceans, and ice fishes. All of these organisms have antifreeze chemicals that prevent deadly ice crystals from forming in their cells.
- Larger animals that exploit the polar food web have thick layers of insulating fat, coupled with fur or feathers.



**Figure 39.17 Polar Ice.** These emperor penguins live in the frozen desert of Antarctica, Earth's coldest continent.

## **FIGURE IT OUT**

**A biome with high average temperature and low to moderate annual rainfall is a (     )**

**a.tropical savanna.     b.temperate deciduous forest.     c.tropical rain forest.     d.taiga.**

## 39.4 Freshwater Biomes Include Lakes, Ponds, and Streams

- Although terrestrial biomes are most familiar to us, aquatic ecosystems occupy much more space. In fact, water covers about 71% of Earth's surface. Only about 3% of all water has a low enough salt content to be considered “fresh.” Glaciers and the great polar ice sheets of Greenland and Antarctica tie up more than two thirds of this fresh water, and most of the rest is in groundwater, soil, and the atmosphere. Lakes and rivers on Earth's surface contain only about 0.009% of the world's water supply.

### A. Lakes and Ponds Contain Standing Water

- **Standing water includes lakes and ponds**, which differ from one another mainly in size and depth. A lake is generally larger and deeper than a pond.
- Light penetrates the regions of a lake to differing degrees, creating zones with characteristic groups of organisms. The lake's **photic zone**, where light is sufficient for photosynthesis, is subdivided into littoral and limnetic zones (海岸带和湖沼带).
- In contrast to the photic zone, the **profundal zone** (深水区) is the deep region of water where light does not penetrate. Scavengers and decomposers, both here and in the **benthic zone** (底栖区) (the sediment at the lake bottom), rely on a gentle rain of organic material from above to supply both energy and nutrients.
- **Lakes change over time. Younger lakes are often deep, steep-sided, and low in nutrients.** These lakes are oligotrophic (贫营养的), which means they are nutrient-poor and therefore low in productivity. They are clear and sparkling blue, because phytoplankton aren't abundant enough to cloud the water. **As a lake ages, however, nutrients accumulate from decaying organisms and sediment. Such a lake is eutrophic**, which means it is nutrient-rich and high in productivity. The rich algal growth turns the water green and murky. The nutrients promote the excessive growth of algae, which sink to the lake bottom after they die. **As the dead algae decompose, deep waters are rapidly depleted of oxygen. Many fish and other animals die.** In addition, microbes respond by switching to anaerobic metabolism; the byproducts are gases with unpleasant, “rotten egg” odors. **A eutrophic lake eventually fills completely with sediments and transforms into a freshwater wetland.**

## 39.4 Freshwater Biomes Include Lakes,Ponds,and Streams

### B.Streams Carry Running Water

- **Streams include brooks,creeks,and rivers that carry water and sediment from all portions of the land toward the ocean.** Along the way, **streams provide moisture and habitat to aquatic and terrestrial organisms.**Rivers are the largest streams. They change as they flow toward the ocean. At the headwaters,the water is relatively clear,and the stream channel is narrow.Where the current is swift, turbulence mixes air with water,so the water is rich in oxygen. **As the river flows toward the ocean, it continues to pick up sediment and nutrients from the channel.**The river widens as small streams draining additional land areas contribute more water.As the land flattens,the current slows. The river is now murky, restricting photosynthesis to the banks and water surface.As a result,the oxygen content is low relative to the river upstream.
- **Rivers depend on runoff from the land for water and nutrients.**Dead leaves and other organic material fall into the river and add to the nutrients.**On the other hand,rivers also return nutrients to the land.**Many rivers flood each year,swelling with melt-water and spring runoff and spreading nutrient-rich silt onto flood plains.When a river approaches the ocean,its current slows and deposits fine,rich soil that forms new delta lands at the mouth of the river.

## **FIGURE IT OUT**

**A worm that lives in lake sediment is in the\_\_\_\_\_zone.**

**a.limnetic**

**b.benthic**

**c.profundal**

**d.littoral.**



## 39.5 Oceans Make Up Earth's Largest Ecosystem

- The oceans, covering 70% of Earth's surface and running 11 kilometers deep in places, form the world's largest biome. **Most photosynthesis on Earth occurs in the vast oceans, contributing enormous amounts of oxygen to the atmosphere. Moreover, oceans absorb so much heat from the sun that they help stabilize Earth's climate.**
- **Food webs in the ocean need nutrients and sunlight.** Supplies of both of these resources—and therefore primary production—are highest in shallow waters near the coasts. In deep water away from the coasts, however, both energy and nutrients can be scarce.

### A. Land Meets Sea at the Coast

- For humans, the world's coasts are a vital source of food, transportation, recreation, and waste disposal. Most of the world's largest cities are located along coastlines, and human populations in those cities are expected to increase in the future. As the human population expands, concerns about coastal ecosystems will likely increase. Several types of ecosystems border shorelines.
- **Estuaries (河口)**
- **An estuary is an area where the fresh water of a river meets the salty ocean.** When the tide is out, the water may not be much saltier than water in the river. The returning tide, however, may make the water nearly as salty as the sea. **Organisms that can withstand these extremes in salinity receive nutrients from both the river and the tides. Estuaries therefore house some of the world's most productive ecosystems. In the open water of an estuary, phytoplankton account for most of the productivity.** In addition, salt-tolerant grasses and other flowering plants dominate the salt marshes that often occur along the fringes of an estuary. Together, these producers support many animals. Important fish and shellfish species spend some part of their life cycle in an estuary. Migratory waterfowl feed and nest here as well. Moreover, almost half of an estuary's photosynthetic products go out with the tide and nourish coastal communities.

## 39.5 Oceans Make Up Earth's Largest Ecosystem

### A. Land Meets Sea at the Coast

- **Intertidal Zone (潮间带)**

- Along coastlines, the intertidal zone is the area between the high tide and low tide marks. **This region of constant change is alternately exposed and covered with water as the tide rises and falls.** Species-rich mangrove forests occupy intertidal areas in the tropics. Constantly shifting sands mean that few producers can take root on the beach, but ocean water delivers a constant supply of dead organisms and other nutrients. Crabs feed on the organic debris and then burrow into the sand to escape the pounding waves, while shorebirds forage for worms and other small invertebrates.

- **Coral Reefs (珊瑚礁)**

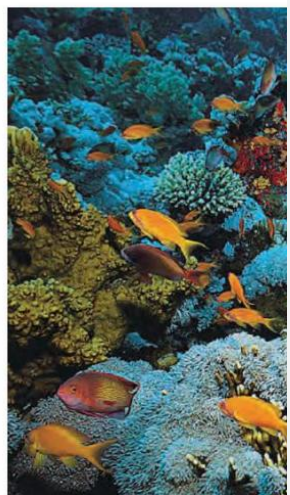
- Colorful and highly productive coral reef ecosystems border tropical coastlines where the water is clear and sediment-free. **Coral reefs are vast underwater structures of calcium carbonate built by coral animals.** The living coral is but a thin layer atop the remains of ancestors. A coral reef, then, is at the same time an immense graveyard and a thriving ecosystem. The tissues of the coral animals house symbiotic algae that are essential for the coral's—and the ecosystem's—survival. The sun penetrates the clear, shallow water, allowing photosynthesis to occur, and constant wave action brings in additional nutrients.



a.



b.



**Figure 39.22 Coastal Ecosystems.** (a) An estuary on the coast of Mozambique. (b) Mangrove trees on Okinawa, Japan. (c) Rocky intertidal zone along the Oregon coast. (d) Coral reef in the Red Sea.

## **FIGURE IT OUT**

**Why do estuaries have such high primary production?**

- a. The changing salinity of the water**
- b. High nutrient input from the land**
- c. The absence of consumers that eat producers**
- d. All of the above are correct.**

## 39.5 Oceans Make Up Earth's Largest Ecosystem

### B.The Open Ocean Remains Mysterious








- The oceans cover most of Earth's surface, but we know less about marine life than we do about biodiversity in a single tree in a tropical rain forest. Not only is this ecosystem vast, but it also houses populations that are sometimes small, usually very dispersed, and nearly always difficult for us to observe. Biologists have explored only 5% of the ocean floor and 1% of the huge volume of water above.
- Marine biologists divide the ocean surface into horizontal zones. The intertidal zone (潮间带) is the shoreline. The neritic zone (浅海区) is the area of relatively shallow seawater between the intertidal zone and the edge of the continental shelf. Sunlight is abundant here, and sediments from the coast contribute nutrients, so the neritic zone supports high primary production and extensive marine food webs. The great kelp forests that fringe many coolwater coastal areas are neritic ecosystems. The oceanic zone (深海区) is the deep water beyond the continental shelf.
- The ocean can also be subdivided according to depth. The pelagic zone (远洋区) consists of all of the water above the seafloor. The upper layer of the pelagic zone, the photic zone (透光区), is the only area where photosynthesis can occur. At the very top of the pelagic zone, the sea surface houses phytoplankton and the zooplankton that feed on them. Large sea animals such as fishes and whales scoop up vast quantities of krill and other zooplankton. Below the photic zone is the profundal zone (深海区), where light is too dim for photosynthesis. Nevertheless, the bodies and wastes of top dwelling organisms provide a continual rain of nutrients to the species below, including great numbers and varieties of jellyfishes, fishes, whales, dolphins, mollusks, echinoderms, crustaceans, and organisms yet to be discovered. The unusual communities that occupy hydrothermal vents (热液喷口) add biodiversity to the benthic zone (底栖区).

## 39.5 Oceans Make Up Earth's Largest Ecosystem

### B.The Open Ocean Remains Mysterious

- The most productive ocean environments arise in zones of upwelling (上升流), where deep currents force cold, nutrient-rich lower layers of water to move upward. The influx of nutrients causes phytoplankton to “bloom,” and with this widening of the food web base, many ocean populations grow. Upwelling generally occurs on the western side of continents, such as along the coasts of southern California, South America, parts of Africa, and the Antarctic. A climatic event called El Niño periodically shifts these ocean currents, greatly disrupting coastal ecosystems .

● SUMMARY

Biomes Considered in Study	Description	Image	Number of Species Sampled
Sclerophyll	Many shrubs; nutrient-poor soils; similar to Mediterranean shrubland		7250
Arid	Some shrubs and trees, few grasses; dry		1683
Wet forest	Many trees; abundant precipitation		1005
Temperate grassland	Many grasses; cold winters; climate varies but is not arid		504
Savanna	Many grasses, few shrubs and trees; summer rain and winter drought		242
Alpine	Shrubs and grasses above the tree line		186
Bog	Permanently wet soil that lacks surface water		84

**Figure 39.25 Biome Descriptions.** The researchers classified ecosystems in the study area into seven biomes.

Photos: (sclerophyll): ©DLILLC/Corbis RF; (arid): ©Paul Edmondson/Getty Images RF; (wet forest): ©Photo 24/Getty Images RF; (temperate grassland): ©DLILLC/Corbis RF; (savanna): ©Natphotos/Getty Images RF; (alpine): U.S. Geological